# The Future of Human Exploration

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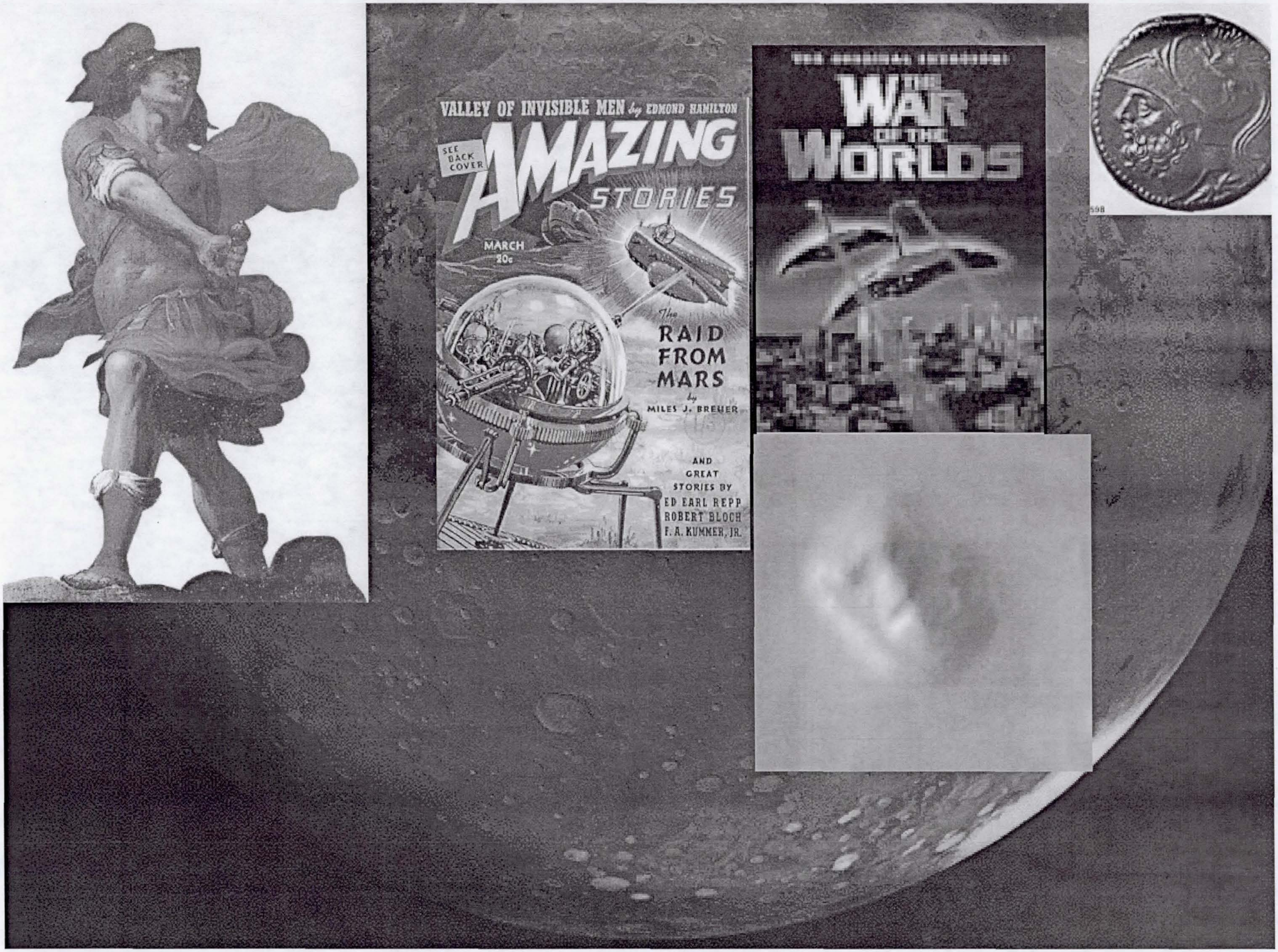
NASA – Johnson Space Center

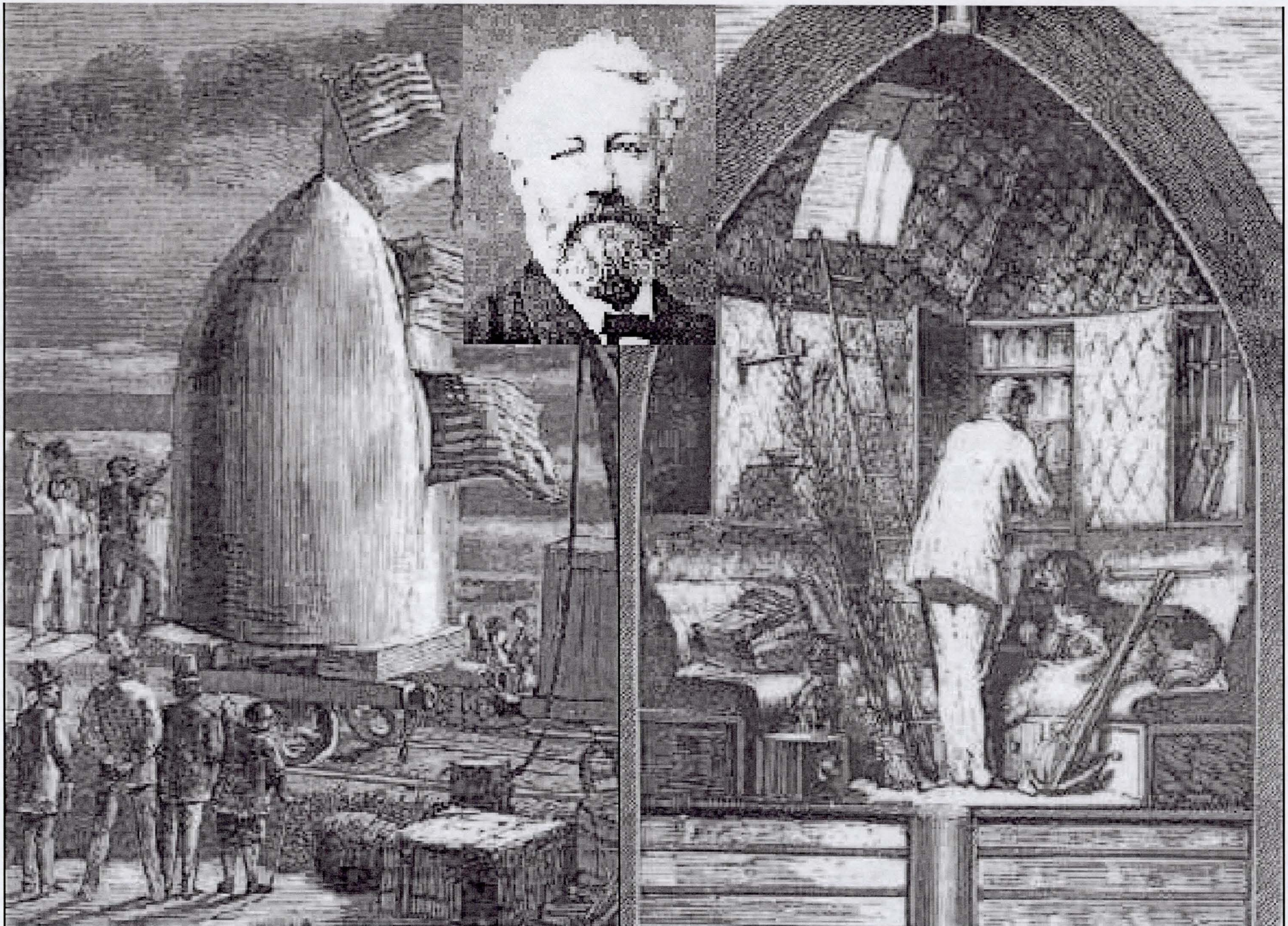
9/07/01


VALLEY OF INVISIBLE MEN by EDMOND HAMILTON
SEE BACK COVER
AMAZING STORIES
MARCH 20c
The RAID FROM MARS by MILES J. BREUER
AND GREAT STORIES BY ED EARL REPP ROBERT BLOCH F. A. KUMMER, JR.
THE WAR OF THE WORLDS


