N87-17766

MANNED MARS MISSION AND PLANETARY QUARANTINE CONSIDERATIONS*

Joseph C. Sharp
NASA Ames Research Center
Moffett Field, California

ABSTRACT

A short review of the history of planetary quarantine, the issues and changes in official advisory groups' pronouncements are presented. Then a discussion of the current situation and some ideas on how best to address them are outlined. Both manned and unmanned or automatic missions are discussed and their advantages and impediments outlined.

The first, and probably the most vexing aspect of this issue is the insufficiency of data that are both conclusive and relevant. Data are needed both about the presence (or its historical existence) of life on Mars, and about the conditions on Mars that may support "foreign" life forms. As a consequence of this paucity of data, proponents of any one side of this multifaceted issue have and will continue to profess the probity of their beliefs. More, better and germane data will tend to lessen the intensity of the discussions.

A little background and a review of the history of Mars Planetary Quarantine will be useful to those unfamiliar with the issues. When exploration of the solar system started to become practical back in the 1960's, there was concern that some terrestrial organisms might be carried to a planet and thereby establish themselves in their new environment. Once established on this non-terrestrial planet or satellite, it was feared that terrestrial organisms would upset the natural environment there and destroy or modify it irrevocably. The subsequent study of such a "contaminated" body would, therefore, become much more complicated and confusing. This would be especially true if the objective was the study of extraterrestrial biology. For these reasons, there was general agreement among scientists that solar system research should be conducted in ways that virtually precluded earthly organisms from "contaminating" the target body. This principle was discussed on an international level by delegates to the Committee on Space Research (COSPAR). These discussions resulted in a resolution establishing a criterion of 10^{-3} chance of contaminating a planet like Mars during the period of "biological exploration." The time period of "biological exploration" was at first assumed to be 20 years. More recently, the period has been extended to 50 years.

The United States and the Soviet Union approached the problem differently. The United States used an analytic approach; that is, all known (or assumed) factors that could lead to "contamination" were considered. Some of these factors were: determination of the "biological load" of a spacecraft (what numbers and kinds of organisms were launched with the vehicle), detailed assessment of the probability of survival of the organisms during the flight to the planet and during entry into the planetary atmosphere, and most important, the probability of growth (P_G) in the organisms' new environment (assuming viable organisms reach the planetary surface - or atmosphere). Of course, there was and is, no way to accurately calculate P_G. It's estimate was based on what we knew of the particular solar system body in question, and in the case of Mars, upon simulation experiments to determine the viability of terrestrial organisms in the Martian environment. The actual setting of P_G on Mars was based on a study of all relevant information available at the time by the Space Science Board of the National Academy of Science. For most solar system bodies, the estimate of P_G was so low that the COSPAR criteria could be met by simply sending a reasonably clean spacecraft. The P_G for Mars was estimated to be high enough to require positive measures to drastically reduce the load at launch. This led to a requirement that the Viking landers be heat "sterilized", as well as protected from later contamination during passage through the Earth's atmosphere.

The Soviet Union implemented the COSPAR resolution by a combination of heat and chemical "sterilizations", followed by an actual determination, of a duplicate spacecraft literally ground up and cultured for all possible organisms. The results claimed to show that no organisms survived these procedures, and hence, there was no chance to contaminate Mars (Vashkov, et al., in "Life Sciences and Space Research", XII, 199, 1974).

NASA has recently developed a new strategy to comply with the COSPAR guidelines on out-bound spacecraft. At COSPAR's last session, this new strategy was accepted. This strategy no longer requires an estimate of P_G. The new proposal suggests establishing, a priori, five categories of solar system missions, and for each category indicating what level of concern exists, and what quarantine measures would be activated for each category. This determination of categories does not, in my view, change the fundamental problem; the stipulation of what category and particular mission will be assigned will be based upon "advice from the scientific community" (in the United Stated probably the Space Science Board). For Mars, some sort of collective judgement will still have to be made, taking into account the planet's "friendliness to terrestrial organisms". This process of determining a judgement is, essentially, what went into establishing a P_G for Mars in the first place.

What is the current status of our knowledge about the environment on Mars relative to growth of terrestrial organisms? As the consequence of a post-Viking assessment of Viking data, the Space Science Board has reduced the P_G for Mars (NASA Publ., "Recommendations on Quarantine Policy", 1975). These recommendations were largely based upon finding no detectable organic compounds at the two landing sites (even in a protected area under a rock); the extremely oxidizing nature of the surface material; and the very high UV flux at the surface. All these facts point to an extremely harsh environment for living organisms from Earth. A note of caution however, viable cocci (bacteria) were brought back in Surveyor equipment by the Apollo 12 crew after several years on the Moon. The environment on the Moon is considered to be far more severe than that of Mars! It would be relatively easy to agree that some terrestrial organisms might survive (not necessarily reproduce) for a long time in some protected niche on, or in, Mars. As an extension of this line of reasoning, most scientists probably would agree the chances of terrestrial organisms eventually growing on Mars is exceedingly low, but their growth cannot be ruled out. If one must be sure of no growth, we would introduce no organisms into the atmosphere, and especially onto the surface of Mars.

