THE ELECTRONIC FIELDBOOK TOOL SUITE: SCIENCE AND DECISION SUPPORT TOOLS FOR STRUCTURED INFORMATION COLLECTION AND DISTRIBUTION DURING ASTRONAUT TRAINING AND HUMAN PLANETARY EXPLORATION

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Introduction: Future human missions to the Moon and Mars will involve Extra-Vehicular Activities (EVA) focused on scientific exploration. Much like during the Apollo missions [1], astronauts participating in these EVAs will investigate scientifically interesting areas, gather a variety of information, and they will be supported by a host of new technologies for managing operations and data collection [2]. To enhance the scientific return of these missions, it is important to accurately record, index and store all the scientific information collected during exploration, and then rapidly distribute it in a structured way amongst the relevant mission support personnel. Such capabilities will be essential for the ground-based science teams supporting these future missions for maintaining situational awareness, enabling them to provide useful and timely feedback to the astronauts and thereby enhance the scientific expertise present on the lunar surface [3]. Astronauts are being trained in future planetary science exploration activities. In this context, the Electronic FieldBook (EFB) [4] has developed into a promising system for supporting field science, including future Lunar and Martian exploration.

The Electronic FieldBook Tool Suite: In order to improve the effectiveness of operations [5, 6], scientists located in a support centre control room should ideally receive, in near-real time, a relevant portion of the data acquired in the field to provide scientific and operational guidance to the astronauts. In addition, astronauts require information pertaining to navigation, decision support tools and other reference information to augment their effectiveness and autonomy. The EFB Tool Suite is a deployable and modular set of tools being developed to address these requirements. The EFB is designed to support field mission operations, scientific data gathering and direct interaction with support teams through the automatic exchange of information. The system provides near real-time situational awareness to mission support teams during scientific traverses. It achieves this through several methods. The system provides a structured way to collect data. Users can document a sampling procedure, retrieve information from several sensors or analytical tools, look up reference information, and take notes. All the information gathered is automatically geo-located and tagged to ensure it is associated to specific sites or samples along a traverse (Fig.1). Decision support for tasks such as sample selection is also provided by the EFB. The suite of tools includes also imaging devices, such as 360-degree cameras, wide high-resolution cameras, panoramic bifocal cameras and microscopes.

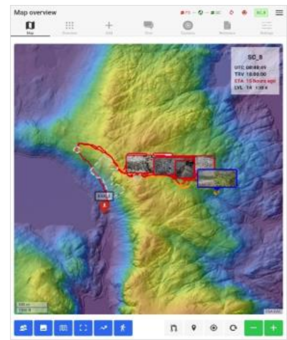

Fig. 1. The EFB interface for traverse overview display.

These devices are wirelessly connected to the EFB tablet and therefore with ground teams. Further analysis can then be carried out using analytical tools directly controlled by the EFB. The system can analyse the data produced using embedded machine learning modules to characterise the mineralogy [7] of samples and inform on their scientific value. The EFB ensures disruption tolerant information exchange, allowing users to continue working regardless of temporary or extended loss of connection. Provided connectivity is present, any user of the system will receive information gathered in near real time, enabling them to direct or support the operations, and provide relevant and informed scientific advice where required.

Conclusions: EFB has been the key supporting tool for ESA's PANGAEA/PANGAEA-X 2018-2021 field campaigns. These campaigns bring together geology, high-tech survey equipment and space exploration. Within this context, the EFB has co-evolved to support both ESA training and testing activities, and provides a solution to the data integration challenges presented by future human scientific exploration in space. Collaborations with European industry and research institutes is actively ongoing for further research and development on the various tools included in the suite.

References: [1] Goddard E. N. et al. (1965) *Project Apollo Field Geology Planning Team*. [2] Coan, D., (2020) *Exploration EVA Concept of Operations*. [3] Hodges K. V. and Schmitt H. (1997) *Geological Society of America Special Paper*. [4] Turchi L. et al. (2021) *Planetary Space Science*. [5] Hurtado J.M et al. (2011) *Acta Astronaut. 90(2)*, 344-355. [6] Young. et al. (2017) *Planetary Science Vision 2050 Workshop*. [7] Jahoda, P. et al. (2020), *The Analyst*.