MARS HUMAN EXPLORATION OBJECTIVES

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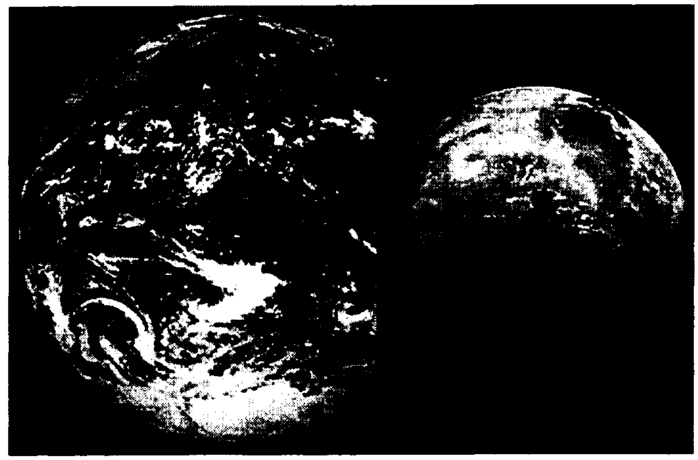
Human Exploration Objectives

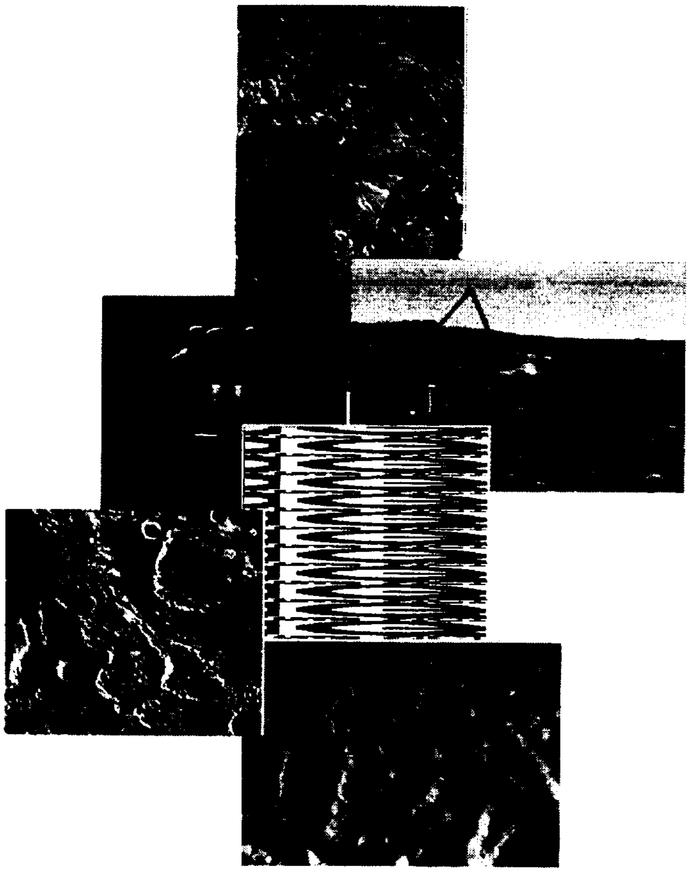
To explore Mars and learn how Mars is similar to, and different from, Earth
- whether life evolved on Mars and, if so, whether and how such life may have become extinct
- whether Mars is still a geologically live planet
- how early Mars may illuminate the history of Earth

- To determine whether Mars has the potential to be a second home for life — toward the eventual establishment of a self-sufficient human presence on Mars
  - Achieve substantial life support self-sufficiency on a local scale in terms of breathable air, water, and food
  - Determine potential for self-sufficient expansion of base capabilities using indigenous natural or processed resources
  - Determine, through exploration/prospecting, the availability of surface and subsurface resources essential for the future growth of human presence



Human Exploration: Science Objectives

Life Past and Present
- Chemical and fossil evidence of life will be sought by sample return missions
  - Will not allow such life to be characterized at the molecular level
- Positive evidence from sample return will motivate a thorough evaluation of how long such life was sustained and if, in fact, life could be extant
- Human exploration will be enabling to such in-depth explorations
- Extant life could exist in hydrothermal vents or in the kilometers-deep subsurface hydrosphere
  - Samples would allow comparison to terrestrial tree of life
  - Would raise challenging problems of sample contamination and of PQ
- Evidence of ancient liquid water on Mars emphasises the choice of particular sites e.g. paleolakes, regions of past hydrothermal activity, runoff channels

