A Short History of Mars Exploration

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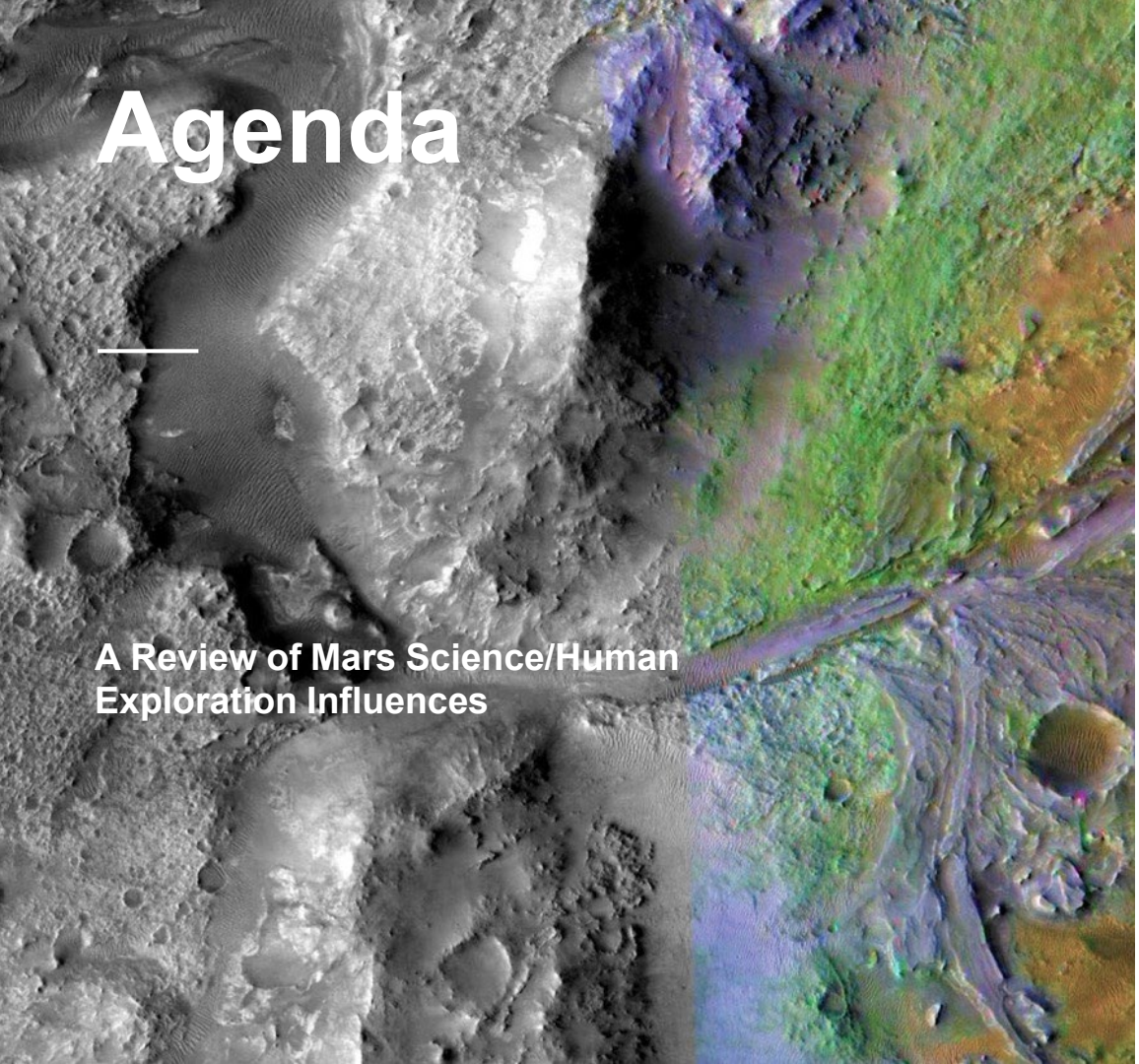
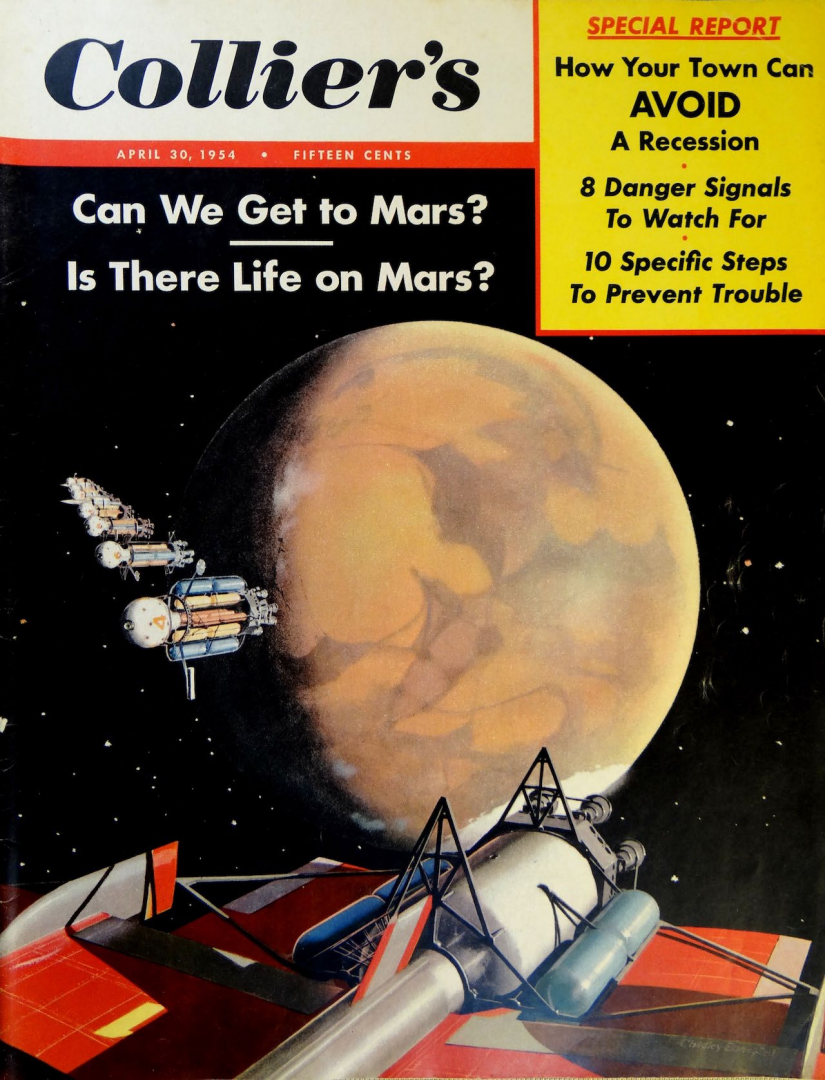


Agenda

A Review of Mars Science/Human Exploration Influences

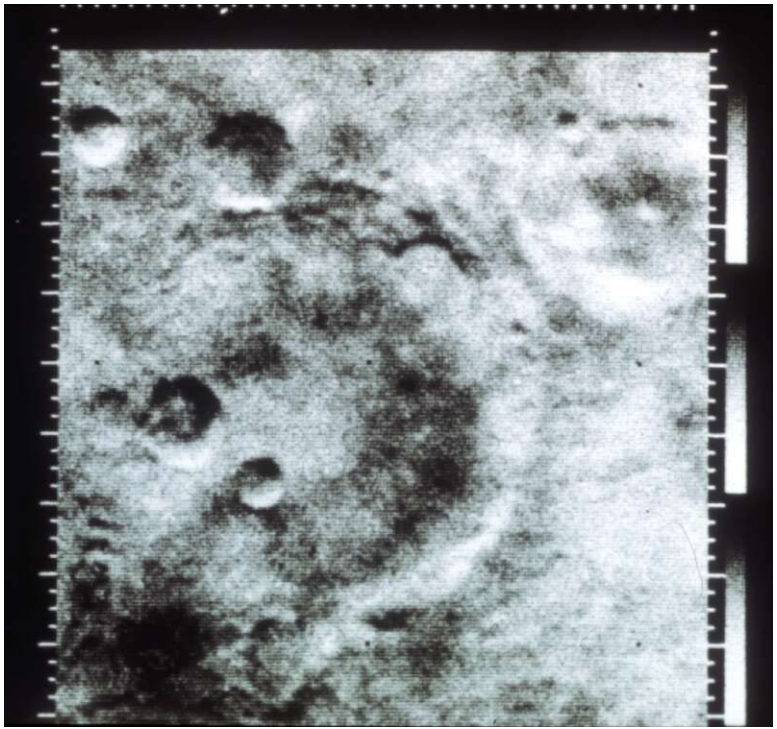
2. Mars Exploration Before 1980



Das Marsprojekt

- While working in New Mexico in early 50s, Werhner von Braun conceived Das Marsprojekt
- Human Exploration and Colonization of a living Mars
- A version was published as a serial in Collier's
- An early, influential, but very naïve view of the first human missions to Mars
- Even von B didn't expect it to happen within a century