What then are the quarantine issues of landing people on Mars? Assume the landing would accur prior to obtaining any relevant and substantially new Martian data. For example, data from the proposed MGCCO mission would alter thinking on this matter by providing a more detailed understanding of the water budget on Mars.

Two or more decades from now, will anyone care whether Mars is contaminated with terrestrial organisms? Almost certainly! While there appears to be a lessening in the fervor of those concerned with this problem, when the time comes, they will probably make an issue of any contamination. Some scientists, truly interested in comparative planetology, will not want to take the risk of introducing terrestrial organisms into the Mars environment. Finally, there will still be open the most fundamental questions, to laymen and scientists alike, of whether indigenous life exists on, or in, Mars. Scientists will probably attempt to insist on an exhaustive test of this idea, and to do so without introducing terrestrial organisms into the environment, assuming none will have been introduced prior to the manned mission.

In order to eliminate or to minimize the risks of contamination of Mars by a manned mission to that planet, should that be our policy, two approaches are available. First is absolute containment of all terrestrial biology while at Mars, and second is obtaining the requisite information prior to sending people. In principle, it would be possible to provide adequate technologies to achieve the former. People do work with very dangerous and highly infectious agents on Earth. An entire technology has been developed to contain these agents. Using a "sterilized" lander (as done with Viking), with adequate filter, vents, pressure regulators, etc., to prevent the escape of spacecraft atmospheric particulars upon human egress and during EVA on Mars. The EVA systems could not leak, as do all current systems. All this would be terribly expensive, but in the long run it may be the only sure approach and it will work only if no failures occur. An intermediate approach would be the use of automated or telepresent devices in place of the humans. The people might be kept in orbit or in a sterilized lander. The rovers and science instruments would, of course, all be sterilized. Since people on or near Mars are going to have to carry their own life support systems with them (either as spacecraft, EVA suits, landers, rovers, etc.) the design of all such systems have to incorporate this very stringent specification.

The second approach to helping eliminate the risk of contaminating Mars is fraught with serious difficulties. Prior to sending people to the surface, we must obtain the necessary information to assure that contamination cannot occur. In the past, many investigators have performed simulations to determine if organisms can grow in the Martian environment, both in the United States and in the Soviet Union. These efforts have shown the UV flux on Mars was the single most potent deleterious agent to terrestrial organisms. It could always be argued that almost any thin layer of shielding material could protect terrestrial organisms, even on Mars. In this connection, it may be of some use to again consider simulation studies. These should be done in the light of Viking data from Mars (e.g., if there is actually no organic material in the Martian environment, which terrestrial organisms could possibly maintain themselves there? What would they eat? If they were photosynthetic, how could they obtain their radiant energy while protected from the UV, etc.?) Some in-depth studies might be useful when the time comes to place a Mars mission into one of the five NASA planetary quarantine categories. In this regard, more information about what makes the Martian "soil" could be extremely useful. We do not know which, if any, nitrogen-containing compounds are in the surface material. If all the nitrogen on Mars is in the atmosphere, this would drastically reduce the kinds of terrestrial organisms that could grow there to a few species of blue-green algae and bacteria. What is the nature and distribution of the postulated oxidizing matter on Mars? As mentioned above, a thorough knowledge of where the water is on Mars, and what translocations of water occur would help immensely in putting limits on the prospects of contaminating Mars.

For these and similar reasons, the more information about Mars that can be obtained on precursor missions the easier the design specification for the manned missions would be. A series of carefully thought-through precursor missions designed to glean data to better assess the probability of contaminating Mars would probably be money and talent well spent. In the final analysis, it must be recognized that all data collected about Mars will serve for ever more accurate analytic assessment of whether or not terrestrial organisms can survive, and grow on Mars, thereby "contaminating" it.

In the end, the best case that can be made to allay the concerns of whose who would protect Mars from terrestrial organisms will be the design of a system that contains <u>all</u> terrestrial organisms. It is quite certain that analytic methods will never give the confidence that well-developed systems and carefully thought-through procedures will give. The pragmatic issue will ultimately be a weighing of the costs versus some ill-defined confidence level. It seems this sort of trade is the forte of NASA and its associated "advisors."

*Many of the ideas and issues in this paper are taken from the work of H. P. Klein. His help in formulating the positions taken herein are appreciated by the author.