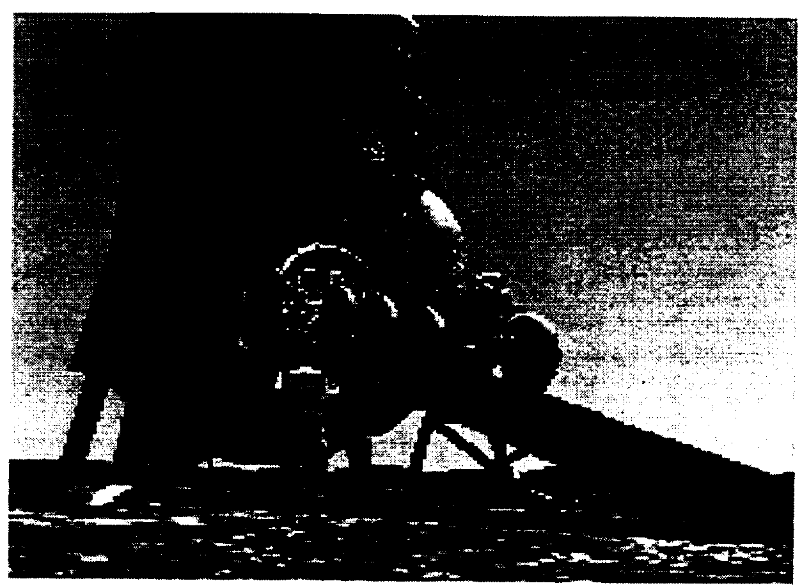


Geoscience and Geologic History

- What is Mars like now?
  - Crust, mantle and core
  - Distribution, type and age of rocks exposed at the surface
  - Is Mars still volcanically active?
  - Is water present in quantity — permafrost and aquifers?
- How did Mars form and how did this compare to Earth?
  - Materials from which Mars formed
  - Accretionary history
  - Timing and nature of differentiation
- How did Mars evolve to its present state?
  - Impact history
  - Volcanic history
    - Is Mars still active?
  - Deformation history and contrast with plate tectonics
  - Erosion and sedimentation history
    - Action of water and ice, atmospheric composition and variation

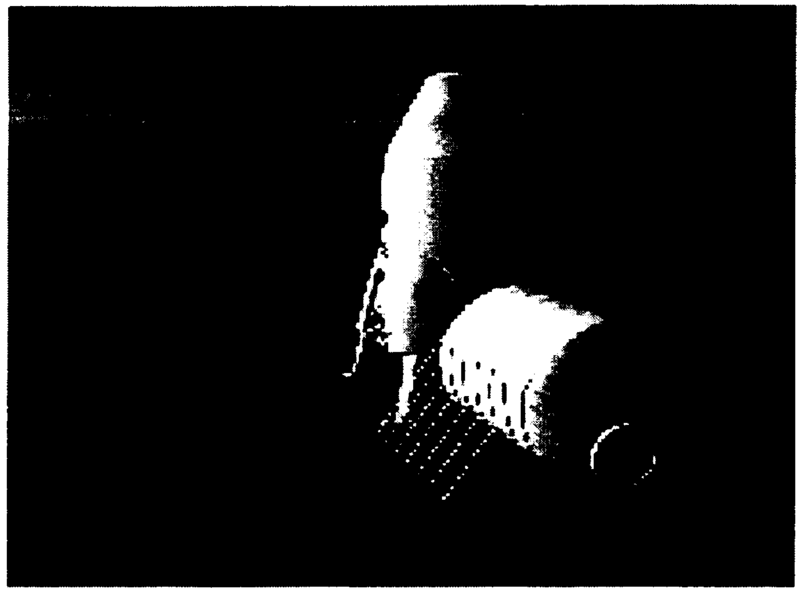
Geoscience and Gelogic History

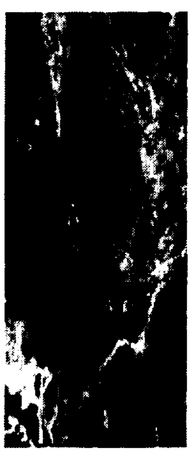
- Precursor missions will allow us to pick sites for human exploration that are both safe and of critical scientific interest
- Crew will carry out Iterative, adaptive field work to collect/ document samples for analysis at the base laboratory and, later, on Earth
  - Systematic survey near base
  - Use of telepresence robots — rovers and airplanes — globally, capable of: returning samples to base; remote sensing; geophysical surveys
  - Pressurized vehicles to increase the radius of action of the crew to hundreds of kilometers
  - Highly capable base laboratory
- Active seismic and em surveys
- Drilling
- Heat flow experiments
- Deploy geophysical stations