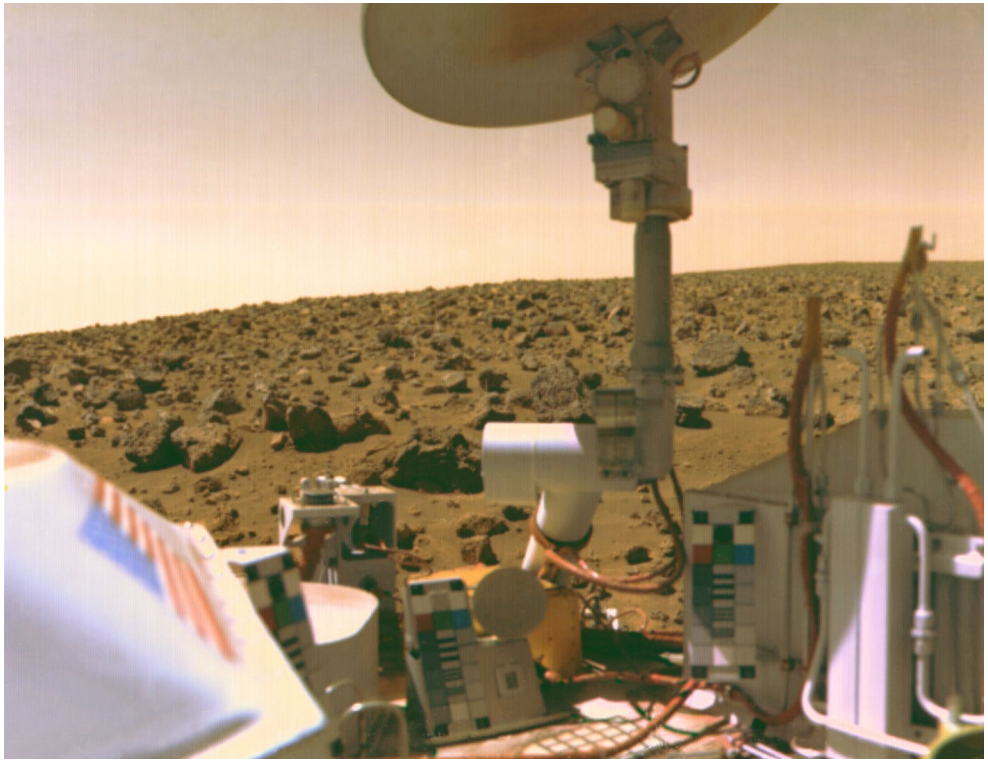
Mars Science in the 1960s



Mariner 4 image of Mars. JPL P7875A.

- 1960s witnessed a series of Mars missions that dispelled the “living Mars” idea
- JPL Mariners found the cold, frozen, cratered Marsscape that we’re very familiar with
- Largely forgotten was a set of human landing *precursor* missions called Voyager
- Far beyond state of the art and were downscoped into the Viking missions of the mid-1970s

Viking missions



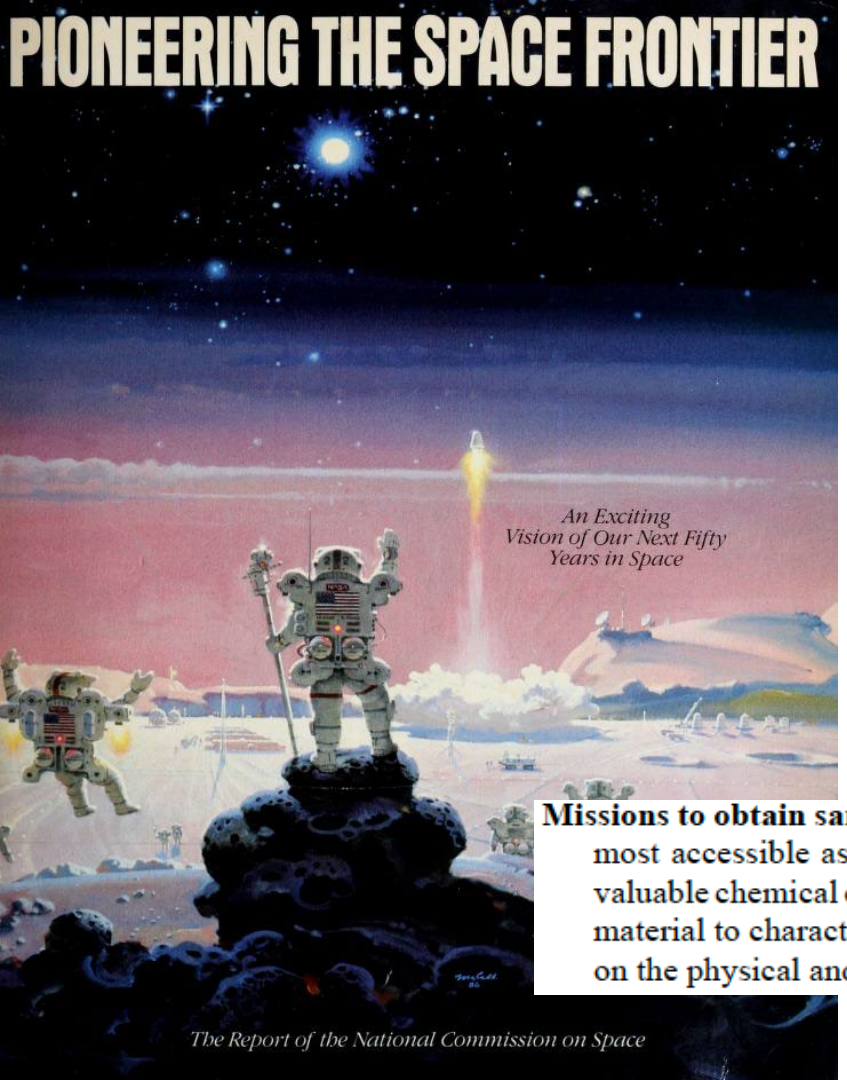
Viking Lander 2 on Mars. JPL PIA01522.

- Viking performed the first search for organics and life processes on Mars
- Exobiology instruments led from Ames Research Center
- Experiments generally viewed as unsuccessful at detecting life
- In retrospect lack of understanding of surface composition made results uninterpretable
- Successor mission planning focused on overcoming this error

Galileo mission launch during STS-34. JPL P35213.

Shuttle Era

- 3 planetary science missions from Shuttle, none to Mars
- Challenger accident resulted in movement of most science payloads off Shuttle
- Also began a search for a new direction for NASA



Mission from Planet Earth / Pioneering the Space Frontier

- Presidential Commission formulated new strategy for creating “Free Societies on New Worlds”
- Largely enterprise-based—prospecting for resources, mining, etc.
- Included a significant scientific component:

Missions to obtain samples from selected sites on our Moon, Mars and its moons, and the most accessible asteroids. When prospector missions have identified the presence of valuable chemical elements, sample return missions will be needed to bring back enough material to characterize the minerals and initiate industrial process development based on the physical and chemical properties of the samples.

