N91-28194

NASA

The Space Exploration Initiative

Briefing to

Space Transportation Propulsion Technology Symposium
Pennsylvania State University

June 26, 1990

Pete Priest
Marshall Space Flight Center

NASA

WHY ARE WE GOING TO MARS?

To strengthen our country's international competitiveness
- technology
- education

To continue America's journey into space

To understand planetary evolution

To enhance our understanding of life in the universe and find out if life once existed on Mars

To fulfill the human imperative to explore

Carry out the National Space Policy goal of expanding human presence and activity beyond Earth orbit into the solar system

Office of Aeronautics, Exploration and Technology

NASA

WHY GO TO THE MOON FIRST?

Learn to build, live and work on planetary surface close to home

Nearby — a 3-day trip and near instantaneous communications

Human experience in partial gravity leads to Mars

New science opportunities

Significant achievement by early next century

An evolutionary approach to "expanding human presence and activity"

Office of Aeronautics, Exploration and Technology

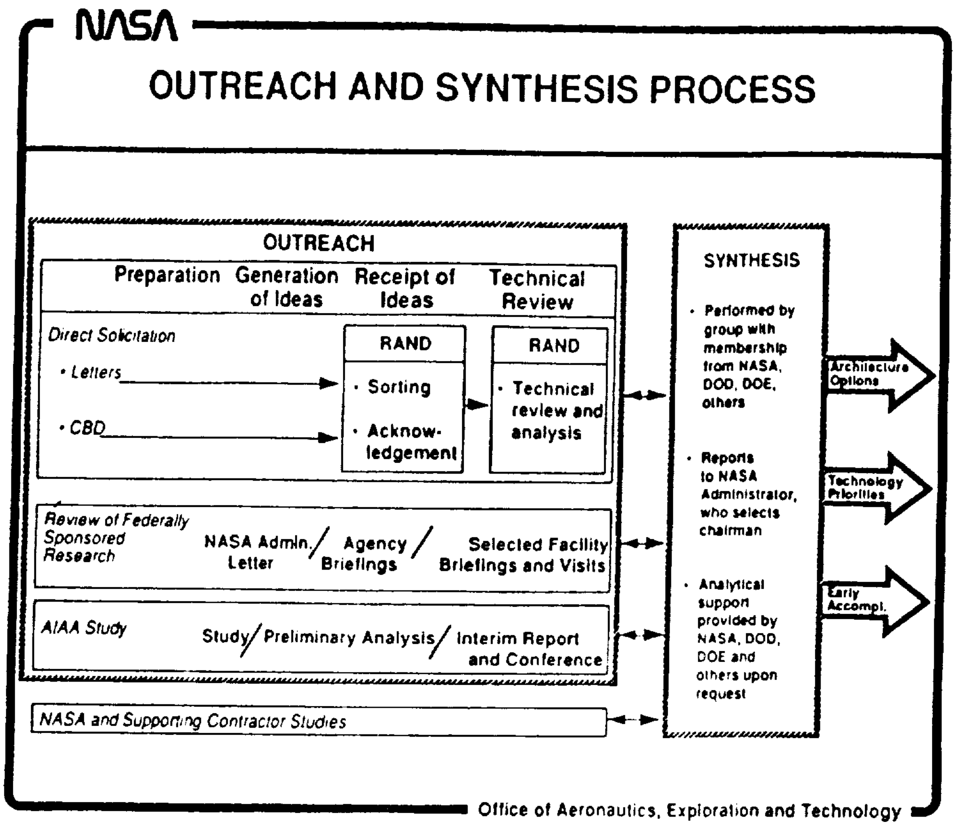
NASA

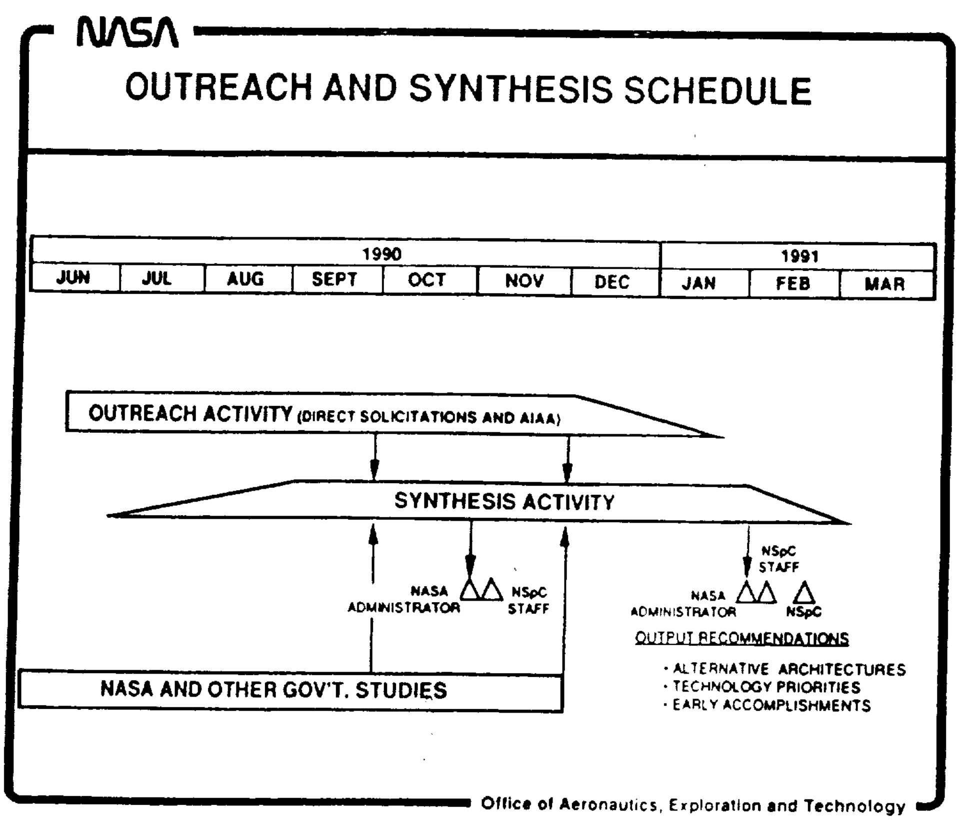
PRESIDENTIAL DECISION ON THE SPACE EXPLORATION INITIATIVE

On February 16, 1990 President Bush approved policy for the Space Exploration Initiative:

- Initiative will include both Lunar and Mars program elements, as well as robotic science missions
- Near-term focus will be on technology development
  - Search for new/innovative approaches and technology
  - Investment in high leverage innovative technologies with potential to make a major impact on cost, schedule, and/or performance
  - In parallel with mission, concept, and system analysis studies
- Selection of a baseline program architecture will occur after several years of defining two or more reference architectures while developing and demonstrating broad technologies
- NASA will be the principal implementing agency while DOD and DOE also will have major roles in technology development and concept definition. The National Space Council will coordinate the development of an implementation strategy by the three agencies