Galileo
1609
Christiaan Huygens

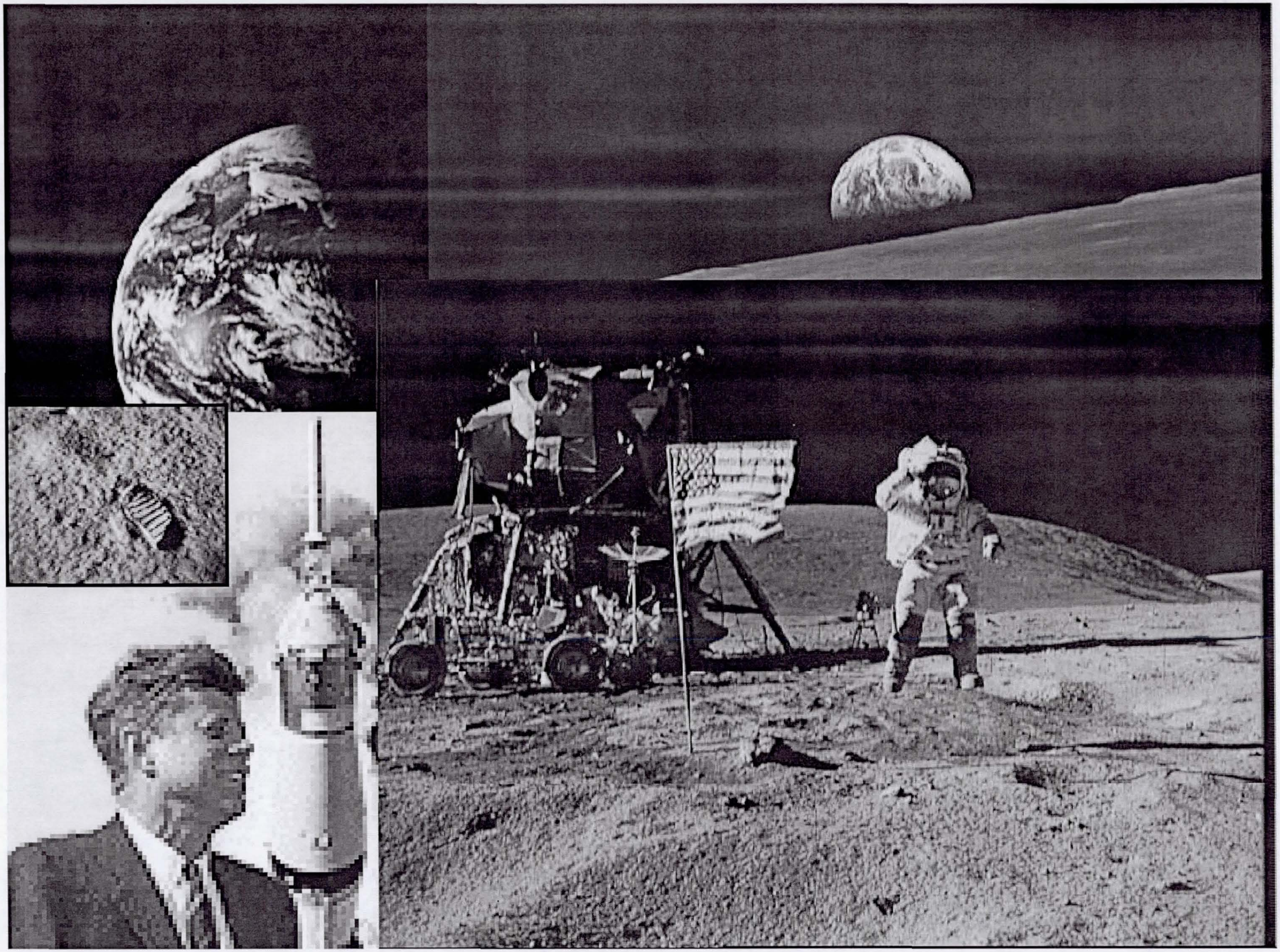
Giovanni Virginio Schiaparelli

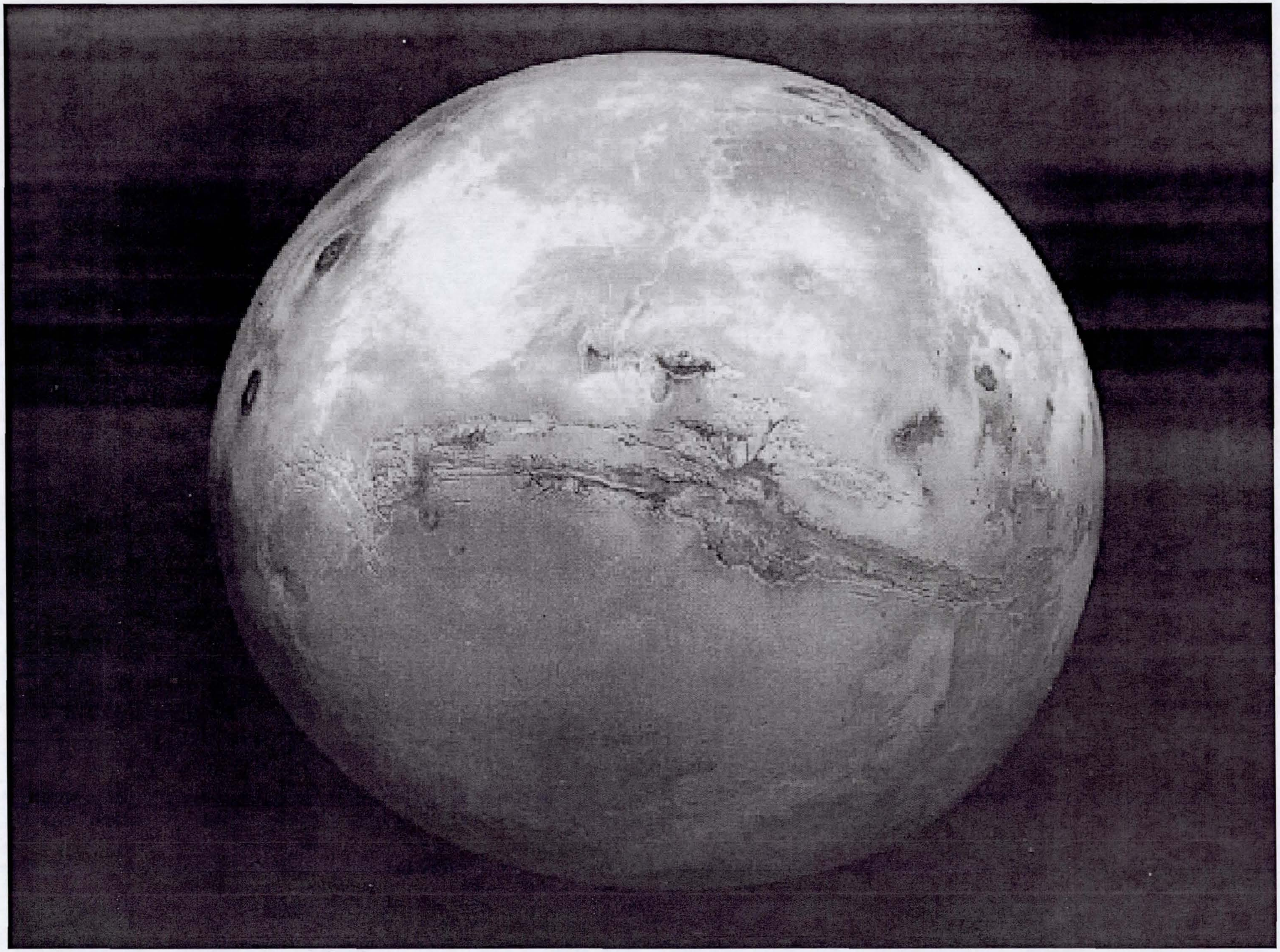
Pages from Schiaparelli's observing notebook, 1879

