Biological Indicator and Test Program for Sterility Assurance for Mars Sample Return Planning

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NASA's next Mars rover launching in summer 2020 will collect and cache promising samples of Mars rock and regolith on the Red Planet's surface. In parallel, the agency is studying a Mars Sample Return Campaign architecture that includes several conceptual missions that could bring those samples back to Earth someday. A fetch rover, Mars ascent vehicle, capture orbiter, Earth-entry vehicle, and sample containment facility are the notional components that would be critical to the success of such a Mars Sample Return Campaign. To prepare for sample return, NASA must adhere to International Policies for planetary protection by ensuring a low probability of release of unsterilized Martian particles into Earth's biosphere. To explore the feasibility of this requirement, based on current sterilization modalities in use, NASA has assembled a sterilization working group comprised of federal, international, industry, and academic subject matter experts. Based on available data gained from previous Mars missions, one key design assumption the working group has agreed upon for the probabilistic risk assessment is that potential Mars-based biology must adhere to Earth-based physics which bounds the physical and biochemical properties of Mars-based life. A series of sterilization/inactivation steps including passive environmental conditions (e.g. solar radiation, UV, deep space vacuum) and active spacecraft systems (e.g. chemical, heat, UV) are being considered to microbially reduce any possible initial Mars-based life starting at the launch into Mars orbit through Earth containment. To validate these active and passive processes, biological indicators (BIs) are being explored for ground-based testing to establish D- and z-values for both single and the additive impact of simultaneous modalities. NASA is taking a widely proven approach to gain expert input for selecting BIs, by surveying the scientific community for the widest spectrum of extreme environmental isolates to include bacterial, spore forming, fungal, archaeal, plasmids, and prions. Preliminary polling identified ~75 candidates, and 13 candidates were down-selected to begin initial testing. Draft test procedures will include relevant portions of the international standard experimental design defined in ISO 11138 "Sterilization of health care products - Biological indicators" and will be performed on spacecraft materials. Future work includes finalizing the candidate list of BIs, standardizing testing procedures, and establishing the candidates D and z-values as input into a probabilistic risk assessment which would inform the spacecraft design and operational scenarios.