Office of Aeronautics, Exploration and Technology


NASA
OUTREACH AND SYNTHESIS PROCESS
OUTREACH
Preparation
Generation of Ideas
Receipt of Ideas
Technical Review
Direct Solicitation
• Letters
• CBD
RAND
• Sorting
• Acknow-ledgement
RAND
• Technical review and analysis
Review of Federally Sponsored Research
NASA Admin. Letter
Agency Briefings
Selected Facility Briefings and Visits
AIAA Study
Study
Preliminary Analysis
Interim Report and Conference
NASA and Supporting Contractor Studies
SYNTHESIS
• Performed by group with membership from NASA, DOD, DOE, others
• Reports to NASA Administrator, who selects chairman
• Analytical support provided by NASA, DOD, DOE and others upon request
Architecture Options
Technology Priorities
Early Accompl.
Office of Aeronautics, Exploration and Technology


NASA
OUTREACH AND SYNTHESIS SCHEDULE
1990
1991
JUN
JUL
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
OUTREACH ACTIVITY (DIRECT SOLICITATIONS AND AIAA)
SYNTHESIS ACTIVITY
NASA ADMINISTRATOR
NSpC STAFF
NSpC STAFF
NASA ADMINISTRATOR
NSpC
OUTPUT RECOMMENDATIONS
• ALTERNATIVE ARCHITECTURES
• TECHNOLOGY PRIORITIES
• EARLY ACCOMPLISHMENTS
NASA AND OTHER GOV'T. STUDIES
Office of Aeronautics, Exploration and Technology

NASA

LUNAR TRANSPORTATION SYSTEM REQUIREMENT DRIVERS

- **Mass delivered to lunar surface**
  - Crew size
  - Lunar base elements
  - Separate or combined crew/cargo flights
- **Type of lunar base**
  - Support a permanent base
  - Man-tended missions only
  - Evolution of lunar base/date of first mission
- **Design approach**
  - Commonality of cargo/crew vehicles
  - Commonality with Mars transportation system
  - Extent of transportation system reuse
  - Extent of on-orbit operations
    - Launch vehicle size
    - Expendable versus space-based reusable vehicles

Office of Aeronautics, Exploration and Technology

NASA

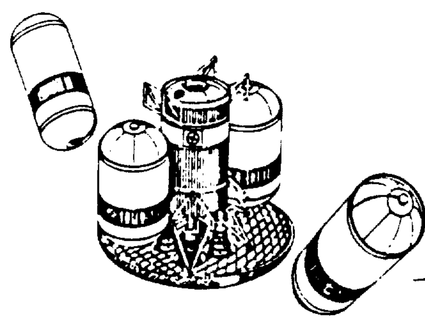
SPACE TRANSPORTATION SYSTEM KEY REQUIREMENTS FOR LUNAR BASE SUPPORT

- Deliver up to 30t of cargo to lunar surface on a single mission
- Deliver 4 crew and up to 15t cargo to lunar surface and return the crew to Space Station Freedom
  - Support continuous human presence at base by crew exchange
  - Support a human tended base by crew sorties to the Moon
- Provide common vehicle design for both cargo and crew delivery to reduce number of hardware developments
- Provide vehicle reuse to reduce vehicle and operational cost
- Use Space Station Freedom as an orbital transportation node for vehicle assembly and staging
- Provide heavy-lift launch vehicle capability that reduces number of launches and on-orbit assembly requirements
  - 60-70t minimum payload to Freedom
  - 7.6 meter payload shroud
- Space transportation system to be available within 10 years

Office of Aeronautics, Exploration and Technology

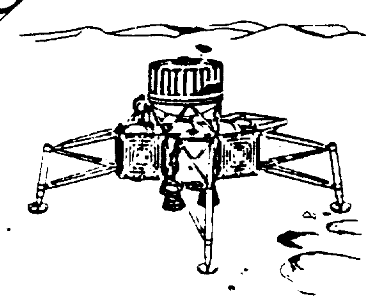
NASA

LUNAR TRANSPORTATION SYSTEM



Lunar Excursion Vehicle
(LEV)

- Payload to surface: 15t plus crew module
- Single stage design
- Liquid hydrogen/liquid oxygen propellant
- 4 engines at 20K thrust each
- Vehicle mass: 32t



Lunar Transfer Vehicle
(LTV)

- Core stage with drop tank design
- Liquid hydrogen/liquid oxygen propellant
- 4 engines at 20K thrust each
- Vehicle mass: 128t

Office of Aeronautics, Exploration and Technology

NASA

LUNAR TRANSFER SYSTEM
CONCEPT IMPROVEMENTS

- **Reduce number of vehicle elements**
  - Single crew module
  - Single P/A module
  - Fewer propellant tanks
  - Fewer engines
- **Avoid LLO cargo transfer**
  - Mate P/L to lander at SSF
  - Fly cargo mission direct from ETO
- **Avoid LLO propellant transfer**
  - Store return propellant in separate tanks
  - Direct return from lunar surface
- **Avoid engine doors in aerobrake**
  - Locate aerobrake on opposite end from engines
  - Allow smaller penetrations (feedlines: STS proven)
- **Enhance crew module access/visibility**
  - Fewer vehicle elements
  - Configuration rearrangement
- **Minimize assembly at SSF**
  - Direct TO LS cargo flights
  - Reduce number of elements requiring assembly
- **Improve cargo accommodations**
  - Fly expendable cargo missions
  - Reduce or eliminate cargo on pilot flights
  - Avoid cargo transfer operations (LLO)

Office of Aeronautics, Exploration and Technology

MARS TRANSPORTATION SYSTEM REQUIREMENT DRIVERS

- **Mass delivered to Mars surface**
  - Crew size
  - Mars base elements
  - Separate or combined crew/cargo flights
- **Long duration of the Mars mission**
  - Launch date/trajectory considerations
  - Habitat module impact
  - Need for artificial gravity
  - Need for radiation shielding protection
  - Desire to reduce mission duration
- **Mars aerobraking**
  - Chemical propulsion/aerobrake versus advanced propulsion concepts (NTR, SEP, NEP, GCR)
  - Aerobraking needed for Mars landing from orbit

Office of Aeronautics, Exploration and Technology

KEY REQUIREMENTS MARS TRANSPORTATION SYSTEM

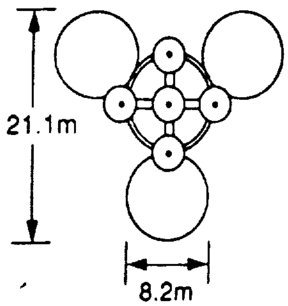
- Deliver 4 crew and 25t cargo to Mars surface on first human landing in 2016
  - Crew and 1t payload returned to LEO
- Deliver 100t of cargo to Mars surface on first cargo flight in 2025
- Provide for reuse (up to two missions) of piloted Mars Transfer Vehicle (MTV)
  - Cargo vehicles and landers are expended at Mars