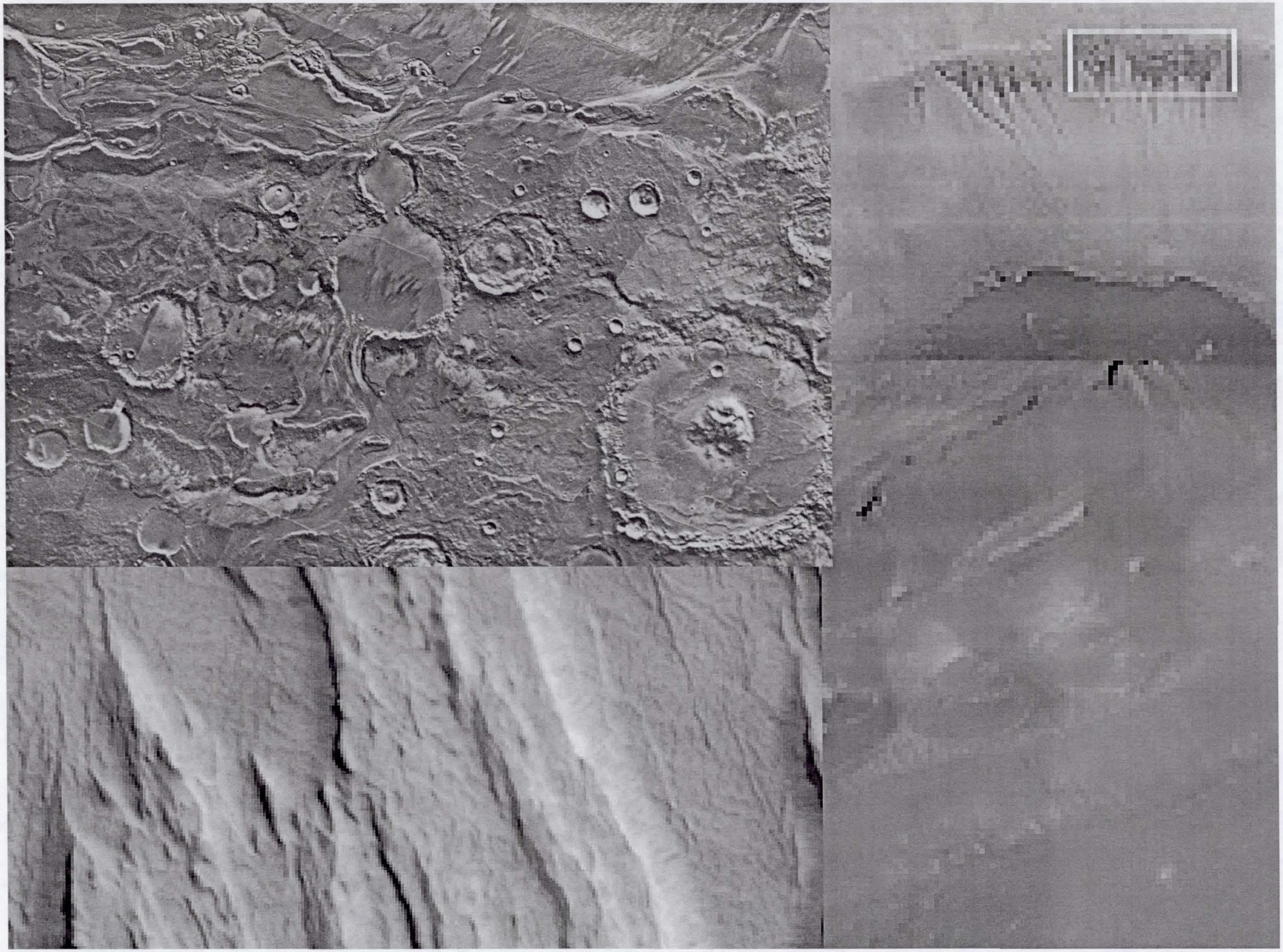


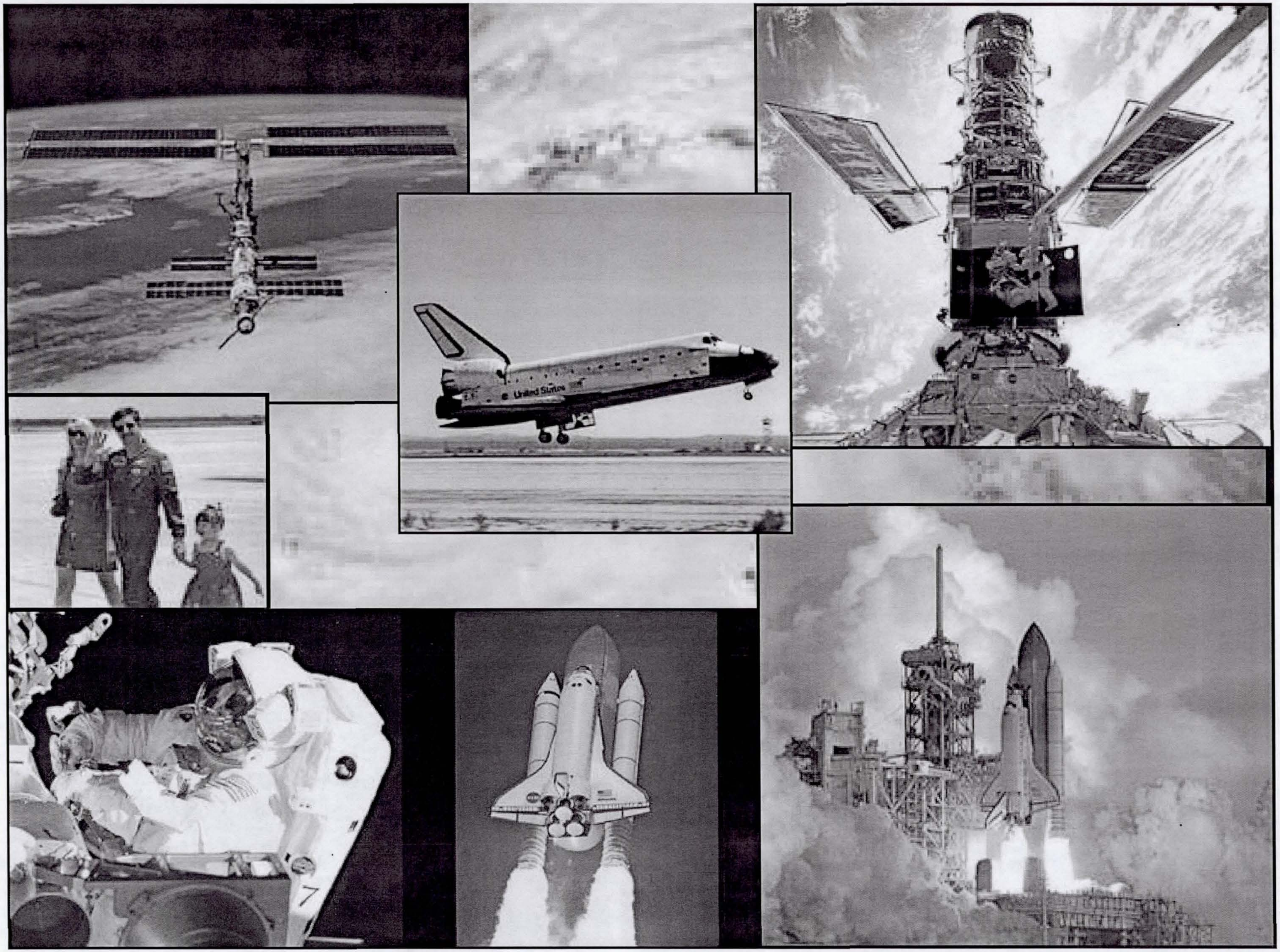
verne_moon2.jpg

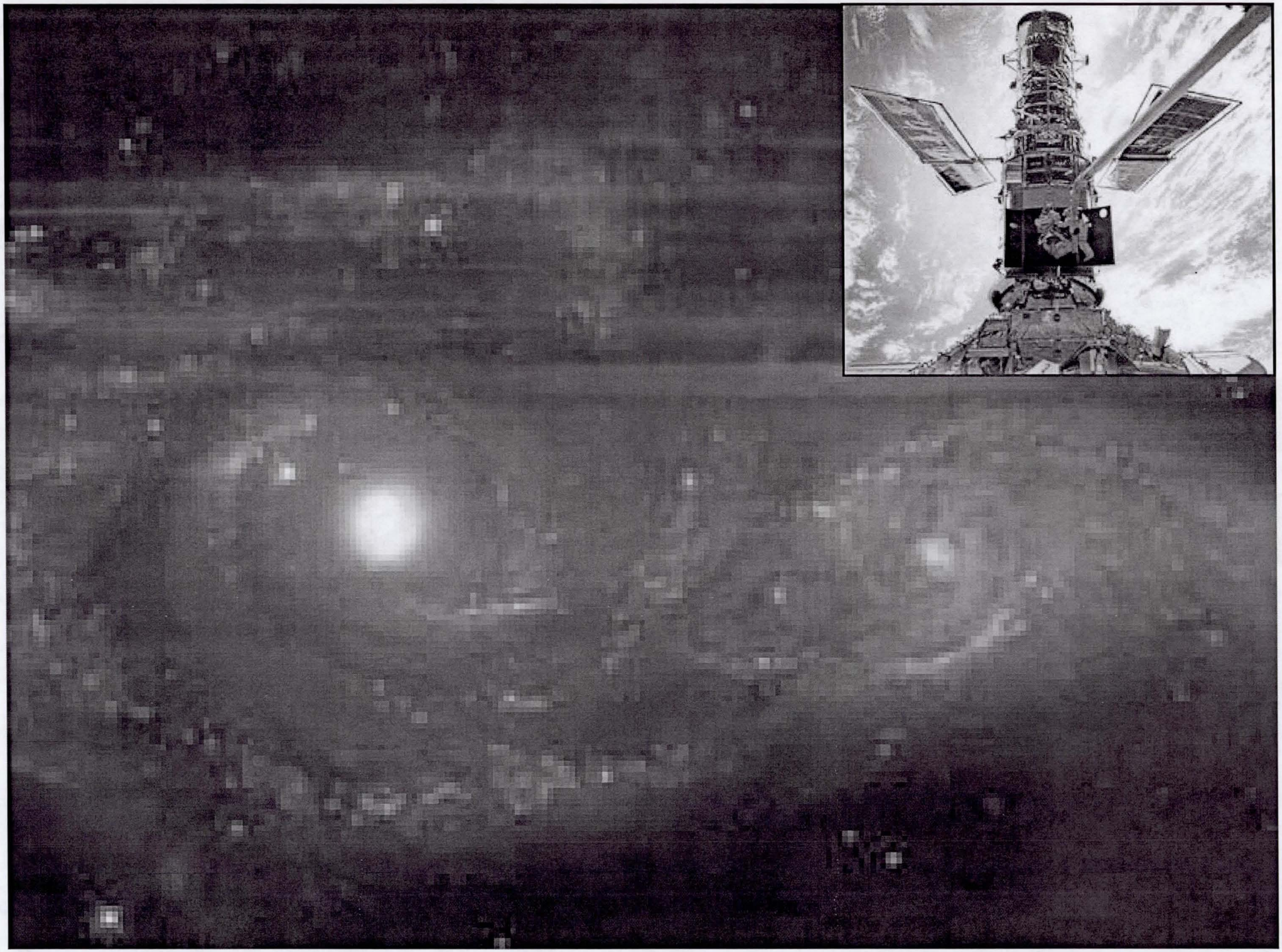
verne_moon1.jpg

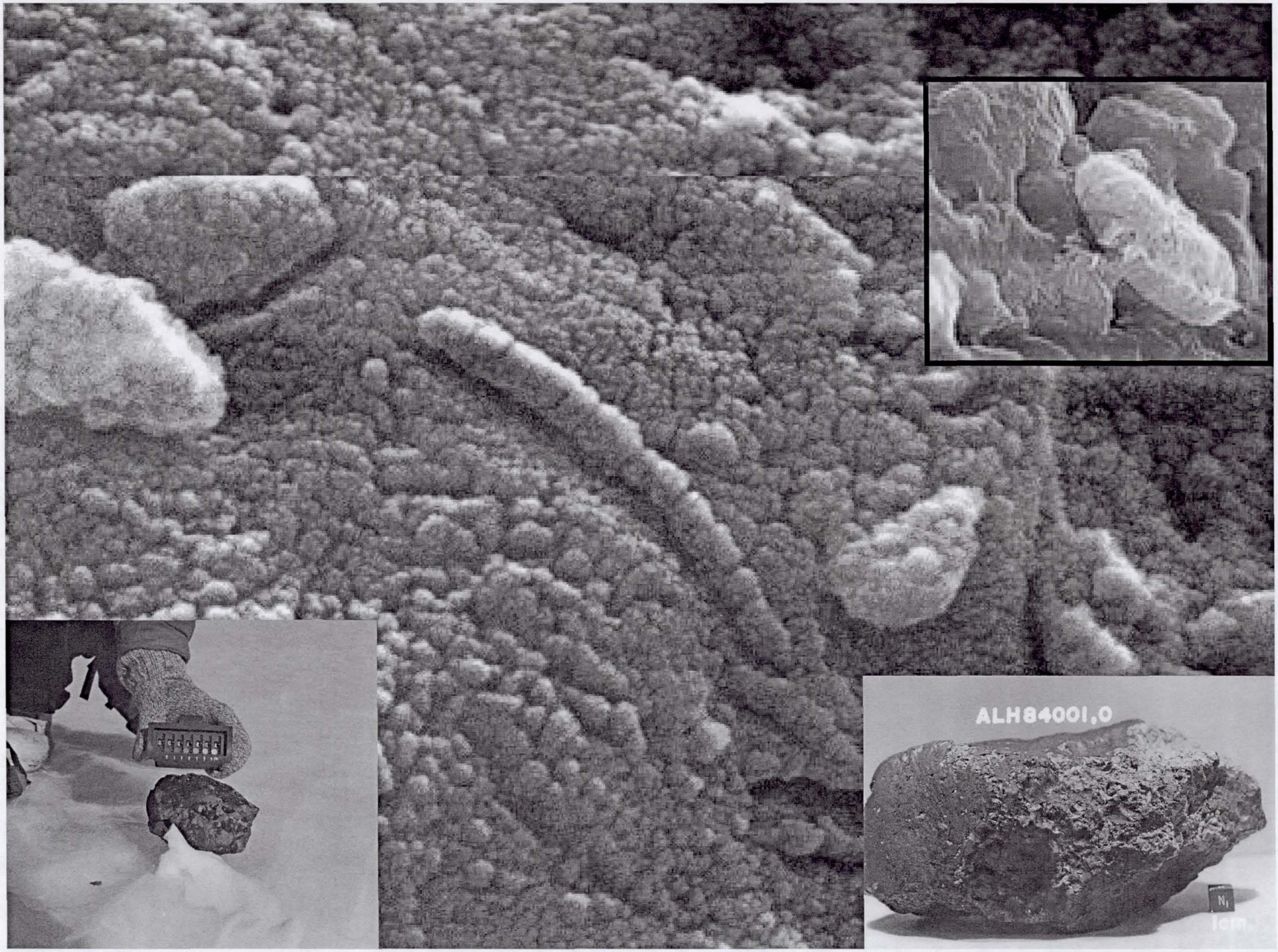







United States

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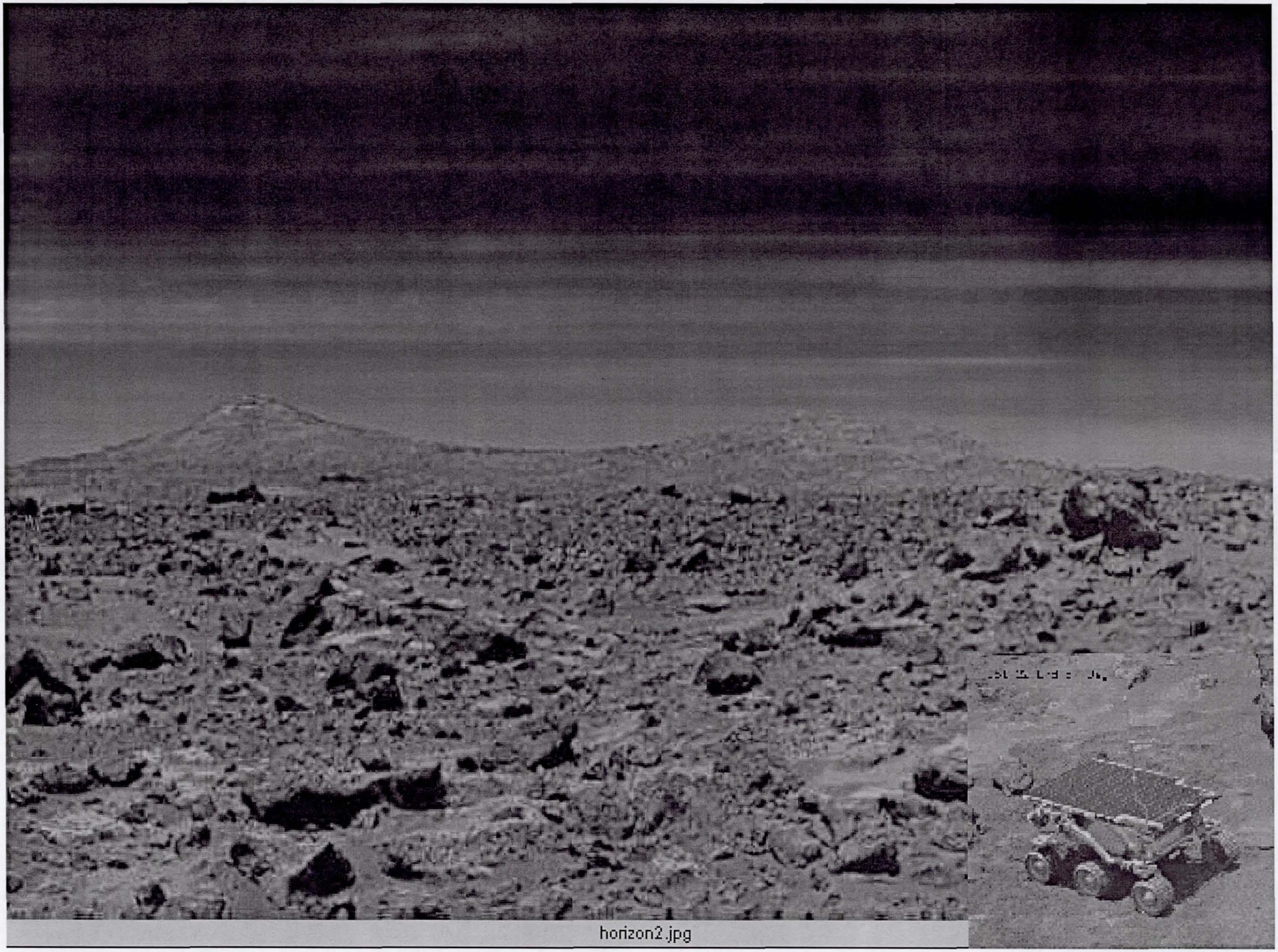
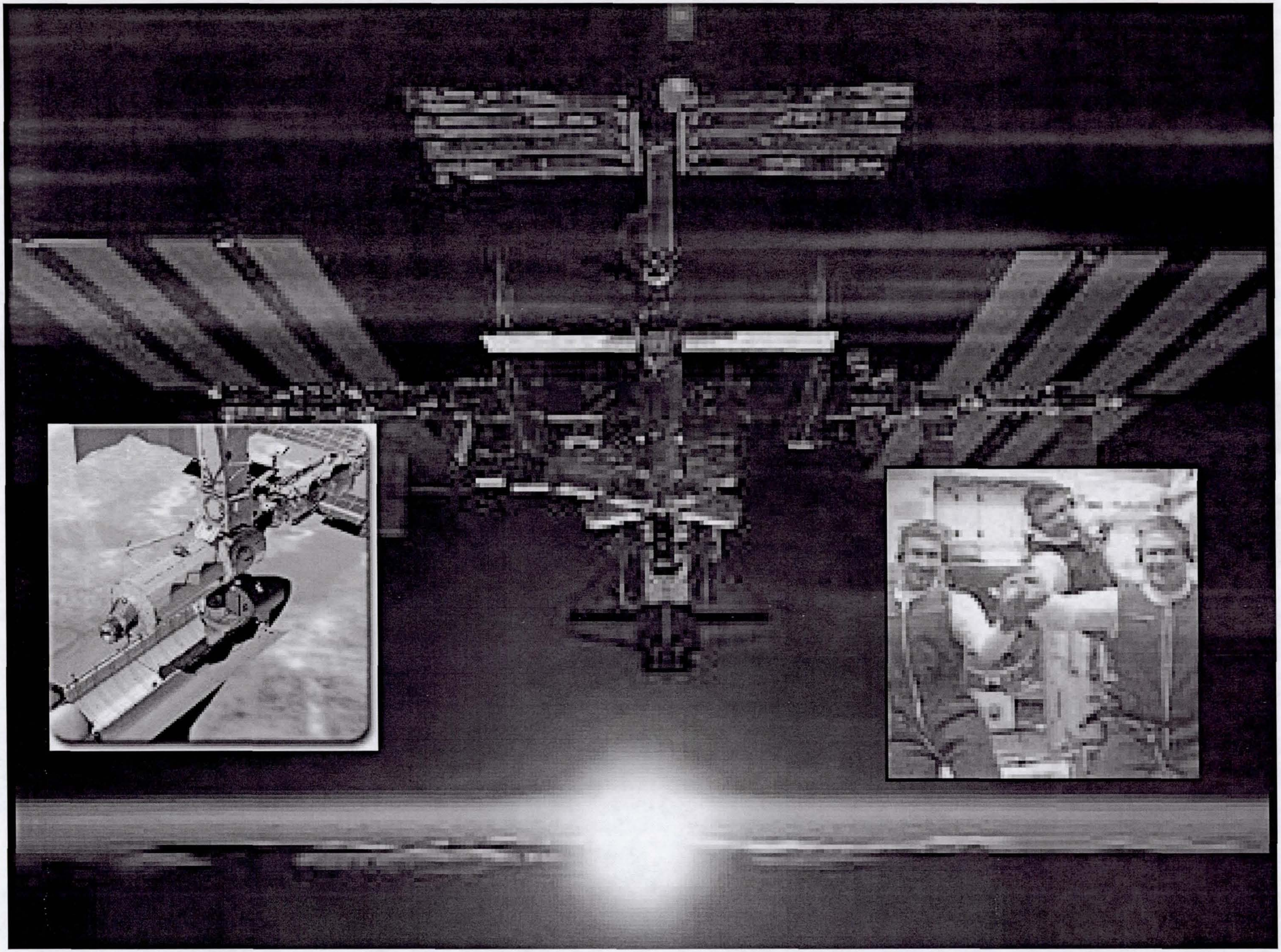
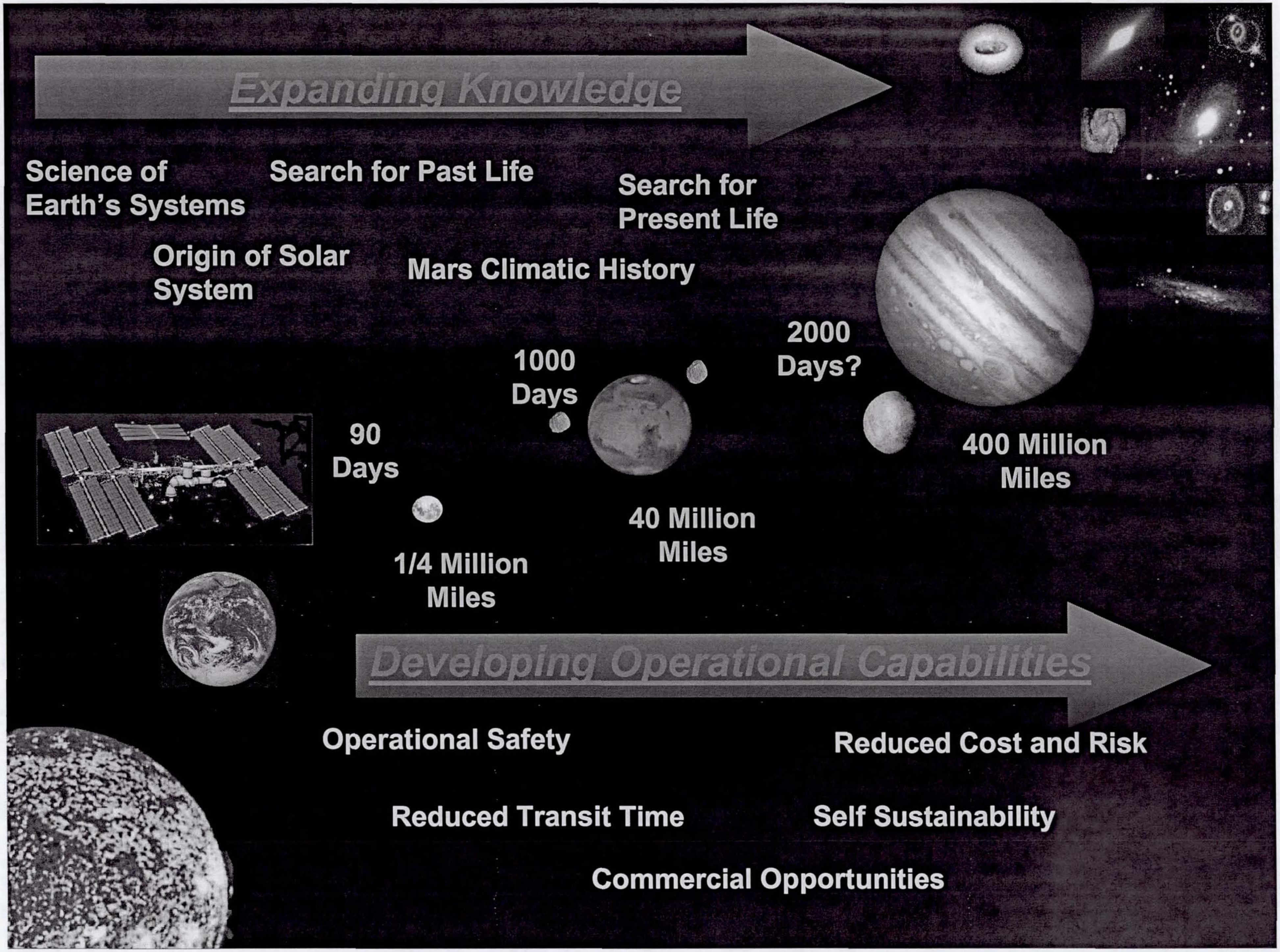

horizon2.jpg




Expanding Knowledge
Science of Earth's Systems
Search for Past Life
Search for Present Life
Origin of Solar System
Mars Climatic History
2000 Days?
1000 Days
90 Days
400 Million Miles
40 Million Miles
1/4 Million Miles
