PREPARING HUMAN EXPLORERS FOR SURFACE SCIENCE OPERATIONS ON THE MOON.
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Introduction: Successful Lunar surface geological exploration will be dependent on a number of different elements, including mission class, mobility capabilities, crew makeup and training, field tools and IT assets that enable efficient data collection, sharing and archiving. These key elements are not independent; when developed together they become the foundation of successful and integrated mission operations. To achieve the best possible lunar surface geological exploration, integration of these elements should start at the beginning of a mission concept, to include the development of mission hardware, crew training and operational concepts.

Mission Class and Transportation: Different geological problems call for different solutions, and in order to solve these problems, operational approaches must be matched to the appropriate solution. We use the idea of mission class to define the operational approaches that can be matched to a given solution.

A Class I mission involves simple sample return for geochemical and radiometric age determination and can be conducted robotically without requirements for extensive mobility. Class II missions involve more detailed robotic exploration and sample return from a complex geological area over time periods greater than one day with requirements for increased mobility and detexterity for the robotic asset. A Class III mission would resemble an Apollo J-mission with as many as 4 crewmembers, a 3-7 day duration, mobility assets to allow 10-20 km radius of exploration and up to 150 kg of sample return capability. A class III mission could be sent to a site previously investigated by a Class II robot, or could be a site where it is clear that human crewmembers will result in the best science return. A Class IV mission involves advanced exploration capability, with durations longer than a Class III mission and exploring around a semi-permanent outpost or on long (100s of km) surface roves, and involving multiple small pressurized rovers (MMSEV-class) that can, if necessary, robotically pre-positioned into a potential exploration area prior to human crew arrival.

Crew Composition and Training: Geologic exploration requires exceptional training in geological observations in procedures, an insight not lost on Apollo trainers. Once engineering missions (AS-11, -12 & -14) were complete, attention turned to conducting extensive geological exploration of the lunar surface. The J-mission crews received in excess of 1000 hours of science training prior to flight, with over 500 hours spent in field geologic training. Future missions will require a similar training commitment, particularly in the lead up to flight. Further, in order to conduct competent science operations, crew selection will be critical. The AS-17 experience of pilot/engineer Cernan paired with a geologist Schmitt proved exceptional and should form the base training model for future human exploration of the lunar surface. Similar crew mixes have been tested on Desert RATS 2010, and have proven the validity of the Apollo 17 experiences.

Conclusions: Current geology training for the astronauts can be generally dividied among three main approaches, including: 1) class room teaching and field exercises during the Candidacy training, 2) a subsequent field assistant program, and 3) integrated analog field tests. Classroom and field exercises incorporate an “outcrop to orbit” perspective. Whether the subject is structural geology, volcanology, or other planetary processes, the topical training integrates orbital observations. The field component of geology training is also integrated with a Crew Office requirement to routinely provide expeditionary training and team building experiences. Today, crew training is motivated by the flight opportunities and training required for missions aboard the International Space Station. This focus will evolve as new opportunities for missions beyond Earth orbit mature, and may once again include the Moon as a target for human exploration for NASA, or NASA support of international efforts to explore the Moon with humans. This includes the Moon either as a target for human surface science operations or as a destination for astronaut operated assets.

The 2010 joint CAPTEM-LEAG study, Lunar Sample Acquistion and Curation Review cited a need to develop a Lunar Exploration Science PI and Science Team well ahead of human landings on the lunar surface. Such a team could support ongoing astronaut training with specific links to lunar exploration. This would involve identification of analog sites relevant to the science topics identified in the New Views of the Moon 2 report. Training would integrate knowledge of mission class, science goals and development of field tools and communications assets that will be necessary for successful human exploration of the Moon.