

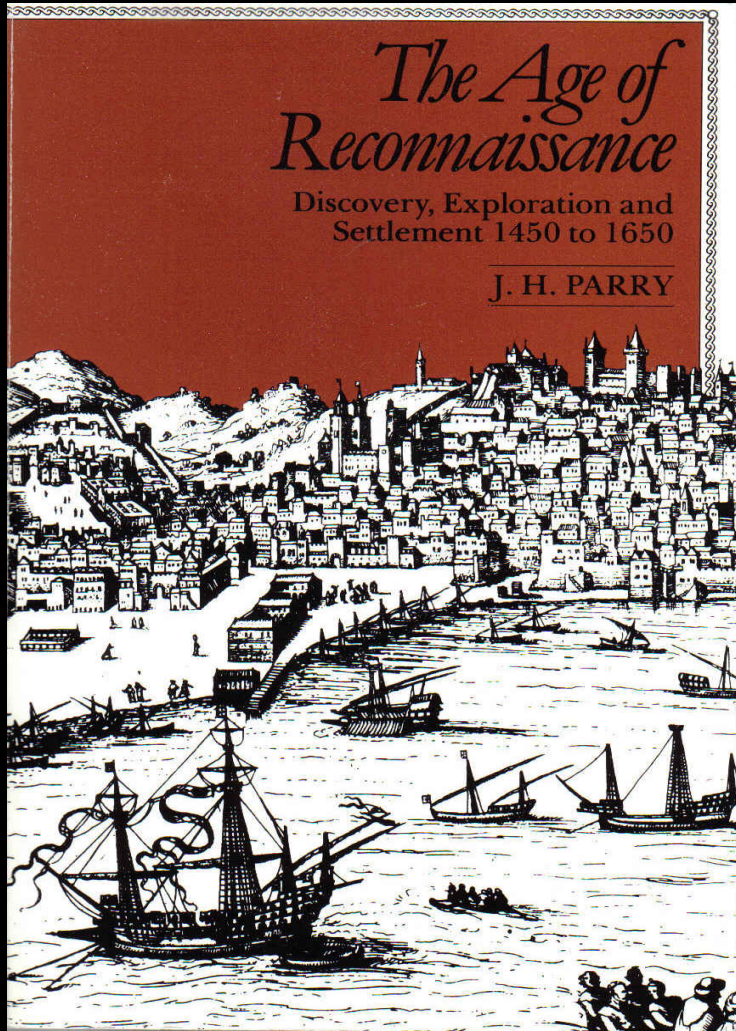
Exploration, Discovery and Culture



The Importance Of The Space Age

Steven J. Dick

The Age of Reconnaissance As Historical Analogy

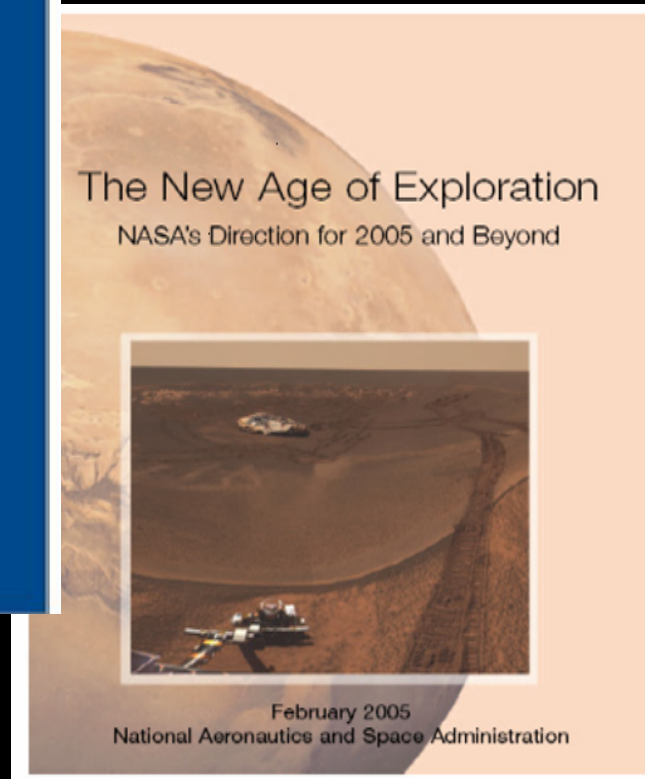
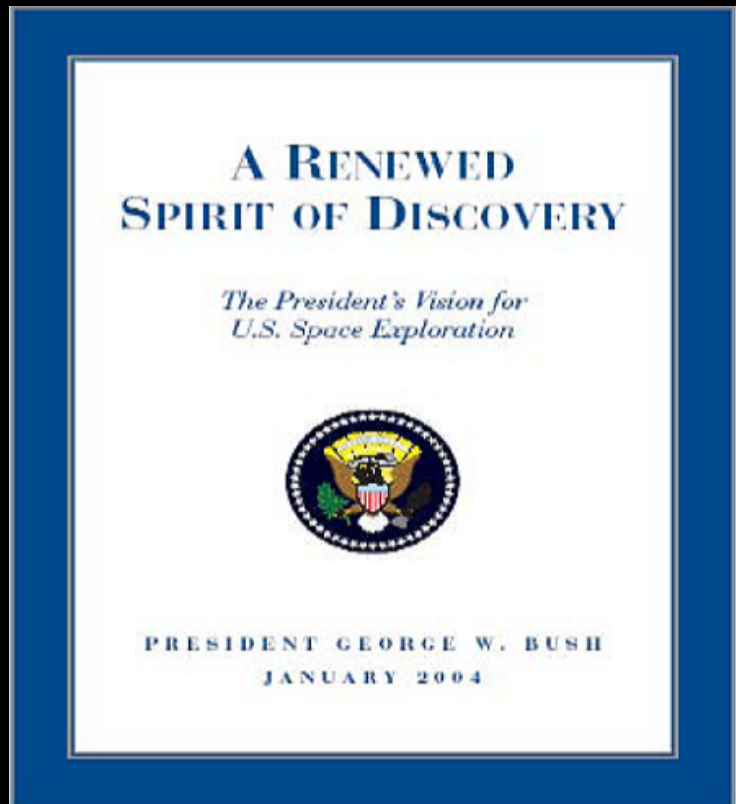


Conditions for the Space Age

The Story of the Space Age

Societal Impact of the Space Age

Spaceflight and the Exploration Analogy

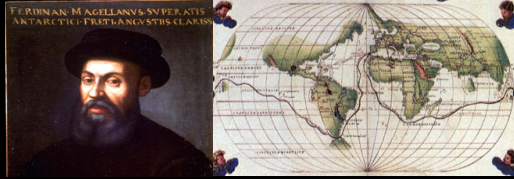


Exploration... Discovery... Knowledge

Columbus
1st Deep Sea Voyage



Magellan
1st Circumnavigation



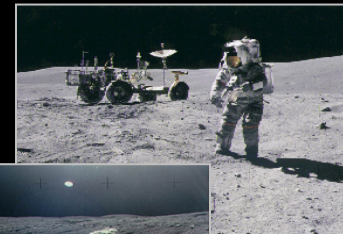
Transcontinental Railroad



Lewis & Clark
Corps of Discovery



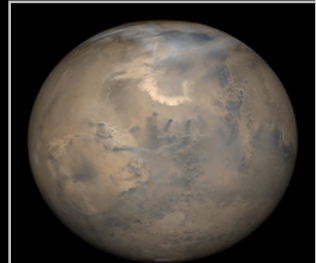
Wright Brothers
1st Flight



Apollo
1st Humans off Earth



... **Mars?**



Three Ages of Exploration

- I. The Age of Discovery, 15th-16th Centuries
 - Economic benefit was the driver
 - Prince Henry the Navigator, Columbus, Magellan, etc.

- II. Geographical Exploration – 18th-19th Centuries
 - Science was the driver – Captain Cook, von Humboldt, Lewis and Clark, etc.

- III. Space Exploration/Ocean Exploration, 1957-
 - Geopolitics and other factors were the drivers;
 - New technology was the means – IGY and Sputnik

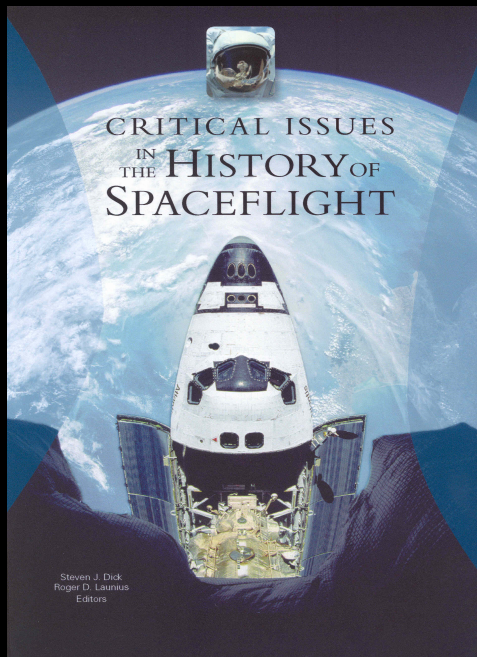
**Conditions
For the Space Age**

Motivations

Age of Discovery

Economic Gain

Religious Conversion



Age of Space

❖ **Exploration**

❖ **National Defense**

❖ **National Prestige**

❖ **Science**

❖ **Economic Competitiveness**

❖ **Survival of the Species**

Infrastructure - Transportation



The Caravel



The Niña, a replica of 15th century caravel commanded by Christopher Columbus



Infrastructure - Ports



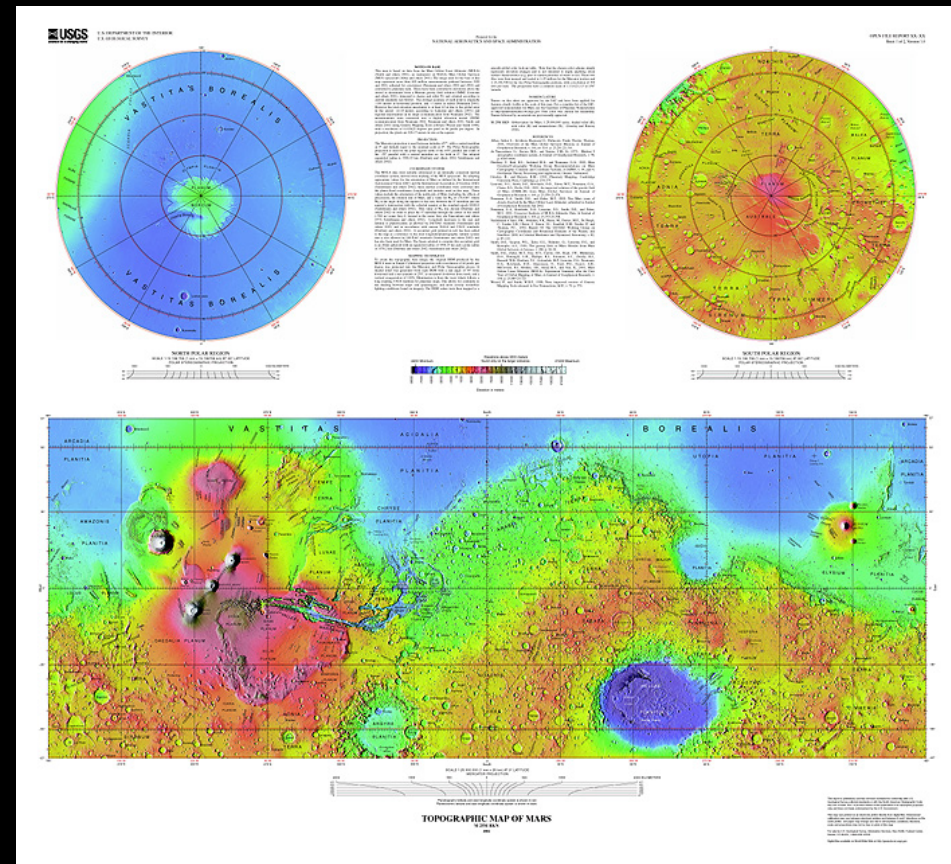
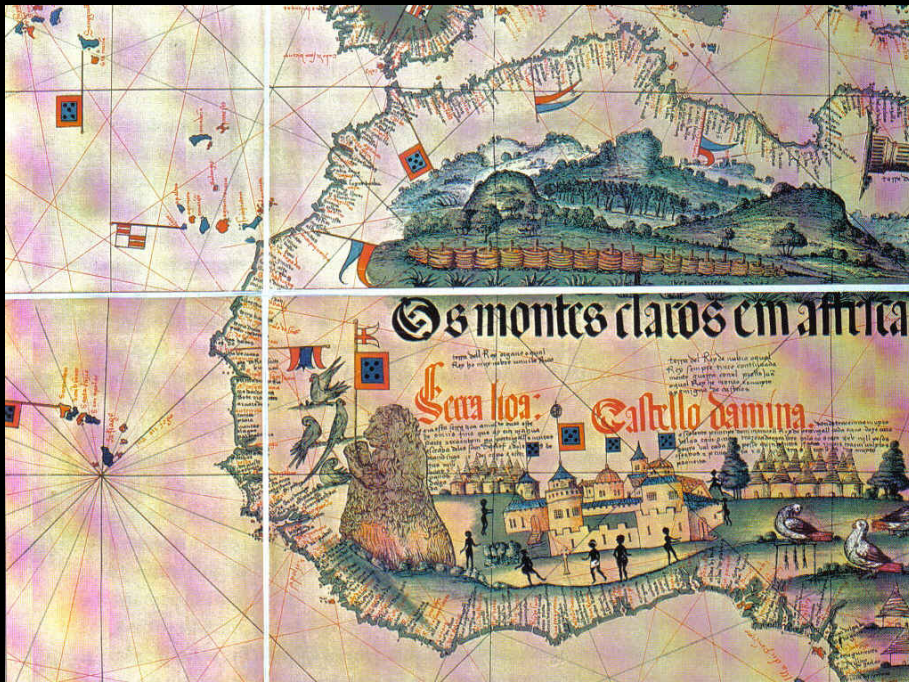
A painting showing the departure of Christopher Columbus from Palos, Spain, by an unknown artist. (Giraudon/Art Resource, NY)

Palos, Spain



Cape Canaveral, November, 1964
Across the Banana River is the
Unfinished VAB at Kennedy
Space Center

Navigation & Cartography



MOLA Map, Mars Global Surveyor

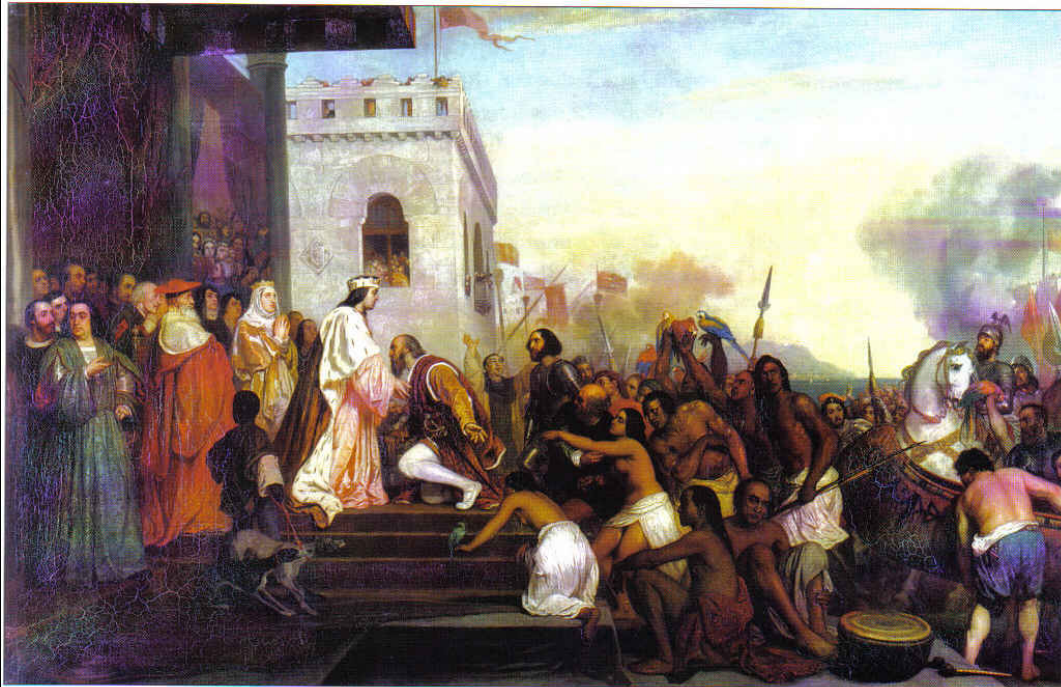
The Voyagers



Vasco da Gama, 1646, by an unknown artist.
(Heritage Image Partnership)



Institutions



A nineteenth-century painting showing Columbus appearing before Fernando and Isabel after completing his first western voyage, by Robert Fleury. (Réunion des Musées Nationaux/Art Resource, NY)



March 1, 1960. NASA's top management from 1958-1960. T. Keith Glennan, Administrator (center), Hugh L. Dryden, Deputy Administrator (left), and Richard E. Horner Associate Administrator (right). The new seal of NASA is above Glennan

Funding

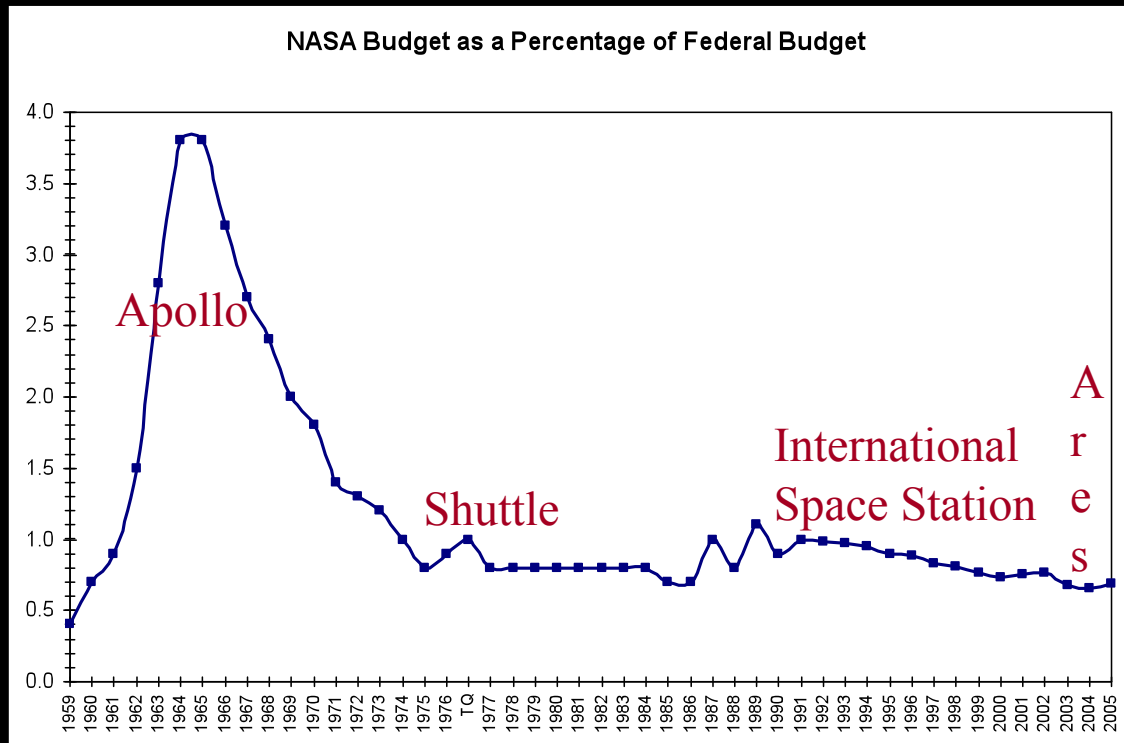
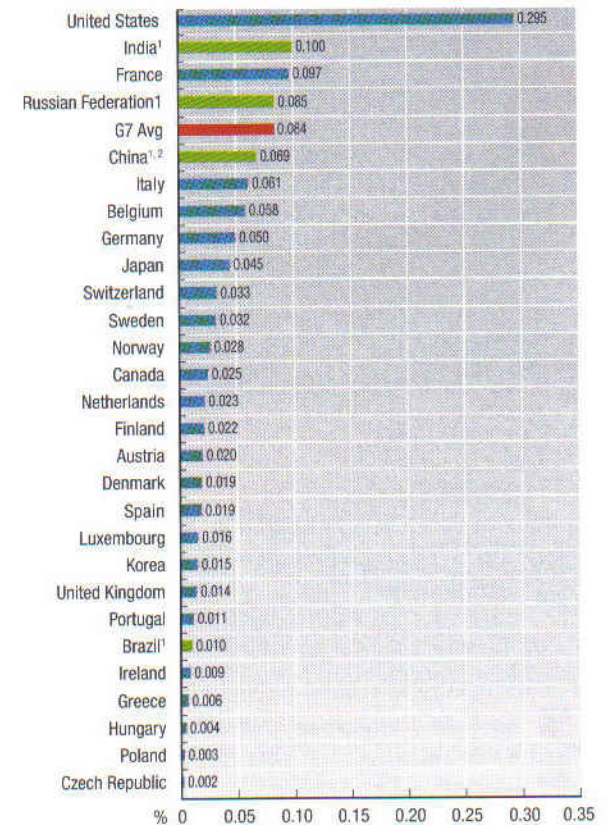


Figure 2.1.1a. Public space budgets as a per cent of national GDP for available OECD and non-OECD¹ countries, 2005



