SCIENTIFIC PHYSICAL AND OPERATIONS CHARACTERIZATION (SPOC) – CAPTURING TERRESTRIAL FIELDWORK IN CONTEXT

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Objectives

- Capture and examine the **relationships between cognitive challenges and physical behaviors** demonstrated throughout **planetary science field campaigns**
- Iteratively develop a **data collection and analysis capability** to facilitate interdisciplinary collaboration and *post hoc* analysis of multimedia data of field scientist behavior

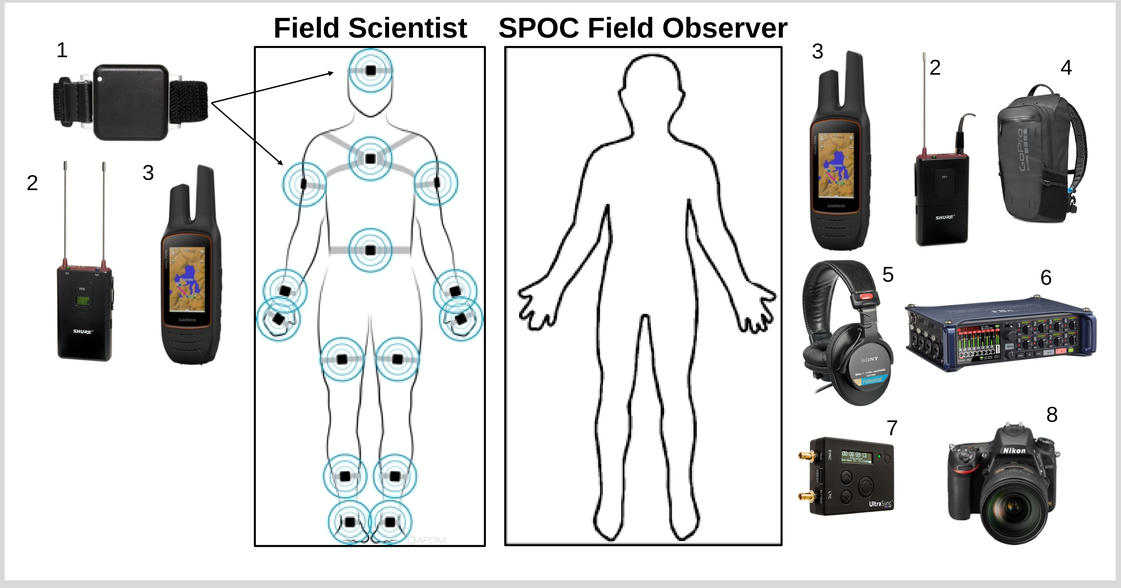
Future human planetary spaceflight missions to destinations such as the Moon or Mars aim to promote human scientific exploration, yet outside of the Apollo program, the spaceflight community at large has limited experience performing scientific exploration. An open area of research is **designing future human missions to enable exploration in support of scientific goals**. One approach to overcome this limited spaceflight experience is to **learn from present-day expert scientists performing terrestrial scientific fieldwork**. By studying and understanding the intrinsic work demands, constraints, and behaviors that field scientists must overcome and perform to achieve their scientific fieldwork objectives in present-day terrestrial settings, their scientific needs can be better understood within the context of proposed future missions and technologies.

Team

- Exploration science engineers and human performance researchers at JSC**:**
  Astromaterials Research and Exploration Science (XI); EVA Management Office (XX);
  Human Physiology, Performance, Protections, and Operations (SK)
- Academic Collaborators at Massachusetts Institute of Technology; University of Miami; Johns Hopkins University

Methods

This poster presents the research formulation, prototype data capture systems, and preliminary testing methods of the Scientific Physical and Operation Characterization (**SPOC**) project. This research employs two complementary methodologies, **cognitive work analysis** and **wearable sensor measurement**, to unpack the cognitive and biomechanical constraints that shape scientists' actions in field settings. Field data collection is supported by commercial off-the-shelf hardware. The intent is to not only describe the bulk physical activities of scientists (e.g. what scientists did in the field) but this data can be combined with the cognitive analyses to understand *why* scientists exhibited these behaviors.