3. The SEI Era

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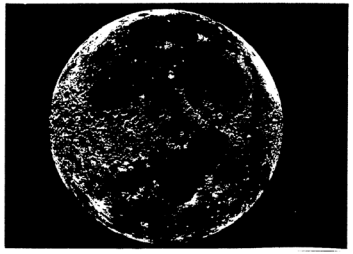
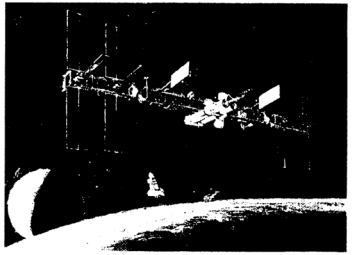
... And then a journey into
tomorrow, a journey to
another planet,
a manned mission to Mars.



... And next, for the next century,
back to the Moon,
back to the future,
and this time, back to stay.

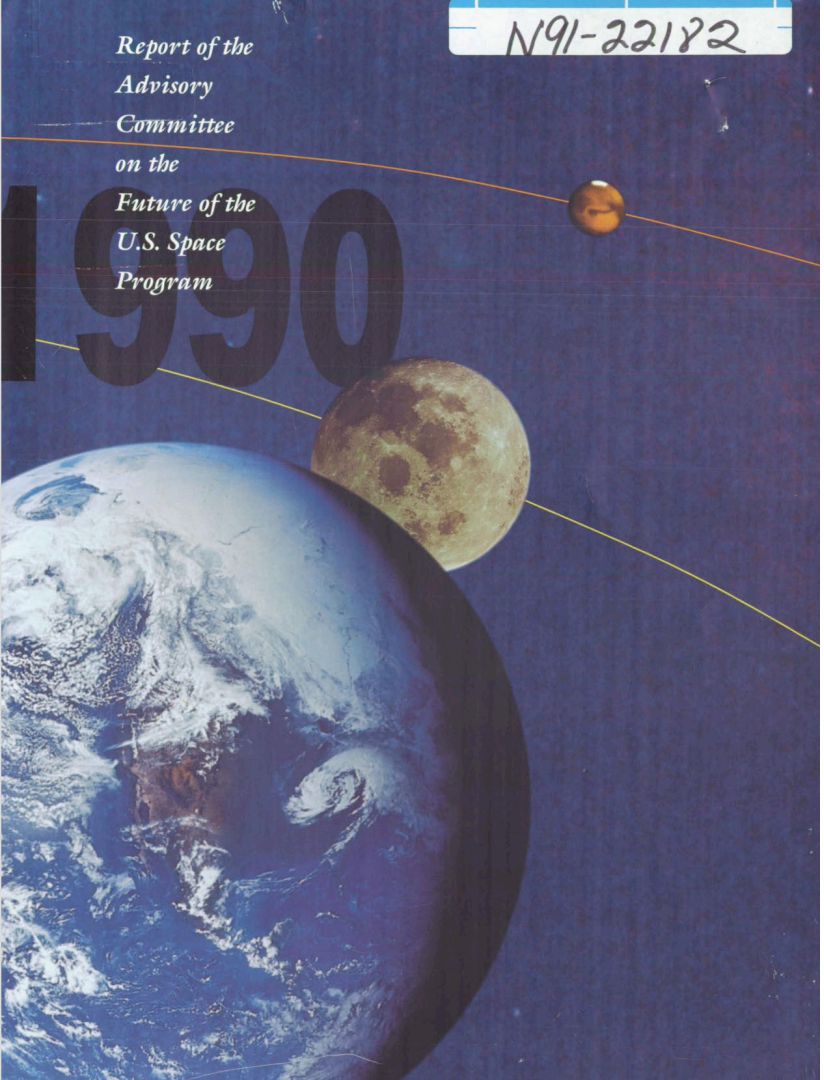


First, for the coming decade,
for the 1990s,
Space Station Freedom,
our critical next step in
all our space endeavors.

ORIGINAL PAGE IS
OF POOR QUALITY

The 90 Day Study

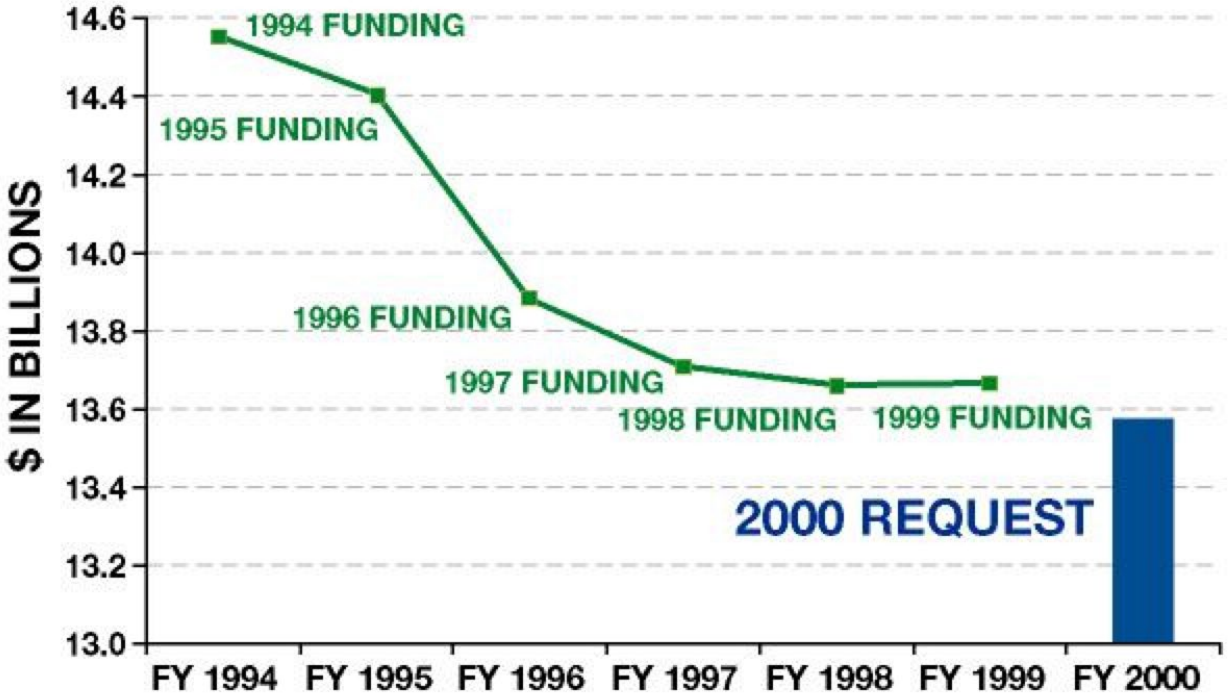
- Pres. GHW Bush sought new direction for NASA in 1989
- Came to be known as Space Exploration Initiative, announced July 20, 1989
- NASA led “90 Day Study” resulted in an exploration plan that again included a scientific component
- Price tag >$500 billion
- SEI died quickly



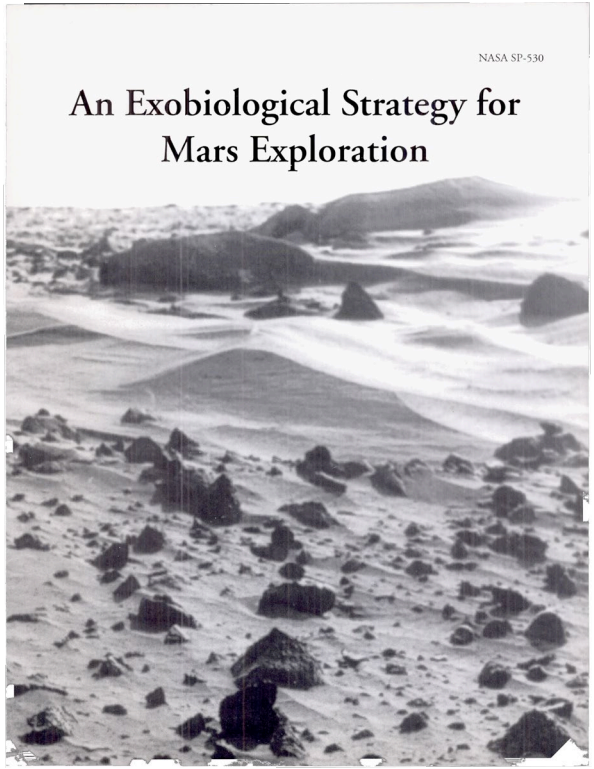
Augustine Committee (1990)

