Human-Robotic Field Relations for the Moon: Lessons from Simulated Martian EVAs. W. B. Garry[1], W. J. Clancey[2], M. X. Sierhuis[2], J. S. Graham[3], R. L. Alena[2], J. Dowding[4], and A. Semple[1], [1]University at Buffalo, Dept. of Geology, 876 Natural Science Complex, Buffalo, NY 14260, brentgarry@yahoo.com, [2]NASA Ames Research Center, Intelligent Systems Division, MS269-3 Moffett Field, CA 94305, [3]NASA Johnson Space Center, S&K Technologies, Inc., Houston, TX 77058, [4]UC Santa Cruz, Moffett Field, CA 94305.

Introduction: Human-robot interactions during extravehicular activities (EVA) on the lunar surface will be important to the efficiency, productivity, and data return of the mission. In preparing for extended stays on the Moon, and eventually Mars, EVA tasks that can be easily automated need to be recognized and experience utilizing robots in the field must be gained. Over the last three years, our team has simulated several EVAs with two "astronaut-geologists" and an autonomous robot all utilizing an advanced, automated system called "Mobile Agents" (MA) with these necessities in mind. Inspired by the Apollo missions and designed for use during EVAs on Mars [1], the MA system monitors and manages EVA navigation, scheduling, equipment deployment, telemetry, health tracking, and data collection. A dialogue system [2] employs a series of voice commands (e.g. "*Move to location x*" and "*Take a panorama*") used by the astronauts to communicate and interact in real-time with their "agents" which are connected wirelessly through a complex relay system [3] to all participating members of the EVA (Astronauts, Robot, Habitat (Hab), Remote Science Team).

Field Tests: Our EVAs were carried out during 3 two-week field tests at the Mars Desert Research Station (MDRS) in Hanksville, Utah (2003-2005). The two "astronauts" and the EVA Robotic Assistant (ERA) (Figure 1) [4, 5], an advanced autonomous test bed robot from NASA JSC, followed various scenarios devised to test both technological and science objectives. A science backroom "on Earth" known as the Remote Science Team (RST) collaborated with the astronauts to plan EVAs and analyze data. Traverses covered up to 2 km and were conducted ≤8 km from the Hab while still maintaining full communication.

EVA Robotic Assistant: The ERA is an autonomous robot that can be programmed to follow a preselected path, controlled remotely from the habitat, or commanded on-the-go by astronauts in the field. The capabilities of the ERA include obstacle avoidance, video tracking, still imaging and 360° panoramic options, sample return and curation, and DGPS. We employed the ERA in the following roles during the EVA scenarios. **1)** ***Reconnaissance*** – solo-scouting of an unexplored location along a pre-set traverse. Astronauts monitored progress and data return from confines of the Hab and used it to plan the following days EVA with the help of the RST. **2)** ***Monitoring*** – Astronauts are automatically "tracked" by one of two video cameras located on the ERA. The video is broadcast back to the Hab for viewing by the Astronauts remaining behind. This job was performed manually from Mission Control during Apollo 15, 16, 17. **3)** ***Network Relay*** – While working in a canyon ~4 m deep, communication was maintained between the astronauts and the Hab by positioning the ERA in a strategic location along the canyon edge. **4)** ***Remote Workstation*** – A science trailer connected to the ERA increases both amount of field equipment and sample return for the astronauts.

Figure 1. Two astronaut-geologists and the ERA with science trailer prepare to leave the MDRS during a simulated EVA in the Utah desert. Image courtesy of NASA.

Application to Lunar Exploration: The EVA scenarios, roles of the ERA, and the MA system can be applied and utilized in Lunar EVAs. This includes reconnaissance of unknown terrain; monitor and relay capabilities while exploring craters or rilles; and instant automated downloading, cataloguing, and association of data for use by scientists back on Earth.

Websites: ERA and Field Tests (Crews 16, 29, 38)
http://vesuvius.jsc.nasa.gov/er_er/html/era/era.html
http://www.marssociety.org/mdrs/index.asp

References: [1] Clancey W. J. (2004) *in* Cockell C. Martian Expedition Planning, *AAS Science and Technology Series, 107,* 411-430. [2] Dowding J. and Clark K. (2005) *Mars Society 8th Int'l. Conf., Abstract.* [3] Alena R. L. et al., (2004) *IEEE Aerospace Conference, Abstract.* [4] Burridge R. R. et al. (2003) *iSAIRAS*, *Abstract*. [5] Graham J. and Shillcutt K. (2003) *iSAIRAS, Abstract*.