Science Objectives -- Considerations

- Science objectives will be achieved primarily through field geologic exploration of sites
  - Capable base laboratory is key to allow rapid interaction
  - Long range transportation is desirable as early as possible
  - Operational autonomy of crew is needed to permit adaptivity
  - Crew will require a range of new cognitive prostheses along with easy communications with terrestrial colleagues
- Complexity/diversity of Mars argues for many bases
- Other considerations argue for one base
  - Maximum/increasing redundancy
  - Maximum/increasing science capability
    - Vehicles, laboratory, drills
  - Quasi-human global access can be provided by telepresence robots





Science Objectives -- Landing Sites

Complexity/diversity of Mars leads to an over-abundance of key sites

A human base that may be the center of operations for many years must be one of compelling and continuing interest

Access to the hypothesized hydrosphere implies that the landing site should be at as low an elevation as possible

Avoidance of seasonal extremes implies a site within the martian tropics

The site of the base will also have to meet other requirements for landing safety and trafficability

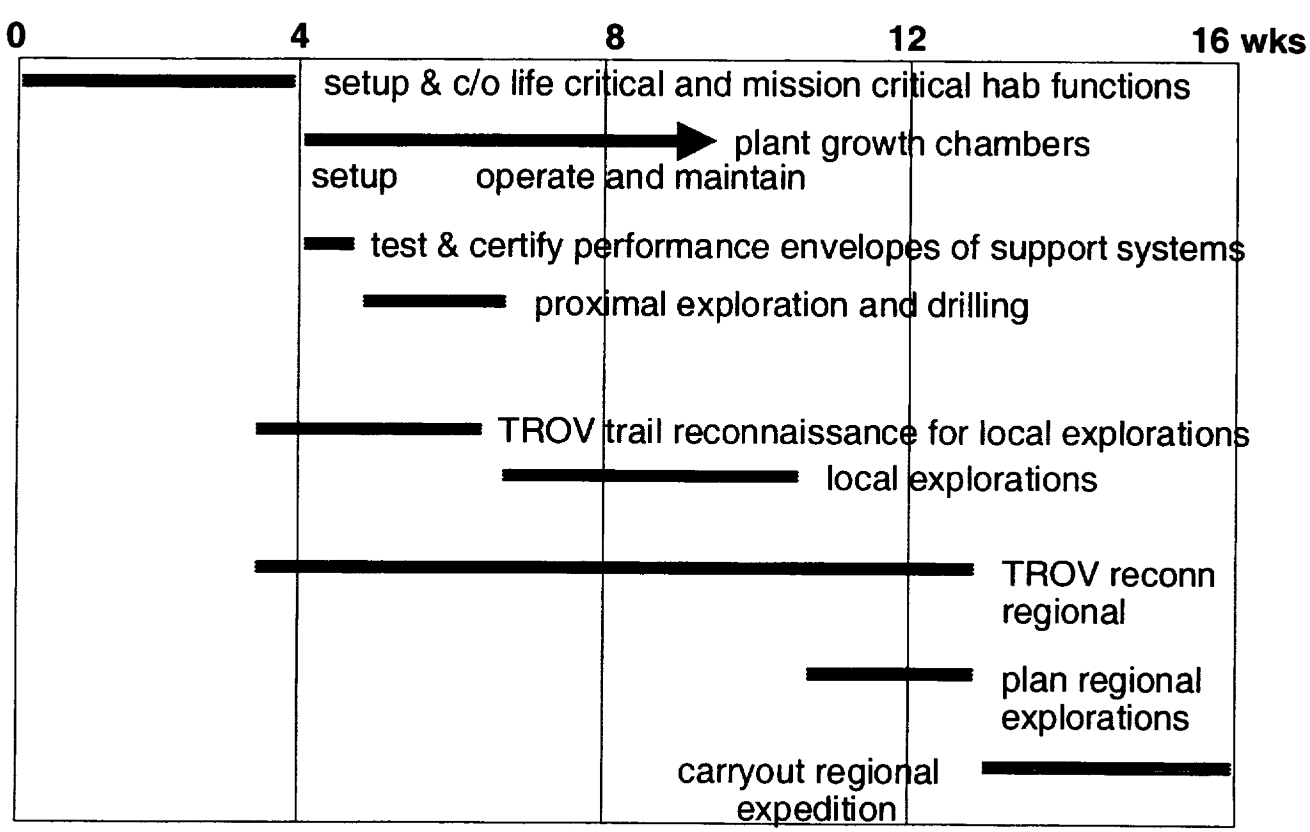
An example of an attractive landing site that appears to meet these needs as we understand them today is:

