**Anticipating Challenges & Opportunities in Planning Human Mars Missions**

**ADDRESSING SCIENCE, TECHNOLOGY, PLANETARY PROTECTION & SOCIETAL ISSUES**

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**OVERVIEW**

In recent strategic planning workshops & studies of long-duration human missions to Mars, experts in astrobotany, mission planning, technology, and commercial communities have focused on important topics and issues that could adversely impact realization of long-term science exploration goals and human missions during the coming decades. There is a clear need for pro-active, coordinated, cross-cutting efforts focused on:

- Development of Planetary Protection (PP) policy requirements for Human Missions and filling key knowledge gaps that have implications for outbound and return mission phases, as well as science exploration and activities on Mars.
- Integrating information from multiple R&TD areas early in mission design to ensure science-supportive infrastructure beyond Earth orbit that also enables safe and reliable long-duration human transportation and habitation on the Mars surface (significantly different than human missions in LEO).
- Continue updating Science Information about Mars and Adopting advances in IT and robotics that may approach human-level capabilities, thereby enabling improvements in science exploration, effective planetary protection, and ensured human health and safety during long-duration missions.

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**NASA WORKSHOP (2015)**

**Workshop Objectives:**
- Capture the State of Knowledge, Identify Key Knowledge Gaps
- Determine R&T& Needs

**25 Knowledge Gaps & R&T Needs in 3 areas:**
- Many cross-cutting issues involve combinations of info on science, health, Mars environment, and technology & operations.
- Identify levels address current COSPAR PP Principles and Guidelines for Human Missions

**MICROBIAL & HEALTH MONITORING**

- What microbial sampling and collection tech & procedures should be used?
- What are/are appropriate technologies for microbial monitoring to mitigate risks to crew, ensure planetary protection & vol. integrity?
- What methodologies and procedures should be used for sample processing to reduce crew time and mitigate contamination concerns?
- What tools and procedures should be used for data collection, storage, and interpretation during missions?
- What is understood about specific microbial responses & heritable changes during extended spaceflight on planet X?
- What are/are needed to determine microbial populations of substrates, vehicles and external environment?
- Develop novel approaches for low toxicity disinfectants and for prevention/recovery from biofilm induced corrosion, fouling
- What diagnostic & treatment options/studies are needed to understand crew health & biomedicine related to microbial & contamination exposure?
- What information is needed to develop acceptable/actual, ethical & operational guidelines for human missions to Mars?

**Technology & Operations for Mitigating & Controlling Contamination**

- Do species escape from PP systems onto surface?
- What is acceptable containment of wastes intentionally left behind (type, location, duration)?
- What are acceptable constraints and procedures on vented materials?
- What microbial contaminations are acceptable from an EVK system? (what concentrations? What are implications for suit material, cleaning tools, collection tech & procedures on vents?

**Natural Transport of Contaminants**

- How do interactions of bioaerosol affect mission success?
- What is the potential for survival and replication of very hungry micromotes in our environ or mission success lines is limited?
- What data or models needed to determine what happens to wind-driven dust, i.e., where might it go? Also, need understanding meteorological conditions throughout several years at particular site(s).
- What is the probability of entraining a highly terrestrial microbe to Mars via different pathways on a human mission?
- What will leak or vent out of pressurized containers or human facilities? (ozone, volume, biological diversity, organic molecules, etc.)
- Antibiotics used during nominal operations? (significant degradation of materials? Differences between active venting vs. leaking?)
- How will we study uncharacterized microorganisms? (methods/tools/etc.)
- What proportion of the entire community do we represent? How can we assess/monitor their viability?
- Understand & establish acceptable contamination generation rates/thresholds for human landing sites (in social sites as point sources of contamination of microbes or organic particles).
- Understand acceptable contamination generation rates/thresholds for human landing sites in context of subsurface contamination, and IMRF of polar regions.

**CONCLUSIONS**

- Stay the course --
- Continue the incremental path forward as outlined in NPI 8020.7. Addressing the list of cross-cutting R&TD gaps will not only help develop effective Planetary Protection Requirements for Human Extraterrestrial Missions, in the long term it will enable more capable and effective science exploration on Mars and beyond, for robotic and human explorers alike.

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**AM IV (2016)**

**Workshop Objectives:**
- Long-stay surface missions, key technologies/capabilities & characteristics.
- Develop plans or options to make missions achievable by focusing on ‘Long Pols’
- Assess Milestones, investment strategy, timeline requirements & priorities for ‘Long Pols’
- System-level Reconfiguration/Reusability
- Transit Habitation, Logistics
- Entry, Descent, and Landing
- Surface Habitation and Laboratory
- Surface Power
- Mars Ascent Vehicle
- Human Health/Biomedicine
- Sustainability

**Workshop & Study Conclusions to Date:**

- Human Mars surface mission could be accomplished by early to mid-2030s with sufficient funding (Engineering & technologies are not limiting factors).
- Human orbital missions are feasible by late 2020’s & can inform later missions.
- EDL systems are the major long pole for surface missions.
- Robotic reconnaissance over the next two decades is essential for preparing for human missions, and also a source of priority science.
- Need to study logistics support, supply nodes, refueling & aggregate needs in more detail to enable sustained human missions.
- There are significant interdependencies among the various habitation modules – transit & surface – suggesting a priority need to assess the value of modularity.
- Surface power looks very promising with the advent of small nuclear fission reactors.
- Lunar missions & operations not likely to add value to initial human missions to Mars.

**COSPAR WORKSHOP (2016)**

**Workshop Objectives:**
- Review Identified Gaps
- List R&T& Needs in Priority Order
- Assess Where/How R&T& can be done (ISS, Earth, Moon, Asteroids, Mars)

**Anticipated Mid 2017.**