Regardless of the destination, the work must start now. NASA is developing the technologies and systems to transport explorers to multiple destinations, each with its own unique – and extreme – space environment. Because sample return requirements are mission specific, the handling protocols are designed specifically for the types of questions the scientific community hopes to answer using samples from a particular planetary destination. ARES curation scientists are collaborating with mission architecture engineers to develop mission goals that are aligned with science goals. ARES scientists participate in analog missions to develop protocol and scientific operations – from mission conception to execution and sample return – to ensure that the requirements of the scientific community will be met and the scientific return to the public will be maximized.

The 2012 Moon and Mars Analog Mission

Lee Graham

The 2012 Moon and Mars Analog Mission Activities (MMAMA) scientific investigations were completed on Mauna Kea volcano in Hawaii in July 2012. The investigations were conducted on the southeast flank of the Mauna Kea volcano at an elevation of ~11,500 ft. This area is known as "Apollo Valley" and is in an adjacent valley to the Very Large Baseline Array dish antenna.

Two of the four MMAMA investigations selected were led by scientists within the ARES Directorate at JSC. These included the Increasing Robotic Science proposal, the miniature Mössbauer spectrometer (MIMOS II), and the MIMOS II combined with an X-ray fluorescence (XRF) spectrometer (MIMOS IIA). The original robotic investigation proposal called for a comparative study of human field work versus the JSC C2 rover (and potentially the C2 rover with a Robonaut torso mounted on it, often called a "Centaur"). Robonaut is a dexterous humanoid robot that was designed and built at JSC, but last-minute travel restrictions eliminated it from the field test. Working with the NASA Regolith and Environment Science and Oxygen and Lunar Volatile Extraction (RESOLVE) project, a NASA Advanced Exploration System Program project hosted at the Kennedy Space Center (KSC), the MMAMA team was able to identify a replacement rover, the JUNO II (shown in figure 1), which was provided by the Canadian Space Agency. In addition, as planning progressed for the 2012 tests on Mauna Kea, an opportunity presented itself to move the MMAMA test site to a more geologically challenging location. This did, however, also reduce the test time from the original 2 weeks to only 3 days. The primary focus of the investigation was to determine the valley formation processes.

The instruments used in the test were selected based on several considerations. The major criteria included 1) applicability to the scientific investigation of the valley, 2) mobility, 3) availability, 4) remote control capability, and 5) weatherproofing capability. The MMAMA robotic investigation involved the use of six instruments, including a ground penetrating radar (GPR), a second-generation

Mössbauer/XRF spectrometer, a panoramic video camera, a magnetic susceptibility meter, a global positioning sensor (GPS) receiver, and a 3-axis accelerometer.