Candor Chasma in the Valles Marineris

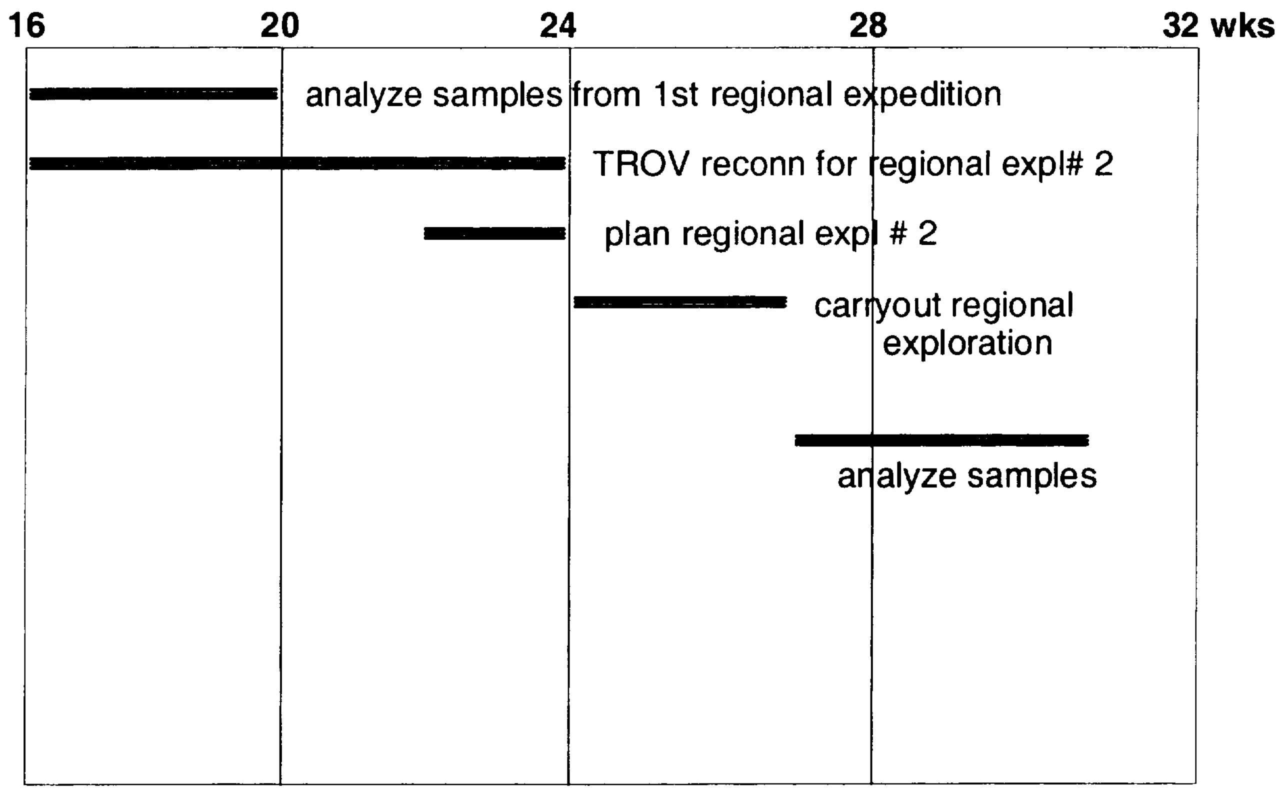
Science Objectives — Allocation of Time

- **Geo-bioscientist *net* time needs to be balanced**
  - **Activity in the field**
  - **Laboratory analysis at base**
  - **Analysis and Interaction with terrestrial colleagues**
  - **Telepresence field work**
  - **Planning field trips**
- **Must have cognitive prostheses and have *support* team of terrestrial colleagues**
- **On a 600 day surface mission, only 60 - 100 days may be spent on EVA in the field**
- **Thorough exploration of the base site, even within 500 km of the base, may take many missions using vehicles of increasing range**

