ISS EXTERNAL MICROORGANISMS: A PLANETARY PROTECTION PAYLOAD READY-FOR-FLIGHT.

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Introduction: Before NASA or COSPAR is able to set planetary protection requirements for crewed missions to locations like Mars there are a number of critical knowledge gaps that must be addressed (1). One of the most important knowledge gaps is an understanding of microbial leakage from crewed habitats and space suits. Current ECLSS (Environmental Control and Life Support System) and PLSS (Portable Life Support System) requirements do not include any provisions to control microbes that may escape along with vented or leaked gasses. The current generation of NASA space suits can leak at rates as high as 100 cm^3 /min. during nominal operation (2). ISS (International Space Station) intentionally vents atmospheric gases like CO_2 to maintain habitable conditions for the crew. Furthermore, every time an airlock is used for EVA (extravehicular activity) there is an accompanying release of internal atmosphere. Since it is not possible to sterilize a crewed mission, it is important that we understand what if any microbes are entrained in these vented and leaked products. It is also important to understand if these microbes can survive on exterior surfaces. Recent sampling of the Russian segments of ISS suggest that bacteria and fungi from inside ISS may be capable of surviving on external surfaces (3). NASA has developed an aseptic sampling tool for use during EVA and plans to collect samples from vents on ISS to build on these results. The results of this work will be used to develop planetary protection requirements for vented and leaked gasses from crewed volumes.

The Swab Kit: NASA has developed and tested a tool kit for collecting microbiological samples during EVA (4). This tool kit contains eight commercially available, 23 mm. diameter, foam swabs that can be used to aseptically collect samples while at vacuum. The swabs are individually housed in aluminum canisters of which six will be used to sample ISS external surfaces and two are control swabs. One control swab remains unused (canister stays sealed), the other is removed, held open for at least 30 seconds and reinstalled without sampling any surface. The canisters are equipped with 0.2 µm Teflon filters. These filters allow the canisters to equilibrate to pressure changes while preventing microbiological contamination. The canisters have been cleaned, sterilized, assembled, and certified for flight in the newly completed Advanced Curation Lab in the ARES Division at Johnson Space Center (Fig. 1). Results from ground-based testing indicate that this tool kit is capable of aseptically collecting microbes while at vacuum without becoming contaminated during pressure changes (5). Based on the results of ground testing we have modified the tool kit to meet NASA safety requirements and improve the ergonomics. We added additional mounting points to give astronauts more options for securing the tool kit during use and tested these modifications in NASA's Neutral Buoyancy Lab at JSC during practice EVA runs (Fig. 2) We also changed the opening mechanism to improve the precision with which swabs can be extracted from the tool kit. We are scheduled to launch on NG-19 (Northrup Grumman's Antares Launch vehicle) and plan to use this kit on an upcoming EVA to collect samples from non-propulsive vents and locations near the U.S. airlock on ISS which are areas of particular interest. Following the EVA, these samples will be frozen at -80˚C and stored on station, within four hours of use (or as soon as possible), until they can be returned to Earth. We will analyze these returned samples using next generation DNA sequencing to determine the community composition and function of external ISS environments.

Results: The results of this study will close planetary protection knowledge gaps for crewed missions and will help NASA determine appropriate planetary protection requirements for life support systems. The tool kit will also be useful for collecting aseptic samples on upcoming crewed or robotic missions and could easily be modified to collect samples with organic contamination control requirements as well.

Works Cited: 1) Race MS, etal. 2015. Planetary Protection Knowledge Gaps for Human Extraterrestrial Missions. 2) Hamilton Sundstrand Corporation. 2017. NASA Extravehicular Mobility Unit (EMU) LSS/SSA Data Book (Rev. V) 588. 3) Deshevaya E, et al. 2020. BioNanoScience 10:81–88. 4) Rucker MA, et al. 2018. p. 1–9. *In* 2018 IEEE Aerospace Conference. IEEE. 5) Danko D, et al. 2021. Frontiers in Microbiology 12:1900.

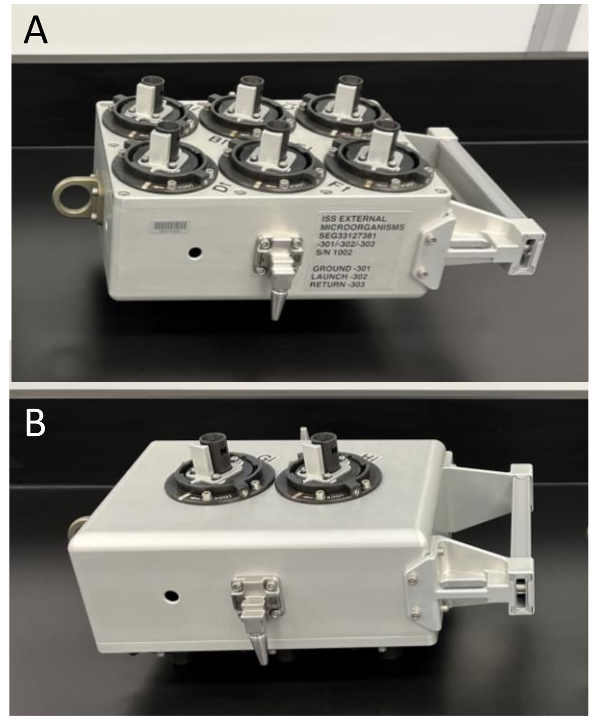

Fig. 1. The ISS External Microorganism tool kit ready-for-flight. A) The six canisters that will sample the exterior of the ISS. B) The two control swab canisters.

Fig. 2. Testing the modified ISS External Microorganisms demonstration sampling kit (lower right on tether) in NASA's Neutral Buoyancy Lab during an EVA practice run.