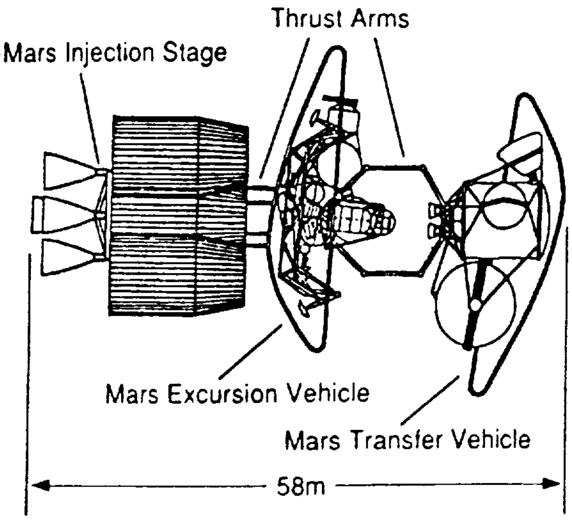
  Piloted missions utilize zero-g for transit phases of missions
- Chemical propulsion (LOX/LH_2) utilized for all propulsive maneuvers (TMI, TEI, etc.)
- Aerobraking utilized at Mars and Earth arrival
- Provide heavy-lift launch capability that reduces number of launches and on-orbit assembly requirements
  - 140t minimum payload to LEO
  - 13.7 payload shroud

Office of Aeronautics, Exploration and Technology

NASA

FULL-UP MARS MISSION VEHICLE IN LEO





MTV	138.7t
MEV	83.6t
TMIS	517.1t
Total IMLEO	739.4t

NASA

MARS TRANSPORTATION SYSTEM CONCEPT IMPROVEMENTS

- **Advanced Propulsion Systems**
  - NTR, GCR, NEP, SEP
  - Parametrics for candidate systems
  - Sensitivities and trade assessments
  - Conceptual Designs
  - Operations and Safety
  - Programmatics
- **Artificial Gravity**
  - "Artificial-g Delta Study" to assess weight, technology, cost and operations penalties
  - Define "From the Start" concept
- **MTS Aerobrake Issues**
  - Aeroheating for Mars aerocapture/entry and Earth aerocapture
  - Landing criteria for cross range, altitude and avoidance maneuvers
  - G&C capture/entry at Mars and Earth
- **MTS Equipment Life and Self Check**
  - Requirements and technical approach to assuring critical equipment operability
  - Parametric examination of sparing level, commonality, spares quantity and MTBF
- **LTS/MTS Crew Modules**
  - Compare MTV space habitat concepts
  - Define common family of habitats for LTV, LEV, MEV and other uses
  - Assess evolutionary growth potential
- **MTS Mission Scenario**
  - Mission analyses of reference and alternate opportunities and profiles from 2009 through 2025
  - Operations sequence assessment for reference system
    - Same for reference systems with artificial-g
    - Same for advanced propulsion

Excerpts from "The Exploration Initiative," an additional paper provided by C. C. Priest with his presentation.

This "Exploration Initiative" package is a compilation of selected NASA policy and presentational material on the President's commitment to space exploration, specifically, to Space Station Freedom, a return to the Moon and, subsequently, a journey to Mars. The material provides a broad, non-technical overview of NASA response to, and support of, President Bush's commitment. In order to hold down the size of the package, a number of charts have been excluded.

Please keep in mind that the Exploration Initiative material is continuously updated as NASA, the National Space Council and others progress in their response to the President's commitment. New charts, as well as material not in this package, is available. Please contact Kristine Johnson (453-9181) or Donna Fabian (453-9177) to see the complete, up-to-date set, and for any assistance.

This "Exploration Initiative Package" is prepared for use by the Office of Exploration and the Office of Aeronautics and Space Technology, but is available to all NASA personnel.

March 1990

Terence T. Finn
Assistant for Policy and External Relations
Office Of Exploration

NASA

NATIONAL SPACE POLICY - GOALS

On November 2, 1989, the President approved a national space policy that updates and reaffirms U.S. goals and activities in space.

- Strengthen the security of the United States
- Obtain scientific, technological, and economic benefits
- Encourage private sector investment
- Promote international cooperative activities
- Maintain freedom of space for all activities
- Expand human presence and activity beyond Earth orbit into the solar system

NASA

VICE PRESIDENT QUAYLE

In May, 1989 the Vice President directed NASA to prepare for a possible major decision on space in a speech by President Bush to be delivered on July 20, 1989

The Vice President called for identification of

- a NASA exploration goal
- significant and visible milestones early in the 21st century
- the resources required (people, facilities, money)

NASA reported to the Vice President that in the final analysis, the nation has but three options for human exploration

- send robots only
- develop a lunar outpost, then go to Mars
- by-pass the Moon and go directly to Mars

EARTH-MOON-MARS PARAMETERS

The Moon

- 239,000 miles from Earth to Moon
- 1/4 diameter of Earth
- 1/6 Earth's gravity
- Lunar day is 28 Earth days
- Trip time: 3 days one way
- *Launch opportunity every month*
- *Communication time: 2.6 seconds roundtrip*

Mars

- 141.6 million miles from Sun
  - Earth is 93 million miles
- 1/2 diameter of Earth
- 1/3 Earth's gravity
- Martian day is 24 hours 37 minutes
  - Martian year is 1.88 Earth years
- Trip time: 6 months to 1 year one way
- *Launch opportunity every 26 months*
- *Communication time: 10.2-41 minutes roundtrip*

NASA'S 90-DAY STUDY

In response to the President's speech, the NASA Administrator created a task force, headed by Aaron Cohen, director of the Johnson Space Center, to conduct a study of the main elements of an Exploration Initiative

The study provides reference material in support of the Vice President and the National Space Council, and enables NASA to better understand technical parameters

The study examined

- technical scenarios
- science opportunities
- required technologies
- international considerations
- institutional strengths and needs
- resource estimates

NASA's study consists of analysis, not recommendations. It summarizes extensive trade studies, reflecting several years of study. It is not a definitive program plan

NASA

EXPLORATION APPROACH

Build upon past and present investments in space

- Apollo, Viking, etc.
- Space Shuttle
- Space Station Freedom

Employ robotic craft along with manned systems

Emphasize science

Build a lunar outpost first

- Research base for science and technology
- Test-bed for humans to Mars

Explore Moon and Mars in phases

Robotics

Emplacement

Consolidation

Operation

NASA

PREREQUISITES FOR HUMAN EXPLORATION

- Exploration technology
- Life sciences research
- Heavy-lift launch and orbiter transfer vehicles
- Robotic missions
- Space Station Freedom