- Yet another blue ribbon study resulted in sea change
- Two key recommendations:
- NASA should prioritize Earth and space science
- Human exploration should become “go as you pay.”
- This became national policy until G. W. Bush administration

FY 2000 BUDGET vs HISTORY



An Exobiological Strategy for Mars Exploration



- Published 1995
- Product of a workshop at Ames Research Center in 1992
- Funded by Michael A. Meyer, discipline scientist for NASA's exobiology program in the 1990s
- Meyer wanted to see "exobiology in action," put to work in exploring the planets
- Panel proposed a five-phase strategy

1. Global reconnaissance focused on the role of water past & present
2. Landed missions at select sites for in situ geochem and mineralogical characterization
3. Deployment of exobiologically focused experiments—search for organics, biomarkers
4. Sample return
5. Human missions

- Encompassed missions in progress: Mars Global Surveyor, Mars Pathfinder, Mars 96

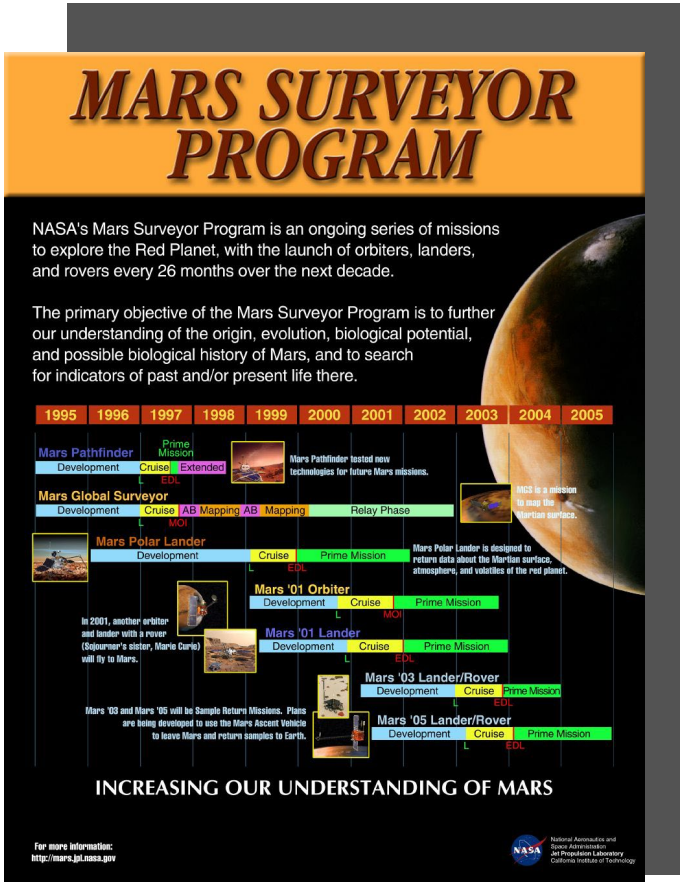
The Rock from Mars

- The 1996 announcement by McKay et.al. of possible biomarkers in ALH84001 provided giant boost to exobiology advocates
- While the evidence was weak, the controversy was *generative.* It triggered a huge amount of subsequent work on/about what should count as evidence, as biomarkers.
- It also helped reverse NASA's budget shrinkage, and gave Mars exploration a big boost
- NASA launched a new Mars exploration program in its wake

NASA S85-39565.

Mars Surveyor Program

- Basis was 2 launches per 26 month opportunity
- 1 orbiter, 1 lander
- All competed.
- Sample return planned for 2003/2005
- 1996: First mission was reflight of Mars Observer instruments—Mars Global Surveyor
- 1998: Mars Polar Lander/Mars Climate Orbiter. Both aimed at water & climate. Both lost.
- 2001: Mars Odyssey mapped water in regolith globally. 2001 lander was cancelled.
- Surveyor program cancelled in 2000 after MPL loss



Restructuring the Mars Program

- New leadership appointed: at NASA, G. Scott Hubbard; at JPL, Firouz Naderi
- Designed a new program during 2000, still planning sample return but in 2011
- Created MEPAG to advise on science strategy on a faster cadence than the decadal surveys
- NASA's Carl Pilcher labelled the science strategy the new program pursued "Follow the Water." Simplified a complex message.
- The new program also had technology funding to develop new capabilities required to carry out sample return

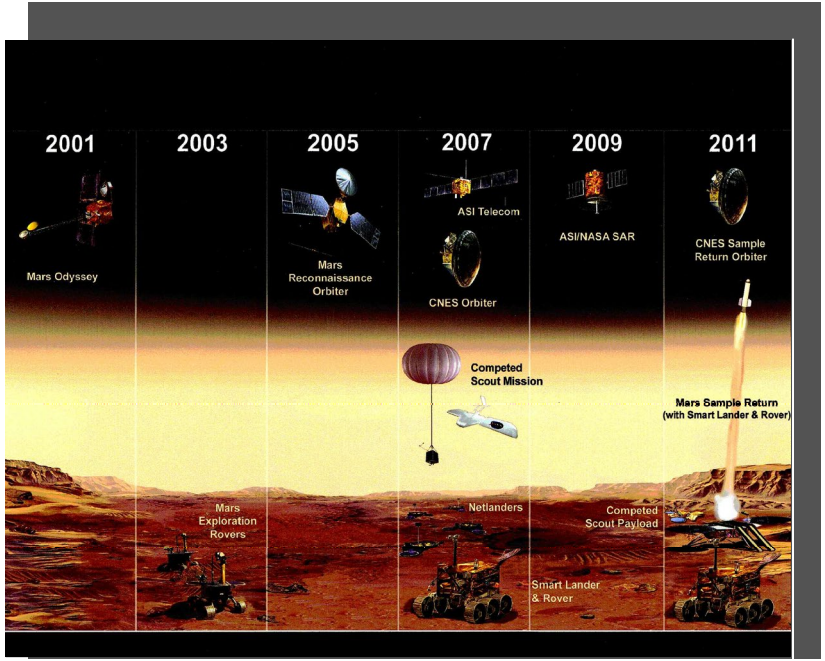
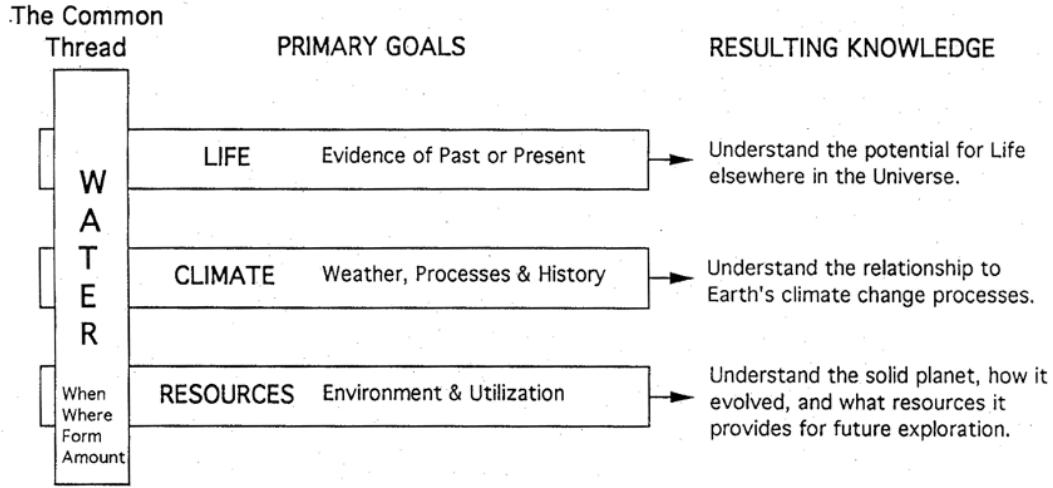


FIG. 3. Chronological view of the missions that constitute the "core program" of NASA's MEP, starting with Mars Odyssey (launched 2001) and continuing up until the first of several MSR missions.

