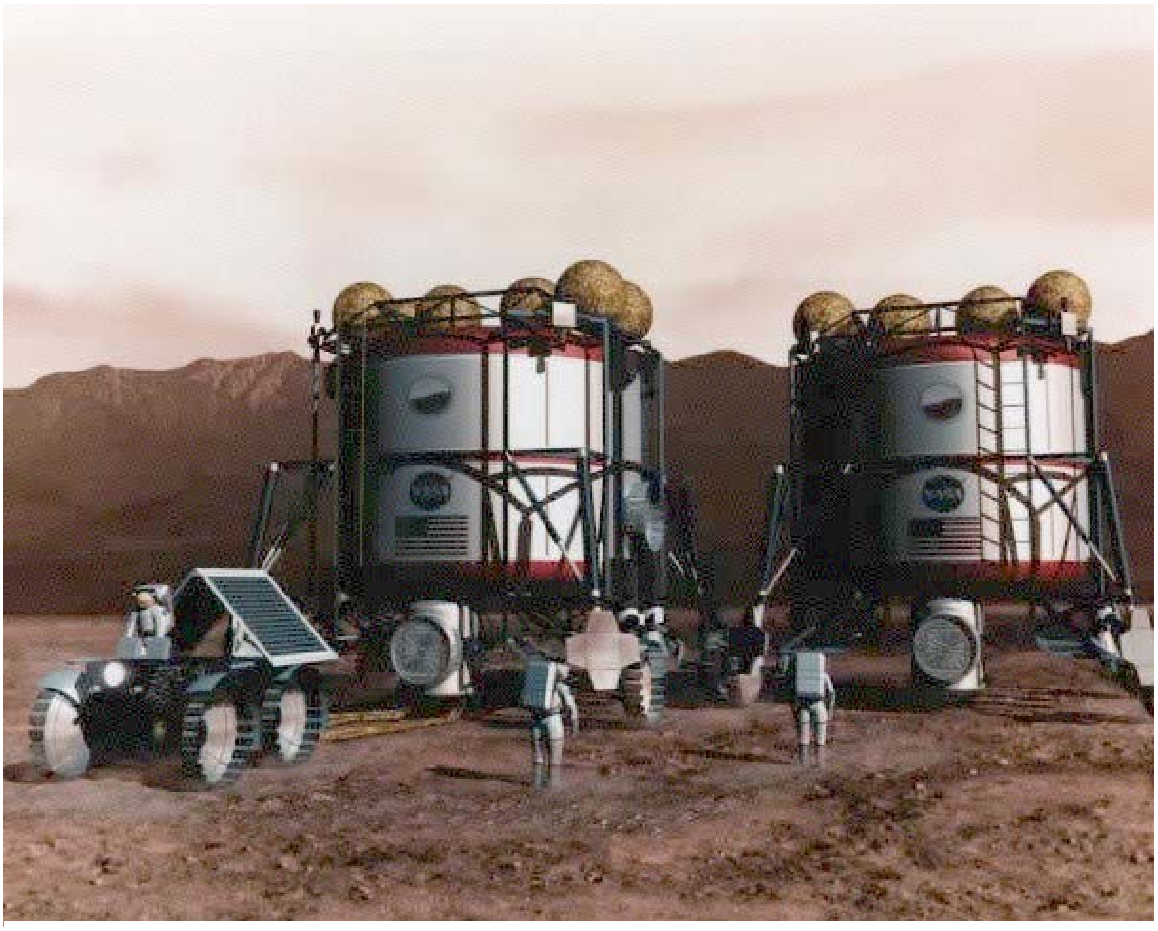
19th Annual Student Space Design Competition

Educational Outreach for the 24th Symposium for Space Nuclear Power and Propulsion
Space Technology and Applications International Forum (STAIF-2007)

Project Statement

Mars Mobile Laboratory

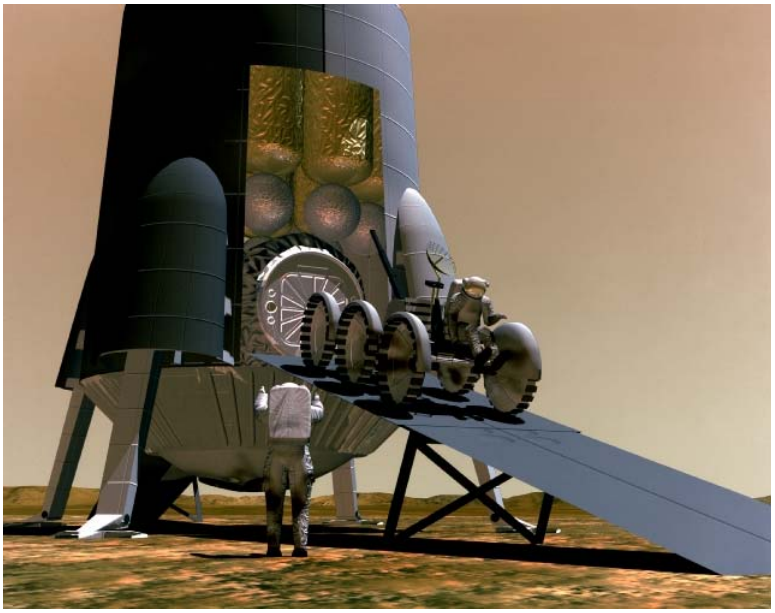


Martian habitat designs developed for the 1993 NASA Design Reference Mission. The habitats are fitted with wheels to allow them to move short distances to join with other landed structures on the surface. Image copyrighted by NASA.