Developing Operational Capabilities
Operational Safety
Reduced Cost and Risk
Reduced Transit Time
Self Sustainability
Commercial Opportunities

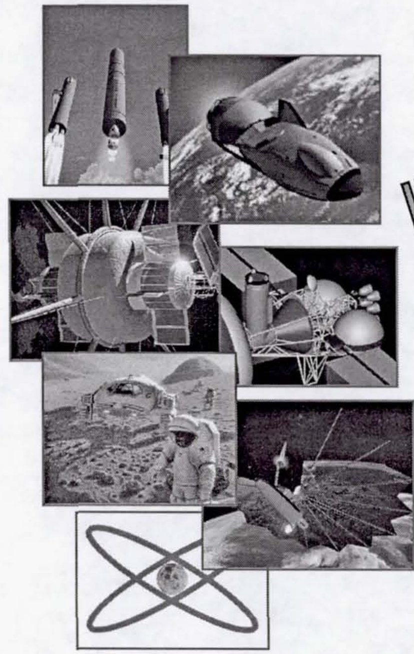
# Core Capabilities & Technologies

| *Common Technology Building Blocks (Core Technologies)* | *Common System Building Blocks (Core Capabilities)* | *Potential Destinations* |
|---|---|---|

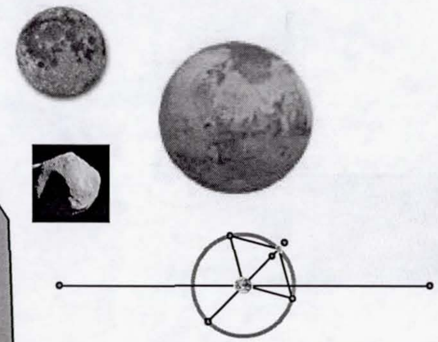
## *Examples*

- Efficient In-Space Prop..
- Aeroassist
- Low-cost Engines
- Cryo Fluid Management
- Robust/Efficient Power
- Lightweight structures
- Radiation Research
- Zero/Low-g Research
- Regenerable Life Support
- Advanced Lightweight EVA