1. Non-OECD countries are Brazil, Russia, India and China.
2. Chinese data based on unofficial estimates.

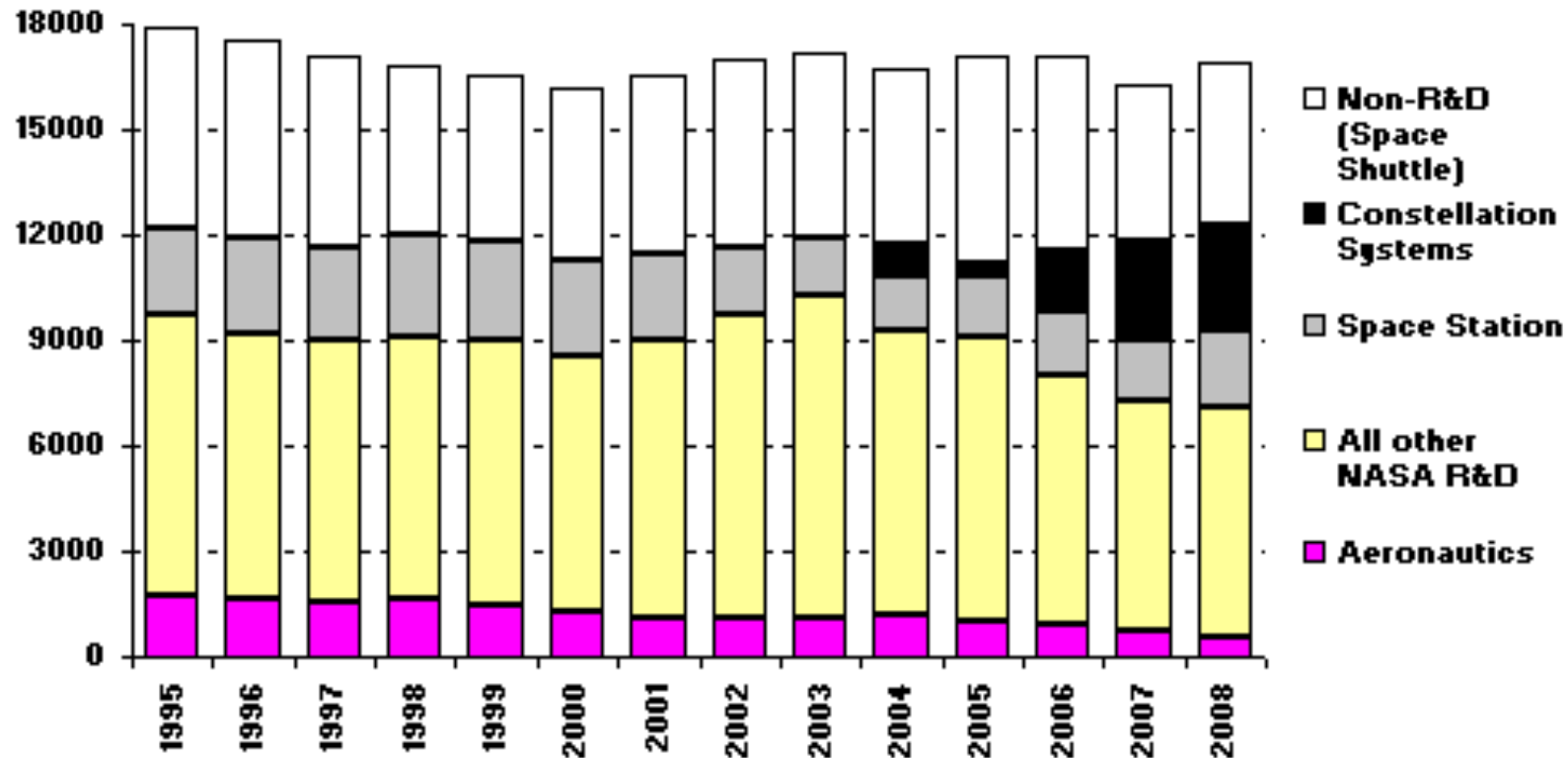
Sources: Budgets: NASA, CSA, ESTP (Europe), JAXA, other national sources.

GDP: OECD (2007), *National Accounts of OECD Countries, Volume I – Main Aggregates*, OECD, Paris, France.

Source: OECD, *The Space Economy At a Glance 2007*

Trends in NASA R&D, FY 1995-2008 *

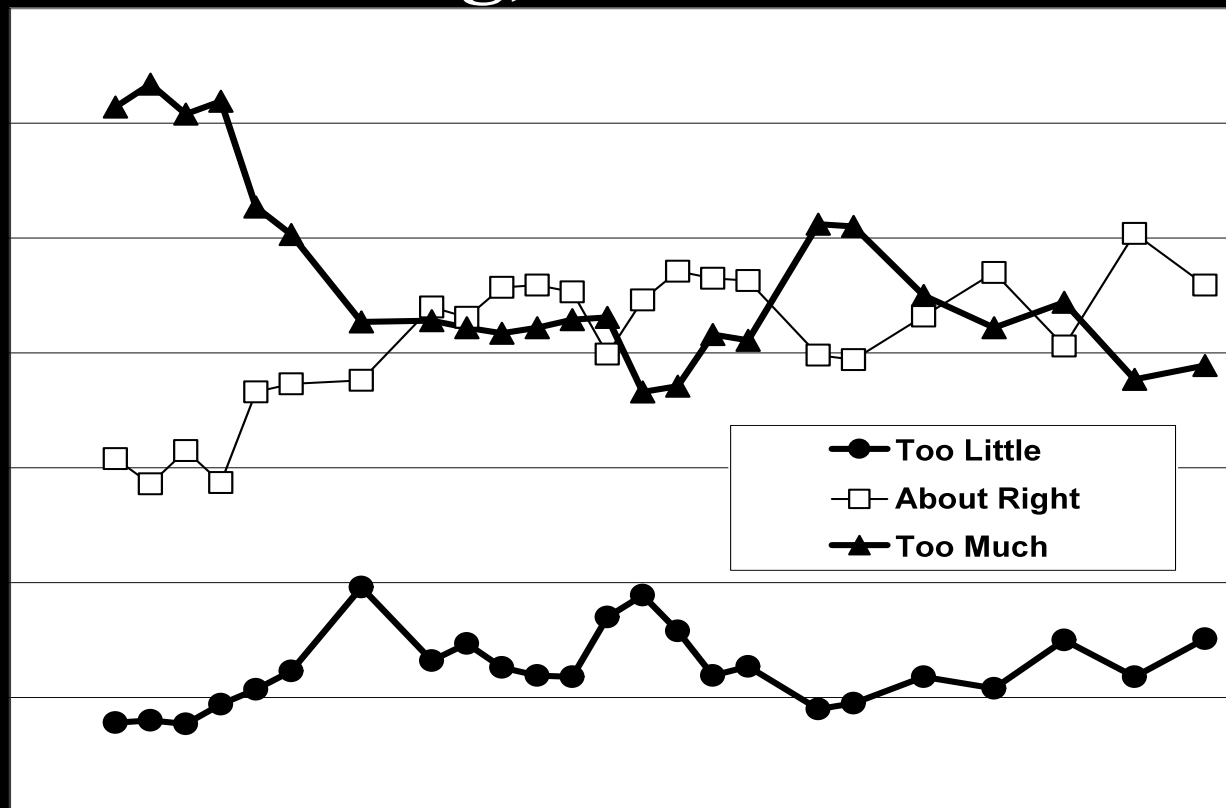
in millions of constant FY 2007 dollars



Source: OMB, Budget of the U.S. Government Historical data. * FY 2008 figures are President's request. FY 2007 figures are latest estimates of 2007 appropriations. R&D includes conduct of R&D and R&D facilities.
 MARCH '07 REVISED © 2007 AAAS



Attitudes Toward Space Program Funding, 1973-2004

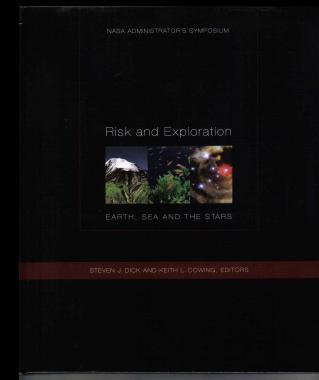


From William Simms Bainbridge

Risk and Exploration

*In a very real sense, the space program is analogous to the exploration
And settlement of the new world. In this view, risk and sacrifice are
Seen to be constant features of the American experience. There is a
National heritage of risk taking handed down from early explorers,
Immigrants, settlers, and adventurers. It is this element of our
National character that is the wellspring of the U. S. space program.*

Report of the Advisory Committee on the Future of the
U. S. Space Program, December, 1990.
Norm Augustine, Chair



The Story of the Space Age
A Journey ...

From the Earth's Atmosphere ...



Neil Armstrong and X-15, 1960



X-43A, Mach 9.8, Nov. 16, 2004

To Earth Orbit ...

Hugging the Coastline Earth Observation



First TV picture from space
TIROS satellite, April 1, 1960



Sputnik, 1957



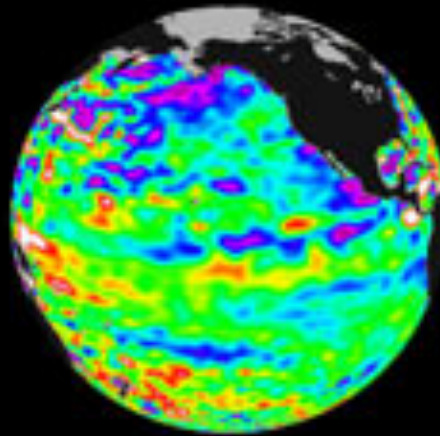
True color mosaic of
Planet Earth
From Terra satellite.
Part of the Earth
Observing System (EOS)
NASA GSFC

Earth Observation at Many Wavelengths

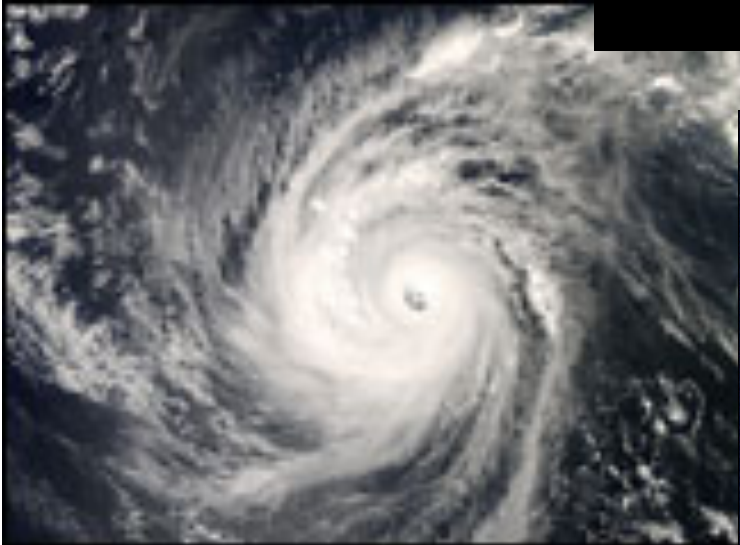
Our Changing Planet

The View From Space

EDITED BY
MICHAEL D. KANE
CLAIRE L. PARSONS
KIM E. PARTINGTON
BOBIN G. WILLIAMS



July 28, 2003

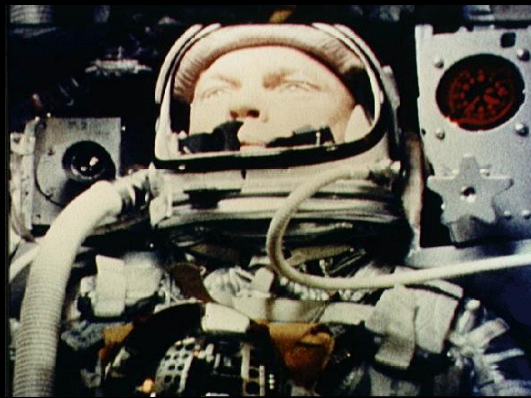


August 22, 1992

Humans in Earth Orbit



Yuri Gagarin
First human in space
First to orbit the Earth
April 12, 1961



John Glenn, Friendship 7,
February 20, 1962
Project Mercury



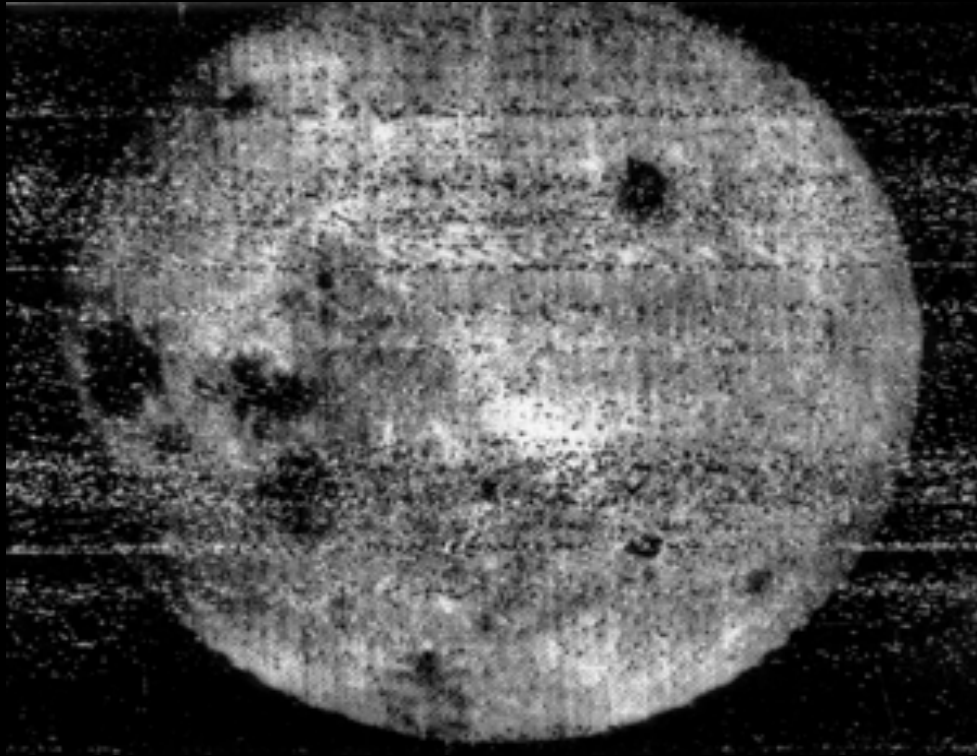
First rendezvous in space
Gemini VI and VII, December 15, 1965

Advanced Human Activity in Earth Orbit



... To the Moon by 1959

First Robotic Reconnaissance

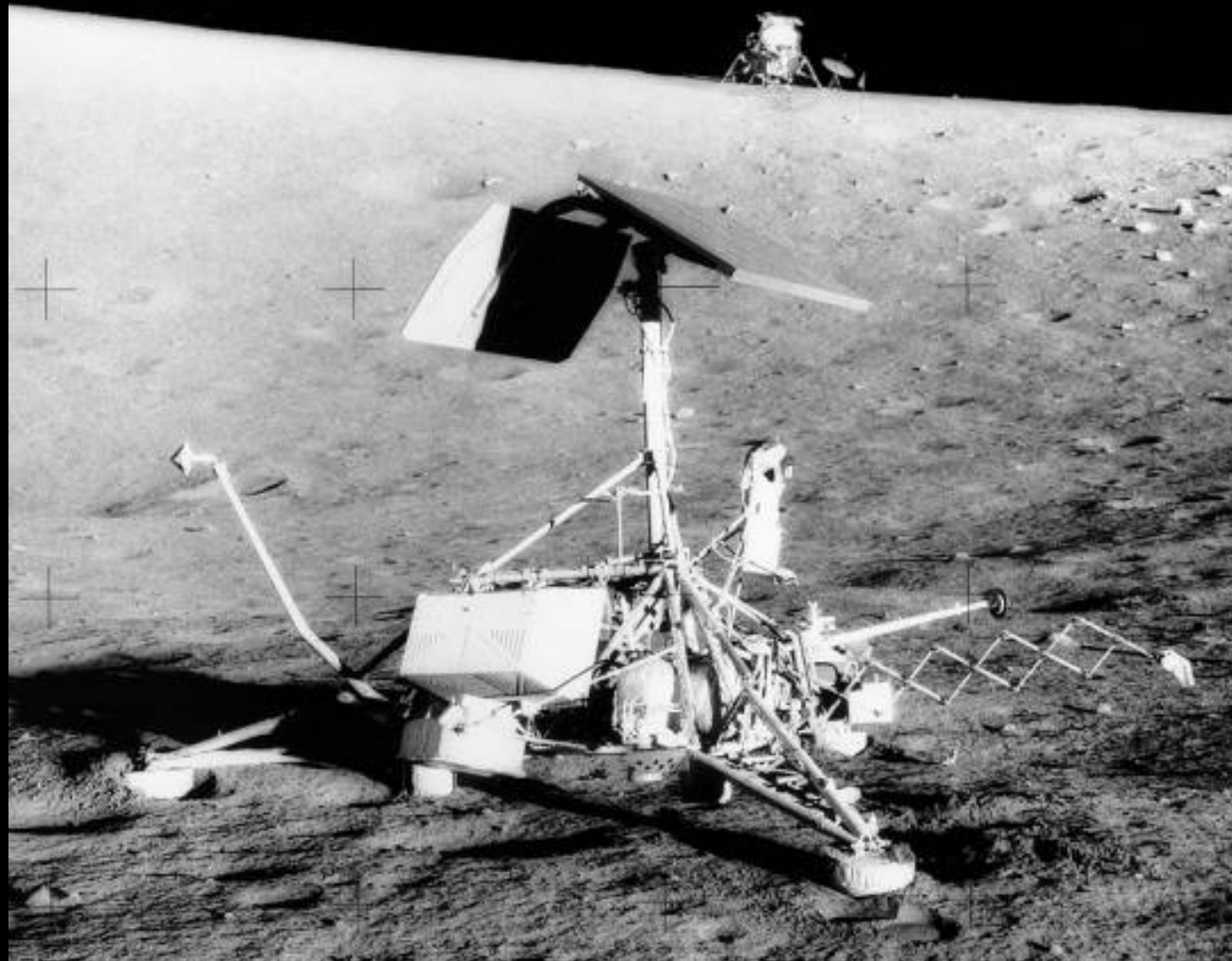


First Image of Far Side of Moon
Luna III October 7, 1959, distance 63,500 km



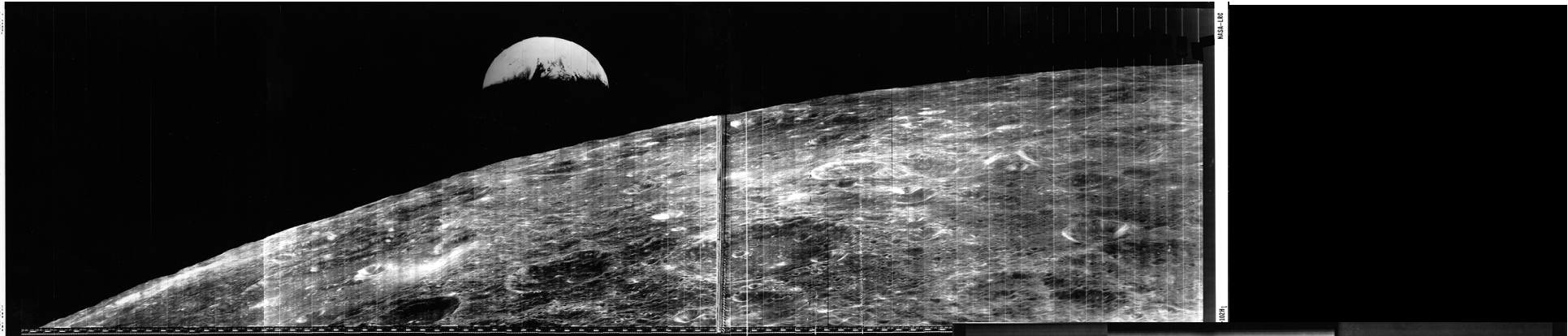
Ranger 7, first image of the Moon
By a US spacecraft, July 31, 1964
17 minutes before impact

First Lunar Robotic Landings



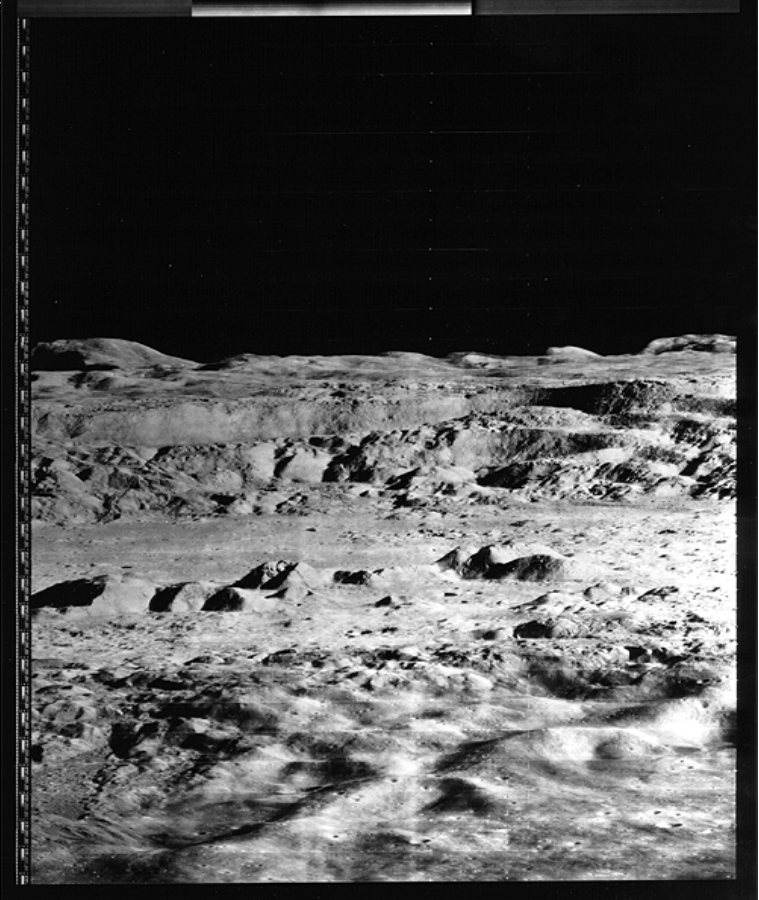
Surveyor 3
Landed April 20, 1967
Visited by Apollo 12
November 1969