Operation Phases

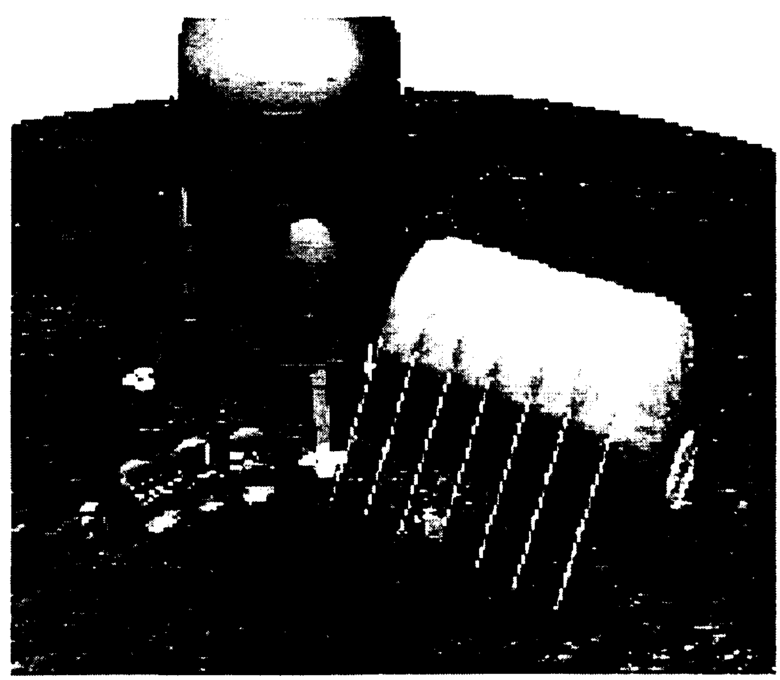


Operation Phases



Habitability Objectives -- General

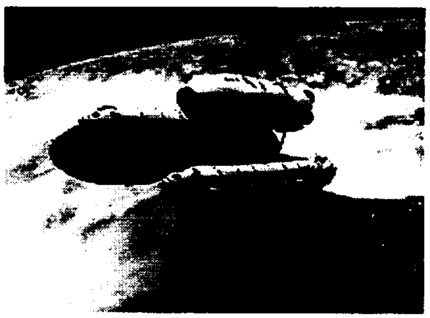
- Demonstrate that self-sufficiency can be achieved on the local scale of a Mars base
- Determine potential for self-sufficient expansion of base capabilities (habitable volume, increased crew sizes, longer duration occupancy, longer range EVA ...) using indigenous natural or processed Mars resources
- Investigate the biological adaptation to Mars over multiple generations of representative plant, animal, and microbial species
- Assay the volatile inventory of Mars available in surface rocks and in the regolith and crust

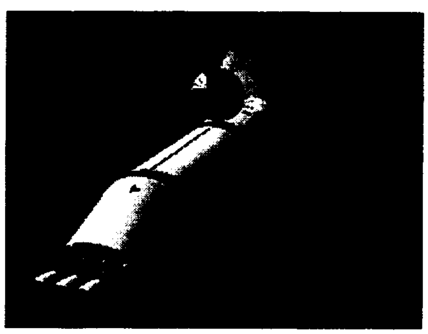


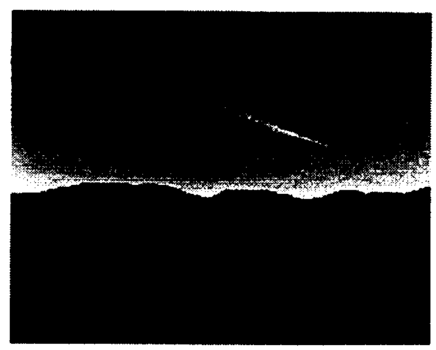
Habitability Objectives
Human Factors Considerations

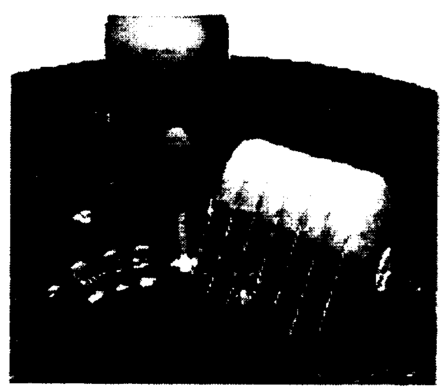
For long duration missions, with inevitably high stress levels, the trade-off between cost and crew comfort must be weighed with especial care —

quality of shelter, water, food, health monitoring, psychological support, communications, rest/ relaxation/sleep, crew factors, crew autonomy, privacy, exercise, human-machine-automation interaction, human-robotic partnership, recreation and entertainment









High quality habitats and environmental design features are critical to relieve stress/increase comfort — increase the likelihood of mission success. Providing little more than the capability to survive invites mission failure.