From Garvin et.al, Astrobiology 1:4, 2001

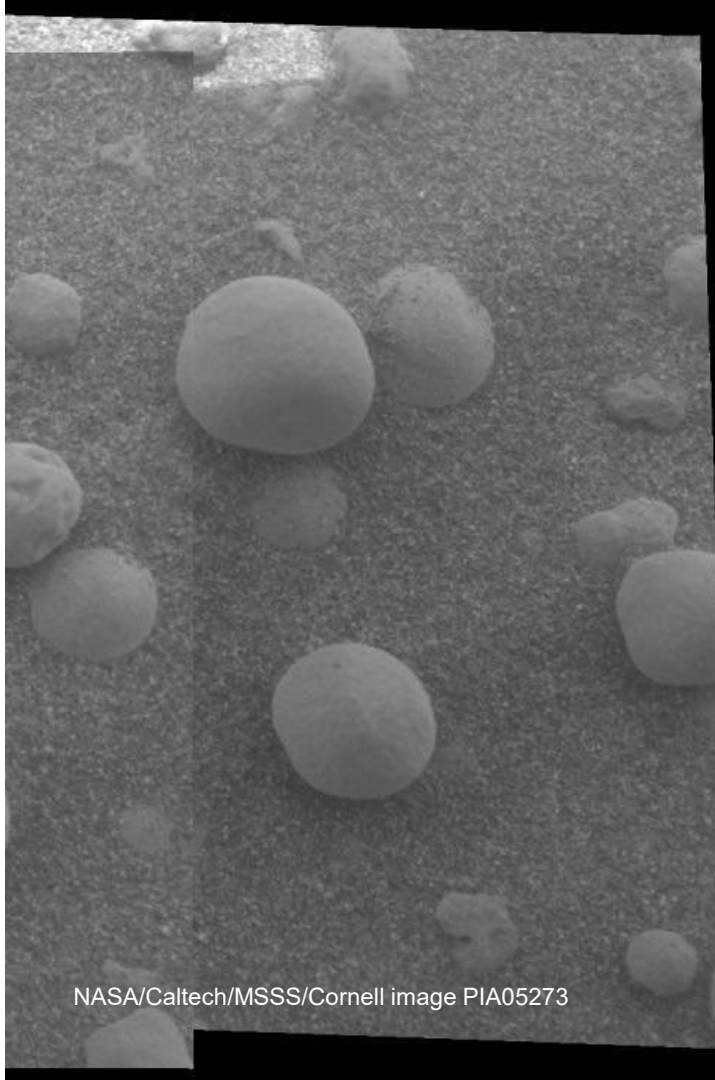
MARS EXPLORATION



Follow the Water

Driving towards life

- The sequence of missions had little trouble finding water's imprint on Mars
- MER Spirit, Mars Phoenix identified water impacts within days of arrival; MER Opportunity and MSL took somewhat longer
- But Sample Return delayed after major budget cut in 2005



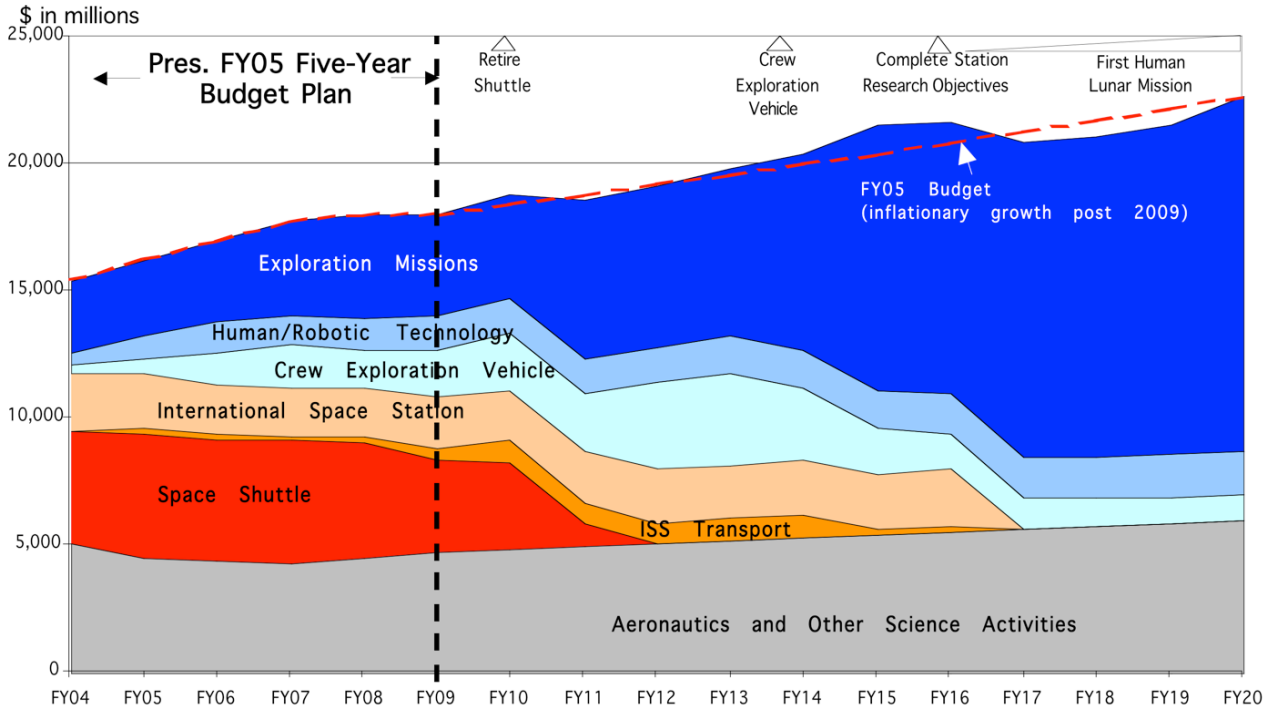
The Vision for Space Exploration

The Vision for Space Exploration

- **"When Christopher Columbus made his voyages across the Atlantic in the 15th and 16th centuries, his ships carried the inscription "Following the light of the sun, we left the Old World." I look forward to joining you as we follow the light of the planets and the stars into the new worlds of the 21st century." –Sean O'Keefe**
  - **Cover letter from NASA, Vision for Space Exploration, 2004**

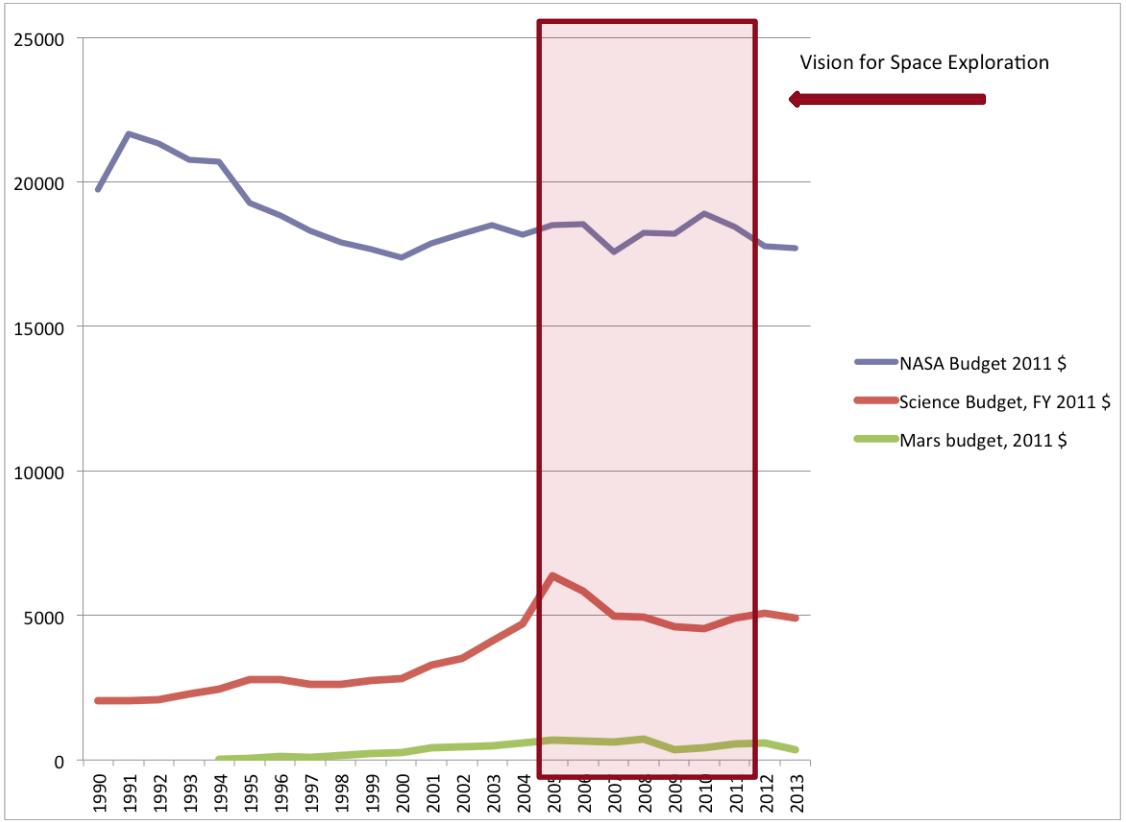
- **"Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations. . ."**
  - **Goal #2 of Vision for Space Exploration**