Intrepid in the
background

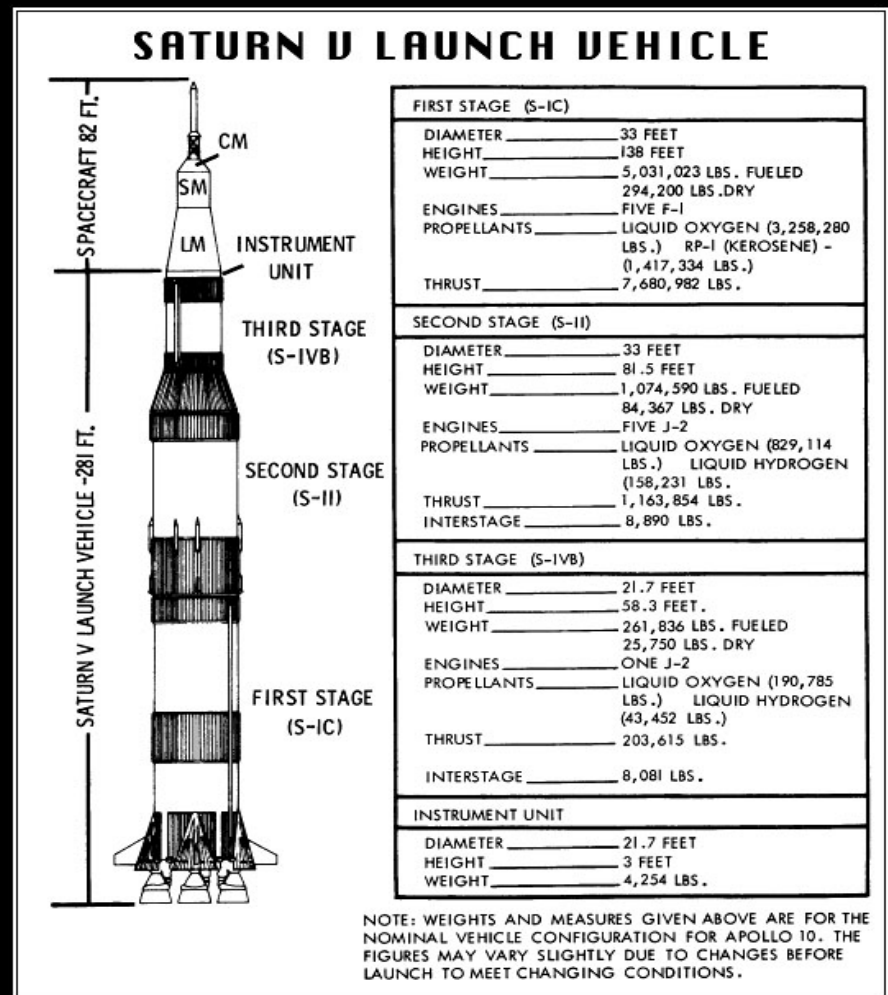


Lunar Orbiter 1 – first good image
of Earth from Moon
August 23, 1966; Range 1476 km

Lunar Orbiter 2 – oblique view of
Copernicus crater, Nov 24, 1966
Range 130 km



Moon Race Era, 1961-1972



Apollo 8

December 21-27, 1968





Apollo 11 Launch
July 16, 1969



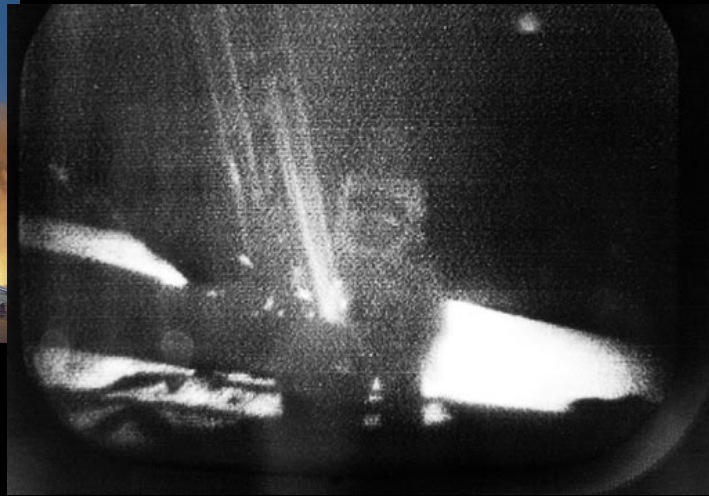
LCC/KSC



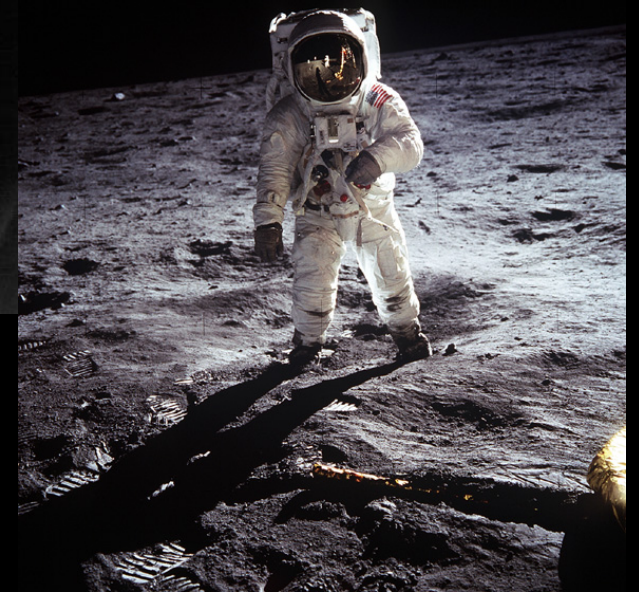
First Footsteps on the Moon



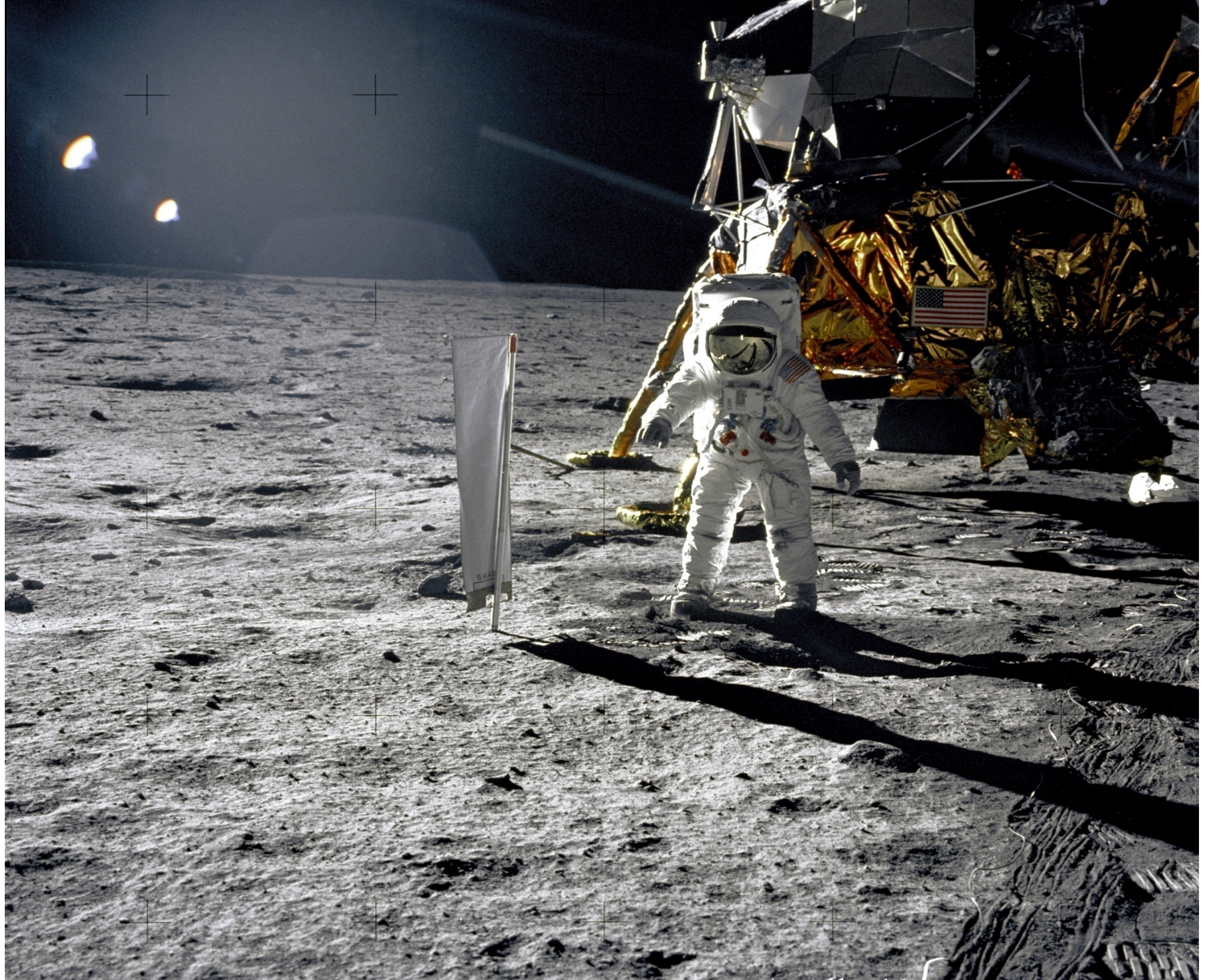
Apollo 11 launch, July 16, 1969

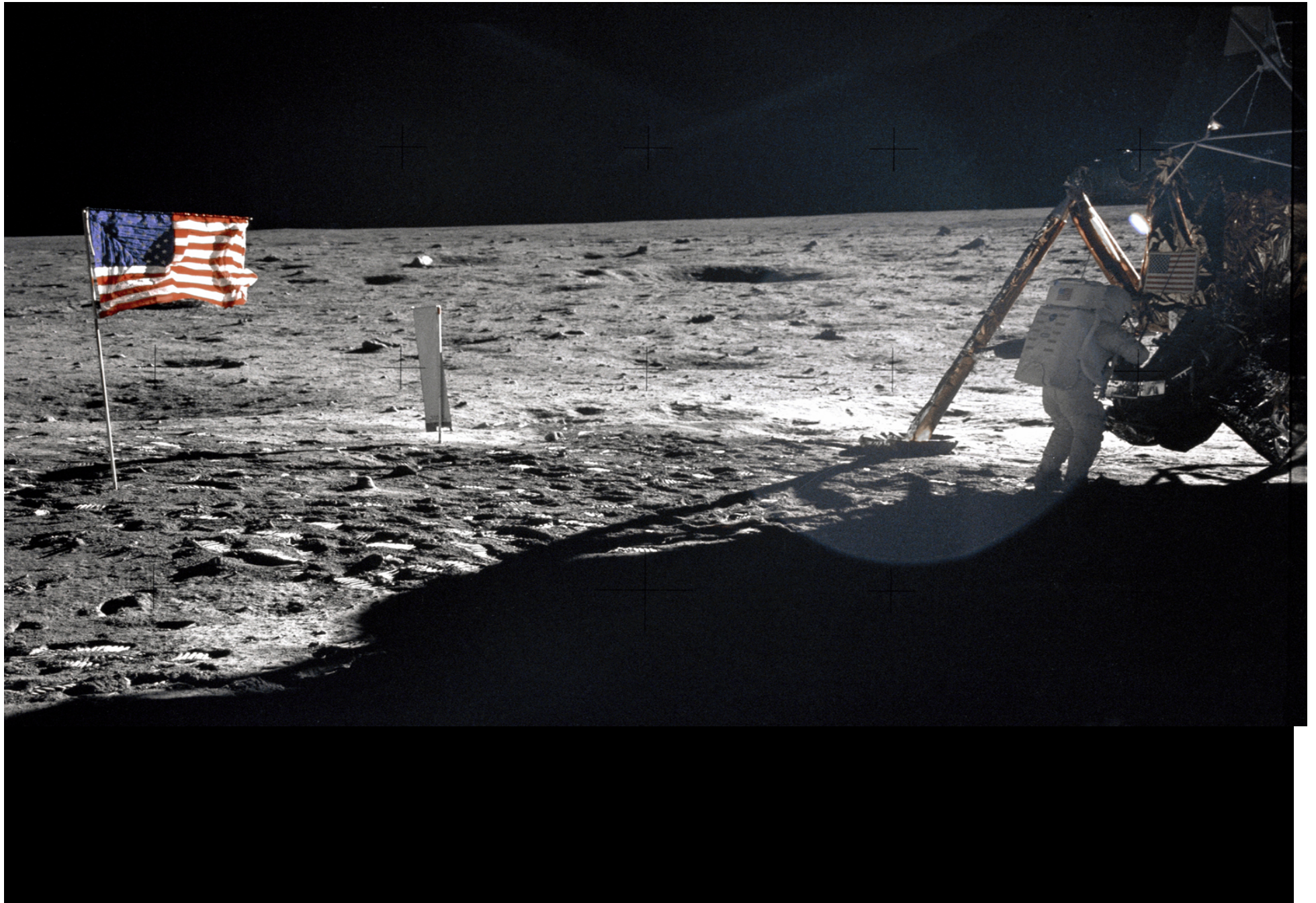


First Step on the Moon, July 20, 1969



Buzz Aldrin, July 20, 1969



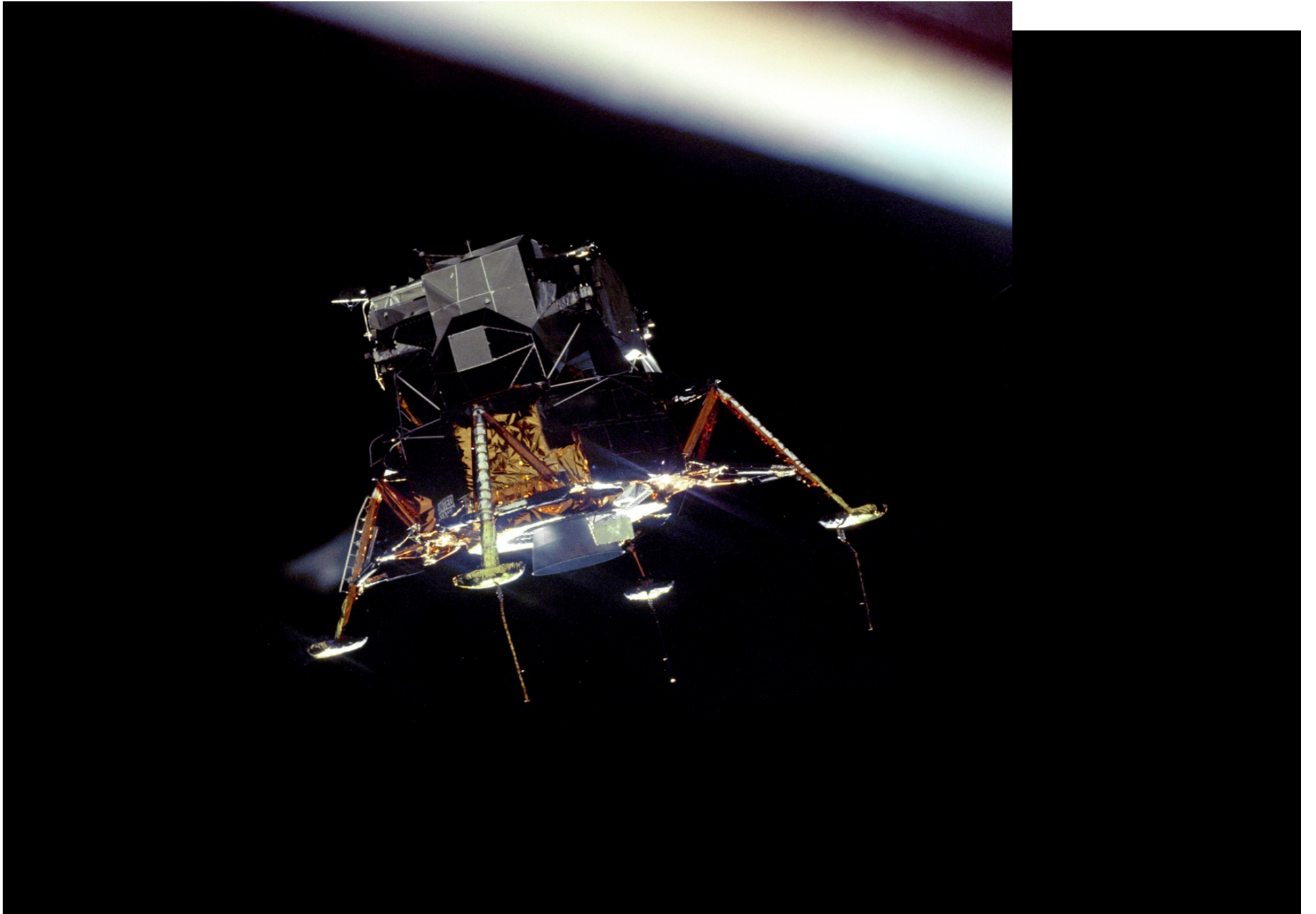


Apollo

- 11 Manned Missions
- 6 Landings
- 300 Hours on Surface
- 80 Hours Outside LM
- Apollo 11: < $\frac{1}{2}$ mile on foot
- Apollo 17: 19 miles in LRV



James Irwin at Hadley Base, Apollo 15, 1971



Apollo Scientific Legacy

- 5,000 pounds of experimental equipment landed on the Moon
 - 840 pounds of Moon rocks returned
- 65 miles were traversed on foot or in the lunar rover in support of field geology and geophysical studies.
- Better understanding of the nature and origin of the Moon and its relation to Earth.
 - Top 10 Apollo science discoveries are found at <http://www.lpi.usra.edu/expmoon/science/lunar10.html>

Was it Worth it?

“500 years from now (if humans have not blown up the planet), the 20th century will be remembered, if at all, as the century in which man began the exploration of space.”

- Pulitzer Prize historian Arthur M. Schlesinger Jr.,

Apollo is "the great American legend of the late 20th century,"
Though replete with heroic astronauts and epic tales, not all that
significant

- Historian of technology Alex Roland

“An accomplishment of mythic proportions, justifying mythic retelling.”

- Steven J. Dick, NASA Chief Historian

To the Realm of the Planets

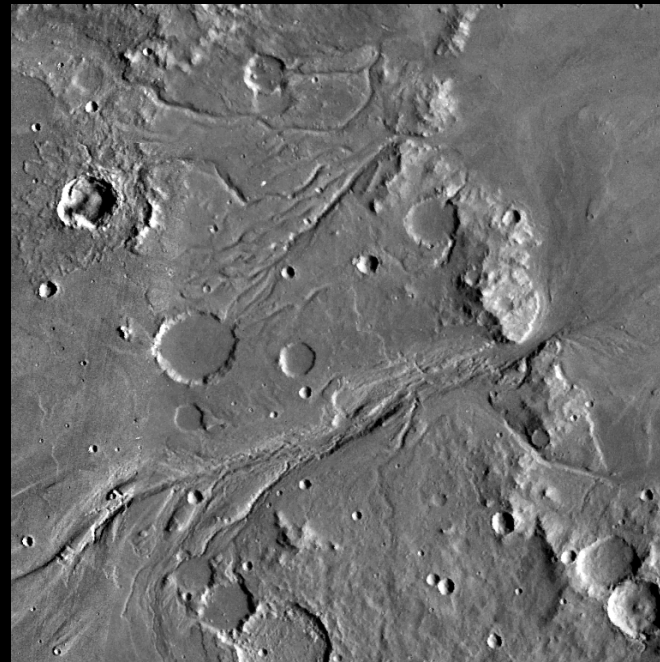


Venus (1962) and Mars (1965)

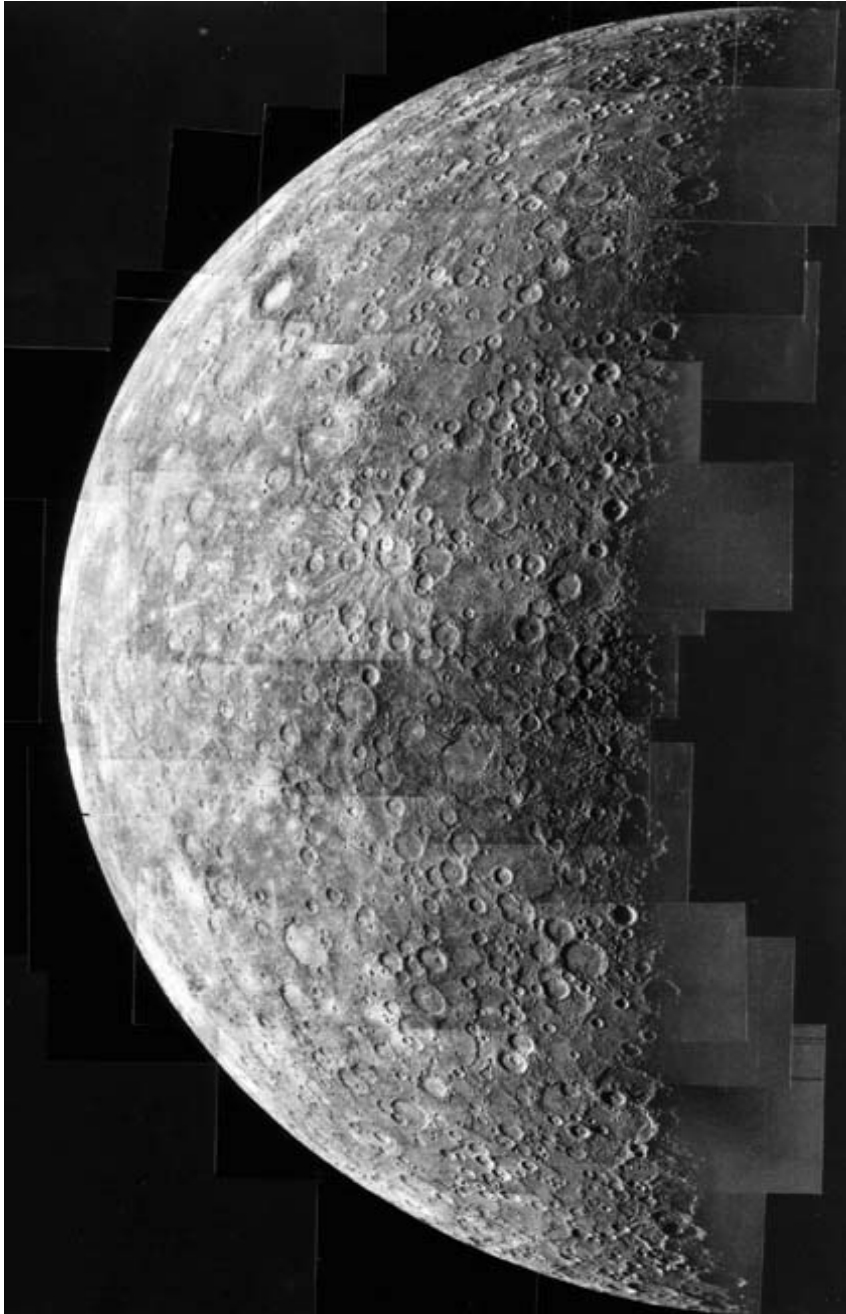
- **Mariner 2 reaches Venus, 1962 - no photos**
- **Mariner 4 reaches Mars, 1965 - craters on Mars**
- **Mariner 9 reaches Mars, 1971 - 1st spacecraft to orbit another planet**



First close-up image of Mars,
Mariner 4, July 15, 1965
Range 17,000 km



Mariner 9 image
225 km across



Mercury, 1974 Mariner 10

Mosaic of Mercury taken by the Mariner 10 spacecraft during its approach on 29 March 1974. The mosaic consists of 18 images taken at 42 s intervals during a 13 minute period when the spacecraft was 200,000 km (about 6 hours prior to closest approach) from the planet.