NASA

EXPLORATION HARDWARE NEEDED

Earth-to-orbit launch vehicles
- Space Shuttle
- Existing expendable launch vehicles
- New heavy-lift launch vehicles

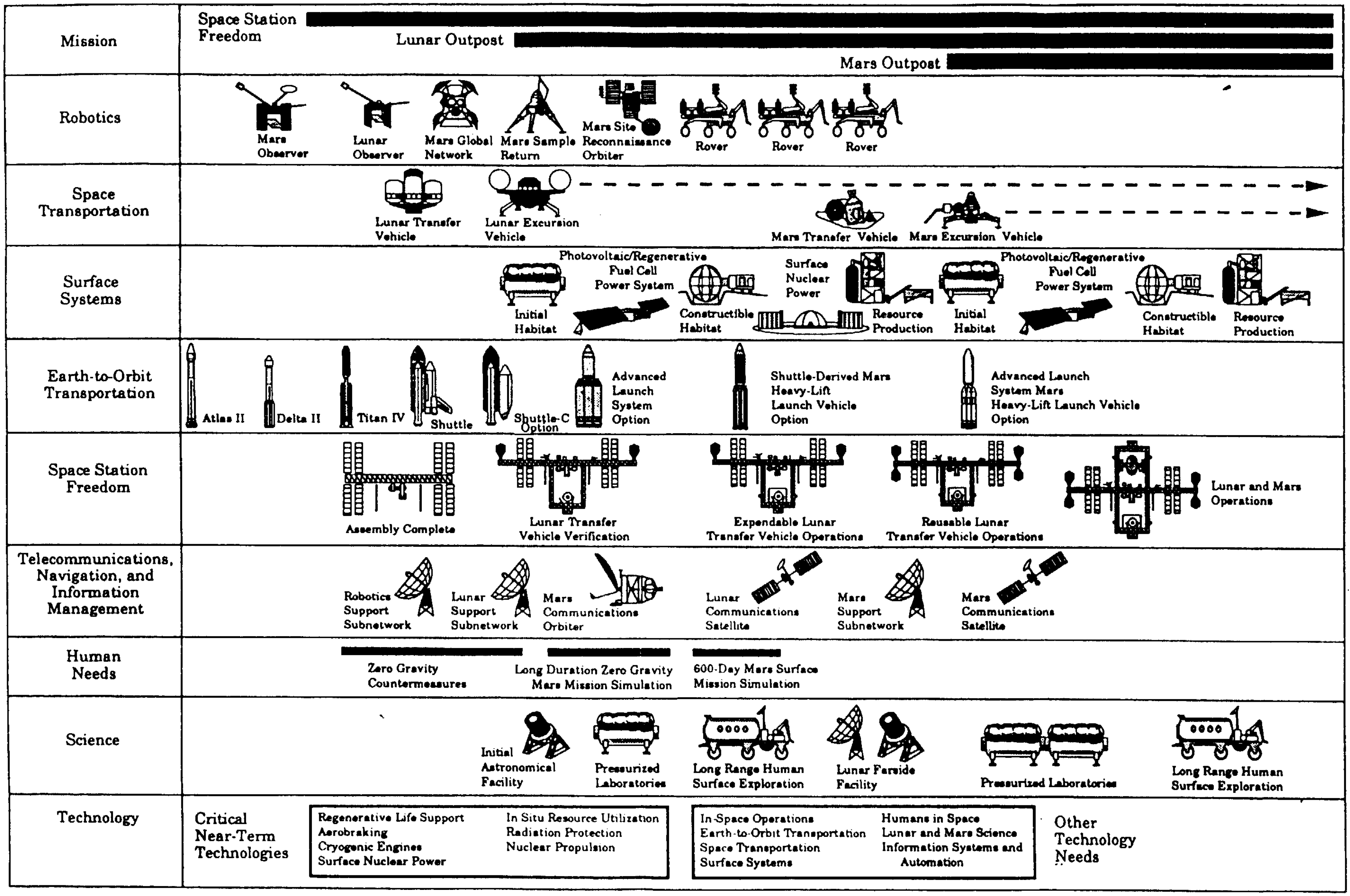
Space Station Freedom
- Life sciences research
- Assembly and operations center

Robotic exploration spacecraft
- Design of subsequent human exploration missions
- Technology demonstration

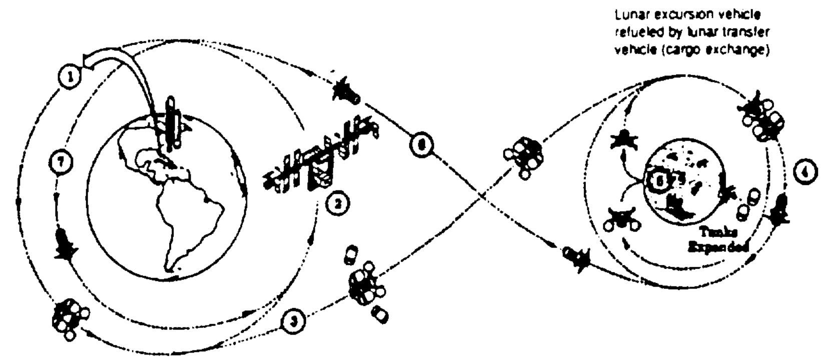
Interplanetary transfer vehicles
- Transportation between Earth orbit and lunar/Mars orbits

Planetary excursion vehicles
- Transportation between planetary orbit and planetary surface

Surface equipment
- Habitats, scientific equipment, rovers, suits, power systems, etc.