Background

Over the last fifty years, dozens of plans have been developed to land the first human beings on the surface of Mars. NASA's most recent plans were outlined in the 2005 Exploration Systems Architecture Study (ESAS) (NASA, 2005). The study called for astronauts to return to the surface of the moon and ultimately send them to Mars. Using experience learned from the lunar landings and the buildup of a permanent lunar outpost, the first human missions to Mars would begin sometime after 2025 (NASA, 2005; Drake, 1998).

NASA is currently focusing on crewed Mars mission concepts that involve long stays on the planet's surface (NASA, 2005). Long-stay missions at a permanent Martian outpost allow for the shortest flight times, which reduce the crew's exposure to cosmic radiation, solar particle events, and microgravity. However, they require surface stays of 450-600 days or more to wait for Earth and Mars to realign for a minimum energy return flight to earth.



Explorers unload a rover from a cargo lander on the Martian surface. The MML would reach the surface inside a lander with an aeroshell similar to this. Image copyrighted by NASA.

The 1993 Design Reference Mission (Hoffmann and Kaplan, 1997) included three classes of surface exploration scenarios from the base of operations, one of which is regional explorations of up to 500 km from the outpost, lasting up to 20 days. These excursions would require the use of larger pressurized vehicles capable of housing the crew for weeks at a time.

Objective

Year: 2018

NASA has begun plans for the first manned mission to Mars to occur in 2026. Six astronauts will stay on the planet's surface for a period of 500-600 days. NASA wants the crew to explore areas hundreds of miles away from their outpost. To enable this exploration, they have made a call for proposals for designs of a Mars Mobile Laboratory (MML). The MML will be capable of being reconfigured to support different science activities such as geological exploration, astrobiology work, to name a few. The exact nature of the activities will be determined by others and does not need to be handled by the MML design team. In this project, you will design a MML meeting the following requirements:

Mission Requirements:

- The MML must be capable of housing at least four astronauts for up to 30 days. Although missions will last only 20 days, 10 extra days must be in the design to provide a safety margin. Consideration for life support should include:
  - Food and water storage or recycling.
  - Maintenance of a breathable atmosphere.
  - Waste handling.
- The MML must have electrical power for life support, lab equipment, communications, transportation, etc. The power source must be able to operate continuously for up to 30 days without external support from the base. Considerations for powering the MML should include:
  - Type of power generation.
  - Location of power generator as well as fuel/energy storage systems.
  - Power allocation to different systems (propulsion, science, communications, etc). Not all systems need to be powered simultaneously. Energy allocated for the lab equipment should be at least 0.5 kW-hr/day.
  - Power conditioning.
  - Thermal management.
- The concept must detail allocated space for necessary functions and systems, which include:
  - Internal lab space for analyzing, storing, and transporting any samples gathered from the surface. The laboratory area should be versatile enough to handle a variety of different experiments that will be determined by others.
  - Storage space for tools to be used in geology surface activities such as hammers, drills, etc.
  - Living space for the crew to sleep, eat, and perform personal tasks.
  - A control area for piloting the vehicle.
  - A bathroom area for hygiene tasks, such as bathing, grooming, and using the toilet.
  - Allocated space inside or outside the vehicle for equipment used in primary systems (power, thermal, mobility, communications, etc.).
- The crew must be able to enter and exit 5the MML in suits to allow them to work on the surface.
- Mars features varied terrain including craters, sandy rock covered plains, hills and valleys, and icy ground which the concept must be capable of traveling over or across. The nature of the mobility system is up to the design team.
  - Possible mobility methods include but are not limited to:
    - Wheeled or tracked roving vehicle.
    - Legged walking vehicle.
    - Rocket powered ballistic “hopper”.

Astronauts explore rock formations for the remains of fossil bacteria during a long range excursion from the main surface outpost. Art by Pat Rawlings. Image copyrighted by NASA.

- The MML will be delivered to Mars in a cargo bay 11 m long with a diameter of 4.5 m (JPL, 2005). The mass of the MML must be less than 40,000 kg (Drake, 1998). Once on Mars, the dimensions of the MML may be expanded beyond the envelope of the cargo bay. However, there should be "no assembly required".

