SCIENTIFIC PHYSICAL AND OPERATIONS CHARACTERIZATION (SPOC): STUDYING SCIENTISTS IN THE WILD TO INFORM HUMAN PLANETARY EXPLORATION OPERATIONS.

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Introduction: The objective of the Scientific Physical and Operational Characterization (SPOC) project is to build an evidence-based description of terrestrial field science to inform the operational, physical, and tool requirements for planetary exploration extravehicular activities (xEVAs). EVAs of the future, including Artemis 2024 and beyond, intend to promote scientific productivity (e.g., LEAG science goals) [1]; however, no clear, objective pathway currently exists to enable this goal, particularly with respect to the desired increase in autonomy imparted to future astronauts. The SPOC project applies expertise in the fields of cognitive systems engineering [2-5], biomechanics, wearable sensors [6-8] and hardware/software to more targetly address these issues. In doing so, a terrestrial field work ground-truth can be established that will benefit human and robotic exploration of other planetary surfaces.

Methodological Approach: SPOC aims to characterize scientific work within terrestrial field deployments for the individual and the team (Fig. 1 and 2). This characterization establishes definitions of work success (performance standards) through observations. These performance standards then inform automated methods for assessing field science strategies and performance at the individual and team levels. In doing so, the level of work success we define can contribute to promote scientific productivity in the xEVA context. We define work success as a relationship between the overarching task goals and the resources of the team, with consideration for the imposed constraints (e.g., from the resources available or the environment in which the tasks take place). The individuals and team can select different strategies to achieve performance standards, which may be characterized through observations. Quantified metrics of these strategies at the individual and team levels will be defined to assess the goal-dependent performance. A specific field team or individual within the team may have low performance on a task, which means that the team's goals may not have been fully met given the resources that were available and the constraints of the environment. The proposed effort characterizes these goals and strategies for scientific fieldwork. From these characterizations, crew required capabilities can be framed as a reference baseline against which EVA systems can be vetted.

Discussion and Next Steps: SPOC team has field tested the audio/video/wearable sensor suites and is actively looking to partner with terrestrial field teams performing lunar and planetary relevant scientific investigations. We are also interested in collaborating on larger proposals with teams interested in more formally conducting operations research relevant to human spaceflight. Critical to the SPOC effort is to study as many field deployments across as many different relevant scientific disciplines as possible. In doing so, we hope to provide the grounded representation of terrestrial fieldwork so that those work demands can be fully accounted for in the human spaceflight planetary setting.

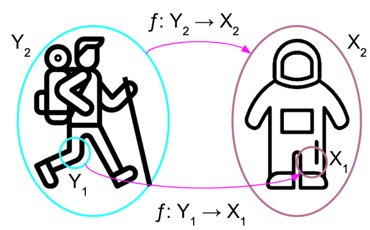

Figure 1: Individual Level Mappings. The individual in a field science domain can map to the EVA domain (f: $Y_2 \rightarrow X_2$, where f is used to operationalize the content between the field science and EVA workspaces).

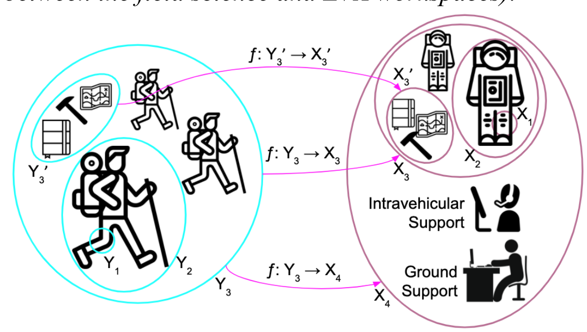

Figure 2: Team Level Mappings. A full team during field exploration includes the crew performing the task (f: $Y_3 \rightarrow X_3$) with their set of tools (f: $Y_3' \rightarrow X_3'$) and can be inclusive of a larger support team (X_4). Each person includes individuals (f: $Y_2 \rightarrow X_2$) with specific tools (f: $Y_3' \rightarrow X_3'$). Outcomes from Y_3 and Y_3' observations can inform the needs of X4 to support the X3 crew (f: Y_3 & $Y_3' \rightarrow X_3$ & X_3' & X_4).

References[1] CAPTEM-LEAG (2010) LPI. [2] Klein, G. A., et al. (1993). Ablex Publishing; [3] Militello, L. G., et al. (2009). *Systems Engineering*, 13, 261–273; [4] Vicente, K. (1999). Lawrence Erlbaum; [5] Miller, M. J., et al. (2017). *JCEDM*, 11(2), 136–165; [6] R. Vitali, et al. (2020). NASA HRP Workshop; [7] R. Vitali, et al. (2020). ICES; [8] T. McGrath, et al. (2018). *Sensors* 18(6), 2018