

A FRAMEWORK FOR LUNAR SURFACE SCIENCE EXPLORATION D. Eppler¹, J. Bleacher², E. Bell³, B. Cohen², M. Deans⁴, C. Evans⁵, T. Graff⁵, J. Head⁶, M. Helper⁷, K. Hodges⁸, J. Hurtado⁹, K. Klaus¹, D. Kring¹, H. Schmitt¹⁰, J. Skinner¹¹, P. Spudis¹, B. Tewksbury¹², K. Young⁵, A. Yingst¹³. 1-Lunar & Planetary Institute, 3600 Bay Area Boulevard, Houston, TX, 77058, eppler@lpi.usra.edu; 2-Goddard Space Flight Center, Greenbelt, MD; 3-University of Maryland; 4-NASA-Ames Research Center; 5-Johnson Space Center; 6-Brown University; 7-University of Texas-Austin; 8-Arizona State University; 9-University of Texas-El Paso; 10-University of Wisconsin; 11-U.S.Geological Survey; 12-Hamilton College; 13-Planetary Science Institute.

Introduction: Successful lunar surface scientific exploration will be dependent on a number of different elements, including: mission concept; mobility; robotic and human crewmembers; crew makeup and training; and geologic field tools and IT assets that enable efficient data collection, sharing, and archiving. These key elements are not independent, and when they are developed together they become the foundation of successful and integrated mission operations. To achieve the best possible lunar surface science exploration, integration of these elements should start at the beginning of a mission concept, to include the development of mission hardware, crew training, and human and robotic operational concepts.

Mission Concepts: Different science problems call for different solutions, and in order to solve these problems, assets and operational approaches must be matched to the appropriate solution. We use the idea of mission concept to define the operational approaches that can be matched to a given solution. Of particular importance is matching the assets to the problem to be solved, so any given mission to the lunar surface has the right assets – robotic and/or human – to accomplish a given scientific activity. Insufficient or excessive assets applied to a problem either puts a given mission in jeopardy of failure, or wastes resources and needlessly increases the risks to human crews.

A Concept I mission involves either a simple sample return for geochemical and radiometric age determination or deployment of geophysical/space physics monitoring assets, and can be conducted robotically without requirements for extensive mobility. Concept II missions involve more detailed robotic rover exploration and sample return from a complex geological area. These missions would be executed over time periods greater than one day, with requirements for increased mobility and dexterity for the robotic asset. In a sense, these could be looked at similar to an Apollo J-mission executed by robots. A Concept III mission resembles an extended Apollo J-mission with as many as 4 crewmembers, duration of up to 14 days, mobility assets to allow a 10-20 km radius of exploration, and up to 150 kg of sample return capability. A Concept III mission could be sent to a site previously investigated by a Concept II robot, or it could be sent to a site

where it is clear that human crewmembers will result in the best science return. A Concept IV mission involves advanced exploration capability, with durations longer than a Concept III mission and exploration around a semi-permanent outpost or on long (100s of km) surface traverses. These long traverses are likely to involve multiple small pressurized rovers that can, if necessary, be robotically pre-positioned into a potential exploration area prior to human crew arrival.

Chapter Approach: This chapter will have two sections. The initial section will establish the first order elements that will be needed to support future lunar exploration in four areas: (1) sample management and analysis; (2) surface measurements; (3) information assets and data management, including scientific record development and management, data dissemination, cartographic and photographic products, and geographic location knowledge requirements; and (4) robotic and human mission operations management, including operations approach, crew training, and operations team philosophy. The second section of the chapter will analyze the open questions developed by the each of the other chapter teams. The goal is to determine the different mission concepts will best satisfy each question and to assess the lunar exploration program implications in terms of developing the first order element to address each question.

Progress Since the First Workshop: Teams covering each of the four areas have been formed, and are in the process of developing the information that will be used to write the first section. In addition, a first draft of the mission concepts section has been written and is in review by the team. Once the other chapters in the volume produce their open science questions, the team will analyze these questions in light of the mission concept discussion, and propose mission sets that could be executed to answer a particular science mission.