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PI Name:	Pierson, Duane L Ph.D.		
Project Title:	Next Generation Microbiology Requirements		
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Program/Discipline:	HUMAN RESEARCH		
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Space Human Factors Engineering		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **SHFH**:Space Human Factors & Habitability (archival in 2017)		
Human Research Program Risks:	(1) **Microhost**:Risk of Adverse Health Effects Due to Host-Microorganism Interactions		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
PI Email:	duane.l.pierson@nasa.gov	**Fax:**	FY 281-483-3058
PI Organization Type:	NASA CENTER	**Phone:**	281-483-7166
Organization Name:	NASA Johnson Space Center		
PI Address 1:	Mail Code SK24		
PI Address 2:	Building 37, Room 1119A, 2101 NASA Parkway		
PI Web Page:			
City:	Houston	**State:**	TX
Zip Code:	77058	**Congressional District:**	22
Comments:			
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Contact Monitor:	Whitmore, Mihriban	**Contact Phone:**	281-244-1004
Contact Email:	mihriban.whitmore-1@nasa.gov		
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As humans continue to explore deep into space, microorganisms will travel with them. Spacecraft missions mitigate the risk of infectious disease through vehicle design and operational controls. The effectiveness of these controls are evaluated by microbiological monitoring of spacecraft, food, water, and the crew that is performed preflight, in-flight, and post-flight. Current requirements associated with microbiological monitoring are predicated on a culture-based methodology where microorganisms are grown on a semi-solid growth medium and colonies are enumerated. Subsequent identification of the organisms requires specialized labor and large equipment and historically has been performed on Earth.

NASA’s current culture-based requirements limit the types of technology that can be used. This limitation is demonstrated by culture-based "measurement criteria", which are in Colony Forming Units (CFU, representing the growth of one microorganism at a single location on the agar medium) per a given volume, area, or sample size. As the

Task Description:	CFU unit by definition is culture-based, these requirements limit alternative technologies for spaceflight applications. As spaceflight missions such as those to Mars extend further into space, culture-based technology (and associated consumables) will become difficult to implement due to limitations in shelf life, stowage volume, and mass. In addition, an extensive amount of new knowledge has become available over the life of the International Space Station (ISS), which give direction for new or modified microbial control requirements for vehicle design and mission operations The goal of this task is to develop and recommend a new set of requirements for vehicle design and mission operations, including microbiological monitoring, based upon “lessons learned” and new technology. These new requirements will be based on (1) Space Shuttle and ISS design and operational “lessons learned” and (2) new/advanced technologies that may be translated for spaceflight monitoring applications. Requirements will be focused on the types of samples, specifically: • potable water • spaceflight food • environmental samples, such as vehicle air and vehicle and cargo surfaces Toward this goal, the specific research aims of this study are: Aim 1 – To use historical data to assess optimal requirements for vehicle design and mission operations. This “lessons learned” approach will be incorporated in a microbial risk assessment approach to recommend removal of unnecessary requirements, optimization of current requirements, and implementation of new requirements. Aim 2 – To assess current and near term technologies for application toward next-generation monitoring requirements. This aim will also focus on defining gaps between optimal requirements and available technologies/flight resources. Aim 3 – To define practical monitoring requirements for (a) immediate development of next generation ground operations and flight hardware and (b) long term goals for future requirements, if different than those delivered in (a).
Rationale for HRP Directed Research:	This Task focuses on studies to (1) define and validate suspected risks and (2) investigate and apply technology toward new mission requirements. Findings from these directed studies will lead to subsequent solicitations. As such, the Task contains components that are Highly Constrained, potentially including data mining of unpublished data, crew medical data and feedback on spacecraft environments, as well as the evaluation of new technology for future spaceflight requirements.
Research Impact/Earth Benefits:	This requirements review primarily focuses on spacecraft; however, several of the lessons learned can be translated to human-microbe interaction in built environments. These range from the simple, straightforward association of uncontrolled water with microbial contamination to the more complex development of potable water requirements using non-culture based monitoring methodology.
Task Progress:	Microbiological requirements that mitigate risk to the crew during spaceflight missions are updated periodically to reflect changes in the scientific understanding of microbial pathogenicity, our knowledge of the response of microorganisms to the spaceflight environment, effects of spaceflight upon human immunity, and advances in monitoring technology. Based upon this new knowledge and available technologies, a review of microbiological requirements was performed by three expert panels held from 2011 through 2013. These panels focused on requirements associated with potable water, spaceflight food, and vehicle air and surfaces specifically described in NASA SPACE FLIGHT HUMAN SYSTEM STANDARD (NASA-STD-3001). The forum on Space Flight Foods was co-sponsored by the Space Flight Foods Laboratory at the Johnson Space Center. Evaluation of the recommendations from all three forums indicated twelve common themes, such as the need for appropriate microbiological training for individuals who would be developing or operating spaceflight systems and guidelines for current and future microbiological monitoring technology. The reoccurrence of these themes in multiple panels reinforced the importance of the consideration of these recommendations. These forums provided the opportunity to formally update and document our knowledge base for spaceflight microbiological requirements. As this type of forum has not occurred in the past 20 years, the amount of data and documentation was extensive. To streamline future efforts, smaller forums should occur at closer intervals, such as every 5 years to both decrease the information to be reviewed and enable more rapid implementation of new technology and scientific findings. While implementation of these recommendations was outside of the scope of this study, the co-sponsorship of a forum with the Space Flight Foods Laboratory accelerated the acceptance of the recommendations toward updated food monitoring requirements. In addition, recommendations concerning potable water monitoring have already been incorporated into a draft of new set of requirements for microbiological water quality that are being used to help design advanced microbiological monitoring hardware for spaceflight. With the completion of these forums, a final report has been prepared. This report is currently being made available for public access.
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