Strategy Based on Long-Term Affordability



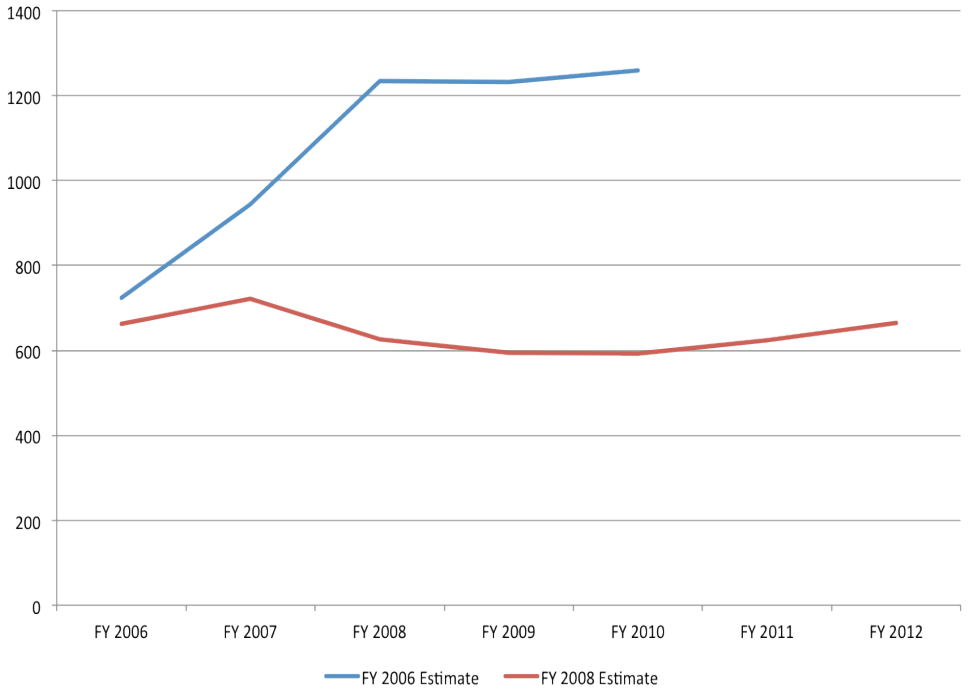
NOTE: Exploration missions– Robotic and eventual human missions to Moon, Mars, and beyond
Human/Robotic Technology– Technologies to enable development of exploration space systems
Crew Exploration Vehicle– Transportation vehicle for human explorers
ISS Transport– US and foreign launch systems to support Space Station needs especially after Shuttle retirement

Mars Program in Context



Data compiled from NASA budget documents.

Evolution of Mars Budget



Data compiled from NASA budget documents.

- May 2005 Mars program budget cut ~$3B below expectations
- Funds largely went to start a new lunar exploration program to support VSE
- End of sample return drive for the early 2010s.

Mars Exploration Goals in the VSE

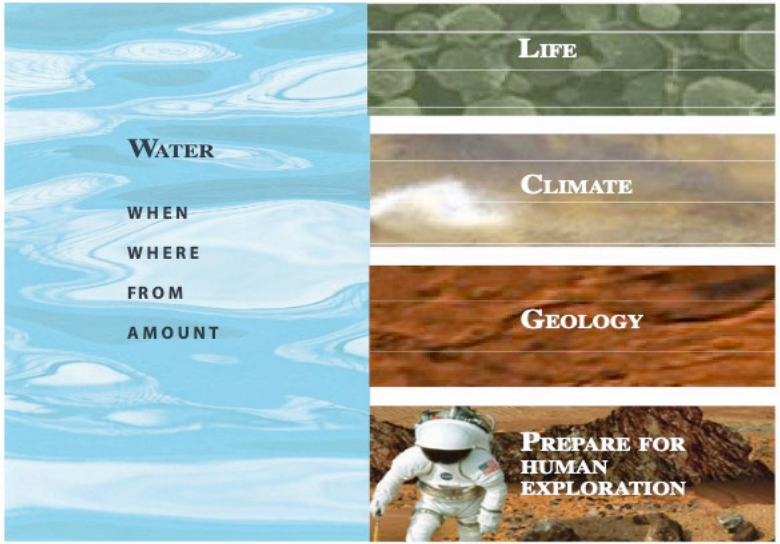


Figure 1. Goals of the Mars Exploration Program.

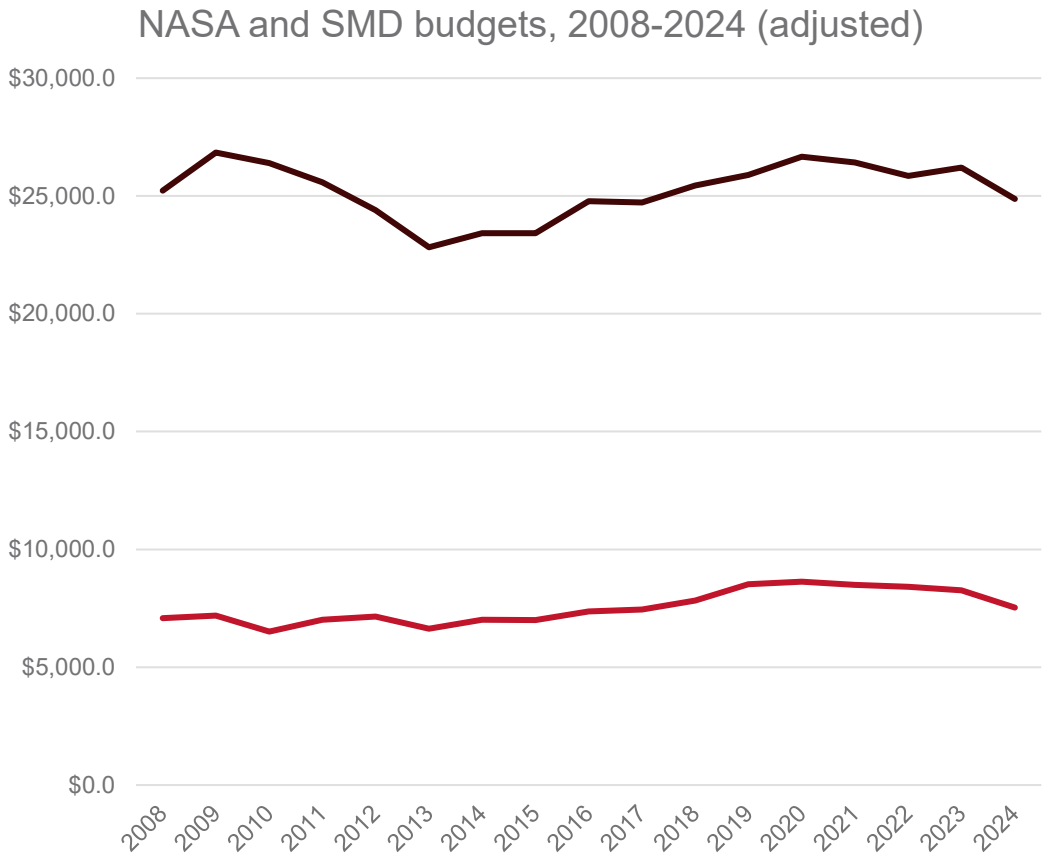
MAPG 2006, Robotic Mars Exploration Strategy, 2007-2016, 7.