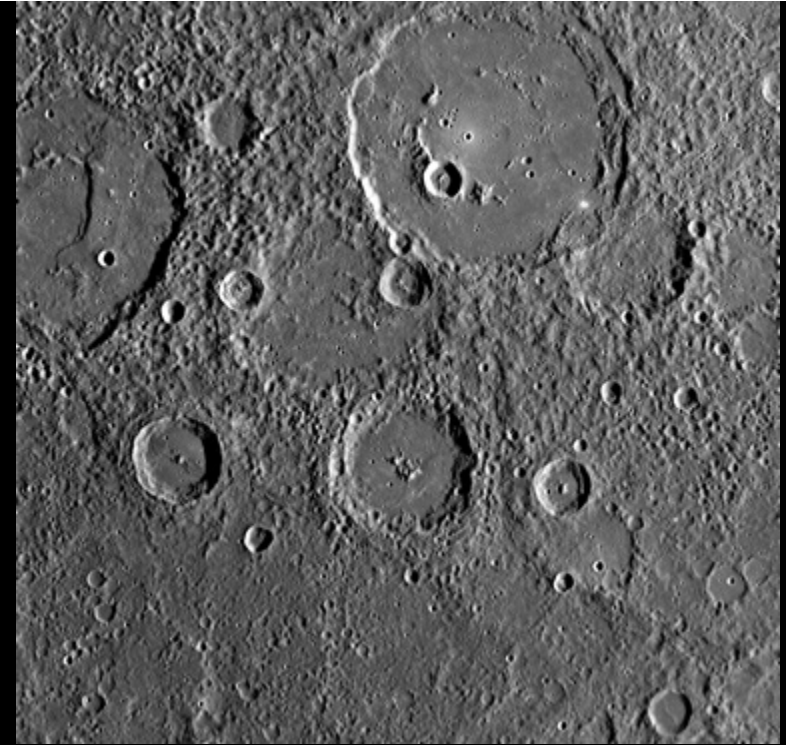
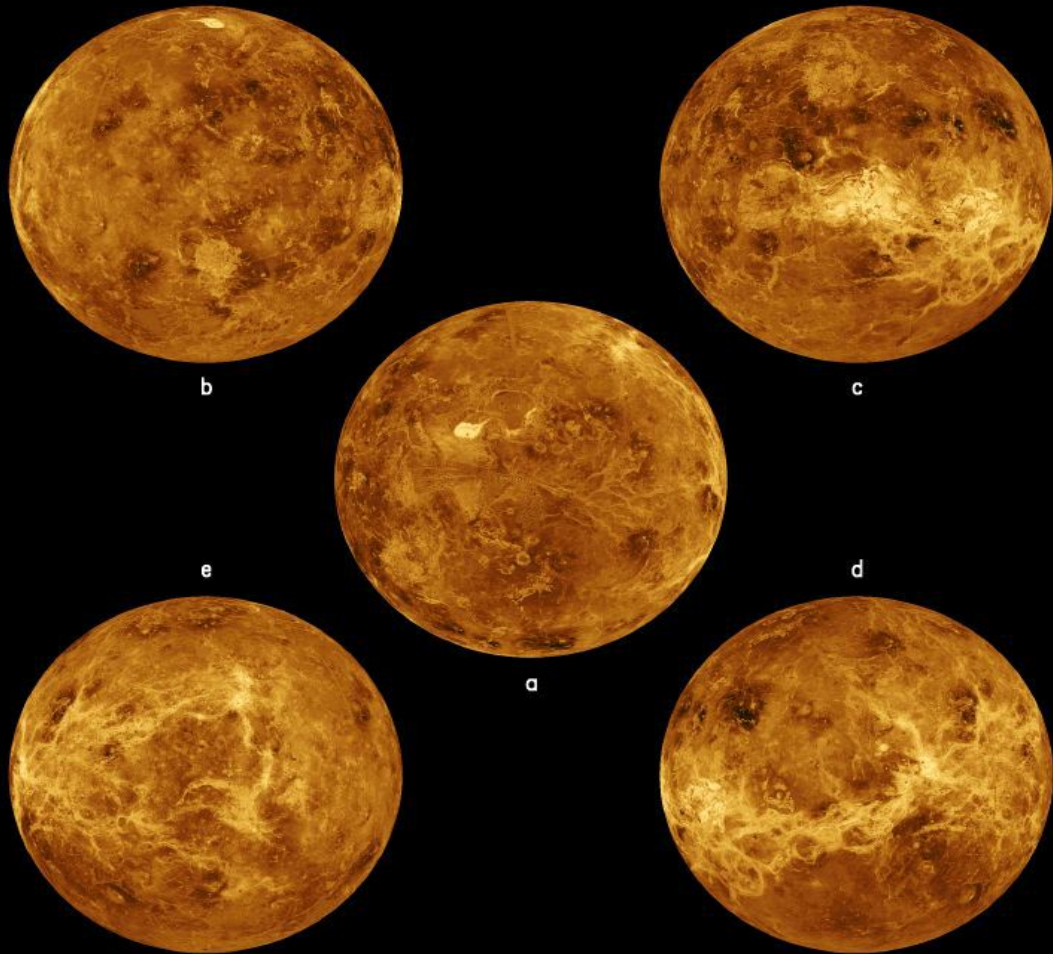
Venus



Venera Lander, first photos from surface, 22 October, 1975



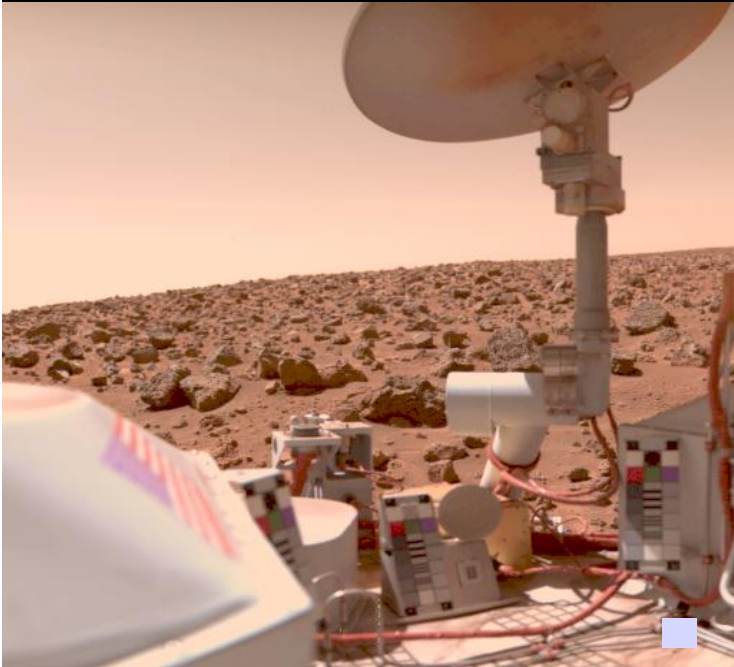
Ultraviolet image of clouds of Venus, imaged by Pioneer Venus Orbiter February 5, 1979



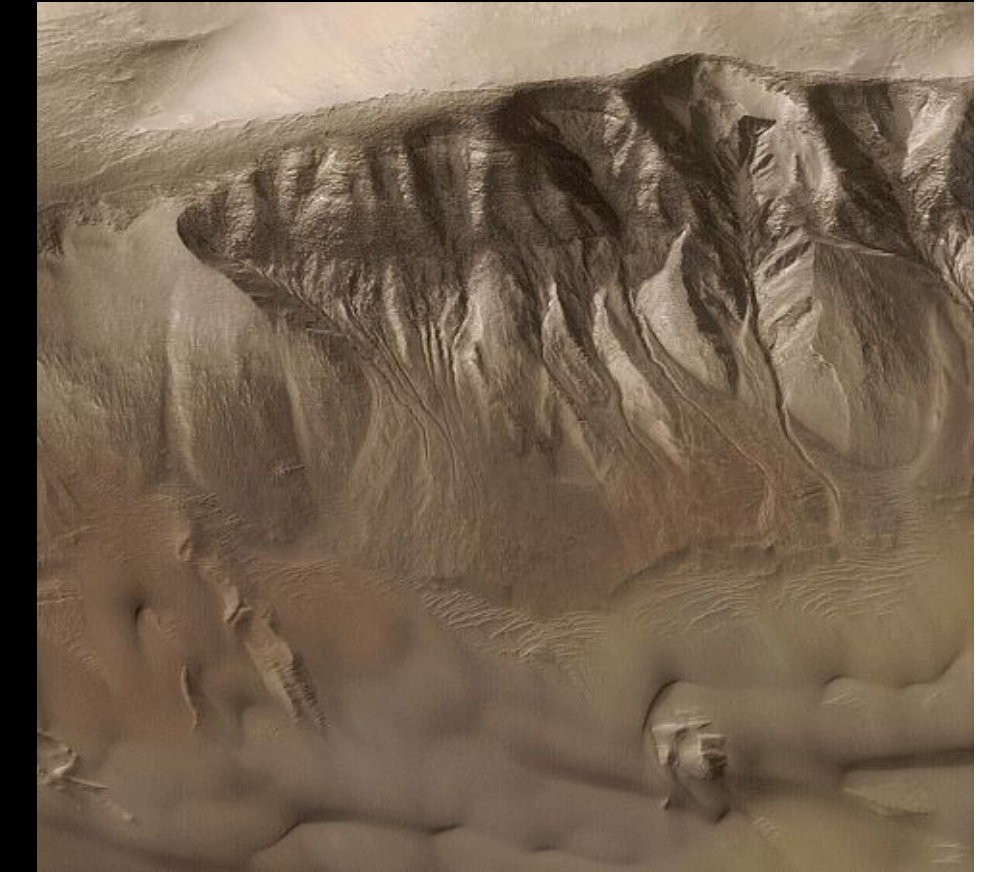
MESSENGER image of Mercury
October, 2008

Magellan composite radar images. Magellan began mapping the surface of Venus in September, 1990, and ended operations October 12, 1994

Mars

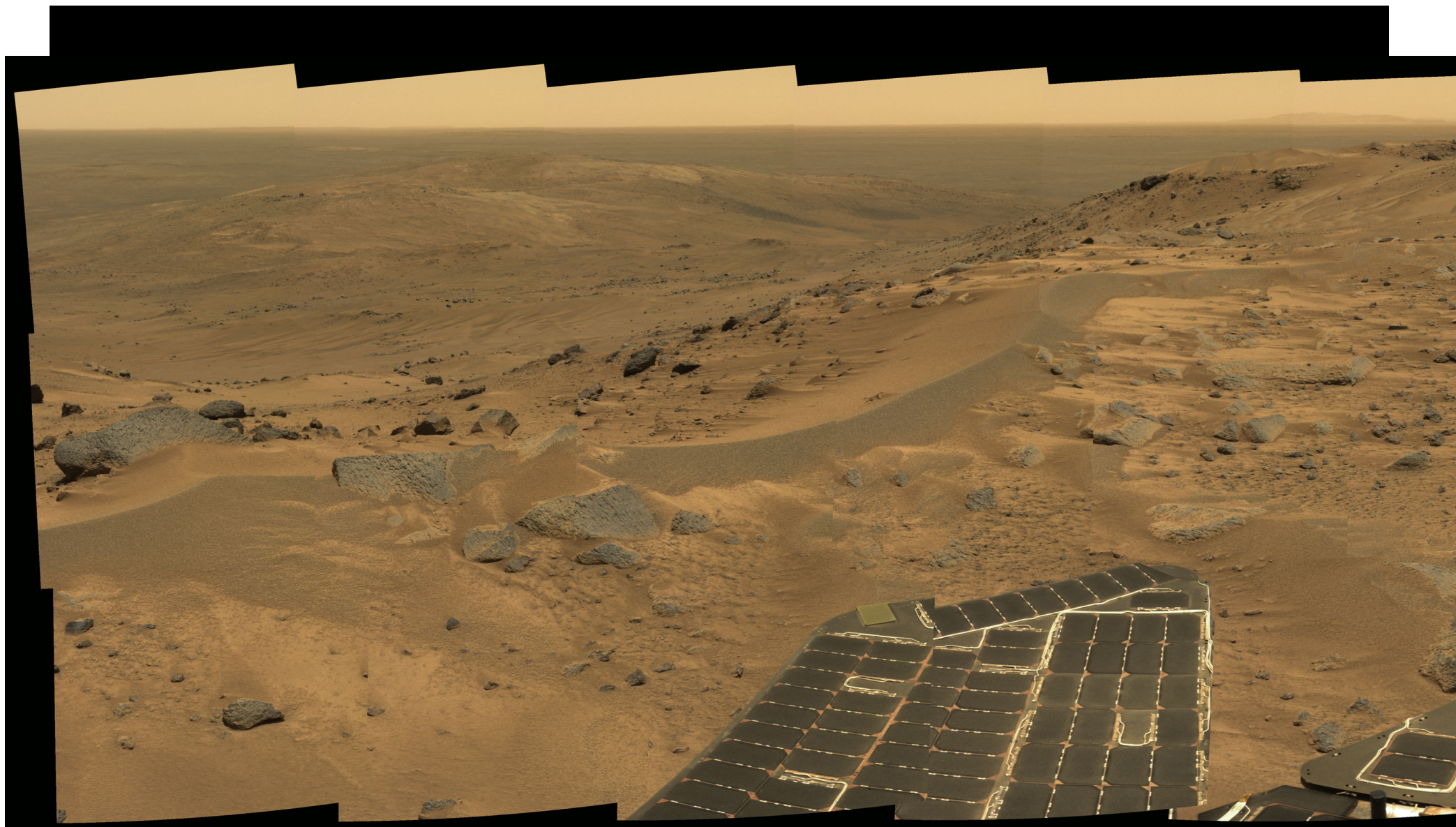


Viking lander, 1976

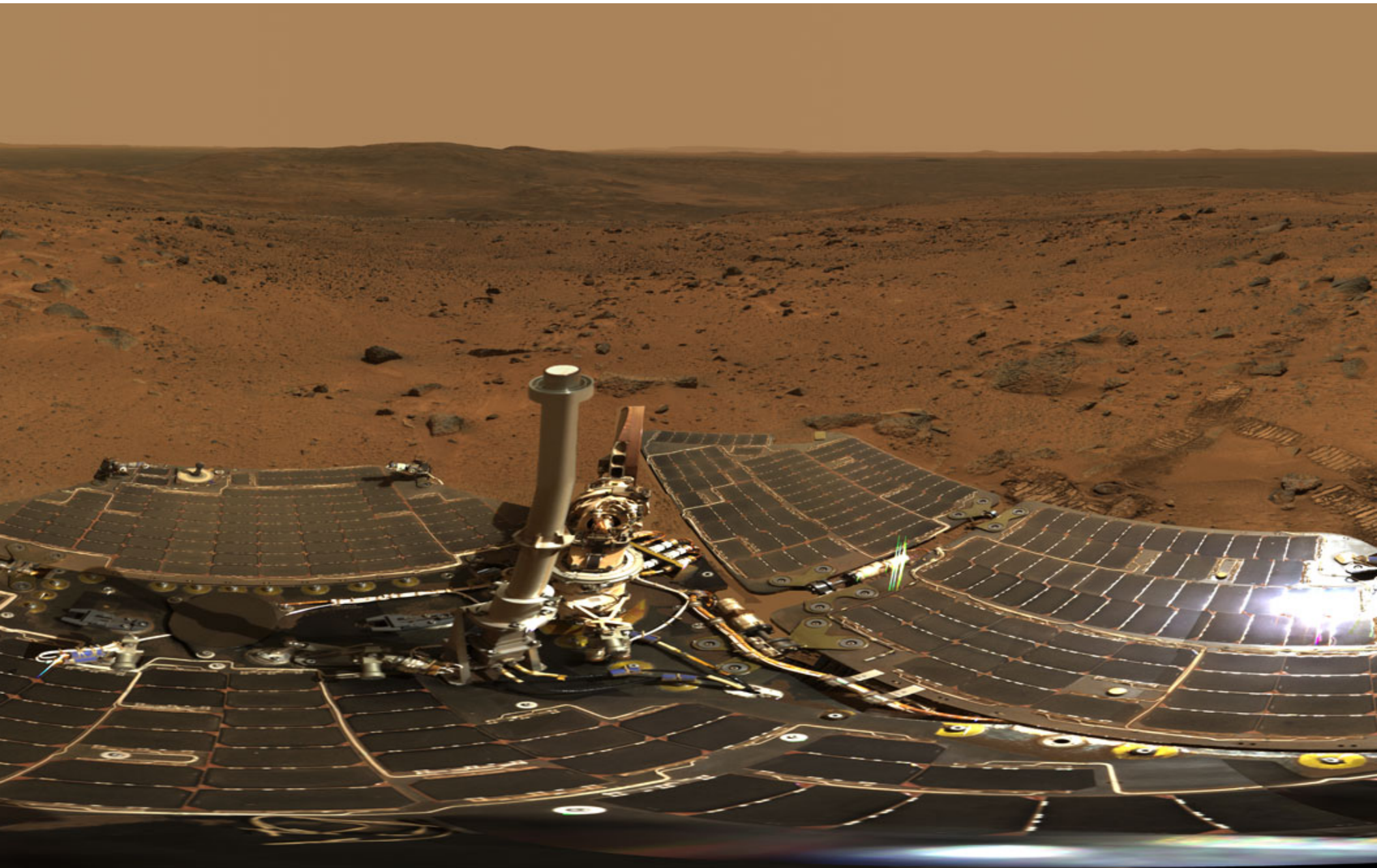


Gullies on Mars, Mars Global Surveyor, 1997

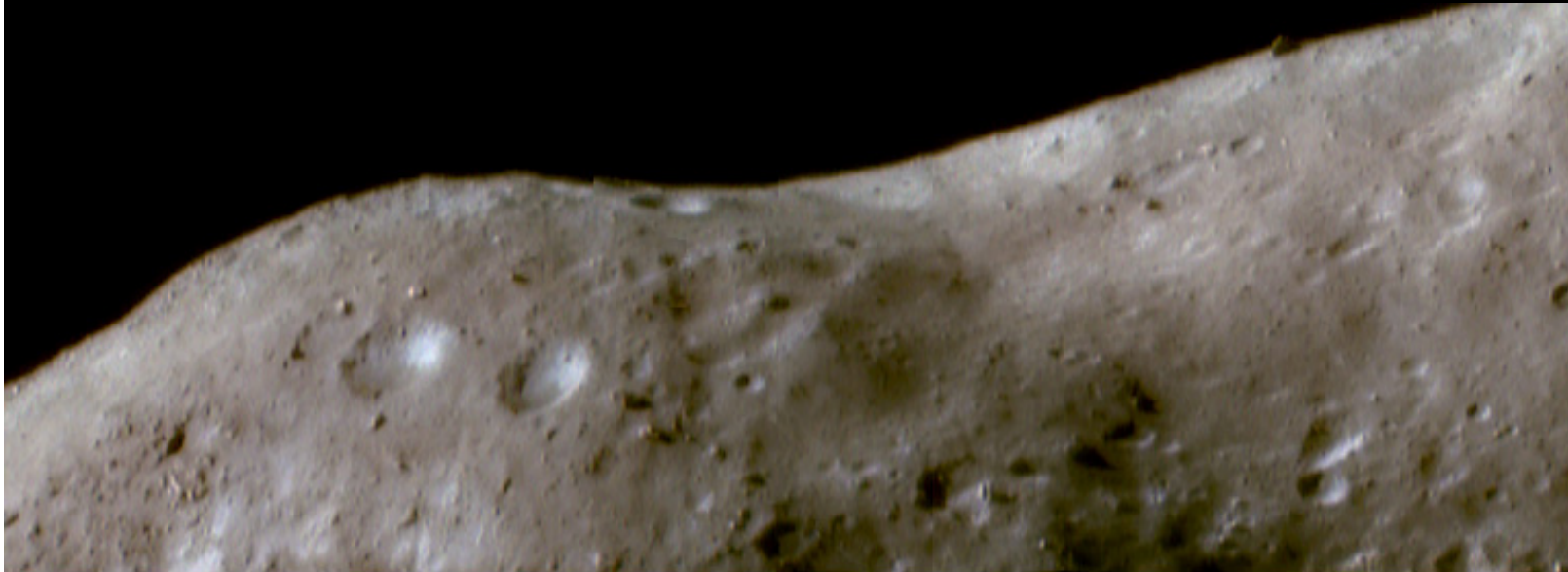
Mars Pathfinder, 1998



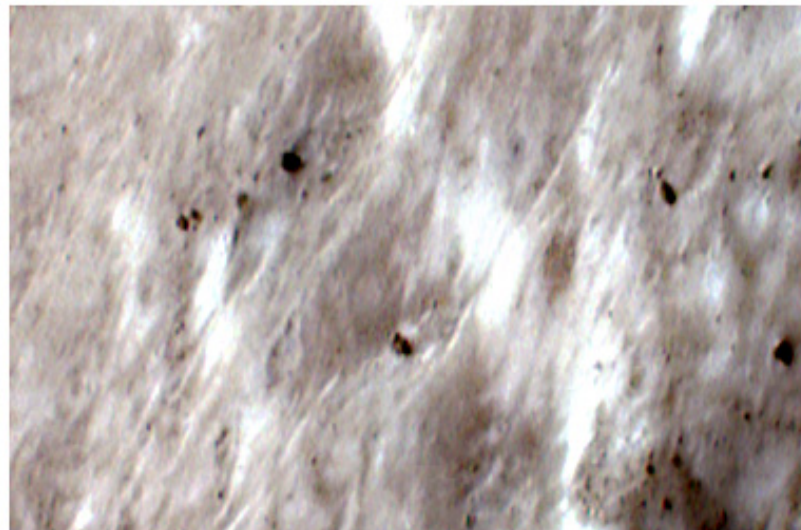
View from Spirit at the top of Husband Hill August 23, 2005

