SSERVI TREX AUTONOMOUS ROVER-BASED SCIENCE IN THE FIELD. E.Z. Noe Dobrea[1], R.C. Clark[1], M. Banks[2], D.R. Gaylord[3], A. Hendrix[1], M. Lane[4], M. Osterloo[5], T. Prettyman[1], R. Watkins[1], D. Wettergreen[6], S.P. Wright[1], and the TREX Team [1]Planetary Science Institute, 1700 East Fort Lowell suite 106, Tucson, AZ 85719 – eldar@psi.edu, [2]NASA Goddard Space Flight Center, Greenbelt, MD, [3]School of the Environment, Washington State University, Pullman, WA, [4]Fibernetics LLC, Lilitz, PA, [5]Laboratory for Atmospheric and Space Physics, U. Colorado, Boulder, CO, [6]Carnegie Mellon University, Pittsburgh, PA 15213

Introduction: The Toolbox for Research and Exploration (TREX) is a NASA SSERVI node. TREX (trex.psi.edu) aims to decrease operational and science risk to future missions by improving our understanding of particulate-rich surfaces. TREX studies are organized into laboratory, lunar, and small bodies studies, as well as robotic field investigation. *Here, we present our plans to test the efficacy of using an automated robotic explorer in the field.*

Robotic systems play a crucial role in the exploration of Solar System bodies and will certainly play a central role in future exploration. Today's robotic exploration is centered around a tight operator/robot iterative process in which a team of operators carefully instructs the robot on every operation. Data rates impede a complete assessment of the field, so science decisions are based on expert, albeit restricted knowledge of the site.

We posit that the description of the activities to be conducted should not be uniquely prescribed by each iteration of commands sent from the operator, but should be open-ended and responsive to ongoing observations, even without iterative operator feedback. Robotic explorers of the future should be able to independently decide which observations to perform in order to address the driving hypotheses with little to no input from an outside operator. Periodically, or when the robotic explorer encounters something that falls outside the realm of expected observables, the robotic explorer would contact the operator to offer updates or request new directions. Our approach transforms the relationship from one in which the scientist/operator team "joysticks" every aspect of the mission into a collaboration in which the human and robot work together. This strategy is expected to improve operations efficiency and increase science yield.

Technical Approach: In order to accomplish this transformative goal, we are integrating multiple tools that will permit a rover to autonomously address science questions using the instrument suite at hand. We combine a new decision-making technique known as the hypothesis map [1] with the Tetracorder system [2 - 4] on Carnegie Mellon's intelligent robotic testbed to enable the rover to autonomously perform observations and analyses, identify targets for contact studies and sample collection, and report higher level findings.

Hypothesis Map: The hypothesis map, which represents the basis for decision making and reporting undertaken by the robot, describes a set of hypotheses to be explored (*e.g.*, the geologic history of a field site), and observables that allow these hypotheses to be weighted (*e.g.*, mineralogy). As the rover queries the terrain, certain hypotheses become weighted toward greater likelihood, as others are eliminated. In conjunction, the rover populates an n-dimensional parameter space of the observables, allowing it to map the spatial distribution of compositional (spectral) endmembers, which can subsequently be targeted for in-depth analysis. Communication with an operator is performed at points where the rover has a) a summary of observations of the mapping area, b) identified sample-collection sites, or c) performed an observation that cannot be fit into the hypothesis map. If the latter occurs, the hypothesis map is reformulated, facilitating an iterative process between hypothesis formulation and exploration.

Tetracorder: To accomplish the hypothesis testing, the rover must be capable of deriving mineralogy from observed spectra. We will use the Tetracorder software to analyze spectra. Tetracorder has been central to dozens of studies on Earth and other planets and moons [2-9]. A Tetracorder module operating in real-time on the rover's computer will allow the rover to constrain mineralogy and address the hypotheses it is tasked to test.

Field Campaign: The objective of our field investigations is to compare the operational efficiency and science yield of current robotic exploration strategies with that of the semi-autonomous robotic exploration system. Fieldwork will be performed at sites containing fine-grained materials analogous to those expected on asteroids and the Moon. We will discuss three locations: the Palouse glacial aeolian loess site in Washington, the carbonate and phyllosilicate-rich exposures at Yellow Cat, Utah, and the phyllosilicate-bearing Hopi Volcanic Field, Arizona. Instruments include UV – IR spectrometers and a gamma ray / neutron spectrometer with active interrogation (GNS). These data will be the inputs Tetracorder. The mineral and elemental data will provide an in-depth picture of the physical and chemical mineralogy of the site and allow the rover to identify locations for contact science and sampling.

References: [1] Thompson, D. R., *et al.* (2011) *J. Field Robotics, July / August*. [2] Clark, R.N., *et al.* (2003) *J. Geophys. Res.* Vol. 108(E12), 5131. [3] Clark, R. N., *et al.* (2010) *J. Geophys. Res.*, 115, E10005. [4] Clark, R. N., *et al.* (2012) *Icarus* 218.