- Cuts slowed pace of Mars exploration
- Evidence of H2O from MER rovers redirected science towards organics, biosignatures, sources of biologically usable energy
- Human exploration precursor goals still pursued, esp. surface radiation, entry dynamics, dust impacts, planetary protection.

Augustine II and After

End of SEI

- Reviewed SEI/Constellation lunar program against costs and funds
- Concluded $6B/year increase in NASA budget necessary to complete
- Also recommended a set of lower cost options
- Ultimately Obama administration chose a Near-Earth asteroid as the next human destination



Data compiled by Planetary Society

- VSE's Constellation program cancelled in 2010
- Successor human program was Asteroid Redirect
- 2010 NASA Authorization required development of SLS
- Also made Mars the eventual human goal:

national.

(5) A long term objective for human exploration of space should be the eventual international exploration of Mars.

(6) Future international missions beyond low-Earth orbit

PL. 111-267, sec. 301.

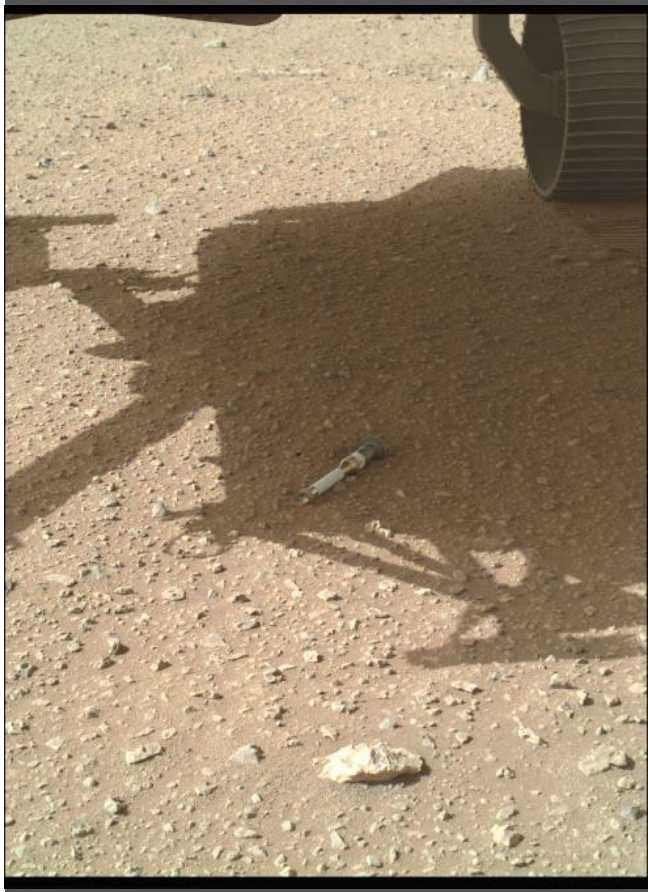
Visions and Voyages for Planetary Science

On the basis of the importance of questions relating to life, the committee concluded that for the more distant future, human explorers with robotic assistance may contribute more to the scientific exploration of Mars than they can to any other body in the solar system. Robotic missions to Mars, either purely for science or as precursors to a human landing, can provide the basic scientific data and lay the groundwork for a human presence. Humans will then take exploration to the next steps by making sense of the complex martian environment, rapidly making on-the-spot decisions to choose the right spots for sampling, performing the best experiments, and then interpreting the results and following up opportunistically.

Vision and Voyages, 2011

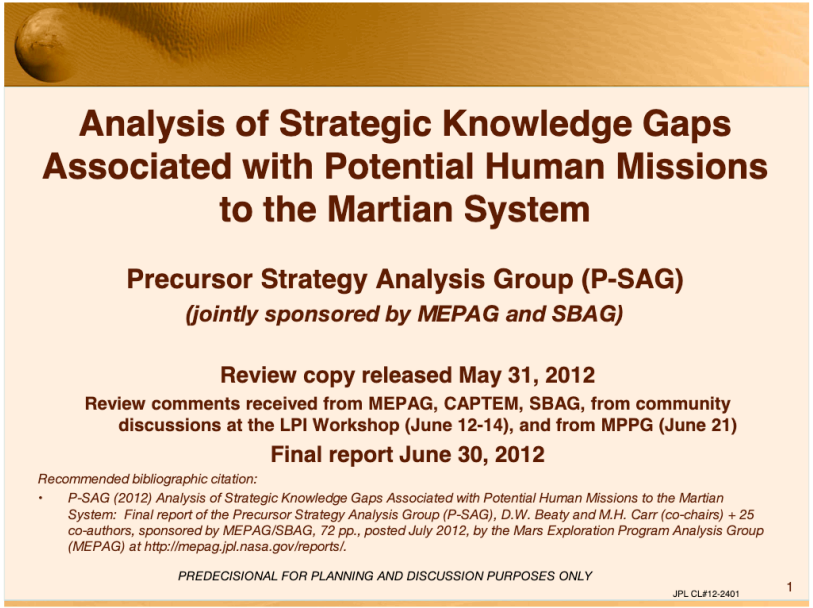
Visions and Voyages

- The 2nd planetary decadal survey made an explicitly astrobiological mission its top “flagship” class mission priority
- ”Mars Astrobiology eXplorer-Cacher,” or MAX-C.
- Was to have been a large, complex two rover mission performed with ESA
- Descoped and delayed to 2020; the ESA component has shifted to 2028
- *Visions* represented the recognition of astrobiology as an important organizing theme for scientific exploration



NASA/JPL-Caltech/MSSS PIA 25340

Mars Planning Post-VSE



Analysis of Strategic Knowledge Gaps Associated with Potential Human Missions to the Martian System

Precursor Strategy Analysis Group (P-SAG)

(jointly sponsored by MEPAG and SBAG)

Review copy released May 31, 2012

Review comments received from MEPAG, CAPTEM, SBAG, from community discussions at the LPI Workshop (June 12-14), and from MPPG (June 21)

Final report June 30, 2012

Recommended bibliographic citation:

- *P-SAG (2012) Analysis of Strategic Knowledge Gaps Associated with Potential Human Missions to the Martian System: Final report of the Precursor Strategy Analysis Group (P-SAG), D.W. Beaty and M.H. Carr (co-chairs) + 25 co-authors, sponsored by MEPAG/SBAG, 72 pp., posted July 2012, by the Mars Exploration Program Analysis Group (MEPAG) at http://mepag.jpl.nasa.gov/reports/.*

PREDECISIONAL FOR PLANNING AND DISCUSSION PURPOSES ONLY

JPL CL#12-2401 1

- 2012: P-SAG chartered to define “Strategic Knowledge Gaps” relating to human expeditions to Mars
- 2012: Mars Program Planning Group chartered to find “options that integrate science, human exploration and technology at an Agency level with Mars Exploration as a common objective.”
- Some technology needs were/are common to both MSR and to human exploration: e.g. entry dynamics and technologies, precision landing; water resource location
- Options included use of SLS and/or use of astronaut recovery of samples