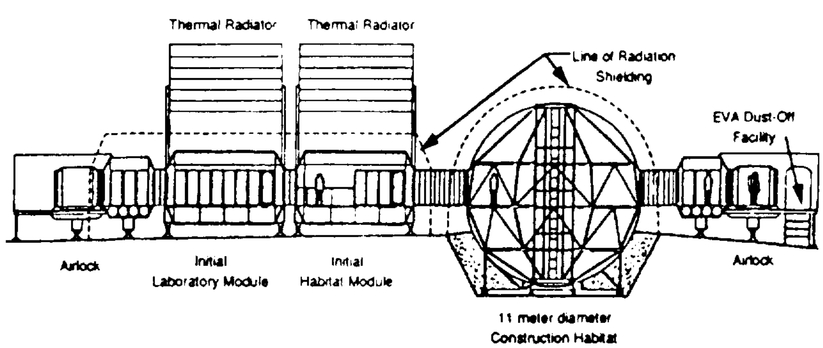

Mission
Space Station Freedom
Lunar Outpost
Mars Outpost
Robotics
Mars Observer
Lunar Observer
Mars Global Network
Mars Sample Return
Mars Site Reconnaissance Orbiter
Rover
Rover
Rover
Space Transportation
Lunar Transfer Vehicle
Lunar Excursion Vehicle
Mars Transfer Vehicle
Mars Excursion Vehicle
Surface Systems
Initial Habitat
Photovoltaic/Regenerative Fuel Cell Power System
Constructible Habitat
Surface Nuclear Power
Resource Production
Initial Habitat
Photovoltaic/Regenerative Fuel Cell Power System
Constructible Habitat
Resource Production
Earth-to-Orbit Transportation
Atlas II
Delta II
Titan IV
Shuttle
Shuttle-C Option
Advanced Launch System Option
Shuttle-Derived Mars Heavy-Lift Launch Vehicle Option
Advanced Launch System Mars Heavy-Lift Launch Vehicle Option
Space Station Freedom
Assembly Complete
Lunar Transfer Vehicle Verification
Expendable Lunar Transfer Vehicle Operations
Reusable Lunar Transfer Vehicle Operations
Lunar and Mars Operations
Telecommunications, Navigation, and Information Management
Robotics Support Subnetwork
Lunar Support Subnetwork
Mars Communications Orbiter
Lunar Communications Satellite
Mars Support Subnetwork
Mars Communications Satellite
Human Needs
Zero Gravity Countermeasures
Long Duration Zero Gravity Mars Mission Simulation
600-Day Mars Surface Mission Simulation
Science
Initial Astronomical Facility
Pressurized Laboratories
Long Range Human Surface Exploration
Lunar Farside Facility
Pressurized Laboratories
Long Range Human Surface Exploration
Technology
Critical Near-Term Technologies
Regenerative Life Support
Aerobraking
Cryogenic Engines
Surface Nuclear Power
In Situ Resource Utilization
Radiation Protection
Nuclear Propulsion
In-Space Operations
Earth-to-Orbit Transportation
Space Transportation
Surface Systems
Humans in Space
Lunar and Mars Science
Information Systems and Automation
Other Technology Needs

LUNAR MISSION PROFILE



1. Payload Delivered to Space Station Freedom
2. Lunar Transfer Vehicle Mated with Payload at Freedom
3. Trans-Lunar Phase with Lunar Transfer Vehicle
4. Lunar Transfer Vehicle Rendezvous with Lunar Excursion Vehicle from Moon
5. Excursion Vehicle Returns to Moon with Payload
6. Trans-Earth Phase with Transfer Vehicle
7. Transfer Vehicle Aerobrake Maneuver and Return to Freedom

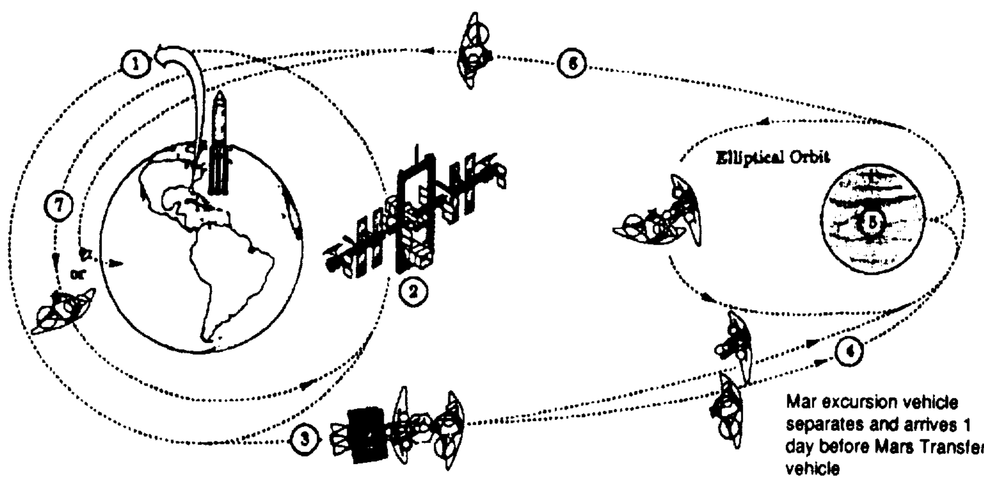
HABITATION FACILITY CROSS SECTION



Space Station-derived modules
and inflatable structures

NASA

MARS MISSION PROFILE



1. Payload Delivered to Space Station Freedom
2. Mars Transfer Vehicle Mated with Payload at Freedom
3. Trans-Mars Phase with Lunar Transfer Vehicle
4. Mars Transfer Vehicle Remains in Mars Orbit; Mars Excursion Vehicle Descends to Surface
5. Excursion Vehicle to/from Mars Surface
6. Trans-Earth Phase with Transfer Vehicle
7. Transfer Vehicle Aerobrake Maneuver and Return

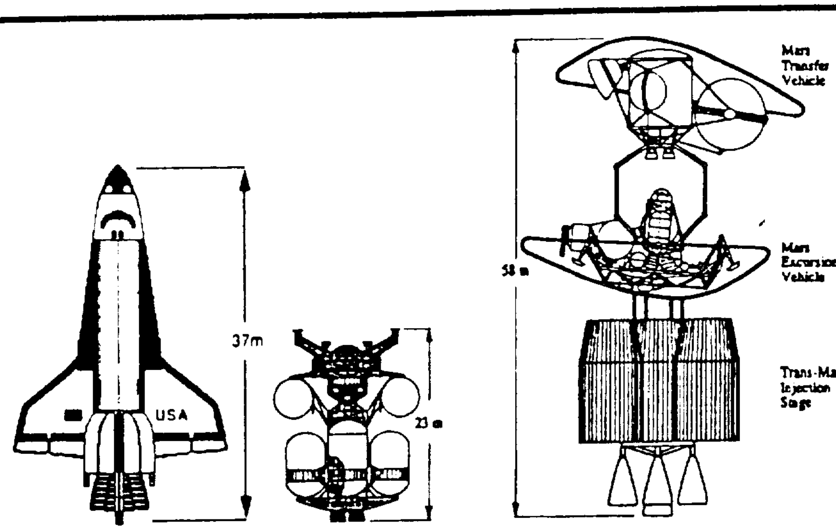
NASA

EARTH-TO-ORBIT TRANSPORTATION

- Lunar outpost and Mars expeditions require large masses in low-Earth orbit 200 → 700 mt/year
- Heavy-lift launch vehicles provide a balance between on-orbit assembly and operations and size of the payloads launched
- Lunar heavy-lift vehicle should provide ~ 70 mt/launch and 3-6 launches per year
- Mars heavy-lift vehicle should provide ~ 140 mt/launch and 3-4 launches per year
- Commercially developed expendable launch vehicles also will be required