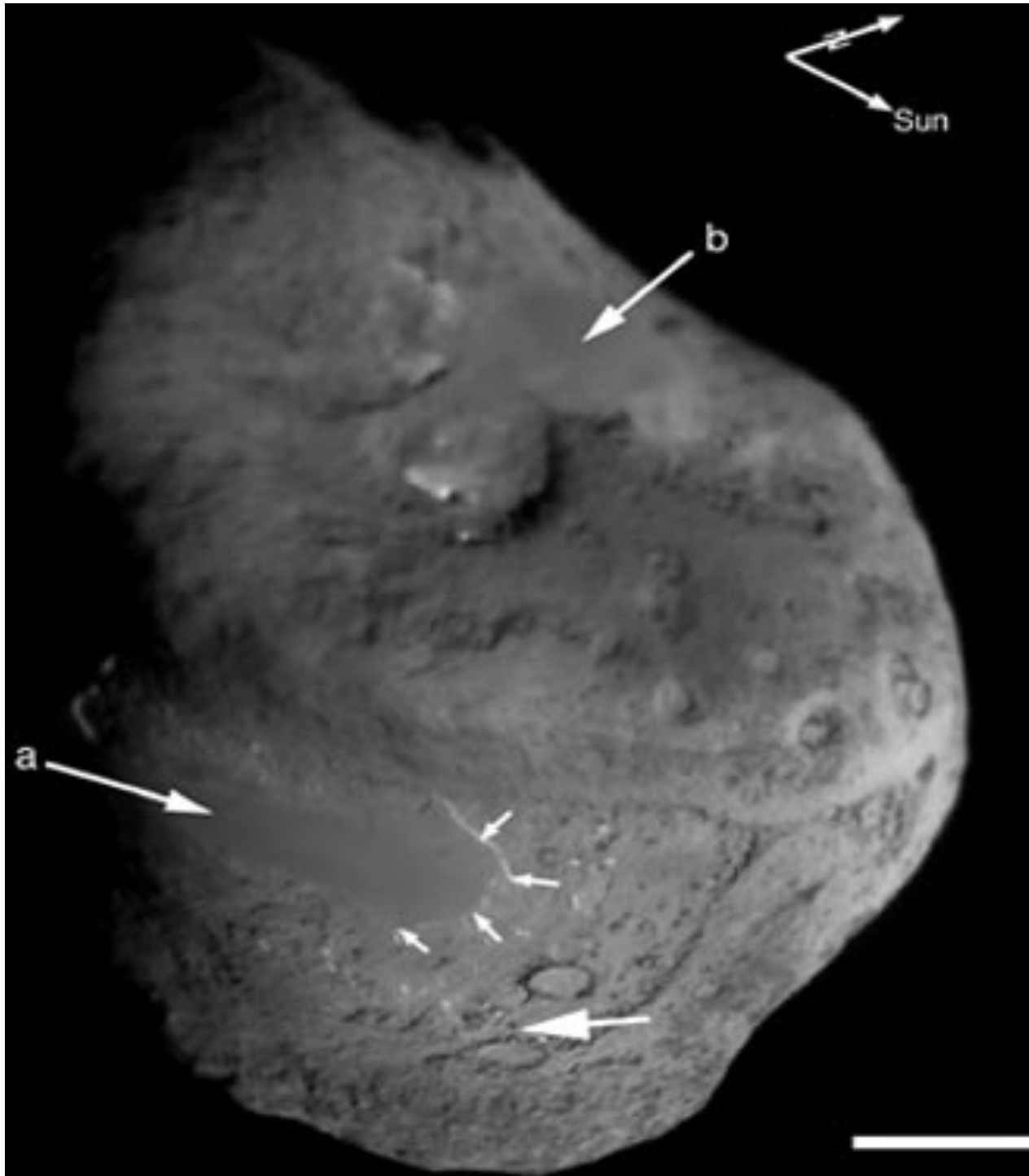


Asteroid Eros from 34 Miles (NEAR-Shoemaker) October 16, 2000



Touchdown
12 Feb 2001



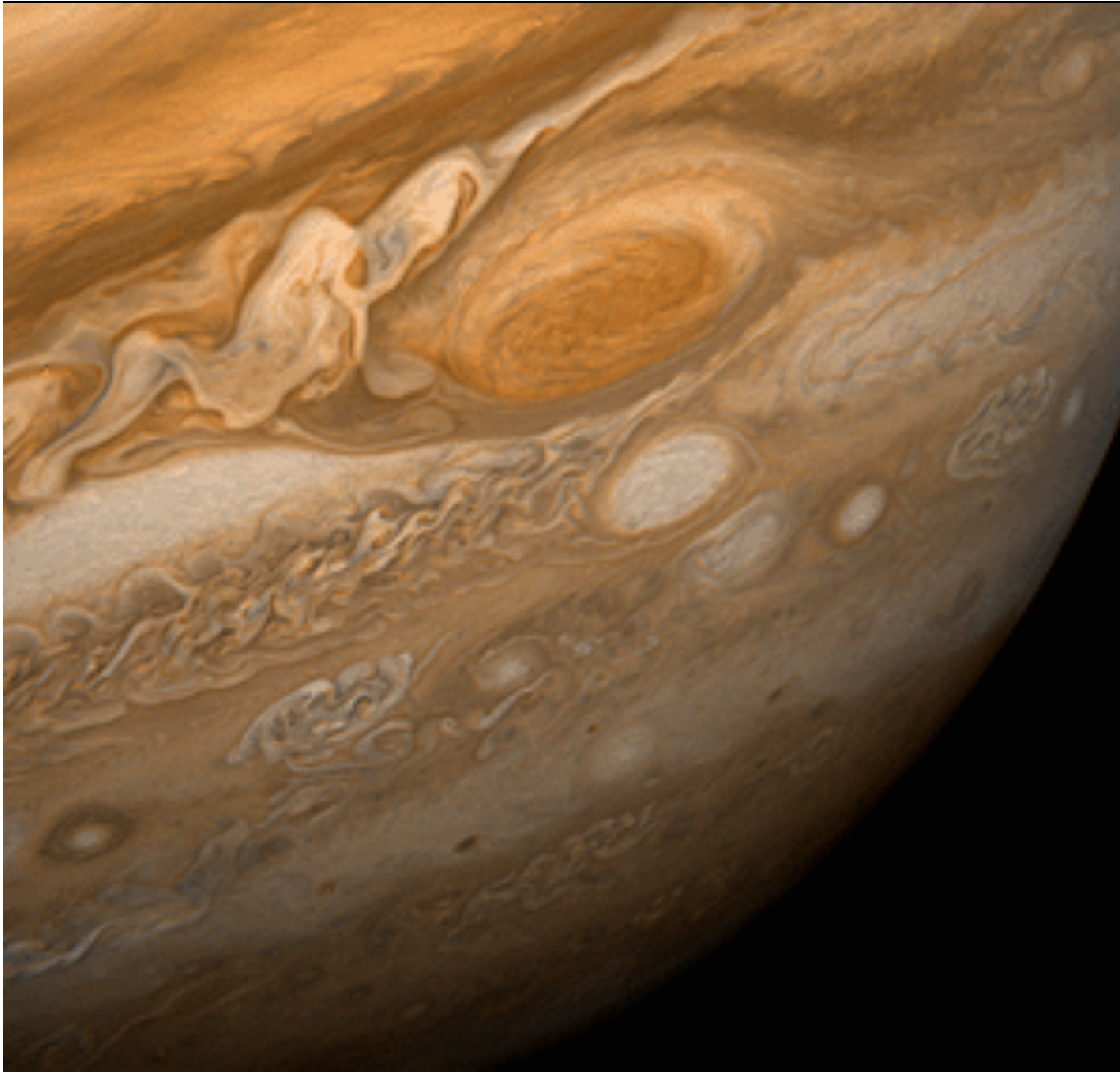


Comet Tempel 1

Viewed by

Deep Impact

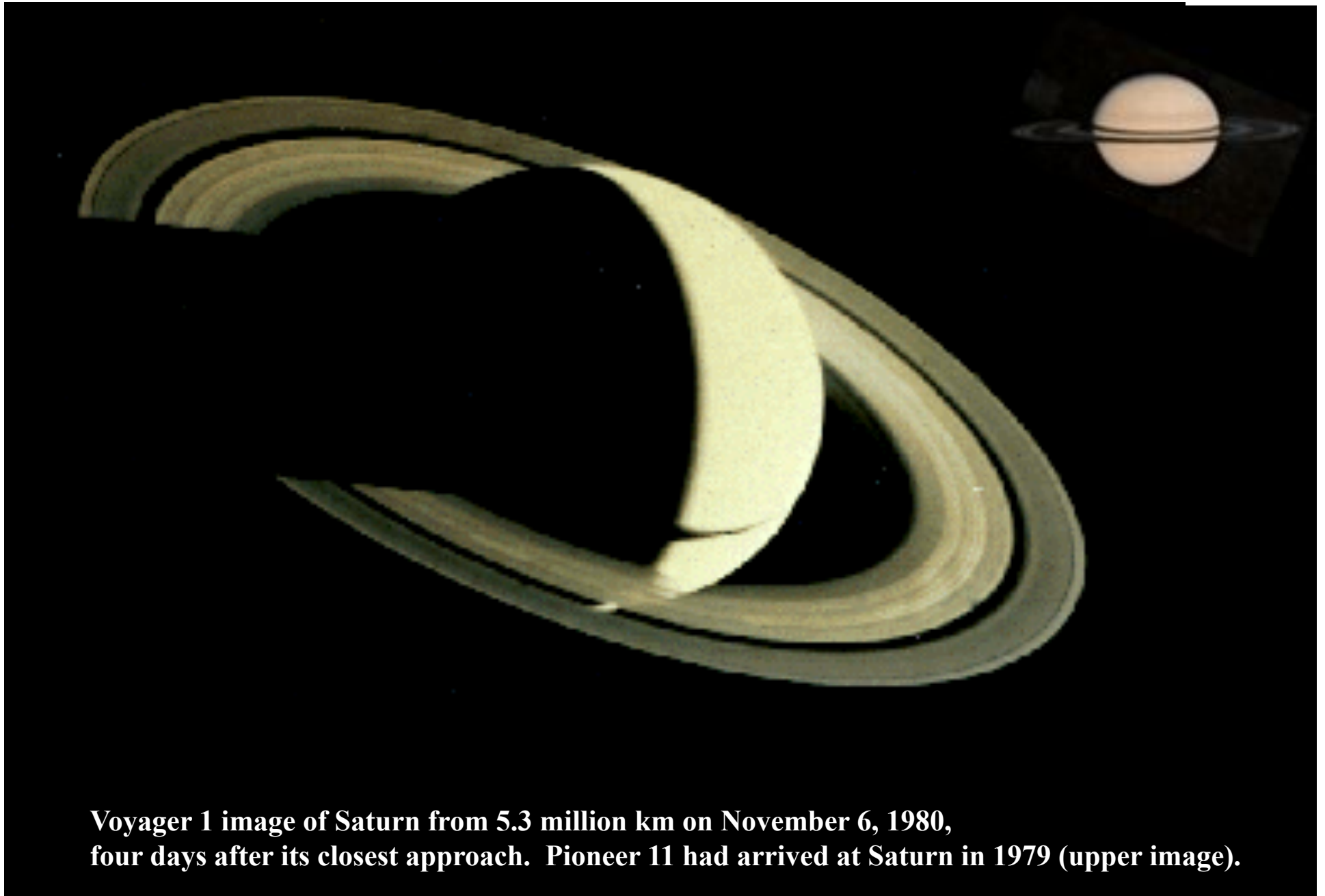
Spacecraft



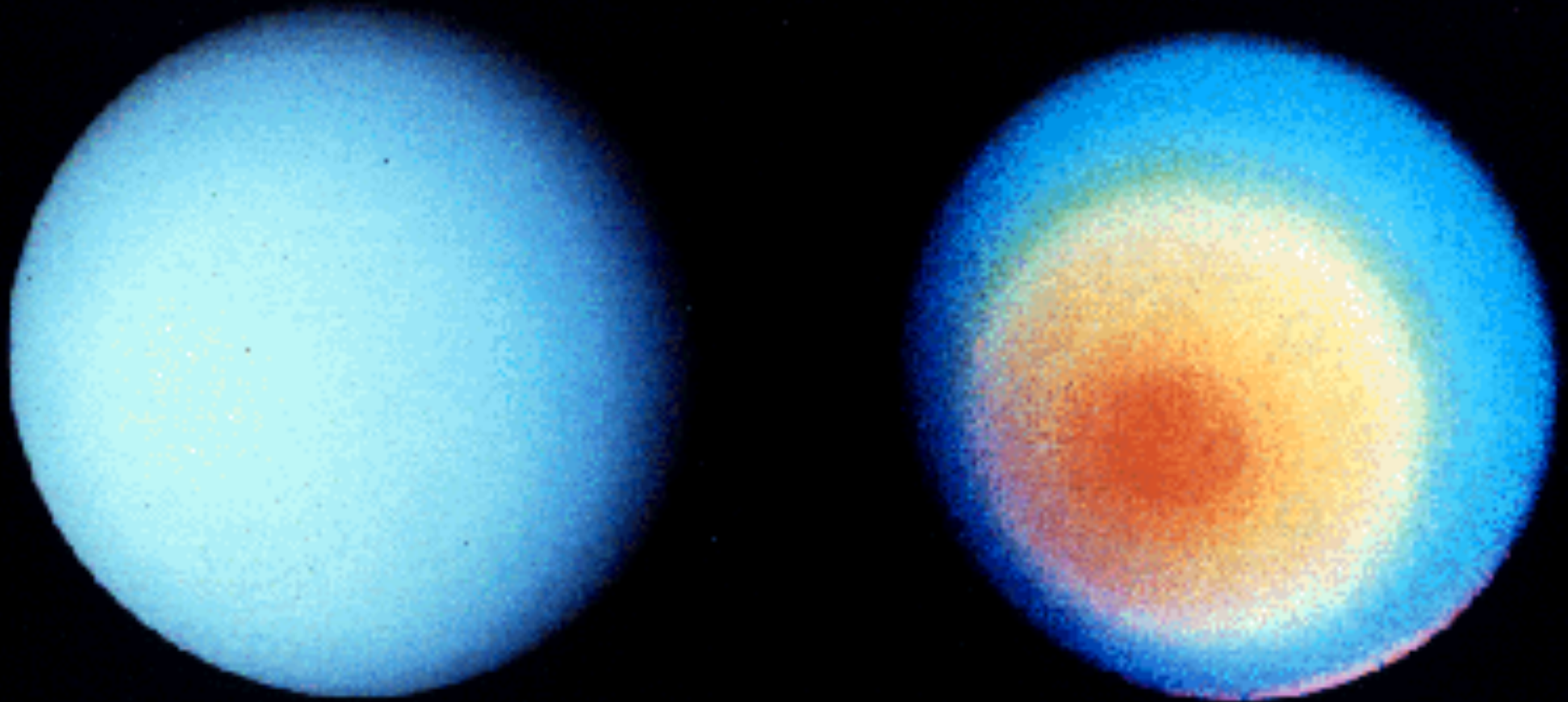
Pioneer
10 & 11
1973-
1974



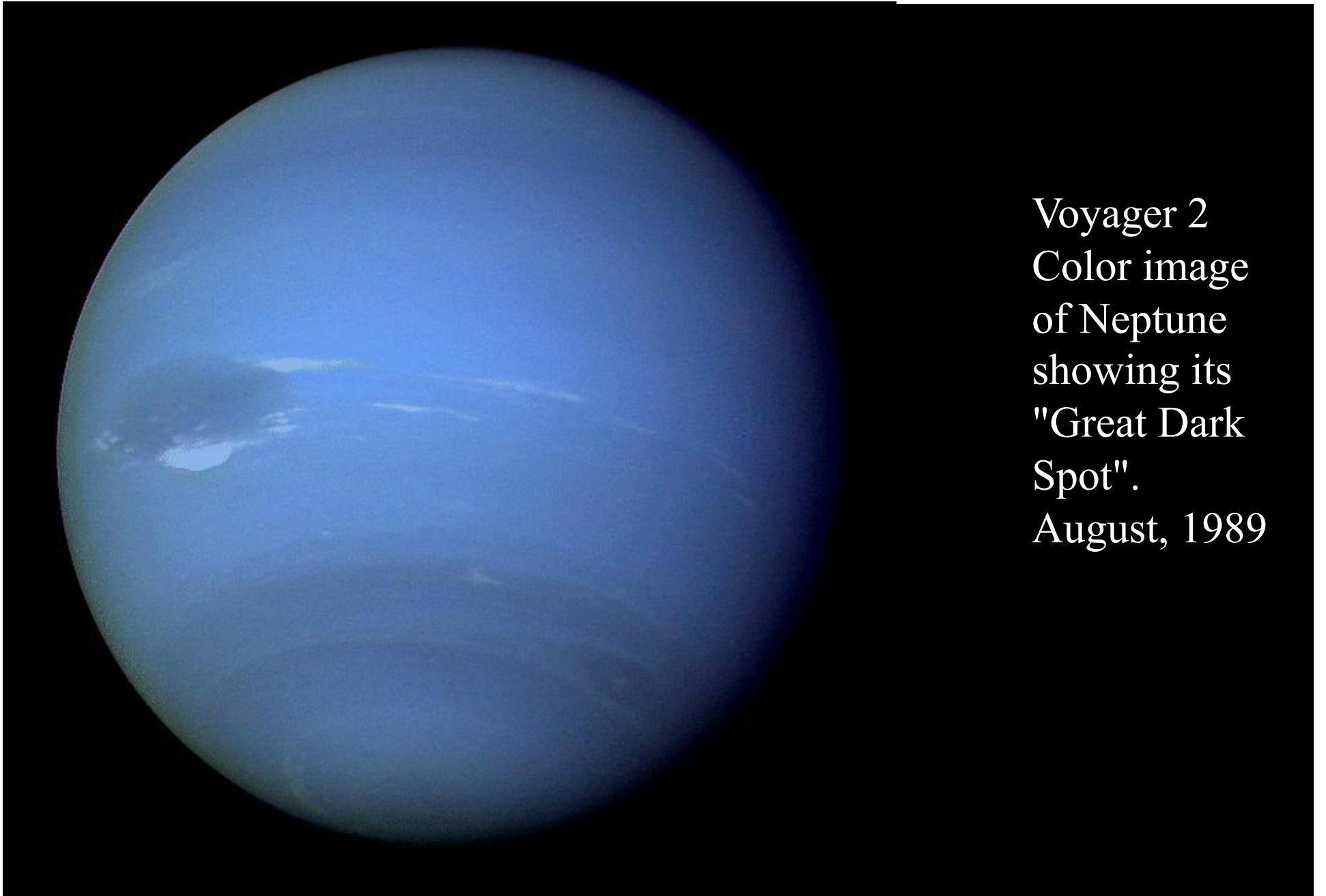
Voyager 1
Jupiter from a distance
of 5.7 million km just
over a week before its
March 5, 1979 closest
approach.



Voyager 1 image of Saturn from 5.3 million km on November 6, 1980, four days after its closest approach. Pioneer 11 had arrived at Saturn in 1979 (upper image).