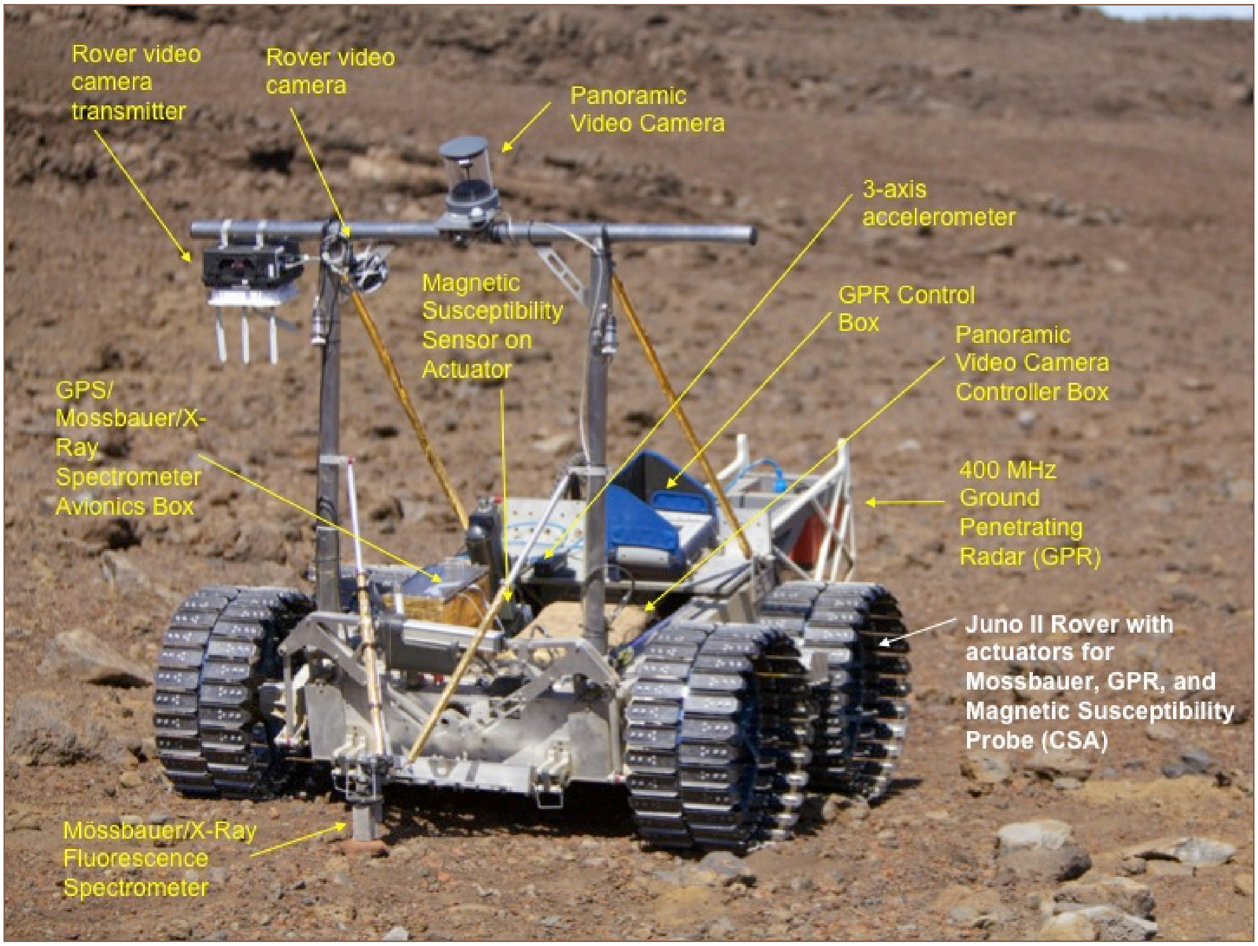

Figure 1.– Juno II Rover with actuators for Mössbauer, GPR, and magnetic susceptibility probe.

During operation in the field, a successful attempt was made to simulate a remote-controlled planetary science mission by minimizing the number of times the rover was physically touched by an operator. The only exception to this was GPR data collection, which required the operator to activate the system that was mounted on the rover each time it was used (several times each day). To accomplish the remote operation, a combination wireless and hardwired on-board instrument suite was developed. During the test, the instruments and rover were controlled by four remotely located operators (see figure 2).

Figure 2.– Rover field team on the side of the cinder cone.

Google Earth images were used as an analog to the orbital images available prior to a planetary "landing" to create notional traverses prior to the mission. Although many legs of the planned traverses could not be executed because of the rugged terrain, the effort still provided a framework from which to vary and maximized the team's efficiency in the field where rapid replanning was required (see figure 3).

The science instrumentation collected geophysical and geochemical information to provide a range of geological context about the test site. This initial evaluation of the geologic context and history of the Apollo Valley (or "landing site") was continually refined by this integrated investigation. For example, the hypothesis that a large, higher-albedo mound was part of a burst glacial dam was confirmed only by walking the formation, and though the orbital data and the video pans showed possible channels or valleys on either side of this structure, it was clear only on the ground that the west valley was the location of the glacial dam breach and the eastern portion of the valley was on a slope. This information, combined with the ability to determine the shape of the mound (the slope was steeper on the west than on the east) and the morphology to the north of it, led scientists to conjecture that the ice-dam hypothesis was possible. Further research and investigation are necessary, however, to definitively state that an ice-dam burst formed the valley.

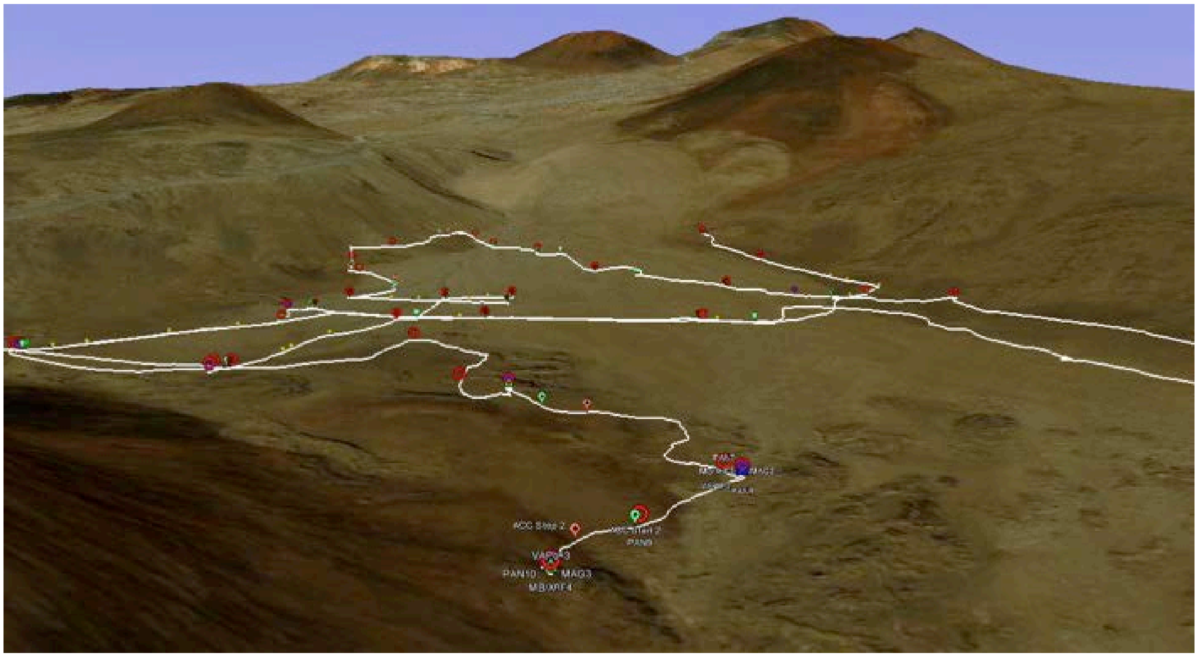

Figure 3.– Mauna Kea Traverse: Perspective view of Apollo Valley, including rover traverse and science locations.

The 2012 MMAMA science activity allowed for a small team to perform significant science over the 3 main days of testing. All personnel worked well together, even though each major instrument set began as a separate proposal (see figure 4).

Figure 4.– The MMAMA Hawaii team.