System Design

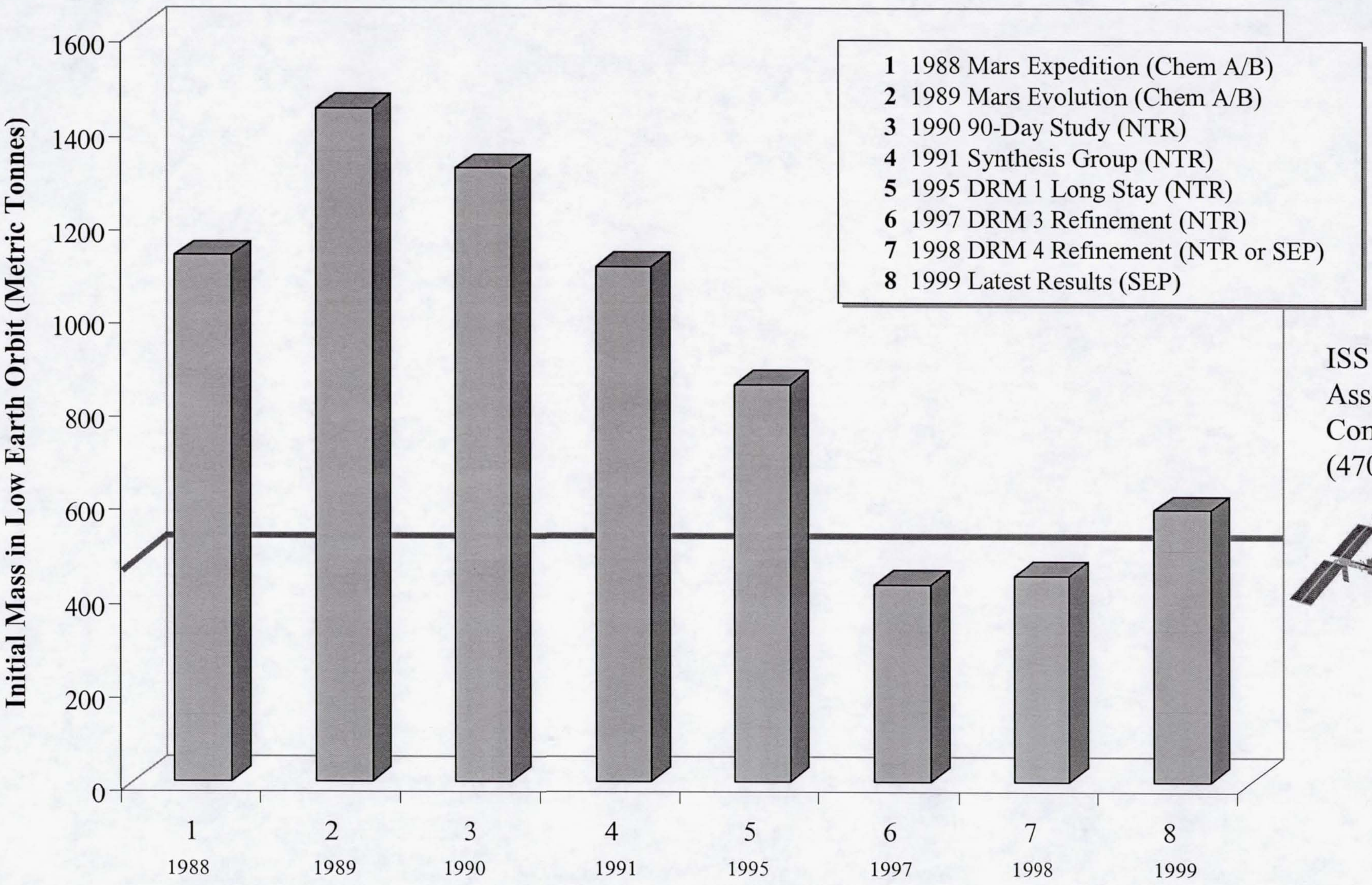


Mission Analyses

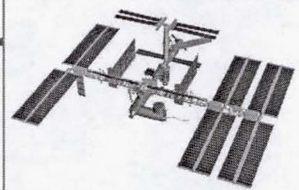


"Breakthrough" Technologies

# Mars Architecture Mass Comparison

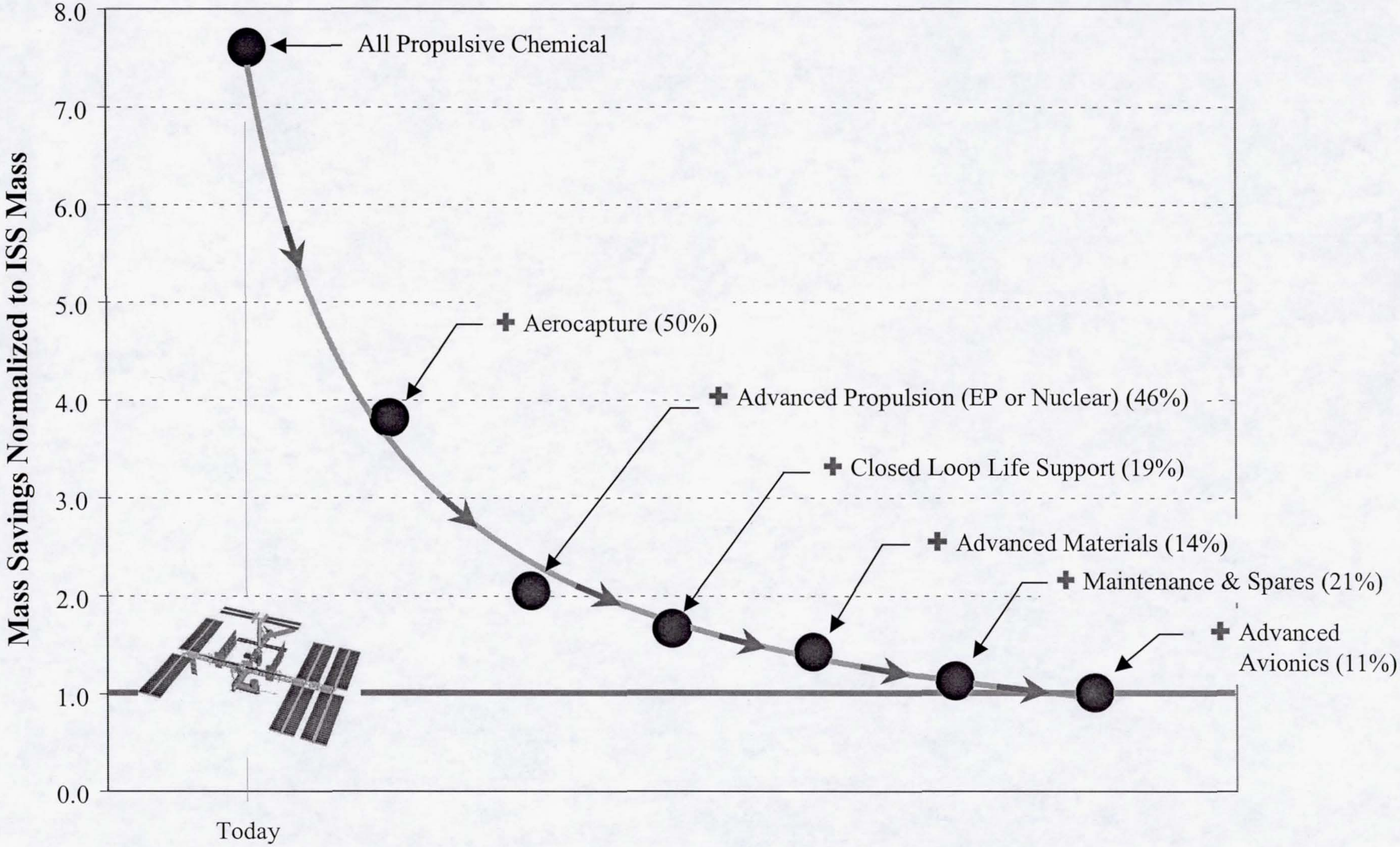



ISS @
Assembly
Complete
(470 tons)

