Comparing Strategic Knowledge Gaps for Human Mars Settlement vs. Exploration.

B. A. Mackenzie[1], [1]Mars Foundation (BMackenzie@alum.mit.edu)

Introduction: An increasing number of people are questioning whether it is possible, and even desirable, to establish a permanent Mars base without conducting human exploration missions beforehand. The major advantages are to eliminate the cost and risk of the return flights. It also avoids the delay of creating and funding a follow-on program for settlement. There may even be more public interest and funding available for a settlement program, compared to the perception of a 'flags and footprints" exploration program.

We list some of the areas of knowledge which would be helpful before establishing such a permanent Mars base, compared to the knowledge needed for round-trip human exploration missions (also known as "Strategic Knowledge Gaps"). Topics include: site selection, reliable access to water, long term effects of various contaminations, and in-situ materials production.

Site Selection / Water supply: For a permanent base, access to water may be the most important site selection criteria. Ideally, a permanent base would be near deposits of ice or permafrost, to use as a source of water. But, the base itself should be on solid ground, to avoid having the habitats or equipment sink if underlying permafrost is accidentally melted. An ideal location might be on a basalt deposit adjacent to an icy alluvial deposit (an ancient river or lake bed), where we can excavate material, evaporate water from an ice deposit.

For an exploration mission, we may choose to recover water from the Martian atmosphere, even if that requires significant energy. This would allow it to be independent of the local site, perhaps even mobile.

Contamination: Trace elements may build up in the habitat environment, food supply, or crew's bodies. These could be from dust brought in after EVA, in-situ produced water or air, or food grown on-site.

An exploration mission might bring food staples from Earth, and only grow salad vegetables, using hydroponics with plant nutrients from Earth. The crew members would only be subjected to possible contamination for less than 2 years while they are on the surface, so a buildup of trace contaminants in their bodies is less of a concern.

In contrast, a permanent base must grow its own food. We propose that a good starting system would be gravel-bed hydroponics, using washed gravel from other excavations. As soon as we have biomass to compost, we may wish to start soil based agriculture. We need to know how soluble various chemicals are in the local regolith. In particular: are we able to deliberately leach out any harmful chemicals? And will chemicals in the gravel or soil continue to leach out and contaminate our food supply?

InSitu Material processing: Can habitats, furnishings, and equipment be manufactured from the local regolith and atmosphere? Possible in-situ manufactured construction materials include: sintered regolith bricks, sintered dust, melted/cast regolith blocks, glass or glass-like materials, basalt fiber, fiber glass, cast basalt, glass block. From the C02 and water, we can make: polyester, other plastics for plastic sheet and 3D printers, plant products such as fiber board and paper.

Scientific studies are focusing on what elements or minerals are present in the regolith for geologic study. For manufacturing, we need to know how they behave in refining processes, and material properties, such as tensile/compressive strength after being drawn into basalt fiber, or sintered into bricks. It would give us more confidence if we could just fuse some regolith on Mars. This would probably take far more energy than would be available from solar panels, or an RTG. But, if we are testing in-situ propellant production on Mars, there might be some surplus methane which could be burned to test sintering of regolith. A dramatic video demo would be to point a miniature rocket motor at the ground, melting the regolith under it.

Agriculture Demo: A dramatic demo would be miniature greenhouse in a Mars lander. We could germinate seeds, and grow the plants for a short time, especially for food crops. There are obvious concerns about biological contamination. This might be of questionable scientific value, but would focus the public's attention on prospects of human exploration and settlement of Mars. To improve the scientific / exploration value we could test the effects of radiation, shielding, or expose the plants to small quantities of regolith and Martian air.

Local Environmental Conditions: All equipment used outside at a permanent base should be designed to last multiple decades, compared to a couple of years for an exploration mission. Thus it is even more critical to understand the effects of atmospheric dust and aerosols, temperature variation, radiation and other environmental conditions.

Less Important: Some information may be somewhat less important for a permanent settlement program, compared to round-trip human exploration missions. Production of quality rocket fuel for ascent vehicles is not critical. Although, we would still want fuel for vehicles and portable equipment, but these could be low Isp fuels such as carbon monoxide-oxygen, instead of methane (CH4) or other fuels with better Isp. The crew will spend less 'long duration' time in space, since it is a one-way trip, not round-trip. Thus health effects of microgravity will be less important, but we should spin the craft for artificial gravity, anyway. On a final note: Back contamination as crew members return to Earth can be avoided, but the relatives of the settlers may object to that.