Assumptions

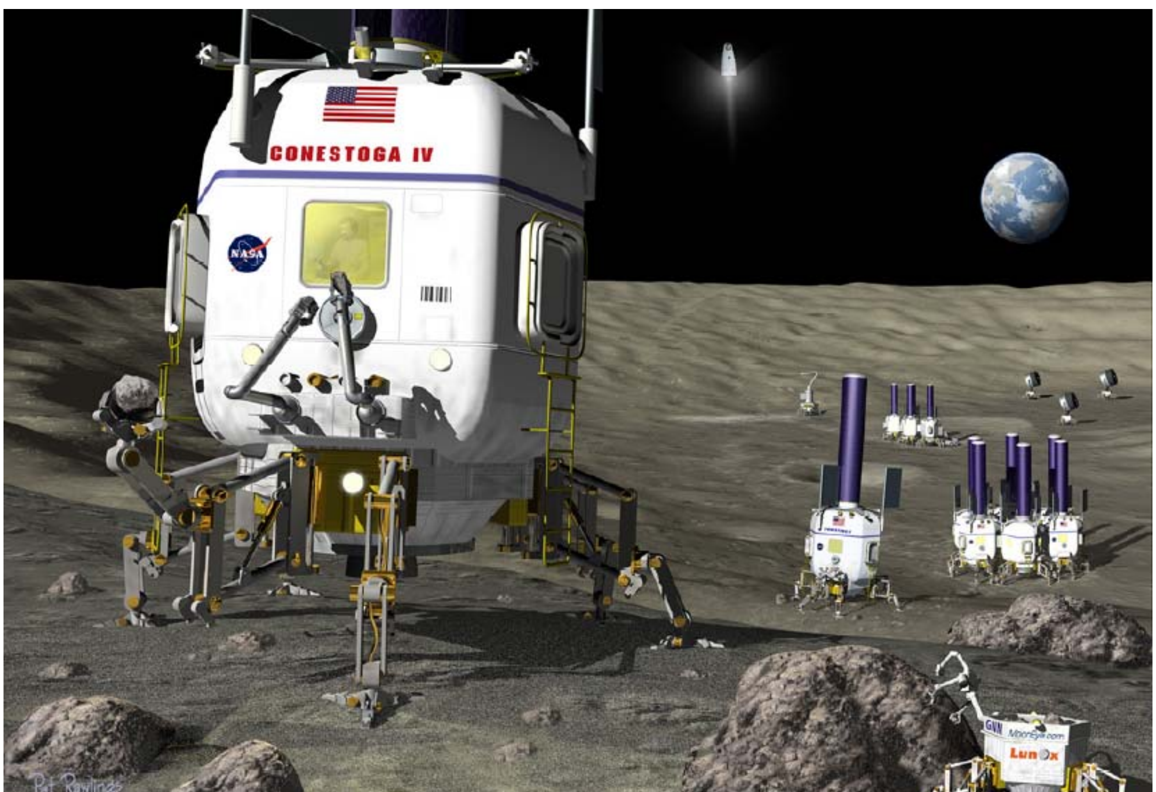
1. The MML will be delivered and deployed directly to the surface from the lander. Designers of this MML need not consider transport of the laboratory to Mars.
2. All experiments will be designed by other scientists and engineers. This project only needs to provide a laboratory platform.
3. Conditions on the surface are consistent with the best current understanding of the planet.

Sources

1. NASA's Exploration Systems Architecture Study: Final Report, NASA-TM-2005-214062 (NASA Headquarters, November 2005)
2. Bret Drake, editor, Reference Mission Version 3.0, Addendum to the Human Exploration of Mars: The Reference Mission of the NASA Mars Exploration Study Team, EX13-98-036 (Houston: NASA Johnson Space Center Exploration Office, June 1998)
3. Stephen Hoffman and David Kaplan, editors, Human Exploration of Mars: The Reference Mission of the NASA Mars Exploration Study Team (Houston: NASA SP-6017, July 1997).
4. "Prometheus Fission Surface Power System (FSPS) - Lunar Task 4", internal JPL/GRC presentation to the ESAS NASA headquarters team. June 2005.

Additional Resources

1. The New Mexico Space Design Competition web page: http://www.unm.edu/~isnps/outreach/SDC.htm)
2. Scientific and/or engineering libraries at the University of New Mexico, New Mexico State University, New Mexico Institute of Mining and Technology, plus other universities and community colleges.
3. The National Aeronautics and Space Administration (NASA) website (http://www.nasa.gov)



Habot is a legged mobile lunar habitat concept introduced by John Mankins. The base is made up of a number of habot modules which can be linked together. A legged walking vehicle presents unique challenges and advantages compared to a wheeled rover. Art by Pat Rawlings. Image copyrighted by NASA.

4. The Jet Propulsion Laboratory web sites(http://www.jpl.nasa.gov) (http://www.nasa.gov/centers/jpl/home/index.html)
5. The Johnson Space Center web site (http://www.nasa.gov/centers/johnson/home/index.html)
6. The Marshal Space Flight Center web site (http://www.nasa.gov/centers/marshall/home/index.html)
7. NASA Technical Report Server (http://ntrs.nasa.gov/) provides a searchable database of NASA reports and publications, many of which are freely available for download in pdf format.
8. The American Institute of Aeronautics and Astronautics (AIAA) website provides a searchable database of publications and papers. At (http://www.aiaa.org), click on “Publications and Papers,” then add your search keywords under “Search the AIAA Electronic Library.”
9. Your school library may have access to Research Databases and Indexes, which can provide full text articles. Recommended databases include Compendex Plus, FirstSearch, etc.