Representative hardware/devices: 1. APDM Opal IMU 2. Shure Wireless Microphone 3. Garmin GPS 4. GoPro Hero 6 and stabilization accessories 5. Headphones 6. Zoom F8n Mixer 7. Timecode Systems UltraSync 8. Various DSLR cameras

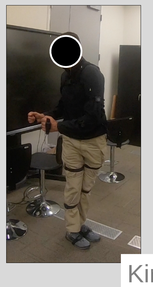
- Integrating applied cognitive systems engineering methodologies [1-3] using unobtrusive qualitative data analyses combined with inertial measurement unit (IMU) system physical characterizations [4-7] to deconstruct terrestrial fieldwork work practices.
- A cognitive task analysis of each observed field campaign will model the cognitive demands (e.g. goals, decision making, problems, etc.) and constraints associated with the fieldwork.
- Additionally, the types of physical tasks and actions being performed (e.g., standing, walking, kneeling, hammering, etc.), the functions of those tasks, and the frequency with which each task is performed will be quantified using a combination of observational techniques with unobtrusive body-worn IMUs along with algorithms for body motion classification.

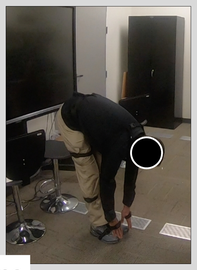
SPOC concept of operation schematic with field deployed sensors and data collection devices.

The SPOC field observer carries and operates professional grade audio/video/photography devices to provide a 3rd person perspective of the scientist(s) working in the field setting. IMU data is collected continuously in the field. Data is stored at the end of each field day. During post-processing analyses, the IMU data are processed to estimate body postures, coordinated movements, and levels of activity.

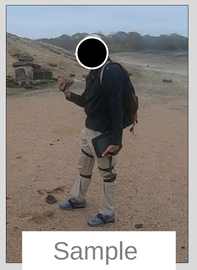
Pilot Hardware and Data Integration

- Equipment fit checks and IMU calibration procedures in development
- Audio/video timecode synchronization, equipment packaging and handling processes in development
- Timecode integration of audio/video and IMU data
- Audio/video post-processing and deconstruction analysis processes underway
- Data storage and automated processing pipeline in trial testing



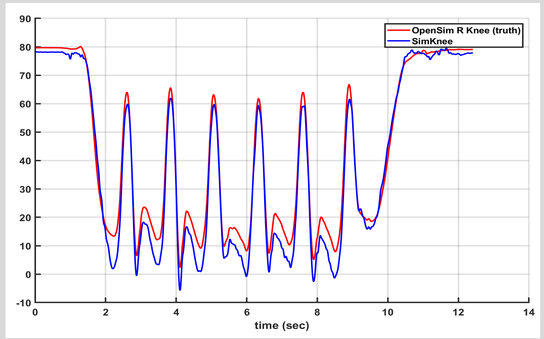


Kinematic Body Calibrations



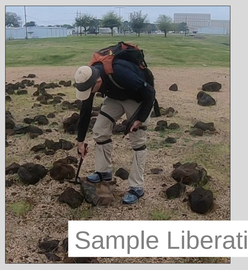
Sample Interrogation

Ambulation



Sample knee axis measurements generated from shank and thigh IMUs. Estimations were performed with calibration-less principle component analysis (PCA) techniques.

Sample collection



Sample Liberation (Hammering)

The goal will be to partner with multiple terrestrial field science campaigns that are relevant to planetary science (e.g. map to Lunar Exploration Analysis Group roadmap goals) [8]. The aggregate data collection and analysis of these field campaigns would provide the opportunity to characterize "Earth-normal" scientific fieldwork to be integrated with ongoing exploration development and testing efforts at NASA JSC that incorporate high-fidelity spaceflight constraints based on reduced gravity testing in pressurized spacesuits.

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References: [1] Miller, M. J. et al. (2017) *J. of Cog. Eng. and Dec. Making*, 11(2): 136–165; [2] Hollnagel, E. and Woods, D. D. (1983) *Inter. J. of Man-Machine Studies*, 18:583–600; [3] Elm, W. C. et al. (2008) *J. of Cog. Eng. and Dec. Making*, 2(3): 249–273; [4] Kim KJ, et al. (2018), *Nature npj Microgravity*, 4:1-8; [5] Kim K.J. et al. (2018)., *Journal of Biomech*, 11(71):151-158; [6] McGrath, T., et al. (2018). *Sensors*, 18(6), 1882–17; [7] Stirling, L. et al, (2016) *PLoS ONE,* 13(6); [8] LEAG V1.3 (2016)