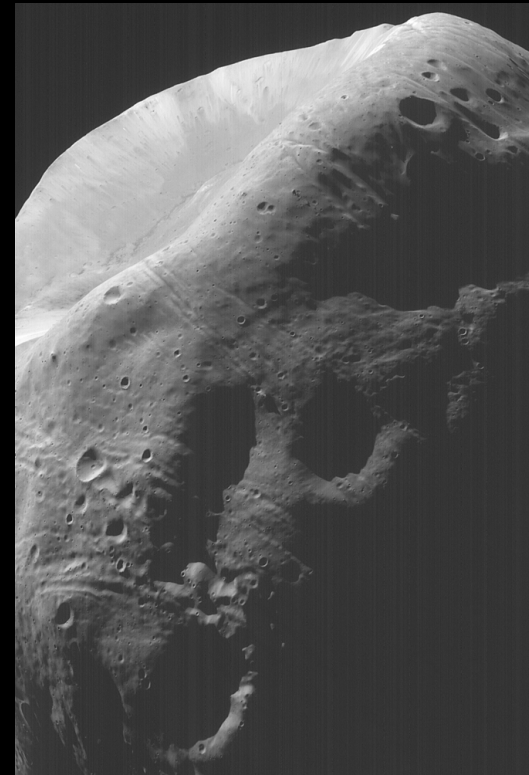
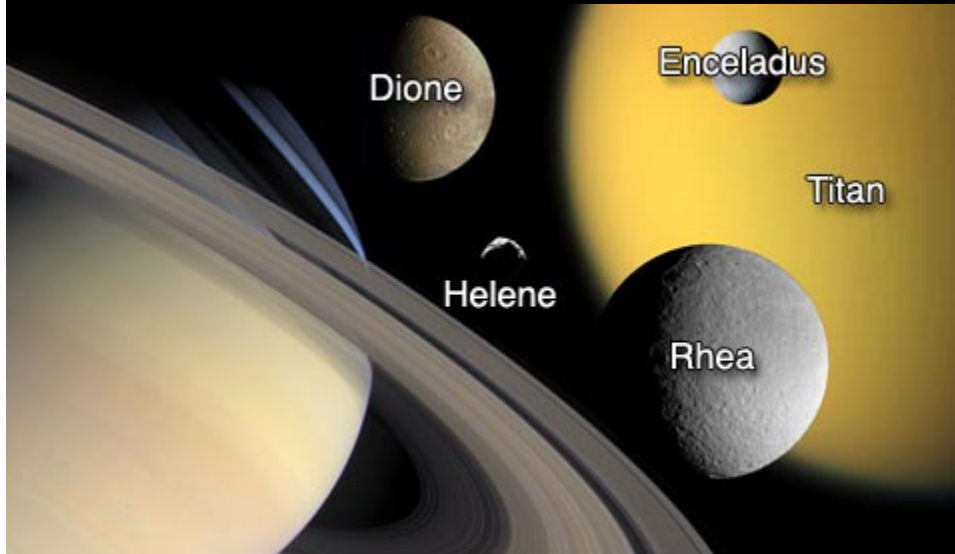


**Two images of Uranus taken by Voyager 2 at
a distance of 9.1 million km.
January 17, 1986**



Voyager 2
Color image
of Neptune
showing its
"Great Dark
Spot".
August, 1989

More Worlds ...

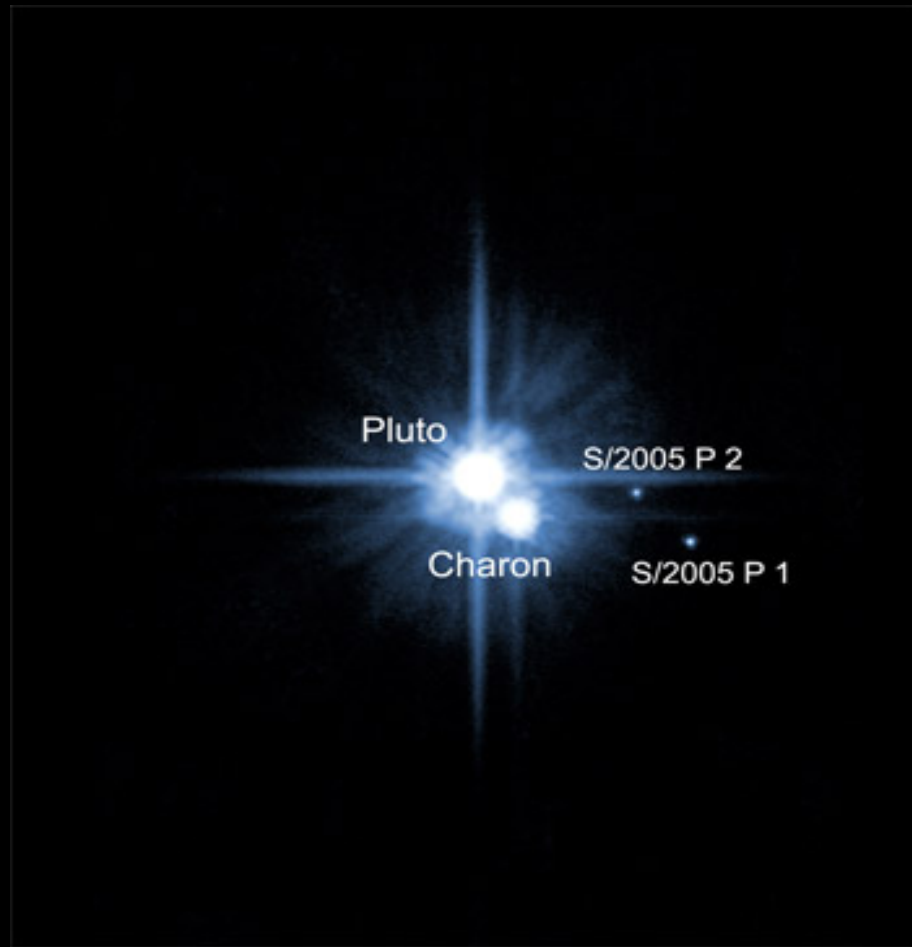


Phobos from Mars Global Surveyor, 1998

> 130 known satellites in solar system



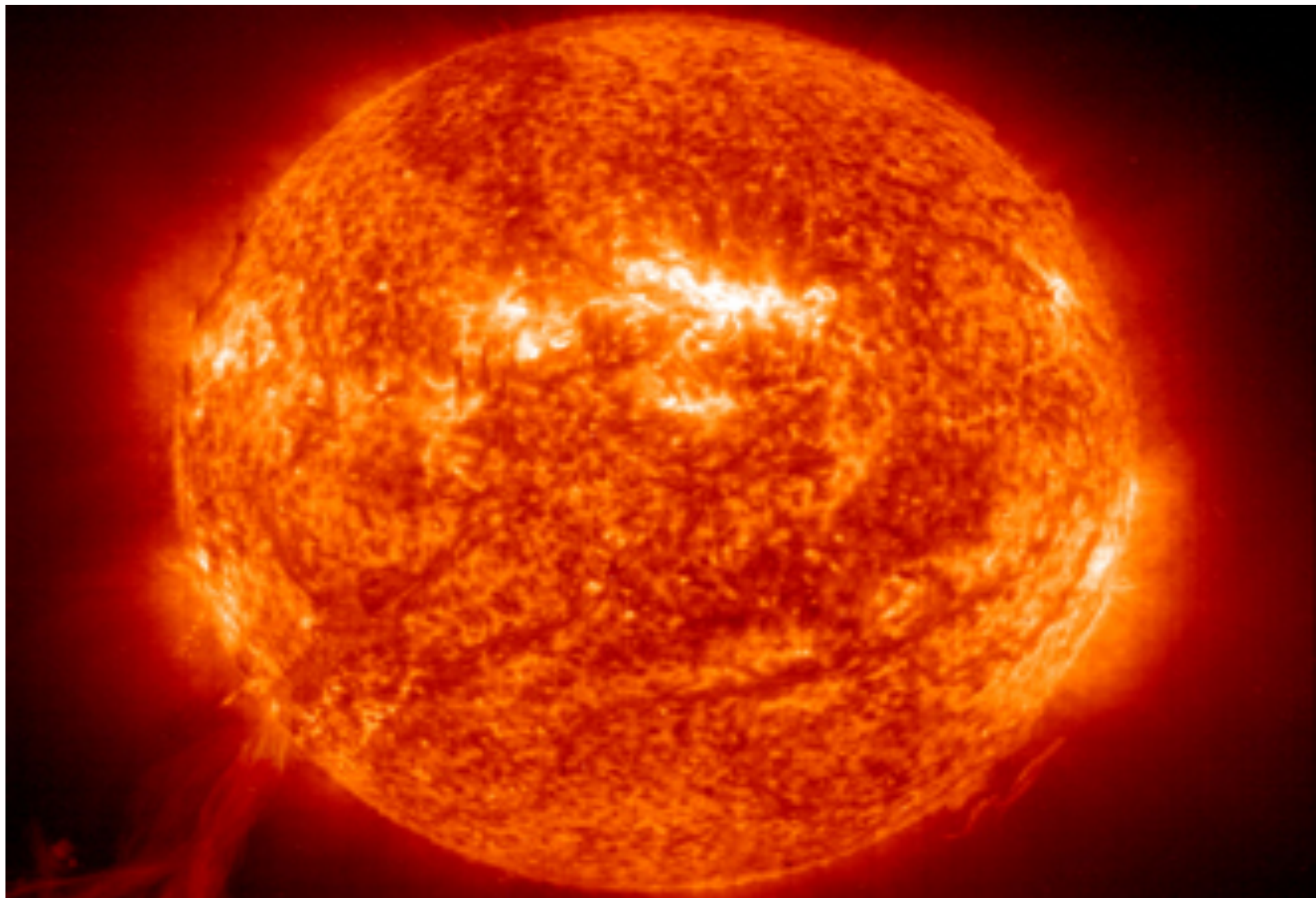
... and a Dwarf Planet



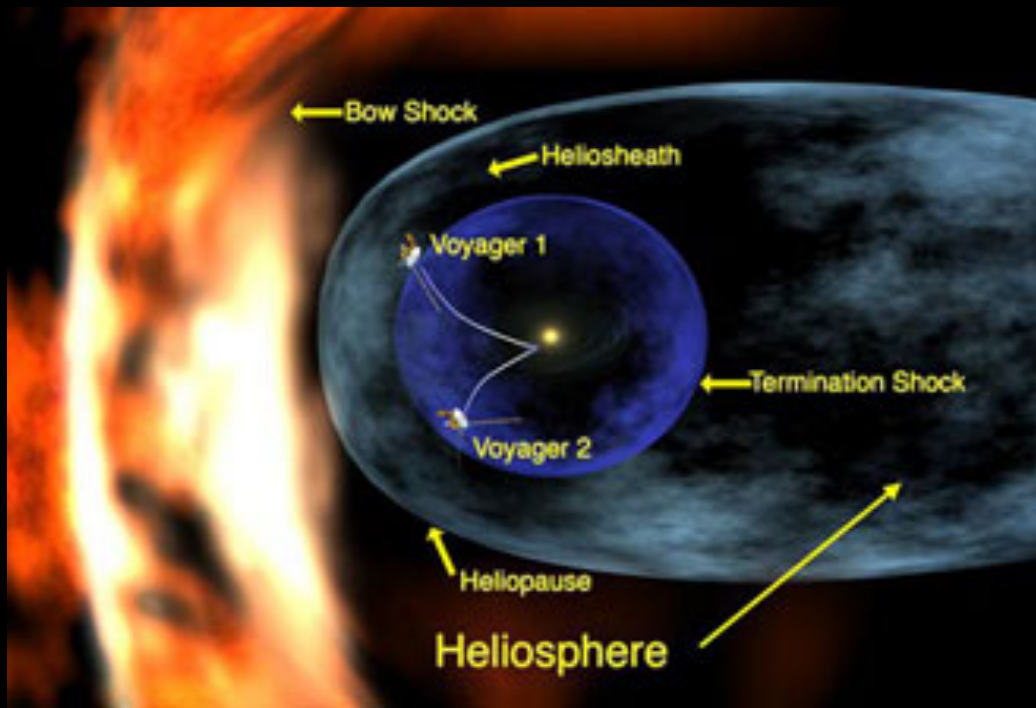
New Horizons
On the way!

Arrival 2015

Hubble Space Telescope two new satellites of Pluto announced October 31, 2005



To the edge of the Solar system ...



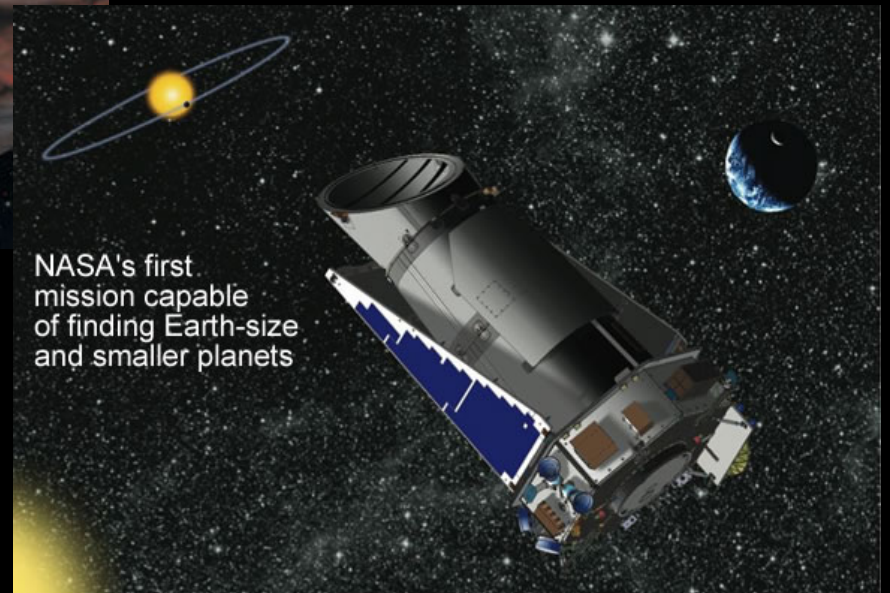
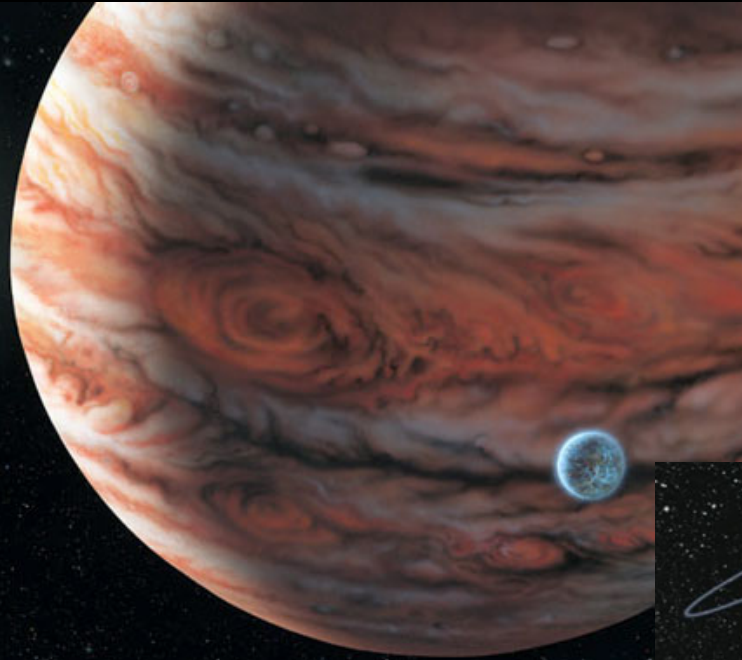
Voyager Record



Voyager Interstellar Mission
On December 16, 2004 Voyager 1 passed
the termination shock at 8.7 billion miles
From the Sun (94 AU)

IBEX Mission, 2008

Yet More New Worlds ... Extrasolar Planets



Sagittarius Star Cloud

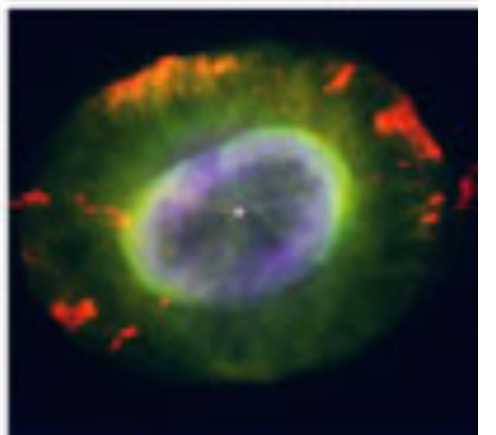
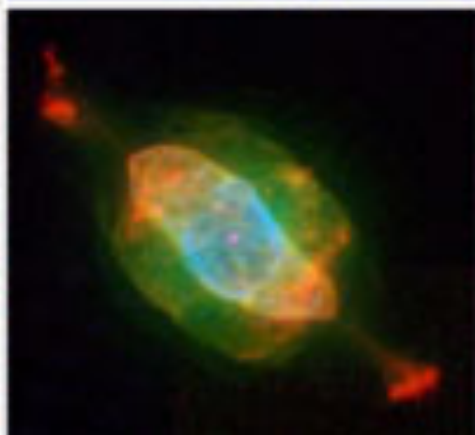
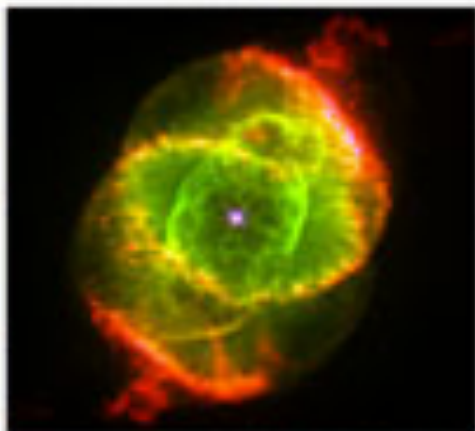
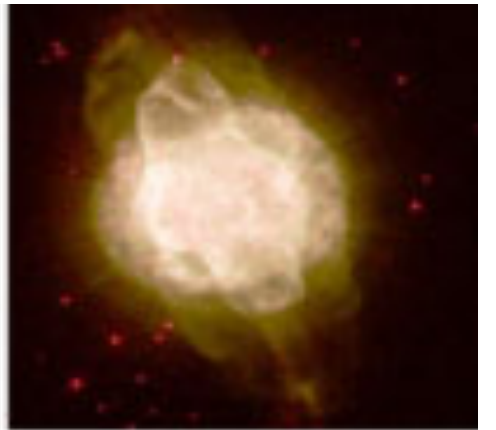
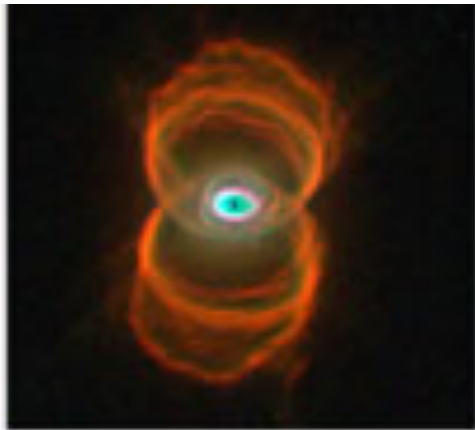
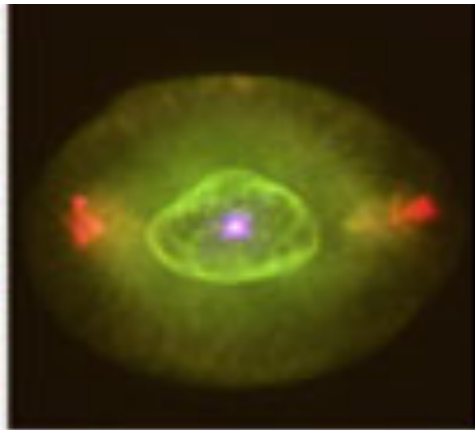


