SCIENTIFIC GOALS AND OBJECTIVES FOR THE HUMAN EXPLORATION OF MARS, 1. BIOLOGY AND ATMOSPHERE/CLIMATE. J. S. Levine[1], J. B. Garvin[2], A. D. Anbar[3], D. W. Beaty[4], M. S. Bell[5], R. T. Clancy[6], C. S. Cockell[7], J. E. Connerney[2], P. T. Doran[8], G. Delory[9], J. T. Dickson[10], R. C. Elphic[11], D. B. Eppler[5], D. C. Fernandez-Remolar[12], J. W. Head[10], M. Helper[13], J. E. Gruener[5], J. Heldmann[14], V. Hipkin[15], M. D. Lane[16], J. Levy[10], J. Moersch[17], G. G. Ori[18], L. Peach[19], F. Poulet[20], J. W. Rice[3], K. J. Snook[21], S. W. Squyres[22] and J. R. Zimbelman[23]
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Introduction: To prepare for the exploration of Mars by humans, as outlined in the new national vision for Space Exploration (VSE), the Mars Exploration Program Analysis Group (MEPAG), chartered by NASA's Mars Exploration Program (MEP), formed a Human Exploration of Mars Science Analysis Group (HEM-SAG), in March 2007. HEM-SAG was chartered to develop the scientific goals and objectives for the human exploration of Mars based on the Mars Scientific Goals, Objectives, Investigations, and Priorities.[1] The HEM-SAG is one of several humans to Mars scientific, engineering and mission architecture studies chartered in 2007 to support NASA's plans for the human exploration of Mars. The HEM-SAG is composed of about 30 Mars scientists representing the disciplines of Mars biology, climate/atmosphere, geology and geophysics from the U.S., Canada, England, France, Italy and Spain. MEPAG selected Drs. James B. Garvin (NASA Goddard Space Flight Center) and Joel S. Levine (NASA Langley Research Center) to serve as HEM-SAG co-chairs. The HEM-SAG team conducted 20 telecons and convened three face-to-face meetings from March through October 2007. The management of MEP and MEPAG were briefed on the HEM-SAG interim findings in May. The HEM-SAG final report was presented on-line to the full MEPAG membership and was presented at the MEPAG meeting on February 20-21, 2008.

This presentation will outline the HEM-SAG biology and climate/atmosphere goals and objectives. A companion paper will outline the HEM-SAG geology and geophysics goals and objectives.

Why Mars? Mars is a diverse and complex world. Many of the same processes/mechanisms have operated and still operate on both Earth and Mars, including a period of early heavy bombardment, the formation of impact craters, the existence of a planetary dipole magnetic field, periods of extensive and widespread volcanism, the existence of surface liquid water, the geochemical cycling of elements between the surface and the atmosphere and the condensation of atmospheric gases forming polar caps, etc.

The geological record suggests that the atmosphere and climate of Mars may have changed significantly over its history. Early Mars may have possessed a denser atmosphere, perhaps with a surface pressure approaching or even exceeding 10000 millibars, the surface pressure of the Earth's atmosphere. A denser atmosphere would have permitted liquid water on its surface. Today, Mars has a thin (6 millibars) atmosphere and liquid water is not stable on its surface for any length of time. Why did Mars change so drastically over its history compared to Earth? What can present-day geological features and geophysical measurements tell us about the history and evolution of the interior, surface and atmosphere of Mars? How extensive and widespread are sub-surface volatiles on Mars? How has the habitability of Mars changed over its history? Was early Mars an abode for life? Is present-day Mars an abode for life? Is there a lesson in the history of Mars to better understand the future of the Earth? These are but a very small subset of the questions that humans on Mars can address.

Why Humans? Humans are unique scientific explorers. Humans can obtain previously unobtainable measurements while on the surface of Mars. Humans possess the abilities and intelligence to adapt to new and unexpected situations in new and alien environments. Human explorers can make real-time decisions. Human explorers have strong recognition abilities. Human explorers can perform detailed and precise measurements of the surface, sub-surface and atmosphere of Mars with state-of-the art scientific equipment and instrumentation. Human explorers can perform detailed and precise in situ analysis on the surface of Mars. The HEM-SAG envisions that the scientific exploration of Mars will be performed as a synergistic partnership between humans and robotic probes, controlled by humans on the surface of Mars. Robotic probes can travel great distances and explore terrains and geologic features not suitable or too risky for human exploration. For example, under human control, robotic probes can traverse great distances from the human landing site and collect and return rock samples to the human base from great distances. At the human landing site, these rock samples can be analyzed and studied on the surface of Mars.