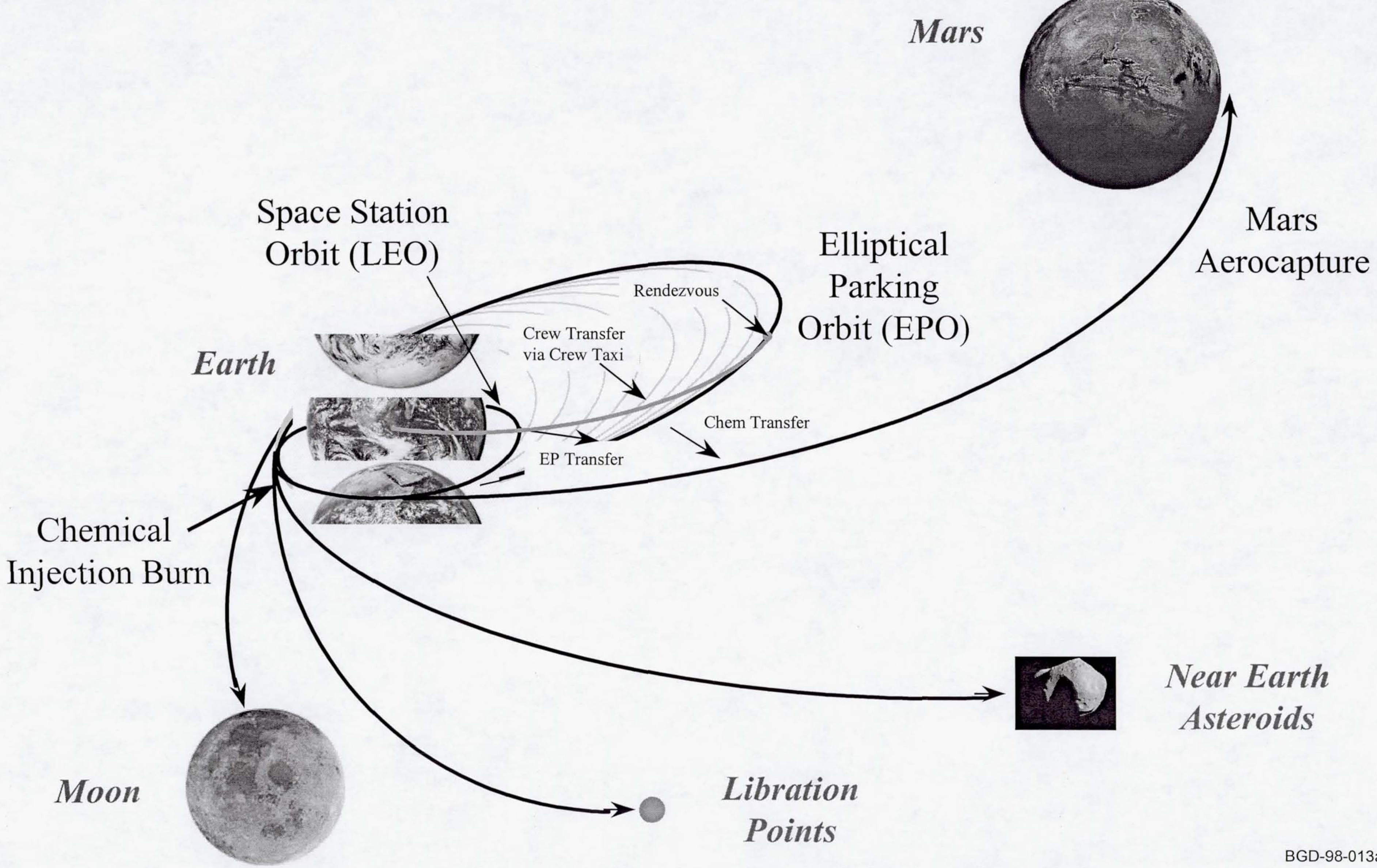


# The Value of Technology Investments

## Mars Mission Example



# High Earth Orbit Staging Mission Scenarios

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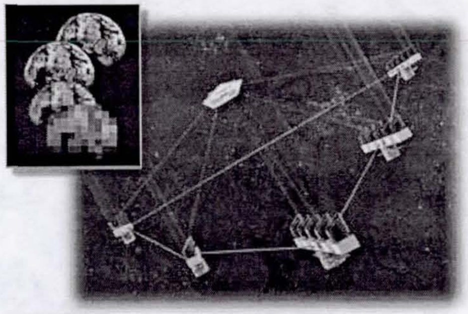
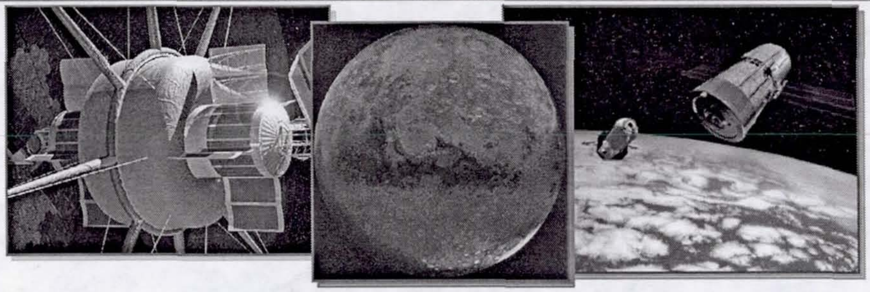
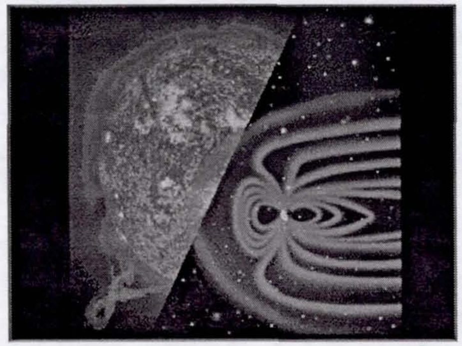




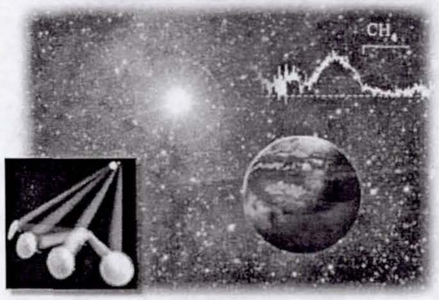
## *Human Mars Exploration*

- Technology Development
- Deep-Space Operational Experience
- Mission Staging (Hybrid Prop Module Fuel Depot)



## *Construct and Deploy Solar Sentinels*

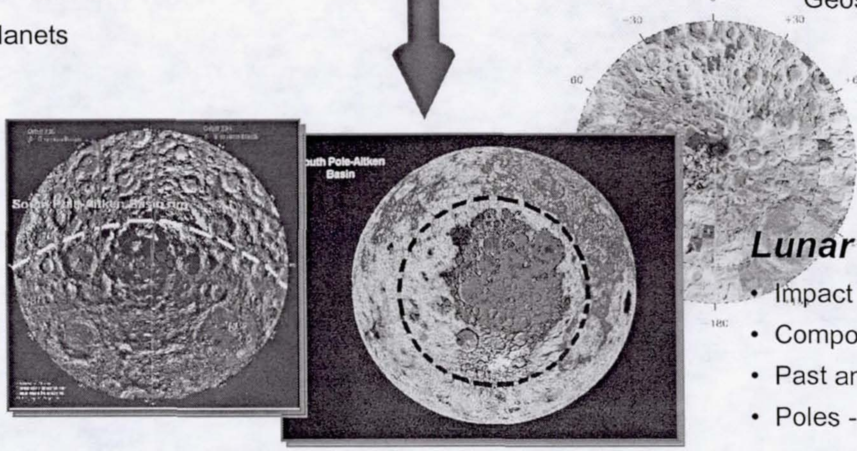
- Search for Location and Mechanism of Solar Flares
- Increase Lead Time and Accuracy for Geospace Forecasts




## *Construct, Deploy, and Service Advanced Astronomical Instruments*

- Detect Biological Activity on Extra-Solar Planets
- Image Surfaces of Extra-Solar Planets

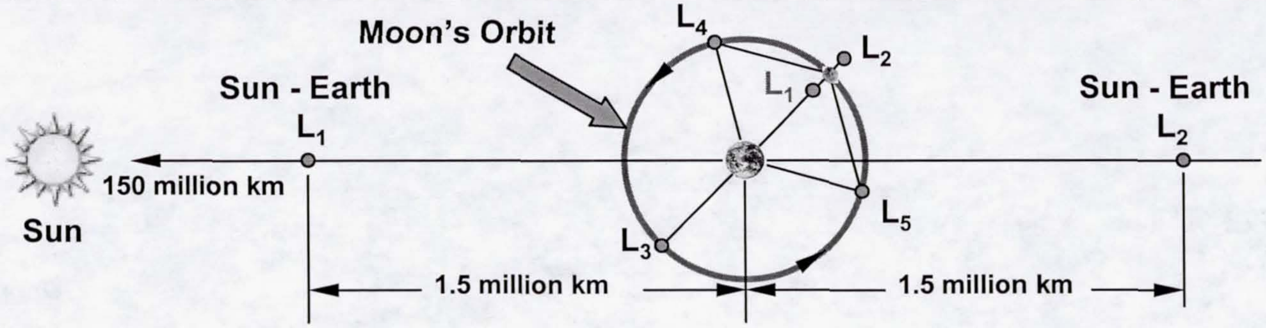
# *"Earth's Neighborhood" Capabilities*

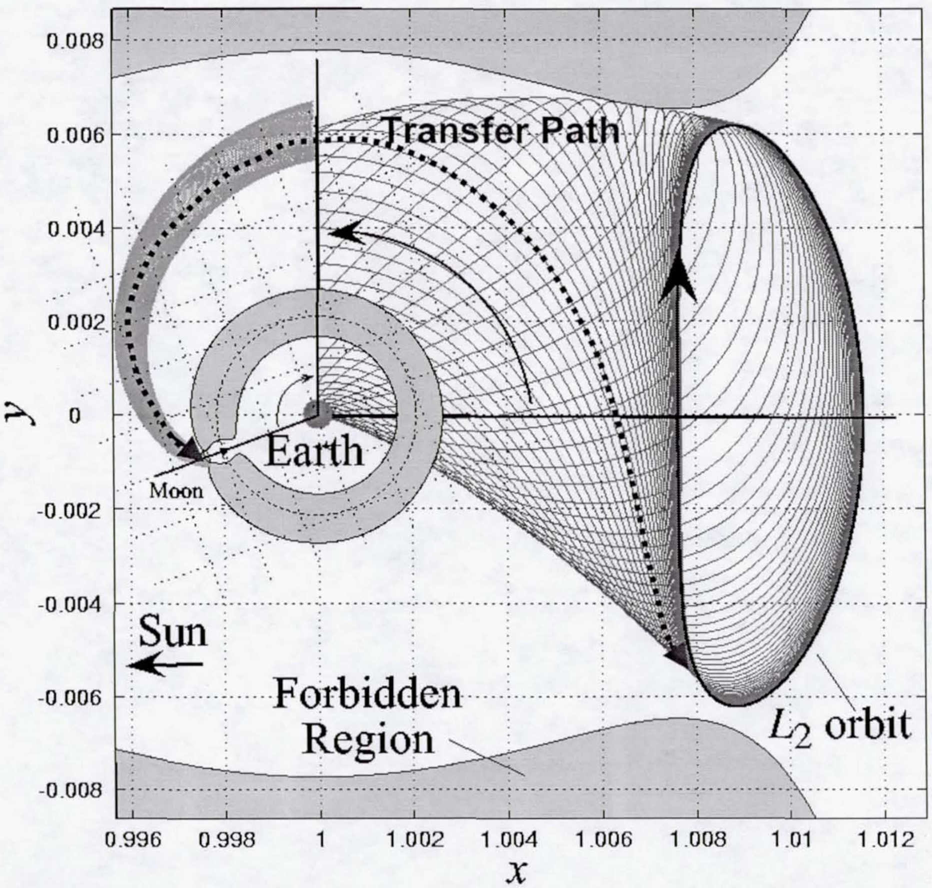


## *Lunar Science*

- Impact History in Near-Earth Space
- Composition of Lunar Mantle
- Past and Current Solar Activity
- Poles - History of Volatiles in Solar System

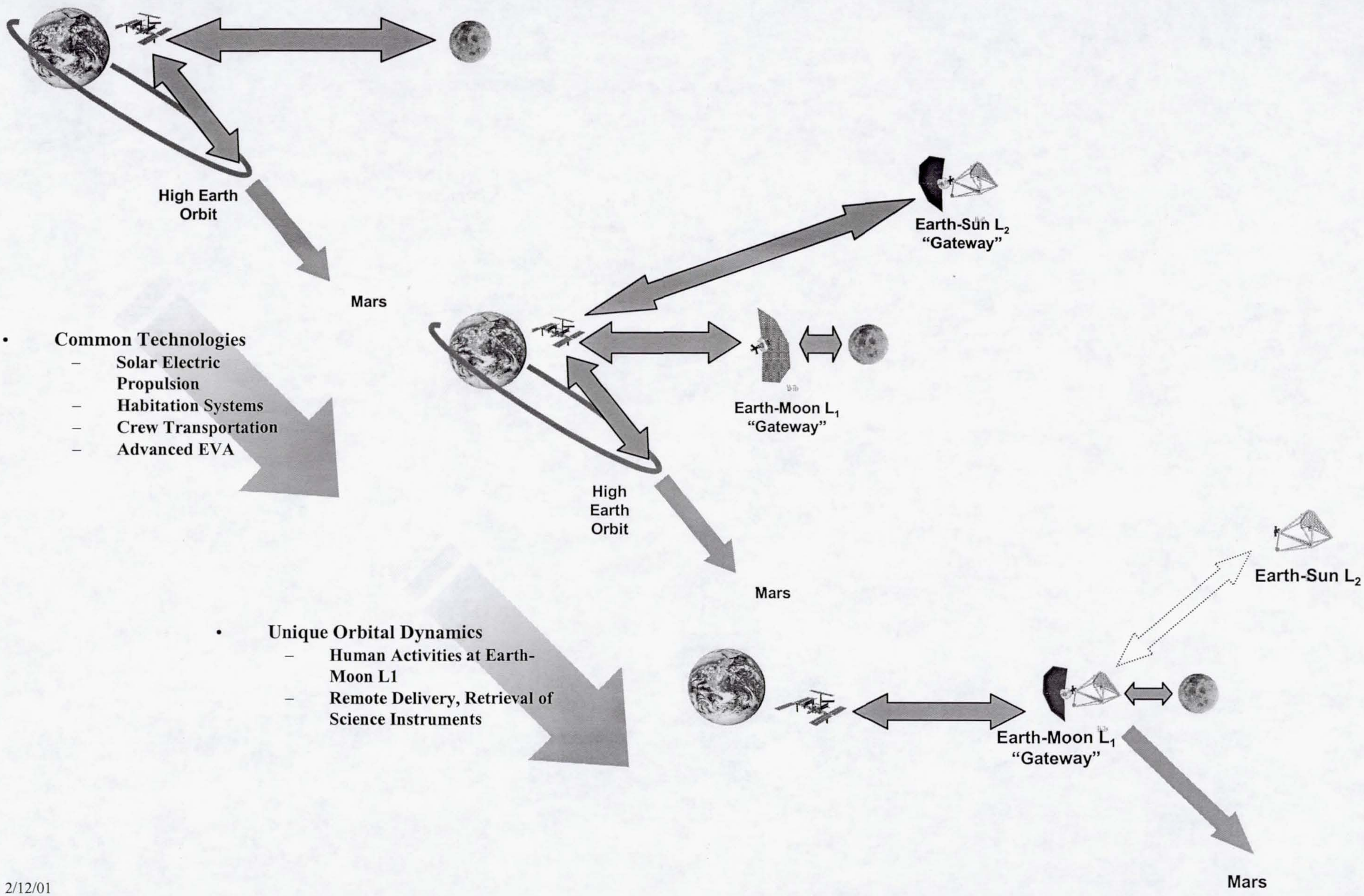
# *Unique Orbital Dynamics*




- Orbital Dynamics in Earth-Moon System Leads to Unique Capabilities
  - Low-Energy Transfer from Earth-Moon L1 to Solar Libration Points and Return
  - Potential Staging Point for Human Mars Missions
- Allows for Earth-Moon L1 Deployment and Servicing of Science Assets