NASA

SHUTTLE AND LUNAR/MARS TRANSFER VEHICLES



Space Shuttle
Mass = 92 metric tons
(Payload = 22 metric tons)

Lunar Transportation System
Mass = 200 metric tons

Mars Transportation System
Mass = 800 metric tons

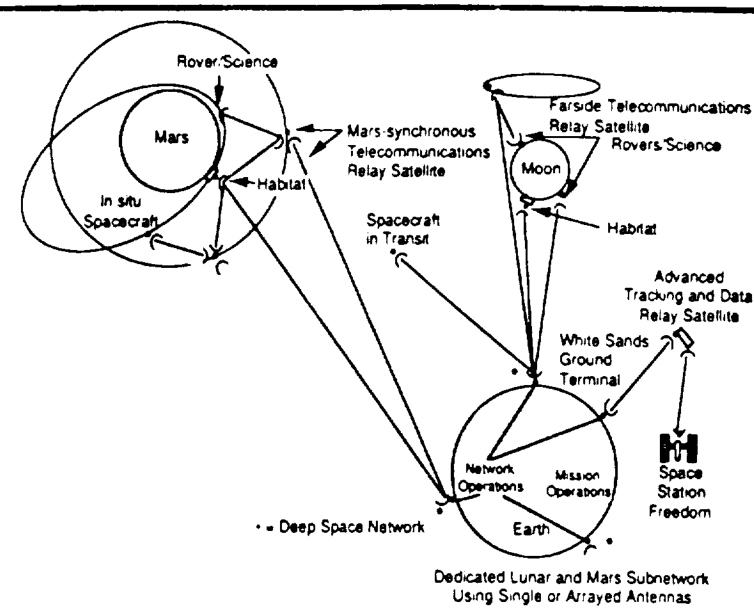
NASA

CHARACTERISTICS OF REFERENCE APPROACHES

	Reference Approaches				
	A	B	C	D	E
	Earliest Moon			No Space Station Disruption	
	Earliest Lunar Outpost	Earliest Mars	Later Mars	Permanently Manned Lunar Outpost	Man-Tended Lunar Outpost
Lunar Emplacement	1999-2004	1999-2004	1999-2004	2002-2007	2002-2007
Lunar Consolidation	2004-2009	2004-2007	2004-2008	2007-2012	2008-2013
Lunar Operation	2010→	2005→	2005→	2013→	2014→
Humans on the Moon	2001	2001	2001	2004	2004
Permanent Habitation	2002	2002	2002	2005	→
Constructible Habitat	2005	2006	2007	2008	2011
Eight Crew	2006	2007	2007	2009	—
Lunar Oxygen Use	2010	2005	2005	2013	—
Lunar Farside Sortie	2012	2008	2008	2015	2022
Lunar Steady State Mode	2012	2008	2012	2015	→
Mars Emplacement	2015-2019	2010-2015	2015-2019	2017-2022	2024→
Mars Consolidation	2020-2022	2015-2018	2020-2022	2022	→
Mars Operation	2022→	2018→	2022→	→	→
Humans on Mars	2016	2011	2016	2018	2016
Extended Mars Stay	2018	2014	2018	2023	2027

NASA

TELECOMMUNICATIONS ARCHITECTURE
FOR THE HUMAN EXPLORATION INITIATIVE



NASA

CONCLUSIONS OF THE 90-DAY STUDY

- Major investments in challenging technologies are required
- Scientific opportunities are considerable
- Robotic spacecraft will be needed
- Current launch capabilities are inadequate
- Space Station Freedom is essential
- Program alternatives do exist
- Opportunities for international cooperation exist
- A long-range commitment and significant resources will be required

NASA

SPACE STATION FREEDOM

A permanently manned, international research laboratory and, later, a staging base for the Moon and Mars

Need for:

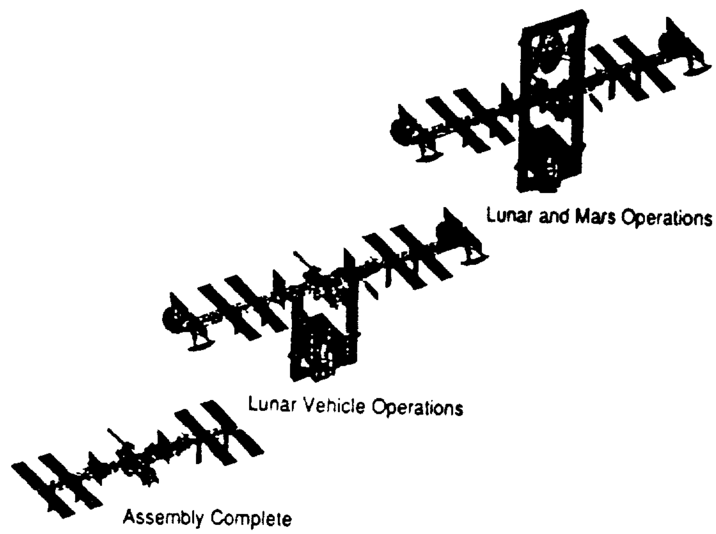
- Life sciences research and microgravity countermeasures
- Technology development and validation
- Development of operational procedures
- Assembly, test, launch, recovery, turnaround of space vehicles

Current design can evolve to the more capable configuration essential for a return to the Moon and human exploration of Mars

President Bush called Space Station Freedom: "our critical next step in all our space endeavors"

NASA

SPACE STATION FREEDOM
EVOLUTION FOR HUMAN EXPLORATION



NASA

STATION AND EVOLUTION

In 1984 President Reagan called for a station that was
- a research facility
- permanently manned
- international in character

Freedom's assembly and operations have made it a transportation node from the very beginning

Freedom's multi-disciplinary research capabilities are a balance between microgravity environment and the need for human presence

Freedom can evolve to support the Exploration Initiative
- additional required resources to be phased in
- international agreements will be honored. Exploration enhancements to come out of U.S. allocation
- hooks and scars on *Freedom* must be protected

Earth-to-Orbit logistic requirements are drivers on transportation node

Current configuration is the correct design for both near-term and later requirements

NASA

HEAVY LIFT LAUNCH VEHICLE

Exploration Initiative requires enhancement of current launch vehicle capabilities

Earth-to-orbit lift capabilities are estimated to be:

- Moon: 60 - 70 metric tons
- Mars: 140 metric tons

New launch vehicle development candidates include:

- Shuttle-C
- Advanced Launch System

There are no major technical impediments to building the heavy-lift launch vehicles we need

Expendable vehicles to play key role in Exploration Initiative

We ought to be initiating development

NASA

SPACE RESEARCH AND TECHNOLOGY

Program Goals

- Increase safety and reliability
- Reduce development
- Enhance mission performance
- Enable new missions