Background and Assumptions: Forecast of science knowledge by this time (~2030): HEM-SAG assumed that the current complement of missions and all on-the-books missions have been flown, that more rovers have successfully flown, that a Netlander-like set of penetrators has flown, and that a sample return mission has been flown, successfully returning samples from the Martian surface.

Infrastructure and Human-Risk Concerns: HEM-SAG assumed the existence of an extensive orbital communications infrastructure, and robotic cargo vehicles (armed with weather stations and robotic recon vehicles to assist in final traverse planning) delivered to the landing site in the previous window. We assumed that all major human-risk issues (e.g., toxicity, radiation, dust hazards) had been resolved or dealt with by research and robotic precursor missions.

Fundamental Requirements for Human Exploration Planning: HEM-SAG assumed that global landing site access was required on the basis of the nature of scientific exploration and the wide range of specific problems to be investigated. This assumption mirrors the consensus of the recent Human Lunar Exploration Planning Workshop in Arizona. We assumed that landing sites similar to those of the Apollo Lunar J-Missions (Hadley-Apennines, Descartes Highlands, Taurus-Littrow) could successfully be accessed on Mars. We assumed that there were no specific human safety landing (e.g., roughness) or operational (e.g., trafficability) constraints. These assumptions are justified on the basis of the success of the Apollo J-Missions, the ~60-year time period between these and the first human Mars mission, and the technology/capability development during this time.

Architecture for the First Three Human Missions: HEM-SAG assumed on the basis of the previous considerations, that the three-mission planning architecture would be Apollo-like, not ViSE-like. "Apollo-like Architecture" means wide surface access, with each mission targeted to a different site at different latitudes and longitudes to optimize scientific exploration. "ViSE-like, or Shackelton-like Architecture" means that all three missions are sent to the same site chosen on the basis of mission operations constraints with the goal of infrastructure development, not exploration.

Mobility and scientific equipment: HEM-SAG assumed a minimum baseline capability of Apollo-like LRV or Mobile Habitat transport for humans out to a radius of ~200 km from the landing site and robotic extension out to a greater radius.

Single vs. Multiple Site Missions: There is no site on Mars that spans the diverse range of surface processes or mineralogy that Mars exhibits. Therefore, it would be necessary to study a multitude of sites to provide context and form conclusions about the geologic history of the planet. Strategic planning of exploration sites could potentially reveal deposits that are consistent over regional and potentially global scales. Several of our fundamental questions *require* multiple sites; crustal magnetism in the Noachian cannot be studied in the same region as Amazonian lava flows, for instance. While any one site would be interesting, no individual site would provide the necessary data to make firm conclusions about the geologic history of Mars.

Mission Surface Stay Time: Members of the HEM-SAG team have multiple field seasons of experience in harsh climates on Earth, from the bottom of the ocean, to the Canadian arctic, to the Dry Valleys of Antarctica. The overwhelming consensus is that a long-duration (500 day mission) is not only recommended, but required to yield significant science return worthy of the time and effort needed to get to Mars. The first week of any human mission to Mars would be occupied by setting up a base camp, establishing communication systems, initial exploration of science targets, and general acclimation to the environment. If this were a 30-day short-stay mission, little time would be left for scientific analysis before preparing to depart. Astronauts will encounter unexpected features on the surface and time must be allotted in the mission to allow them to explore and design experiments at the exploration site.

A key focus of any human mission to Mars will also be monitoring how active the surface of the planet is today. Staying for almost an entire Mars year will permit detailed analysis of aeolian activity and will provide valuable insight into the climate of present-day Mars. Provocative new observations from the Mars Orbiter Camera have also suggested that liquid water may exist transiently on the surface of Mars today, and a long-duration mission would maximize the chances of observing this phenomenon.

References: [1] MEPAG, 2006. Mars Scientific Goals, Objectives, Investigations, and Priorities: 2006, J. Grant, ed., 31 p. white paper posted February, 2006 by the Mars Exploration Program Analysis Group (MEPAG) at http://mepag.jpl.nasa.gov/reports/index.html.