# *Architecture Evolution*



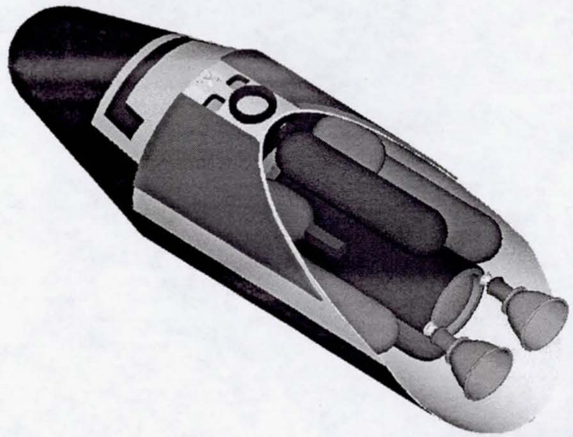

- Common Technologies
  - Solar Electric Propulsion
  - Habitation Systems
  - Crew Transportation
  - Advanced EVA

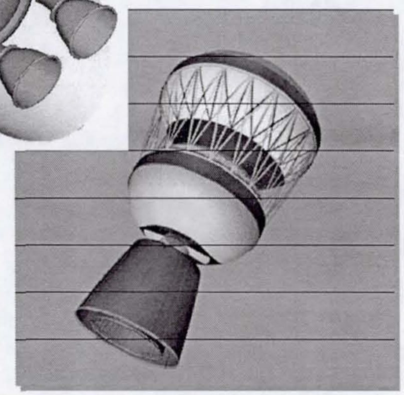
- Unique Orbital Dynamics
  - Human Activities at Earth-Moon L1
  - Remote Delivery, Retrieval of Science Instruments

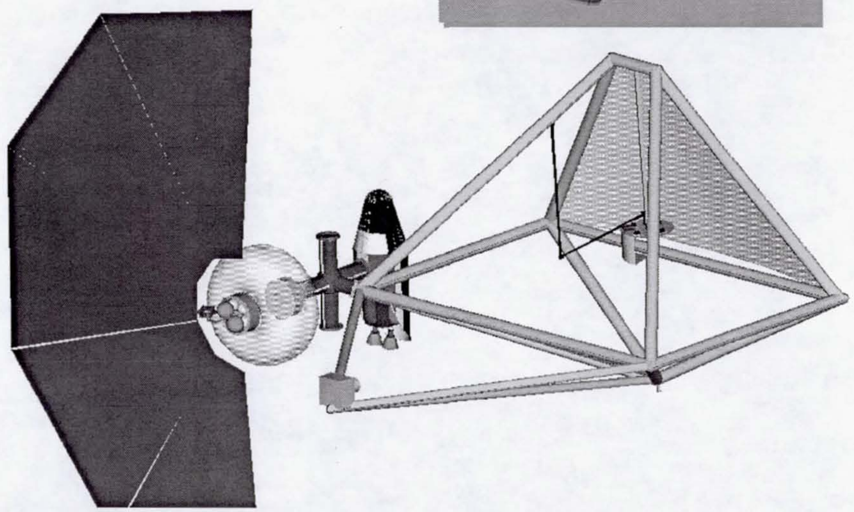
# Earth's Neighborhood, Libration Points Architecture

***Key Attributes***

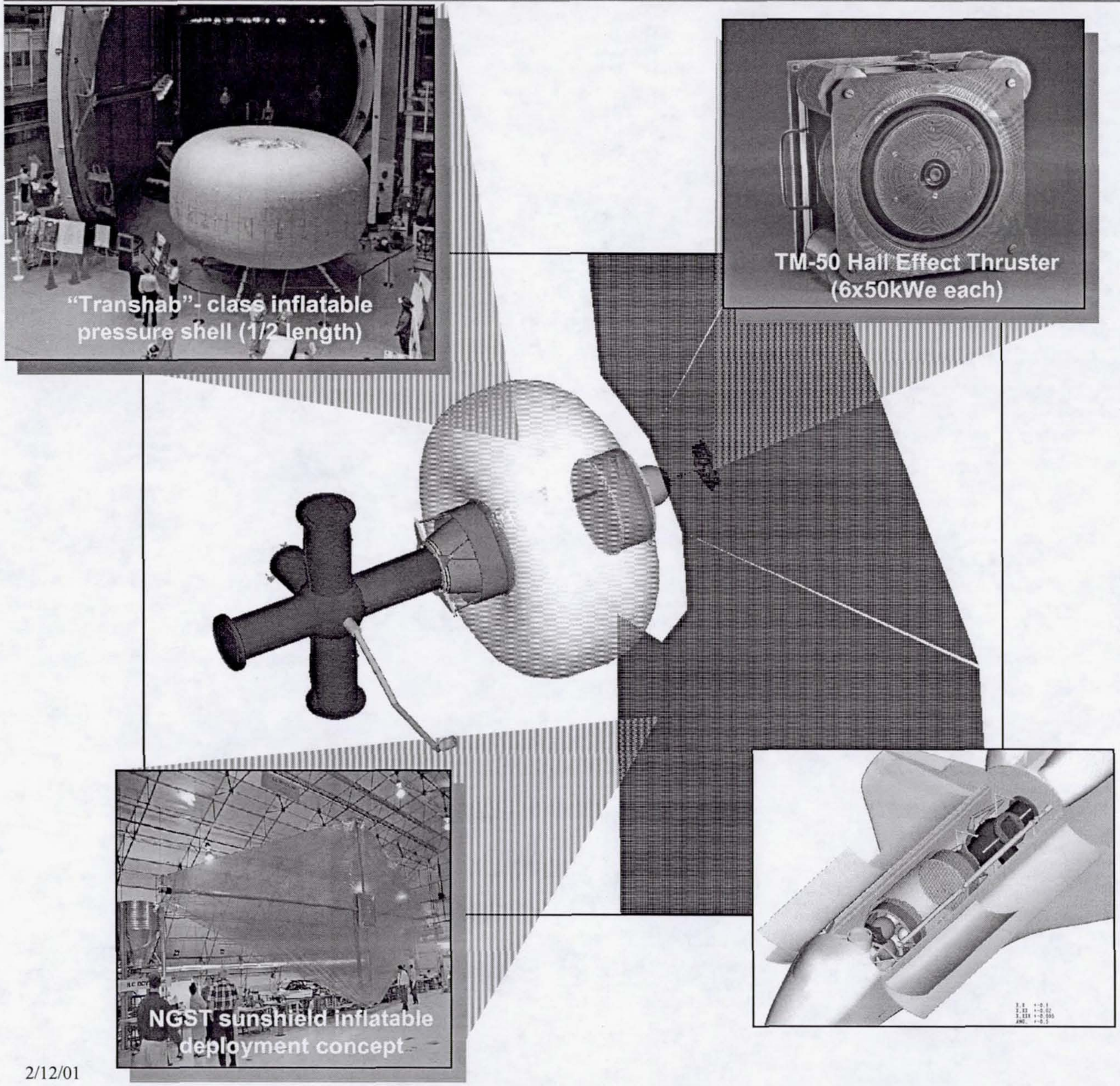
- Crew of 4
- 65 day mission duration
- Deployment, assembly, and servicing of large complex science facilities to achieve revolutionary discoveries
- ISS integral as a staging platform
- Serves as a "stepping stone" by providing an opportunity to test technology and operational concepts, reducing risk of future exploration endeavors
- Architecture can be bought "by the yard" resulting in increasing capabilities and operational experience
- Modest augmentation of commercial launch vehicles
- Common architecture elements for all Earth's Neighborhood missions







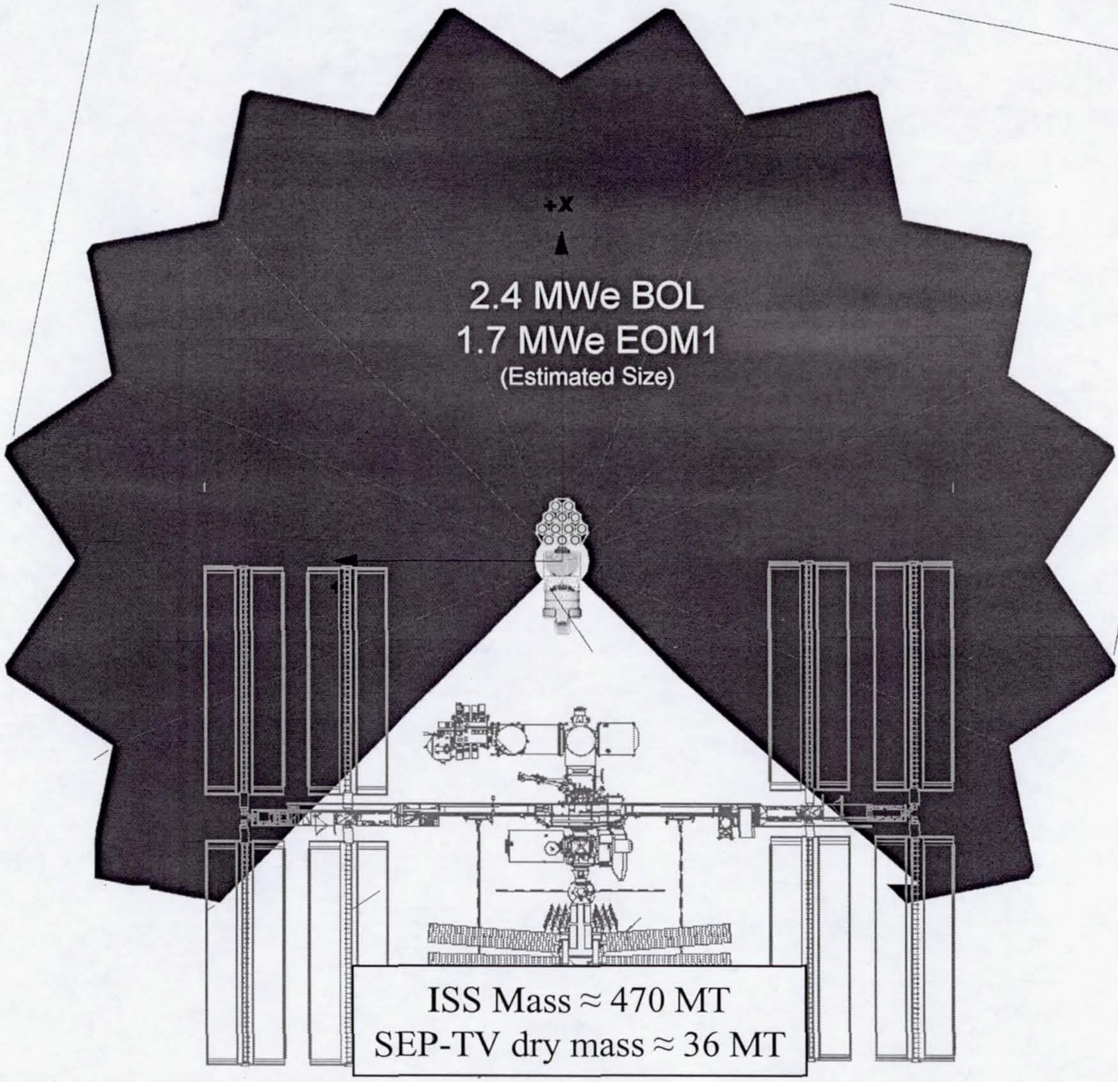
# Lunar $L_1$ "Gateway"