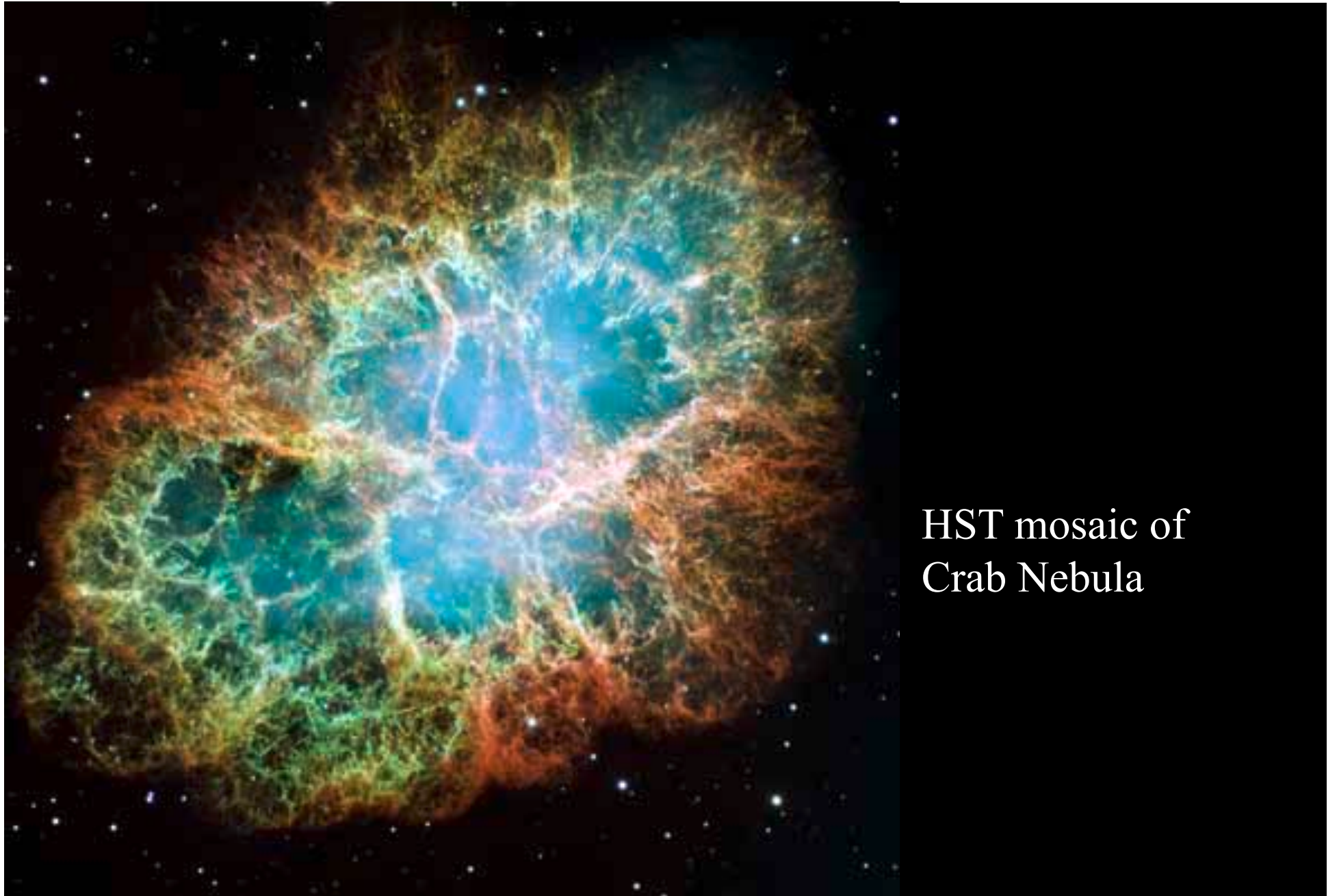
**... to the Realm
of the Stars**

Hubble
Heritage



HST and Spitzer
Image of Orion
Nebula





HST mosaic of
Crab Nebula



**... and the Realm
of the Galaxies**

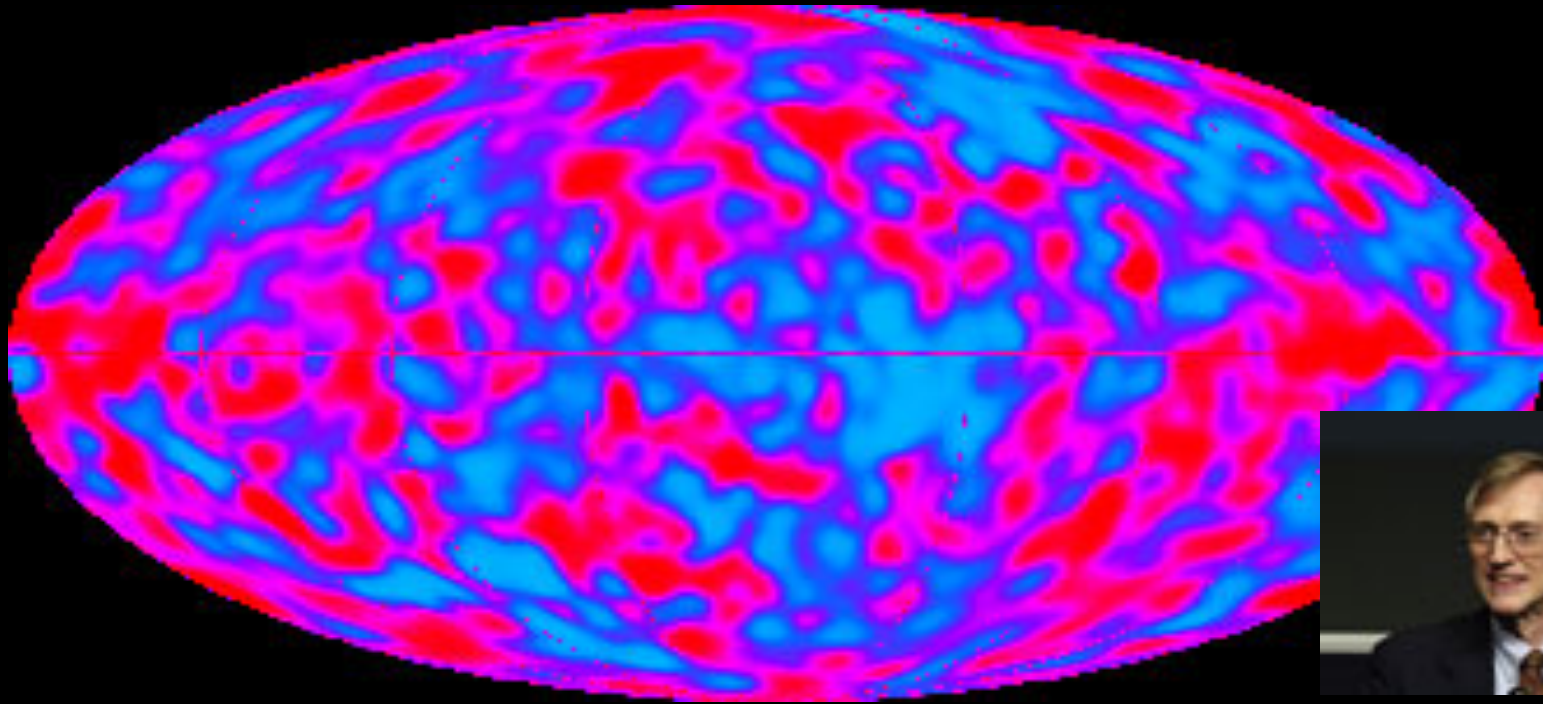
**Hubble Ultra Deep
Field, 2004**

Whirlpool Galaxy · M51



Hubble
Heritage

To the Beginning of Time

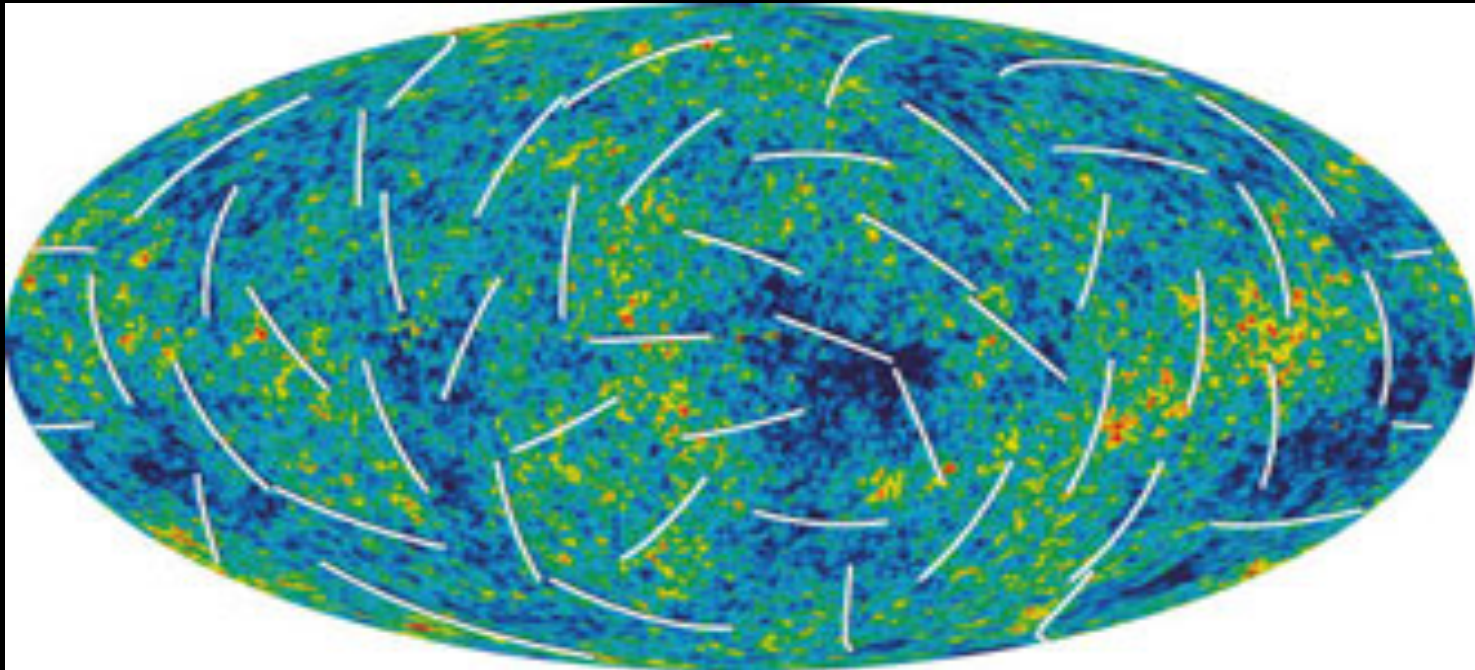


John Mather
NASA 2006 Nobelist

Cosmic Background Radiation data from COBE Satellite, 1992

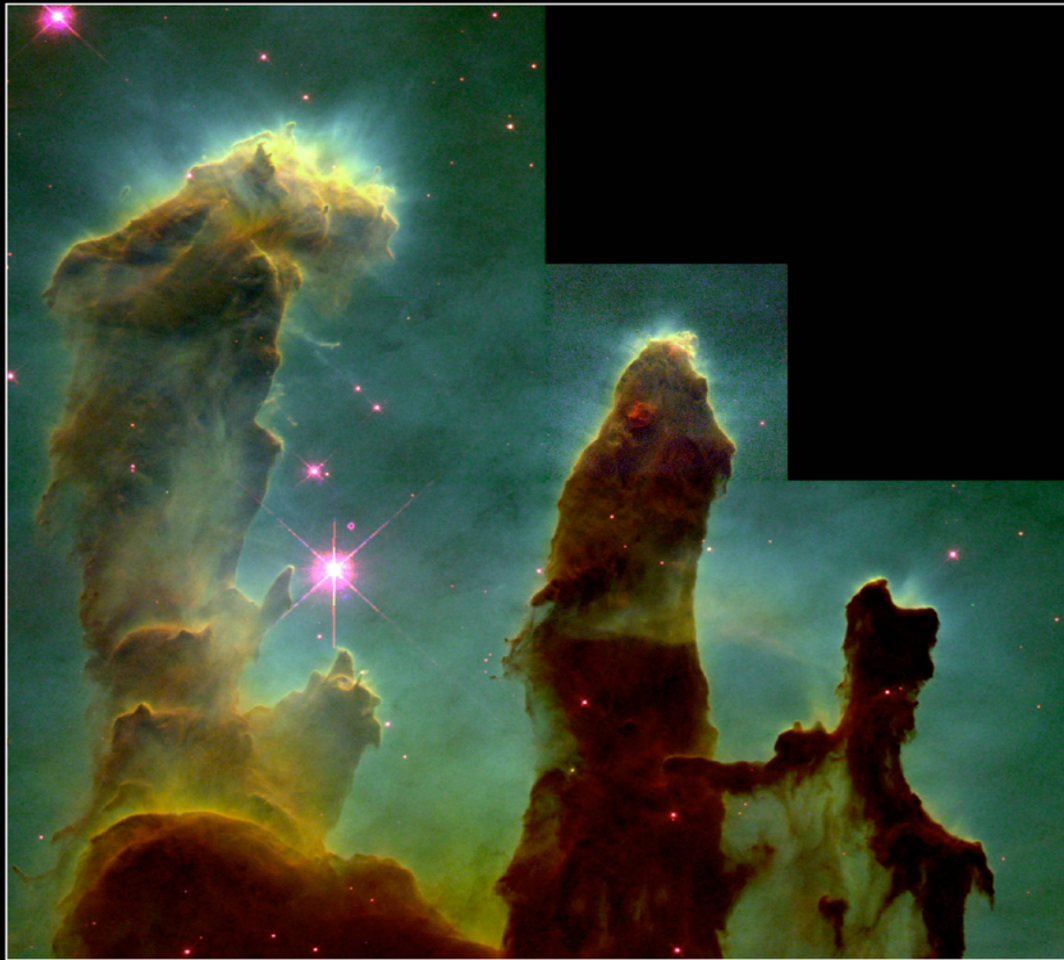
The cosmic microwave background fluctuations are extremely faint (red is hotter), only one part in 100,000 compared to the 2.73 degree Kelvin average temperature of the radiation field.

... and with even greater resolution



Where COBE measured temperature variations to one part in 100,000, WMAP measures those variations to less than one part in 1,000,000. Colors indicate warmer (red) and cooler (blue).
2006 Data from the Wilkinson Mapping Anisotropy Probe

Space Telescopes Have Opened the Electromagnetic Spectrum From the Visible ...



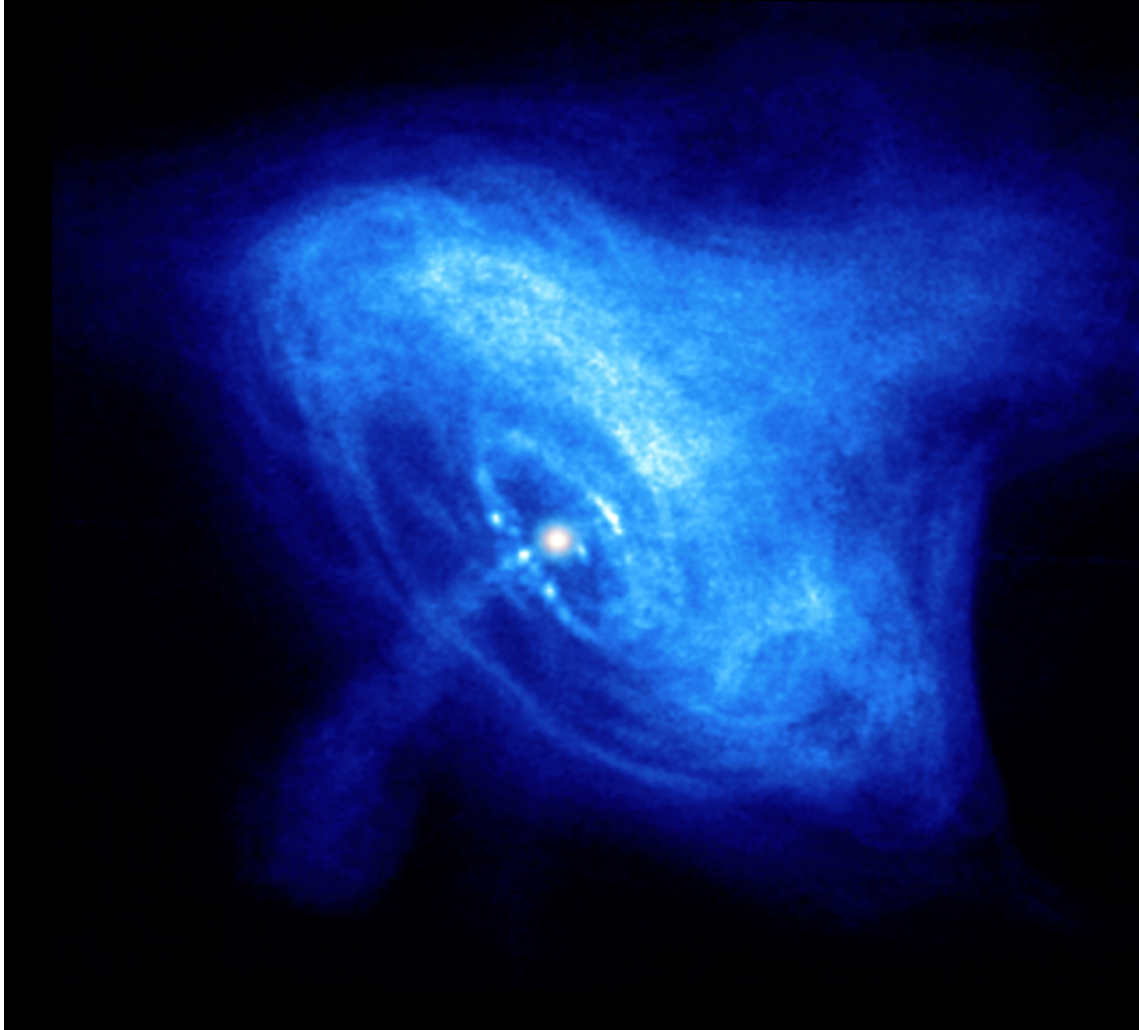
Eagle Nebula,
Hubble Space Telescope image
April, 1995

To Infrared ...



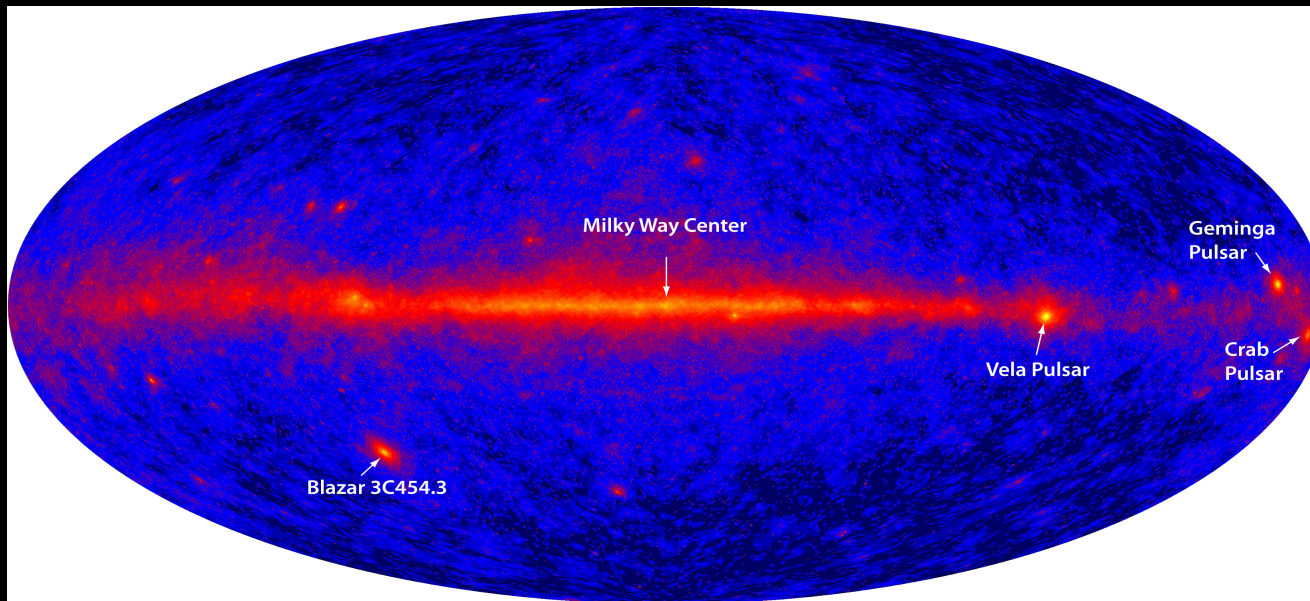
Images from the Spitzer space infrared telescope

... to X-ray



Chandra X-ray wide field
view of Crab Nebula
April 6, 2001

... and Gamma-Ray



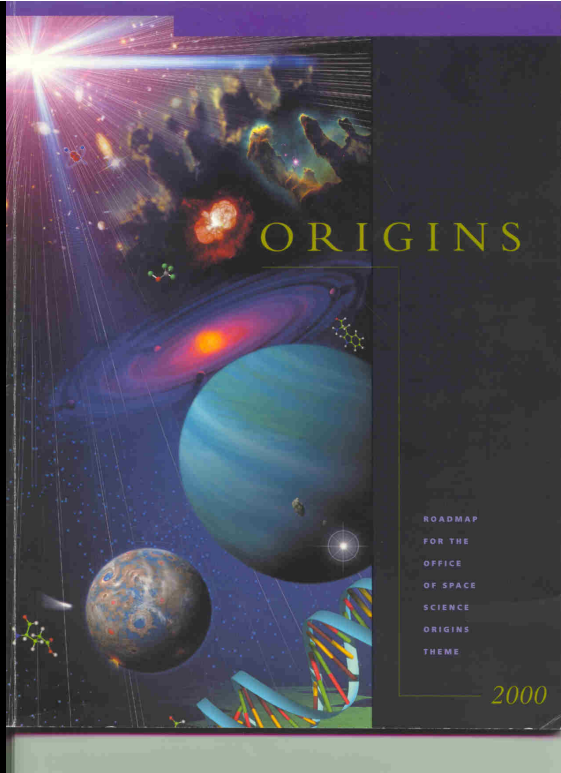
The Fermi Gamma-ray Large Area Space Telescope (GLAST)
All-sky view reveals bright emission in the plane of the Milky Way (center),
bright pulsars and super-massive black holes.

Credit: NASA/DOE/International LAT Team

Cosmic Evolution Has Demonstrated our Place in the Universe ...



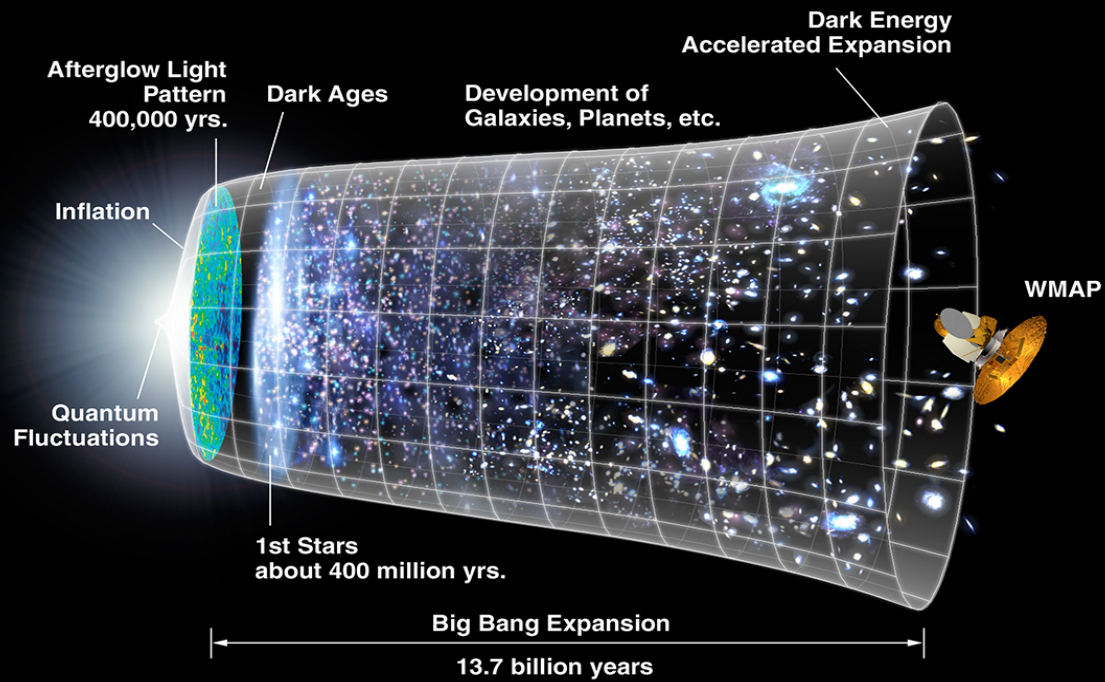
David DesMarais, Thomas Scattergood and Linda Jahnke/ NASA Ames, 1986, reissued 1997.



... NASA Has Played a Central Role in Understanding Cosmic Evolution

“Following the 15 billion [13.7] year long chain of events from the birth of the universe at the Big Bang, through the formation of chemical elements, galaxies, stars, and planets, through the mixing of chemicals and energy that cradles life on Earth, to the earliest self-replicating organisms – and the profusion of life.”

