A prototype tool for assessing forward contamination from space suits

M. Rucker[1] ,M. S. Bell[2], C. L. Castro[3] ,A. Hood[1], G.B. Malli Mohan[4] C. Mason[5] . A. B. Regberg1, S. E. Stahl[3] K., Venkateswaran[4] M. Walker[2] and S. L.Wallace[5] M. Walker[2] [1]NASA/Johnson Space center, Houston, TX 77058 [2]Jacobs@NASA/Johnson Space Center, Houston, TX 77058, m; [3]JES Tech, 16870 Royal Crest, Houston, TX 77058, [4]NASA Jet Propulsion Laboratory . 4800 Oak Grove Dr, Pasadena, CA 91109, [5]Weill Cornell Medical College Department of Physiology and Biophysics (BX 75) 1300 York AveNew York, NY 10065 [6]Biomedical Research and Environmental Sciences Division, Johnson Space Center, 2101 NASA Parkway, Houston TX 77058;

Crewed exploration missions dramatically increase the capability for large-scale sample collection and return activities, but they also increase the possibility and likelihood of forward contamination. Systematic research on forward contamination from uncrewed spacecraft has steadily progressed since the Viking missions, but parallel research on contamination from space suits has not. Current space suits have leakage rates as high as 100 cc gas/min.[1], but it is unclear how many or what types of microbes are exiting the suits along with this gas. The Human Forward Contamination Assessment team at NASA's Johnson Space Center (JSC) has developed a prototype swab tool[2] that is capable of maintaining sterility during pressure changes associated with entering and exiting vacuum. The primary objective of recent Extravehicular Activity (EVA) Swab Kit testing is to characterize the type of microorganisms typically found on spacesuit external surfaces under suit differential pressure conditions. Most human-associated microorganisms can fit through a 0.5 to 1.0 μm gap. Understanding potential leak paths will inform future hardware design decisions. Knowing which types of microorganisms may leak from EVA suits provides a basis for subsequent studies to characterize the viability of those organisms under destination conditions, as well as how far they might spread through natural or human-influenced processes. The results of EVA suit molecular microbial community analyses will inform NASA exploration mission operations and hardware design, and help close Strategic Knowledge Gap B5, Forward Contamination to Mars

We sampled suits as a secondary activity during tests conducted in two different vacuum chambers at Johnson Space Center. Samples were analyzed at Johnson Space Center and at the Jet Propulsion Laboratory using a variety of culture based techniques to grow bacteria collected from space suit surfaces during vacuum testing. We also used 16S rRNA tag sequencing and shotgun metagenomics to characterize uncultivatable microbes and environmental DNA from these surfaces.

Preliminary testing with this tool has confirmed that the design is capable of maintaining sterility while transitioning in and out of vacuum. We were unable to culture bacteria or fungi from negative control samples that were sterilized prior to testing and witnessed the entire testing procedure without being opened. Culture based results indicate more than 10 bacterial and at least one fungal species from space suit surfaces are capable of surviving up to 4 hours at vacuum. Current protocols for cleaning space suits prior to use are focused on crew health and safety rather than sterilization of the suits and thus microbiology of suit external surfaces are indistinguishable from the environment in which they are tested. In order to characterize and quantify forward contamination from space suit leakage, more controlled testing with these tools is necessary.

We have developed and tested a prototype tool for collecting samples from space suits during Extra Vehicular Activity. Preliminary testing of this tool has demonstrated that it can be used to collect samples at vacuum and that these samples will remain uncontaminated during testing. Additional testing will provide valuable insight into Planetary Protection, Astrobiology, Space Biology, ISS, and Human Research Programs needs as we prepare to send human explorers in search of life beyond Earth.

References

1.Kuznetz Lawrence H. S *Space Programs and Technologies Conference* (1990). 2.Bell, M. S. *et al. 46th Lunar and Planetary Science Conference*, 2103 (2015).