STRATEGY FOR THE EXPLORATION OF MARS. M. P. Golombek, Jet Propulsion Laboratory, Caltech, Pasadena, CA 91109.

Introduction: This abstract discusses a strategy for the scientific exploration of Mars by reviewing those that have been proposed previously by various science advisory groups. The strategy for exploration is based on first obtaining a global assessment or reconnaissance level of knowledge about Mars before more detailed study of specific locations with large rovers and sample returns. It also suggests a progression of missions and information needed for setting up outposts and ultimately eventual human exploration.

Review of Exploration Strategies: About 10 years ago the NASA appointed Mars Science Working Group prepared “A Strategy for the Scientific Exploration of Mars” [1]. This document was prepared in response to the Space Exploration Initiative [2], which proposed a new roadmap for exploring space. Although the Space Exploration Initiative was never carried out, the report by the Mars Science Working Group [1] stands as the last comprehensive strategy document to review the science objectives and precursor knowledge required for human missions and to propose a strategy for exploring Mars. This document reviews previous COMPLEX [3, 4], Space Science Board [5], and SSEC reports [6, 7, 8] and proposes a strategy for exploring Mars leading up to human exploration. The strategy proposed was reiterated by subsequent COMPLEX [9], SSES [10], OSS [11], and ESA [12] reports until the Mars Surveyor Program was instituted [13].

The exploration strategy suggested [1] involves an initial phase of global assessment in which information is gathered on the distribution of materials, environmental conditions and the geological, biological, and climatological history of the planet (Fig. 1). This reconnaissance phase of exploration included both global remote sensing (obtained by Mars Observer at that time) and a network mission to obtain “ground truth” at a number of sites. This ground truth was intended to provide calibration points for the global remote sensing data in terms of both the chemistry and mineralogy as well as the distribution and type (rocks, soil, sand, etc.) of surface materials. This reconnaissance phase of exploration was followed by a more detailed evaluation of specific locations that appeared scientifically or programmatically interesting. This phase of exploration used site characterization orbiters, rovers and sample returns to obtain detailed information of a smaller number of sites before a site was selected for a robotic outpost or human landing (Fig. 1).

A review of how the recommendations of COMPLEX, SSEC, and SSES have varied through time [1-11] shows that the missions recommended by these science advisory groups generally follow what the engineering community believes is possible within the programmatic environment. From the 1970s through the mid to late 1980s, investigations of local sites and sample returns were stressed over global investigations. With the scientific realization from the study of Viking orbiter data that the climate may have varied with time on Mars and that the early environment may have been different than today’s, global scale investigations were emphasized. Sample return missions were effectively abandoned by the early 1990s [e.g., 4, 9] after the results of the Mars Rover Sample Return study showed how expensive this class of missions are and as the programmatic environment stressed less expensive missions. By the mid 1990s the science advisory groups were advocating a global remote sensing mission that was followed by a network mission [9, 10]. By the late 1990s, sample returns were again stressed [11] in response to the putative evidence of life in the Mars meteorite Alan Hills 84001. The recent loss of the Surveyor missions in ’98 and technical and cost studies of sample return missions have resulted in a re-evaluation of the Mars Exploration Program. As was the case for previous changes in the recommendation of these advisory groups, there have been few changes to the important scientific questions and objectives for Mars; what has changed has been the relative emphasis of certain kinds of science and the programmatic environment.

Exploration Strategy: There are many advantages to performing a phase of truly global reconnaissance before committing to the detailed exploration of particular locations as outlined by the Mars Science Working Group [1]. At the most general level, obtaining information to answer general questions prior to obtaining information to answer very specific questions yields a logical progression of knowledge about a planet. What rock types make up the crust of Mars? What are the 100 or so morphologic/geologic units mapped from the Viking images? What is the internal structure of the planet? Is it still geologically active? What is the climate on Mars and how does it vary with time? These are all basic questions that need to be addressed along with the specific questions that drive the program (life, climate and resources). In fact it can be argued that trying to answer the questions that drive the program without also addressing other fundamental aspects of Mars produces a less balanced
flow of information that could lead to erroneous conclusions.

Global reconnaissance involves both global remote sensing as well as obtaining "ground truth" for calibrating that remote sensing data. Just as a field geologist might begin interpreting airphotos before mapping an area, he or she would certainly go into the field to check those interpretations before actually carrying out detailed field mapping. This phase of ground truth should not be limited to near equatorial latitudes, but should investigate the planet from pole to pole. The importance of obtaining ground truth information from the higher latitudes is particularly important for future human exploration. Landing sites and outposts for human missions likely will be driven by the availability of resources, such as water, which may be more prevalent at higher latitudes. The exploration of higher latitudes is thus equally important to the study of life, climate, and resources.

Performing this phase of global reconnaissance before selecting sites for more detailed study will allow the return of samples to Earth better suited to addressing the program goals than if a sample return site were selected without this information. In particular, obtaining multiple ground truth sites will allow a much better understanding of the diversity of materials available on Mars. Selecting a landing site with this information will result in a site and samples much better suited to addressing the objectives of the program (life, climate and resources). Without the ground truth, there will be substantially more uncertainty in the interpretation of what is actually at the landing site than if the remote sensing had many calibration points.

The global reconnaissance phase of exploration can be accomplished in a number of ways; generally, orbital remote sensing missions followed by ground truth at a large number of locations or network missions are considered. This reconnaissance phase of exploration would be followed by the detailed study of locations by rovers where the most important scientific questions can be addressed, including the return of samples from these locations.