WMAP Spacecraft - 2003



Societal Impact of the Space Age

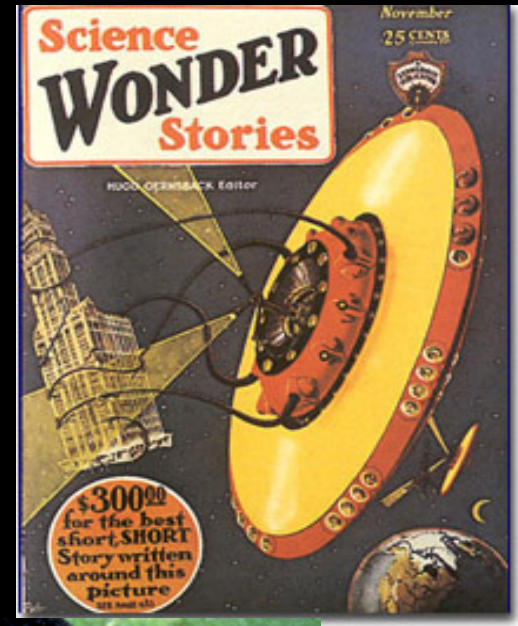
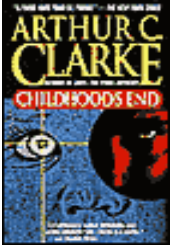
... Tuned in to the Cosmos!





**Space, the final frontier.
These are the voyages
of the starship
Enterprise. Its five-year
mission: To explore
strange new worlds. To
seek out new life and
new civilizations. To
boldly go where no man
has gone before ...**

ETI in Popular Culture



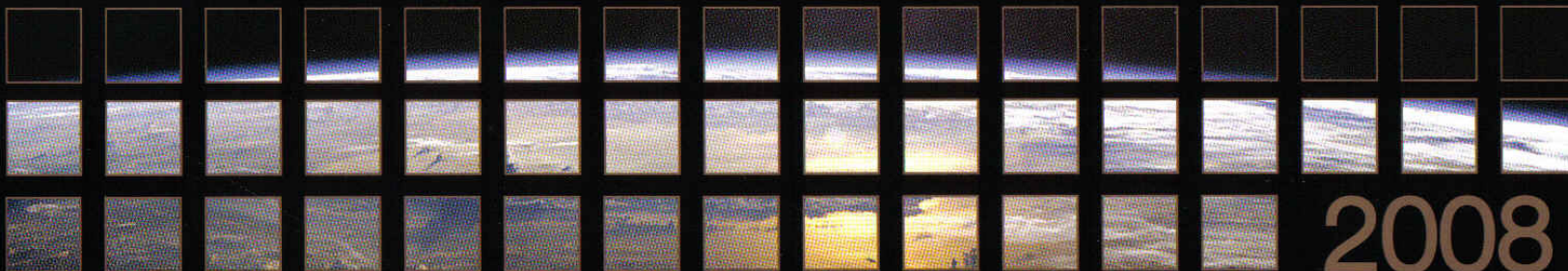
National Aeronautics and Space Administration



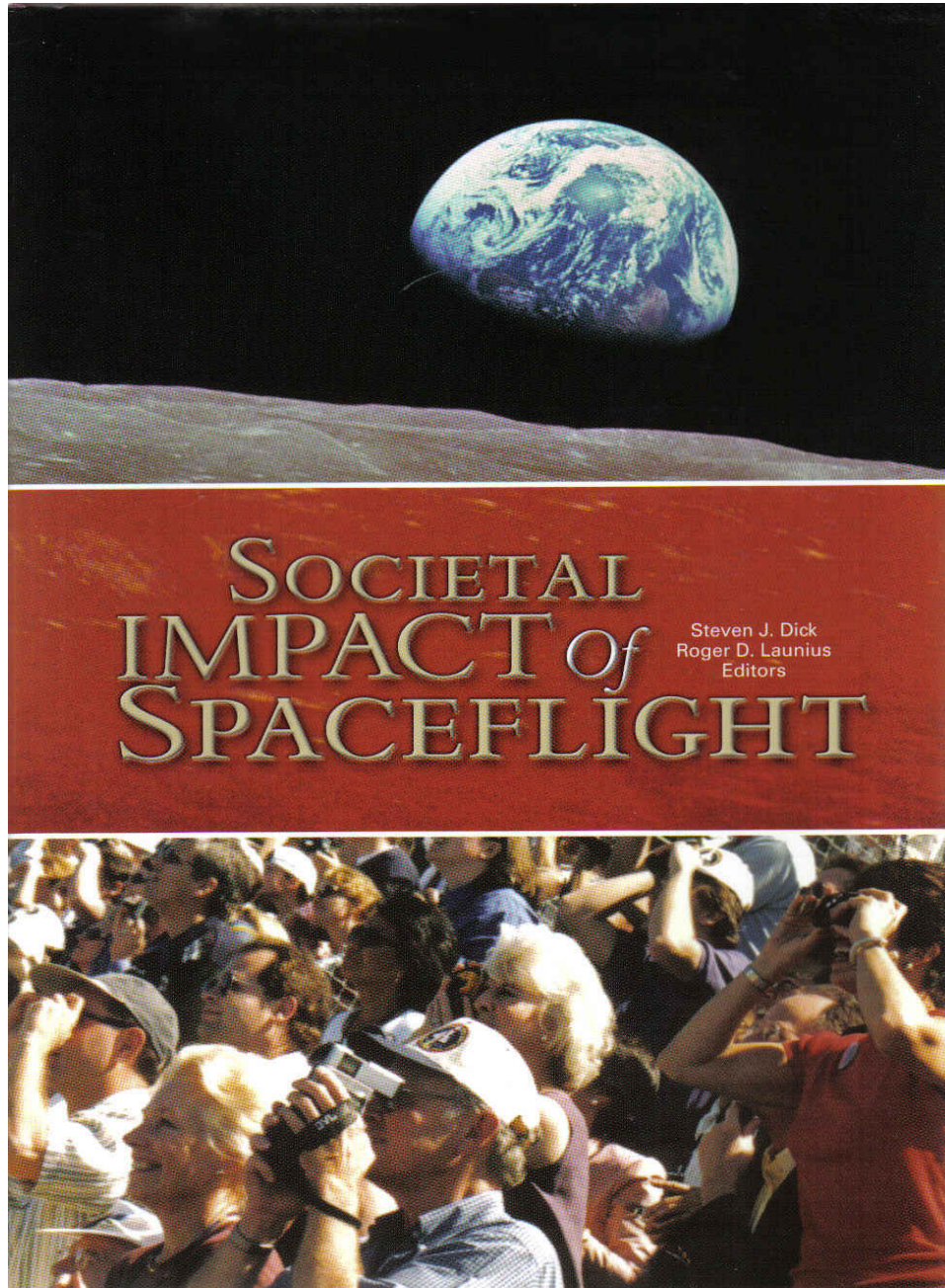
SPINOFF



50 YEARS OF NASA-DERIVED TECHNOLOGIES (1958-2008)

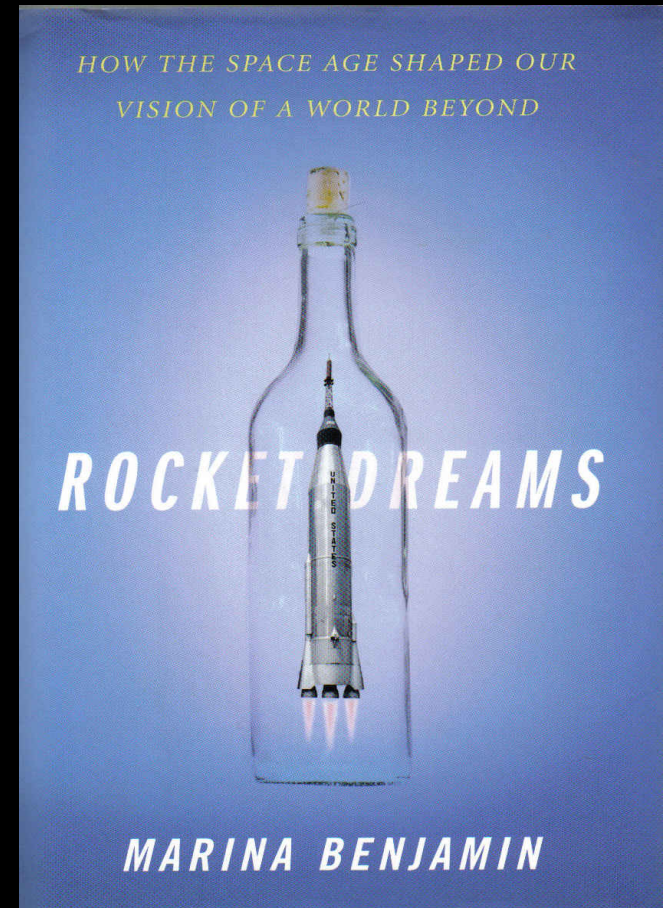


2008



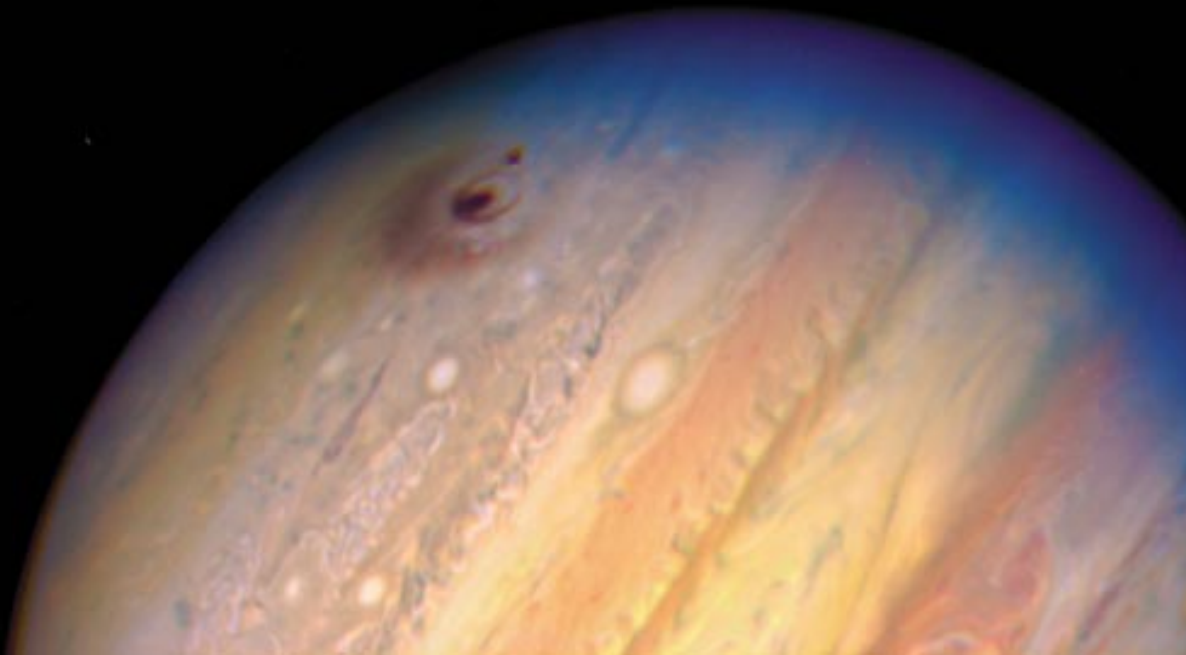
- Commercial and Economic
- Applications satellites & the Environment
- Scientific Benefits
- Education & Inspiration
- National Security
- Philosophical Impact
- Exploration & Creative Society
- Future: Survival of the Species?

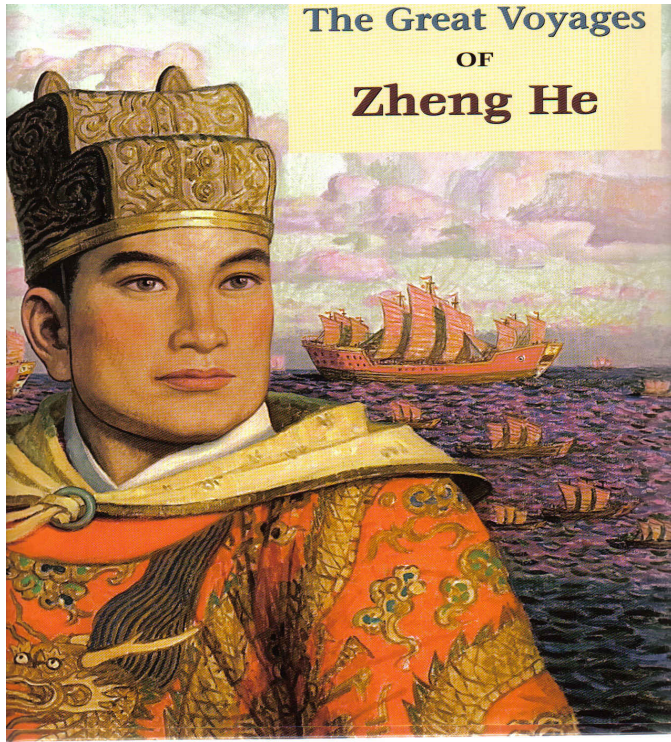
Impacts on Worldview



Societal Impact:
Objects Can Hit the Earth Too!

Survival
of the Species

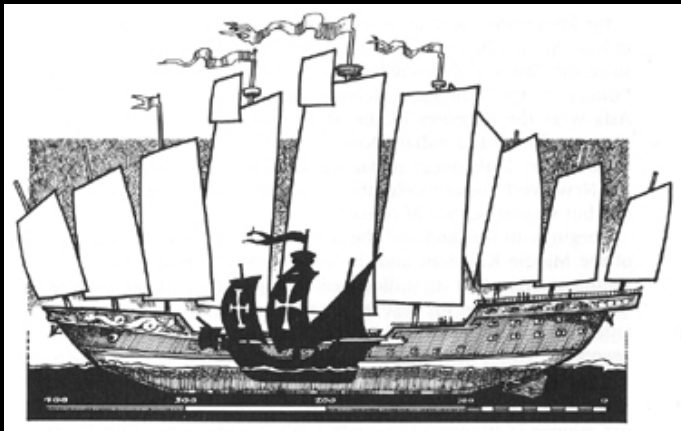




Is Exploration Necessary
For a Creative Society?

Zheng He And Ming China

Ming China (1368-1644)
Early Ming China a great maritime
power – characterized by the
Treasure Fleet



7 Voyages, 1405-1433

Hundreds of ships

Tens of thousands of men

15th Century Chinese ship compared to the Santa Maria

AN IMPROBABLY SMALL WORKER in gray coveralls tugs at a thick iron chain, his mouth set in a resolute line. The chain extends to an overhead pulley and back down to the midpoint of a massive square log that the worker is slowly, excruciatingly trying to turn on its side. Few tasks are too gargantuan in today's China, but this is a bit much. The log is 52 feet long and weighs more than eight tons.

Finally, it tips over with a resounding *thump*. Once this log is sanded and varnished, it will become part of a titanic reproduction, based partly on archaeological evidence, of a boat captained by Zheng He, China's legendary fifteenth-century explorer. T. J. Jia smiles approvingly from under his white supervisor's hard hat. A good-humored man with wide-set eyes, his supple leather jacket and flawless English hint at a privileged background. He is a former Chinese foreign ministry official with an MBA from the Garvin School of International Management in Arizona. He stands in a large, hangar-like warehouse. Outside, the brown waters of the Yangtze River roil by. "We've had to import *balau* wood from Malaysia," Jia says apologetically. "We don't have it in China anymore. The forests are gone."

Rebuilding a Treasure Ship

In its 15th-century
navy, China discovers
a model for its new
global ambitions.

by MARA HVISTENDAHL

This is just a slight inconvenience. Jia is deputy general manager of Dragon Boat Development Company, which is overseeing the project with the city of Nanjing. With a \$10 million budget and a three-year timeline, he can afford to import wood for historical accuracy. The company even uses many fifteenth-century construction methods, which explains why the tiny workman uses a pulley instead of a forklift.

China's leaders are seizing on history as a tool to influence the perception of the nation abroad. Through a careful, calculated celebration of Zheng He and his travels, the government hopes to project an image of itself as open and benevolent—a powerful but peaceful nation interested in trade, not domination. But history and archaeology don't always cooperate.

The story of the boat now being reconstructed begins in 1402, when a dynamic young prince named Zhu Di ousted his brother by force, usurping the Ming throne. For centuries, China had been dominated by Confucian advisors who convinced the emperors to spurn international commerce and look inward. Referred to as the Yongle (meaning "eternal happiness") emperor, Zhu Di wanted to reinstate foreign trade, invite in foreigners, and unite "the four seas"—what China then saw as the rest of the world. The following year, he ordered the construction of a fleet larger than any in history, with 317 boats. Its centerpiece was majestic "treasure ships," named for the wealth of goods they carried. According to historical sources, each ship boasted a tall, curled prow, nine staggered masts, and 12 red silk sails. Watertight compart-



Using many 15th-century techniques, shipbuilder Fang Jiebo works on what will become one of the ribs of a reproduction of a massive "treasure ship" captained by the Muslim eunuch explorer Zheng He. Modern Chinese officials want to use Zheng He's legacy to shape perceptions of their country's rise to global prominence.

Long March rocket
Launches manned
Shenzhou spacecraft



Zheng He and the Treasure Ships:
A Model for China's New Global
Ambitions

Massive reproduction of Treasure Ship
Being built in ancient Ming shipyard
At Nanjing

Archaeology, March/April 2008

Lessons Learned # 1

**Analogies are Suggestive
Guides ONLY: We Cannot
Predict the Future**

Lessons Learned # 2

**It is Always Tempting To
Sacrifice the Long Term
for the Short Term**

**(and Almost Always a Bad Idea –
Unless there is no long term)**

NASA at 50 still suffering from NASA at 12

Lessons Learned # 3

Human Spaceflight should Continue

Robotic Spaceflight should Continue

**Both are Synergistic and in the
Tradition of Exploration**

Lessons Learned # 4

Risk and Exploration:

Safety is the # 2 Priority,

Not the # 1 Priority

The # 1 Priority is to GO

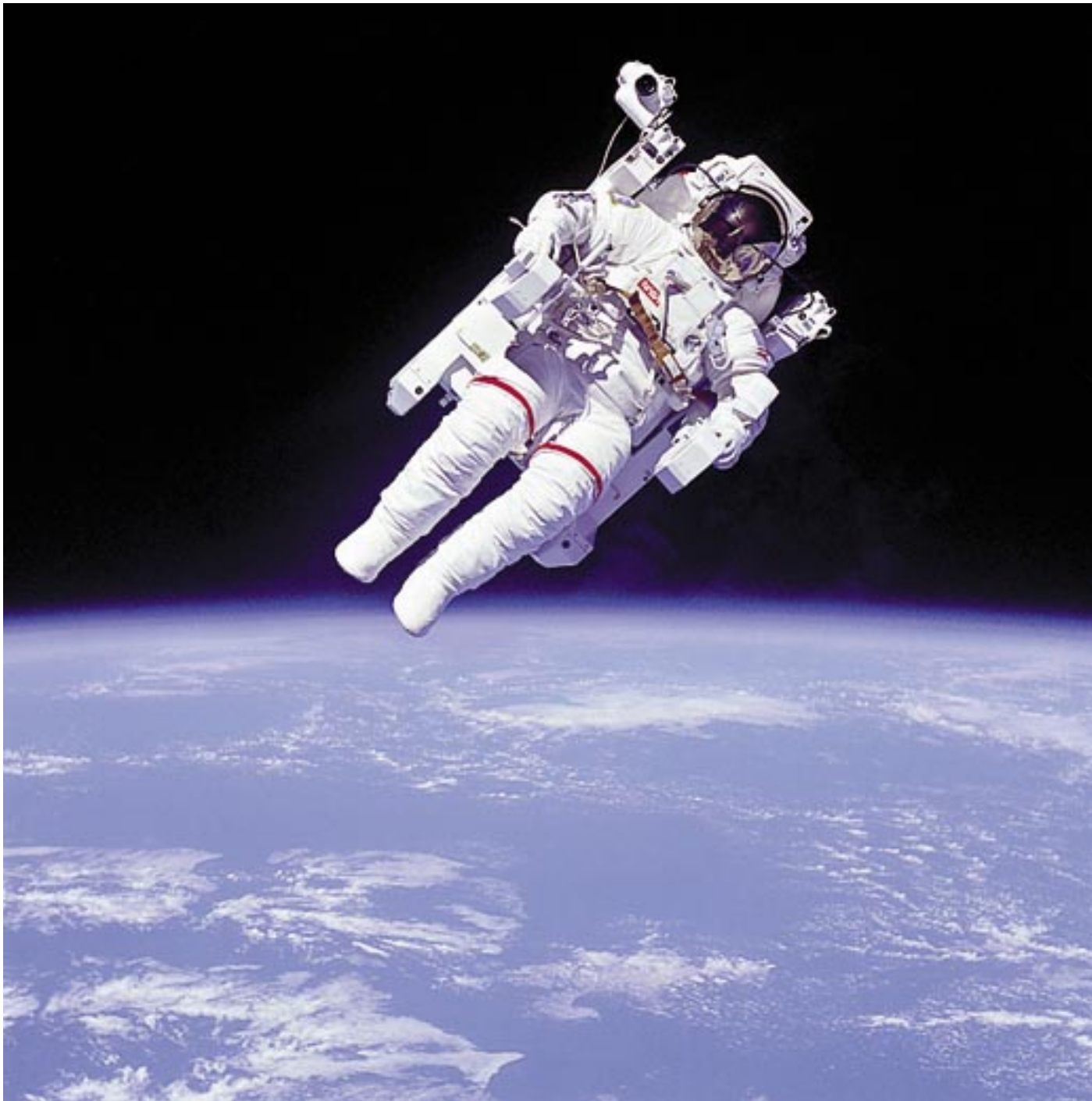
Otherwise There is no Exploration



History Shows
Exploration is
Not a Destiny
But a Choice
That each Society
Must Make ...

Humans & Robots
Together

Servicing HST, 1993



What Will
Our Choice Be
In the New
OCEAN OF
SPACE?

Bruce McCandless II
During STS 41B, 1984



THANK YOU!