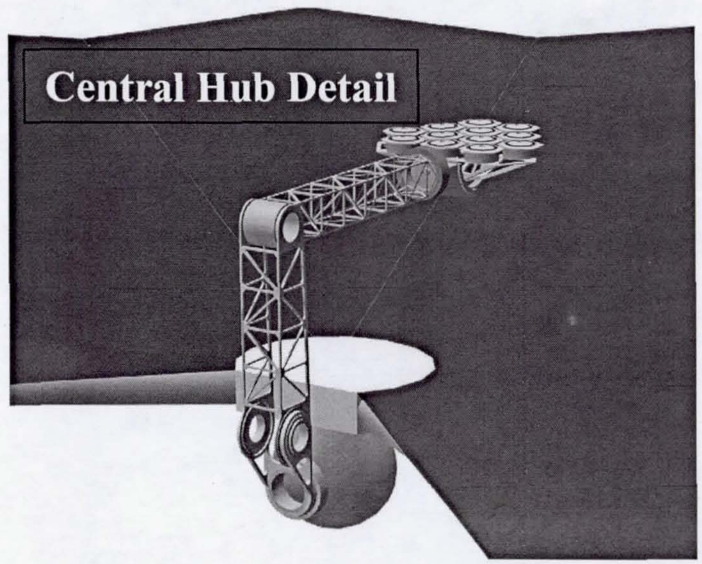

***Key Attributes***

- Crew of 4
- Global lunar access – 3 day
- Lunar polar outpost – 30 days
- ISS integral as a staging platform
- Lunar missions serve as "stepping stones" by providing an opportunity to test technology and operational concepts, reducing risk of future exploration endeavors
- Architecture can be bought "by the yard" resulting in increasing capabilities and operational experience
- Modest augmentation of commercial launch vehicles
- Common architecture elements for all Earth's Neighborhood missions

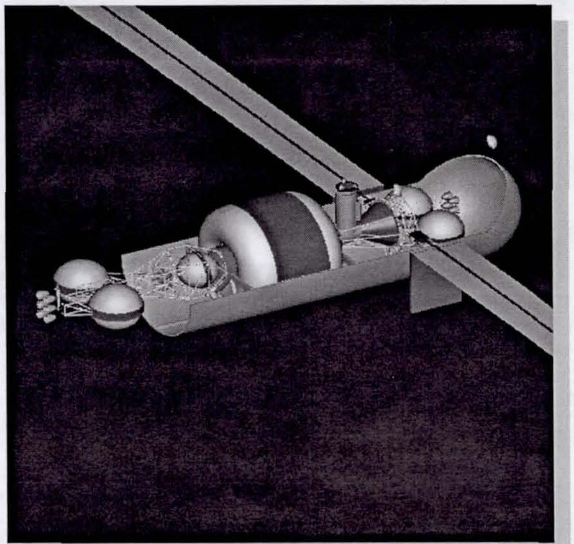
# Solar Electric Propulsion Concept




- Array sized to provide 1700 $kW_e$ throughout first mission
- 14700 m² $CuInS_2$ array area
- 171 m span (wingtip-wingtip)
- 17 x 100 $kW_e$ Hall Thruster Propulsion
- Articulated boom thruster gimballing

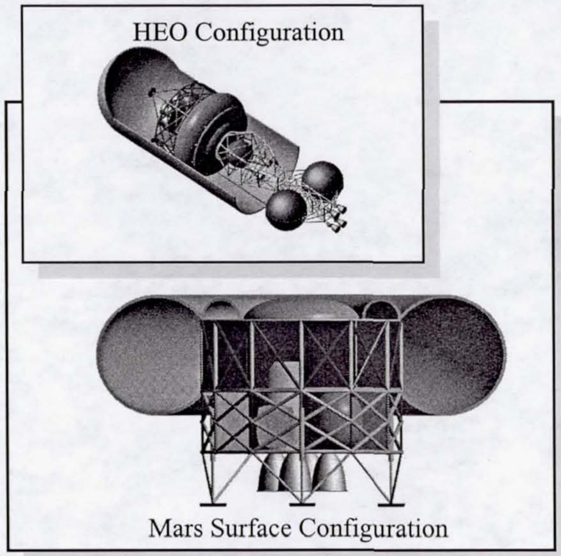


# Mars Mission Vehicle Concepts



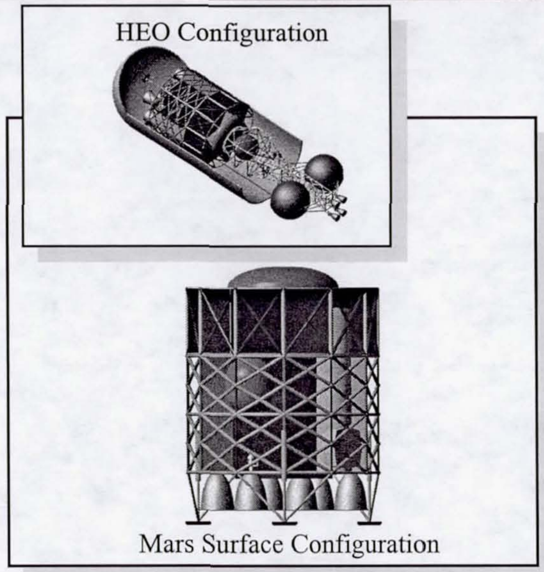
### *Mars Transit Vehicle*

- Supports mission crew of six for up to 200-day transits to and from Mars
- Return propulsion stage integrated with transit system
- Provides return-to Earth abort capability for up to 30 hours post-TMI
- Total Vehicle Mass in High-Earth Orbit = 188 mt




### *Mars Surface Habitat*

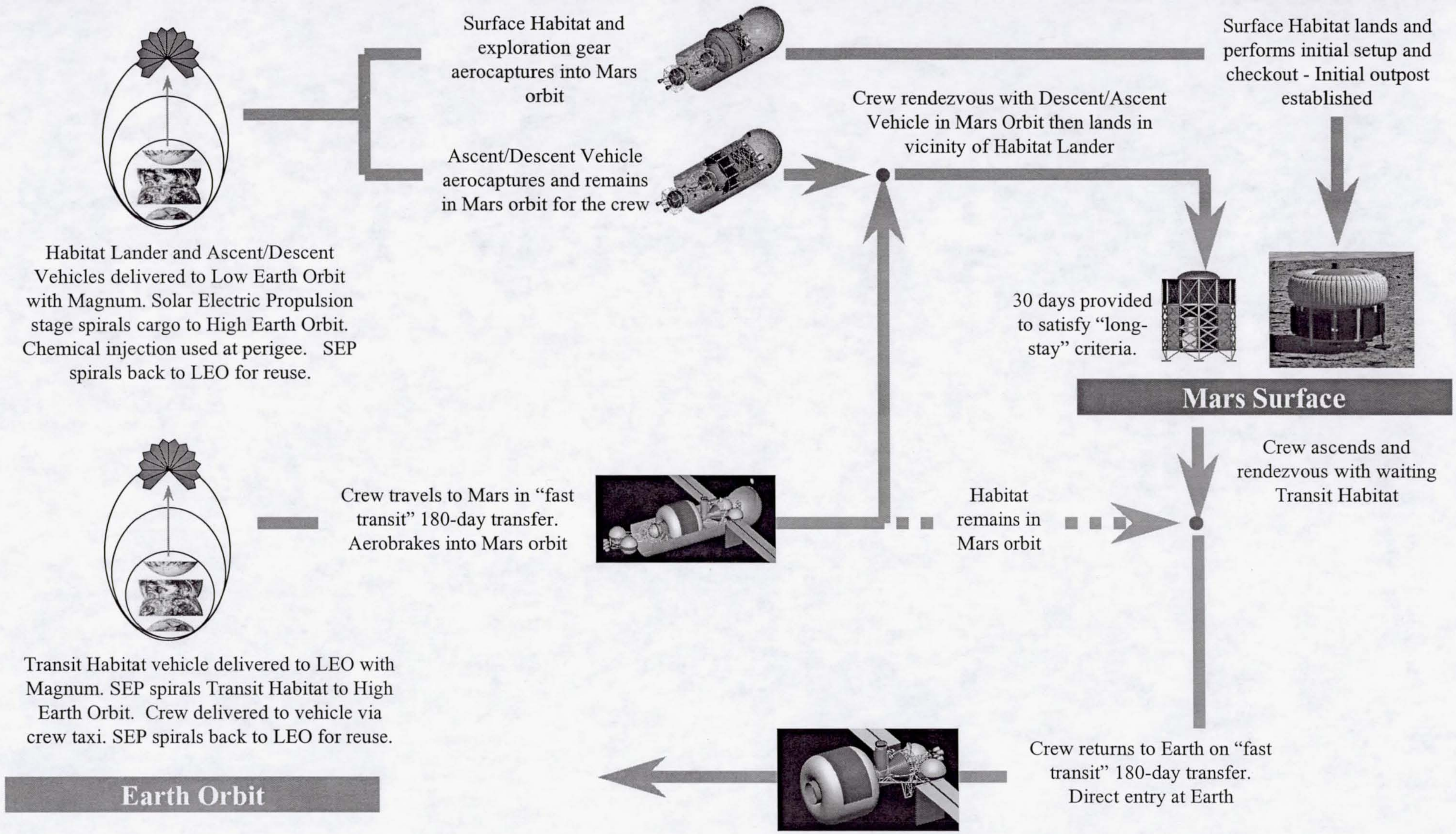
- Vehicle supports mission crew of six for up to 18 months on the surface of Mars
- Provides robust exploration and science capabilities
- Descent vehicle capable of landing 36,000 kg
- Total Vehicle Mass in High-Earth Orbit = 99 mt




### *Descent/Ascent Vehicle*

- Transports six crew from Mars orbit to the surface and back to orbit
- Provides contingency abort-to-orbit capability
- Supports six crew for 30-days
- Vehicle capable of utilizing locally produced propellants
- Total Vehicle Mass in High-Earth Orbit = 103 mt

# Mars Mission Overview

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