Program Elements

- Research and Technology Base
- Civil Space Technology Initiative (CSTI)
- Exploration Technology Program
- In-Space Technology Experiment Program (INSTEP)

NASA

EXPLORATION TECHNOLOGY MISSION APPLICATIONS SUMMARY

Technology Thrust	Technology Program Area	Moon Robotic	Moon Human	Mars Robotic	Mars Human	Other Solar System Exploration
Space Transportation	Aerobraking		●	●	●	◗
	Space-based Engines		●	○	●	○
	Autonomous Vehicles Maneuvering		◗	◗	◗	◗
In-Space Operations	Cryogenic Fluid Systems		◗		◗	
	In-Space Assembly and Construction		◗		◗	○
	Vehicle Servicing and Processing		◗		◗	○
Surface Operations	Space Nuclear Power	◗	●	◗	●	◗
	In Situ Resource Utilization		●	◗	●	
	Planetary Rover	◗	◗	◗	◗	◗
	Surface Solar Power	○	◗	○	◗	◗
	Surface Habitats and Construction		◗		◗	
Human Support	Regenerative Life Support		●		●	
	Radiation Protection		●		●	
	Extravehicular Activity/Suit		◗		◗	
	Space Human Factors		○		○	
Lunar and Mars Science	Sample Acq. Analysis, and Preserv.	◗	○	◗	○	◗
	Probes and Penetrators	○		◗	○	◗
Information Systems and Automation	High-Rate Communications	○	○	◗	◗	◗
	Exploration Automation and Robotics	◗	◗	◗	◗	◗
	Planetary Photonics	○	○	◗	○	◗
Nuclear Propulsion	Nuclear Thermal Propulsion				●	◗
	Nuclear Electric Propulsion				●	◗
Innovative Technologies and Systems Analysis		○	○	○	○	○

LEGEND ○ High-Leverage Technology ◗ Enabling For Some Systems ● Critical Technology

NASA

SOME CONCRETE EXAMPLES

EXPLORATION	→ Aeroassist flight experiment
TRANSPORTATION	→ Structural analyses for solid rocket motor redesign
SPACE STATION	→ Erectable truss structure
SPACE SCIENCE	→ Silicon CCD area arrays for Space Telescope
BREAK THROUGH	→ Photonics (optical processors)

These are but a few examples of successful products developed by NASA's space research and technology program

NASA

ADDITIONAL EXAMPLES: R&T PRODUCTS FOR SPACE SCIENCE

- Spacecraft ground operations automation — *Voyager*
- Deviser planner — *Voyager and Galileo*
- Advanced TWT amps. and low noise receivers — *CTS, ACTS, Mariner Mars Observer*
- Massively parallel processor — *Climate modeling*
- Millimeter accuracy laser ranging system — *LAGEOS*
- Spacecraft charging model — *GSFC, JPL, Industry*
- High power/voltage transistors — *Industry*
- SAR technology — *SeaSat, SIR (A, B, and C)*
- Heat shield design and analysis — *Galileo probe*
- Silicon CCD area arrays — *Hubble Space Telescope, Galileo*
- Fiber optics rotational sensor — *CRAF/Cassini*
- X-band uplink-down converter — *Galileo*
- Advanced digital SAR processor — *Magellan*
- IR sensors — *SIRTF instruments*
- CO_2 laser — *EOS, LAWS*

NASA's space research and technology program is also developing products in the fields of space transportation, space station, exploration, as well as "breakthrough" fields where payoffs would be extremely high

NASA

TECHNOLOGY REPORT TO CONGRESS

Concerns: NASA's space technology programs not sufficiently focused to meet the needs of long-term space exploration as outlined in the President's speech in July 1989.

Requirement: *Provide a report by February 1, 1990** on specific technologies needed to meet the development and operational requirements of the President's space exploration initiative.

- Prioritize technologies both technically and financially
- Include five-year funding profile

Source: Senate Appropriations Committee Report accompanying H.R. 2916, the Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriation Bill, 1990, page 113.

* Targeting for March 1

NASA

EXPLORATION LIFE SCIENCES

- Radiation Protection
- Reduced Gravity Countermeasures
- Life Support in Habitats and Space Vehicles
- Extravehicular Activity
- Medical Care
- Behavior and Performance

Earth ➡ Freedom ➡ Lunar Outpost ➡ Mars

NASA

RADIATION PROTECTION

Earth's magnetic field protects us from radiation emitted by solar flares, and shields us from galactic cosmic rays

Radiation beyond Earth orbit is cause for concern

Radiation strategy for the Exploration Initiative includes

- determination of career dose limits and crew selection criteria
- development of countermeasures
- development of shielding strategy for both vehicles and habitats
- development of early warning systems and "storm shelters" for protection from solar flare radiation

NASA will develop guidelines with the National Council on Radiation Protection and Measurements

- NASA will adhere to the radiation principle of as low as reasonably achievable (ALARA)

NASA

ARTIFICIAL GRAVITY?

Microgravity exposure causes major physiological change

- Bone mineral loss
- Muscle atrophy
- Cardiac deconditioning

Current countermeasures (exercise) may be insufficient for the lengthy voyage to Mars

Strategy to test and evaluate necessary zero-g countermeasures will utilize

- Soviet long duration experience
- Space Shuttle extended duration orbiter
- Space Station Freedom and eventually
- The lunar outpost itself

Current approach: plan a zero-g Mars transfer vehicle, but begin low level definition of an artificial gravity system just in case

Humans must be certified for journey to Mars

NASA

SCIENCE: SIGNIFICANT OPPORTUNITIES

Excellent science to be done on both Moon and Mars

- Robotic science
- Human interactive science

Fundamental scientific themes

- Origin and history of Earth and Moon
- The origin of life/life on Mars
- Global climate change
- Search for other solar systems
- Fate of the Universe

Research opportunities cover many disciplines

- Solar Physics
- Geology
- Biology
- Astrophysics
- Chemistry
- Space Physics

NASA

ROBOTIC SPACECRAFT

Key tasks

- Determine suitable/desirable landing and outpost sites
- Provide design data for human mission elements
- Conduct science investigations
- Develop basis of science investigations for human explorers

Select from high payoff candidate missions

For the Moon, emphasis on selecting landing/outpost site

- Lunar Observer

For Mars, emphasis on science and human mission success

- Mars Observer
- Global Network Mission
- Sample Return/Local Rover
- Site Reconnaissance Orbiter
- Mars Rovers

Robotic missions are integral to human exploration initiative

NASA

SCIENCE ON THE MOON

Lunar origin/evolution
- Impact origin theory ⇔ common origin with Earth
- Larger role for planetary scale collisions?

History of the Sun (preserved in lunar soil)
- Solar wind trapped in regolith
- Buried regolith provides time resolution

Extinctions caused by impacts
- Evidence in lunar cratering record?