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Mars 2020 SDT

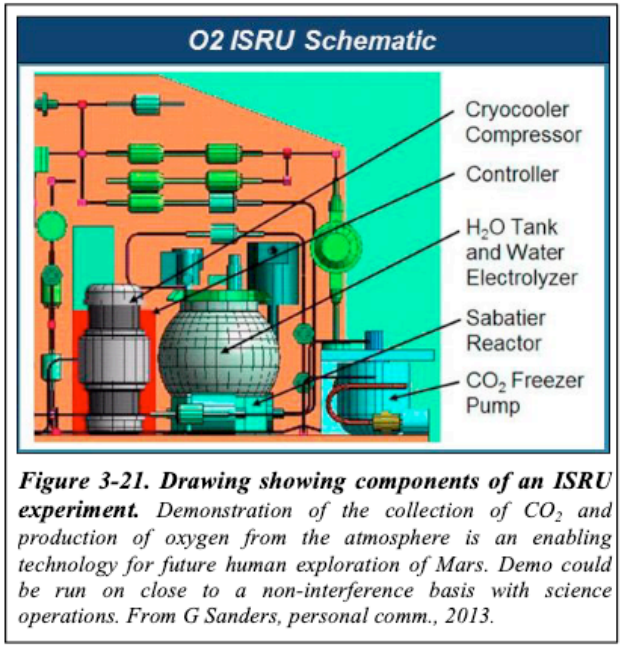
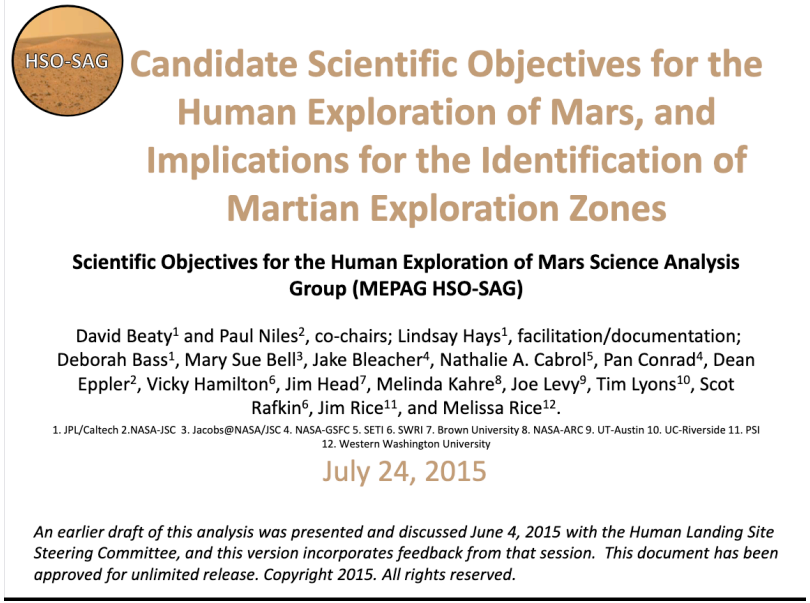


Figure 3-21. Drawing showing components of an ISRU experiment. *Demonstration of the collection of CO_2 and production of oxygen from the atmosphere is an enabling technology for future human exploration of Mars. Demo could be run on close to a non-interference basis with science operations. From G Sanders, personal comm., 2013.*

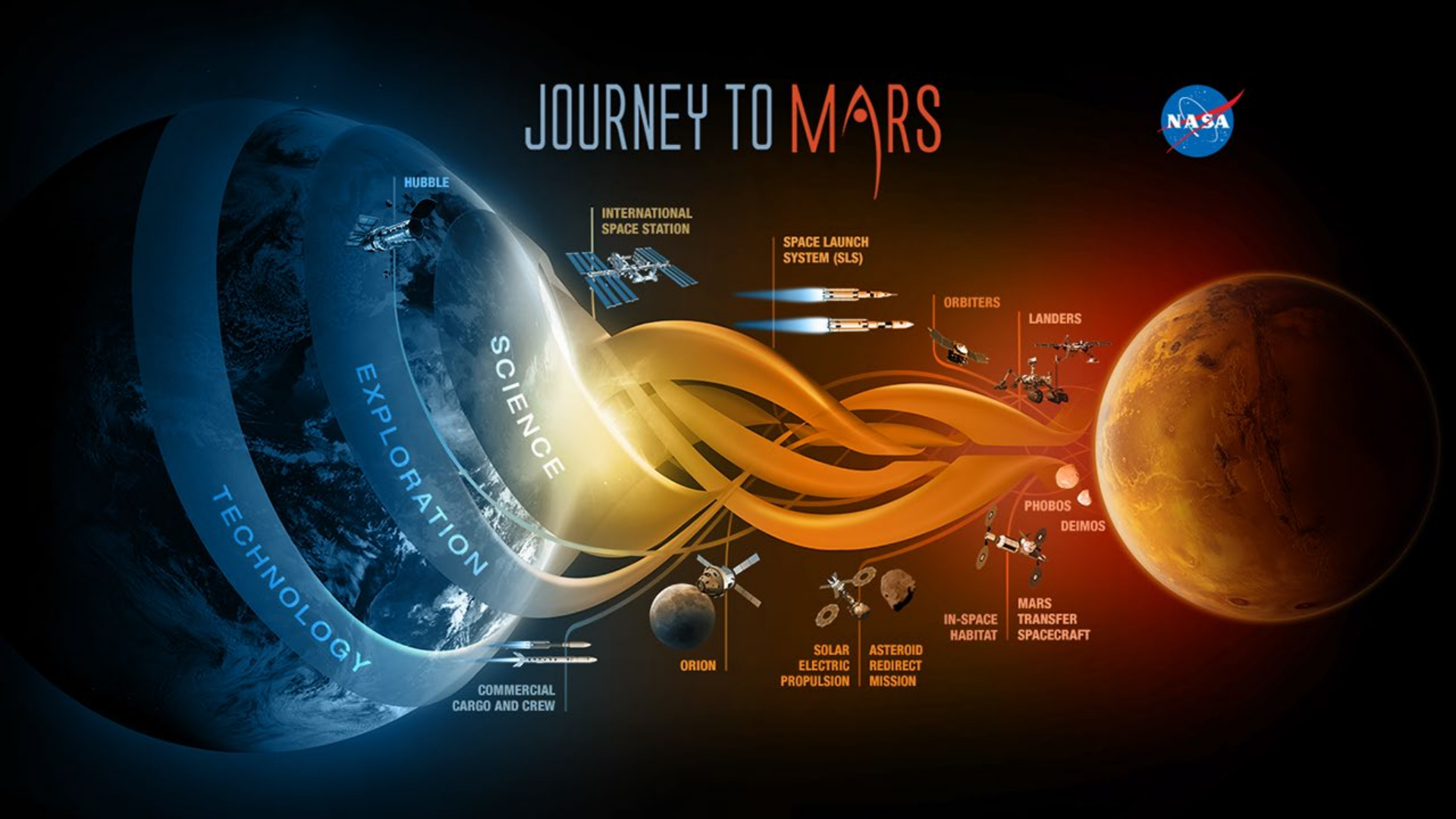
- 2013 M2020 Science Definition Team charter specified that the mission include an “opportunity” for a payload element supporting future human exploration
- Astrobiology-focused mission searching for “signs of past life”
- Should prepare “a returnable cache of carefully selected and documented surface samples”
- Argued for ISRU as the highest priority payload for human exploration

Mars 2020 SDT, p. 63.

Robots+Humans on Mars



- 2015 saw MEPAG consider scientific objectives for human exploration
- Also examined advantages to science of having human explorers, including interaction with/use of robotic systems


JOURNEY TO MARS
NASA
HUBBLE
INTERNATIONAL SPACE STATION
SPACE LAUNCH SYSTEM (SLS)
ORBITERS
LANDERS
SCIENCE
EXPLORATION
TECHNOLOGY
PHOBOS
DEIMOS
ORION
SOLAR ELECTRIC PROPULSION
ASTEROID REDIRECT MISSION
IN-SPACE HABITAT
MARS TRANSFER SPACECRAFT
COMMERCIAL CARGO AND CREW

Artemis Program

- Dec. 2017 decision to end Asteroid Redirect in favor of returning to the Moon didn't alter status of Mars as a "horizon goal" for the human exploration program
- Makes the mid-2030s timeline discussed in the 2010s unlikely—Artemis' Lunar Gateway is scheduled to still be under construction in 2031


NASA
Jet Propulsion Laboratory
California Institute of Technology
JPL

Key References

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- Space Policy Archive: https://csps.aerospace.org/resources/space-policy-archive?page=1