Unparalleled resolution, sensitivity for astronomy/astrophysics
- Large apertures
- Interferometric arrays
- Cosmic Ray Observatory

Life science
- Basic research: radiation environment, low gravity effects ...
- Supporting Mars exploration

NASA

SCIENCE ON MARS

Planet most like Earth
- Has an atmosphere, evidence of warmer past
- Mars has intrigued humans for generations

Search for life on Mars
- Life may have existed long ago
- It may still exist in protected underground environments
- Answers will provide clues about evolution of life

Global climate change on Mars
- Examine chronology, characteristics of changes
- Understand role of geologic processes (e.g., volcanism, weathering)
- May enhance our understanding of changes on Earth

Human and robotic exploration
- Both important for complex field studies

Human presence key to advancing understanding

NASA

ROBOTIC MISSIONS TO MARS

Purpose

- Secure a better understanding of the planet
- Provide data to assist in designing manned systems
- Support selection and certification of outpost sites
- Return sample for scientific analysis
- Demonstrate readiness to proceed with human missions

Missions

- 1992 Mars Observer
  - Establish global data base
- Mars Global Network Mission
  - Employ landers to provide high-resolution surface data
- Mars Sample Return Mission (MSRM)
  - Return samples for analysis
- Mars Site Reconnaissance Orbiter
  - Provide details to characterize landing sites
- Mars Rover Mission
  - Certify sites and explore the planet's surface

NASA

INTERNATIONAL COOPERATION

Precedents are mixed

- Apollo/Viking: U.S. only
- Space Shuttle: primarily U.S.
- Space Station Freedom: international partnership
- Hubble Space Telescope: international participation

Advantages are significant

- Access to first-rate technical capabilities
- Reduction in costs
- Stronger ties with other nations
- Foreign resources tied to U.S. initiative

Disadvantages not to be discounted

- Dilution of control
- Management complexity
- Reduced U.S. leadership
- Vulnerable to political climate

Significant opportunities exist

NASA

INTERNATIONAL COOPERATION

Japan

- Limited experience
- Ambitious aspirations
- Growing capabilities: H-II vehicle and Space Station module
- Interested in lunar resource utilization

Europe

- Technically expert
- Seeking autonomous capabilities in manned space flight
- Partner in Space Station, and designing Hermes space plane
- Would seek equality in any future initiative

U.S.S.R.

- Returned lunar samples robotically in 1970s
- Active planetary program, had focused on Venus
- Interest in Mars, but limited success
- Proposed a manned Mars project with the U.S.

Canada

- Built Canadarm for Shuttle
- Building Mobile Servicing System for Space Station Freedom
- Significant robotic capabilities
- Would probably welcome a role in this area

Other Nations

- China, India and Brazil have small space programs
- Desire to participate?
- Role for nations with small or no space experience?

NASA

EXPLORATION OUTREACH ACTIVITY

- In a September 1989 letter to the Vice President, the NASA Administrator said the agency would explore a complete range of options including technologies and mission architectures upon completion of the 90-Day Report
- In a December 1989 letter to Admiral Truly, the Vice President requested NASA take the lead in a nationwide search for new ideas and innovative technologies "to ensure all reasonable space exploration alternatives have been evaluated."
- Responding in late January 1990, the Administrator Truly wrote that NASA would do so, employing "an array of formal and informal mechanisms to reach the widest segment possible of the American scientific and technological communities"
- Likely mechanisms will include NASA Research Announcements (NRA), site visits and reviews with national laboratories and other agencies, aerospace industry analyses, AIAA assessment and conference, and direct solicitation of professional societies and individuals
- NASA will incorporate a review mechanism, with participation from outside the agency, to select promising ideas and technologies for funding in FY 1991
- Reviews by, and discussions with, the National Research Council, the NASA Advisory Council and the National Space Council will be part and parcel of the outreach activity

NASA

CURRENT ACTIVITIES

- Working with the National Space Council staff to structure a nation-wide outreach program to search for technical innovations and new ideas
- Merging Office of Aeronautics and Space Technology and Office of Exploration
- Continuing our preliminary science planning in conjunction with the Office of Space Science and Applications
- Developing implementation plans for exploration technology initiatives
- Planning exploration mission studies
- Working with National Space Council staff in support of Council recommendations regarding international affairs
- Supporting National Research Council (NRC) and Aerospace Industries Association (AIA) reviews of the Exploration Initiative

NASA

NATIONAL SPACE COUNCIL

Mandated in FY 1989 NASA Authorization Act and established pursuant to an Executive Order signed April 20, 1989

Purpose: "to provide a coordinated process for developing a national space policy and strategy for monitoring its implementation"

Members: Vice President - Chairman

Secretary of State	Chief of Staff to the President
Secretary of the Treasury	Assistant to the President for National Security Affairs
Secretary of Defense	
Secretary of Commerce	Assistant to the President for Science and Technology
Secretary of Transportation	Director of Central Intelligence
Director of the Office of Management and Budget	Administrator of NASA

NASA is currently supporting the Council's efforts to develop decision packages for the President on a human exploration strategy.

NASA

TWO INDEPENDENT REVIEWS

The National Space Council has requested two independent reviews of the Exploration Initiative:

AEROSPACE INDUSTRIES ASSOCIATION (AIA)

- chaired by Jim Harrington of Kamen Aerospace Corp.
- looking at strategy and the process for implementing the Exploration Initiative
- to recommend a management methodology
- targeting late March, 1990 for completing report

NATIONAL RESEARCH COUNCIL (NRC)

- chaired by Guy Stever of the National Academy of Sciences
- looking at the scope and content of NASA's 90-Day Report
- to address technical assumptions, alternative technologies, and schedule/cost considerations
- targeting late February, 1990 for completing report

NASA supportive of both AIA and NRC Studies

NASA

SOME CONCLUDING THOUGHTS

NASA will support National Space Council activities and welcomes independent external reviews of the Exploration Initiative

Outreach for new ideas and new technologies will be broad in scope

Near-term NASA focus will be on

- technology strategies
- mission architecture
- planning for science

The Space Station Freedom program must receive full support

This is a "long-term, continuing commitment" and all of us must be prepared for a lengthy period of planning and policy development

NASA

THE PRESIDENT STATES THE GOAL

"Our goal: To place Americans on Mars—and to do it within the working lifetimes of scientists and engineers who will be recruited for the effort today. And just as Jefferson sent Lewis and Clark to open the continent, our commitment to the Moon/Mars initiative will open the Universe. It's the opportunity of a lifetime—and offers a lifetime of opportunity."

President George Bush
Remarks at the University of Tennessee
February 2, 1990

PRESENTATION 1.1.2

NATIONAL SPACE TRANSPORTATION STRATEGY