A MISSION CONCEPT BASED ON THE ISECG HUMAN LUNAR SURFACE ARCHITECTURE.
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Introduction: The National Aeronautics and Space Administration (NASA) is participating in the International Space Exploration Coordination Group (ISECG), working together with 13 other space agencies to advance a long-range human space exploration strategy. The ISECG has developed a Global Exploration Roadmap (GER) that reflects the coordinated international dialog and continued preparation for exploration beyond low-Earth orbit – beginning with the International Space Station (ISS) and continuing to the Moon, near-Earth asteroids, and Mars [1]. The roadmap demonstrates how initial capabilities can enable a variety of missions in the lunar vicinity, responding to individual and common goals and objectives, while contributing to building partnerships required for sustainable human space exploration that delivers value to the public. The current GER includes three different near-term themes: exploration of a near-Earth asteroid, extended duration crew missions in cis-lunar space, and humans to the lunar surface.

Lunar Surface Reference Mission: The ISECG design reference mission (DRM) for human exploration of the lunar surface utilizes mobile habitation systems in the form of pressurized rovers, so that a series of five missions could in theory explore five different locations with the same set of surface infrastructure [2]. A space transportation architecture to enable these surface missions would include an evolvable deep space habitat (eDSH) located in cis-lunar space, and a lunar lander with a reusable ascent vehicle maintained at the eDSH and disposable descent stages. The descent stages, crew, and mission payloads could be delivered to the eDSH by a variety of launch vehicles and spacecraft. Each individual surface mission would support up to 4 people for up to 28 days. It is assumed that the pressurized rovers could be relocated via autonomous and teleoperated traverses between crewed missions. The notional surface campaign in the ISECG DRM focused on the South Pole-Aitken basin. Here we suggest an alternative campaign that focuses on the nearside Oceanus Procellarum.

Kepler Crater: The initial landing for the surface campaign site would be near the impact melt ponds just north of Copernican-age Kepler crater, as mapped by Öhman et al. [3] in figure 1. The primary scientific objective would be to sample the melt ponds and local basalts for age dating. Though this type of mission could likely be accomplished with a simple robotic probe, it is thought the first human mission in the campaign will likely be shortest in duration (7-14 days), and entail quite a bit of surface system check-out and testing for the follow-on missions. Though not specifically stated in the ISECG architecture, it is assumed that crews can explore out to a radial distance from the landing site of at least 25-30 km.

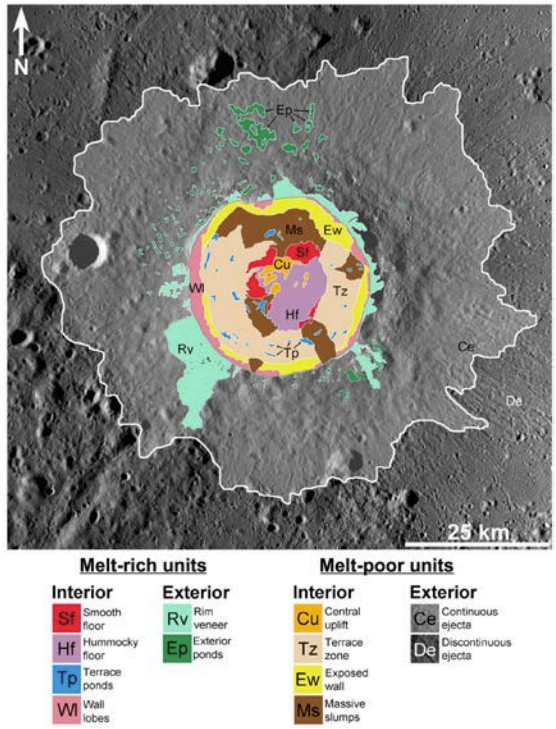

Figure 1 Geomorphic sketch map of Kepler (Ohman et al. 2012)

Reiner Gamma: The location for the second human mission would be Reiner Gamma, with its light- and dark-colored swirls and magnetic anomaly. The scientific objective would be to better understand this enigmatic feature, and others like it distributed around the Moon. The traverse from Kepler would be approximately 625 km, but the ISECG architecture proposes only one human mission per year, so there would be many months available to cover this distance across a mostly smooth mare surface. Along the way, the traverse crosses several major mare basalt units with ages spanning 1.5 by, as mapped by Hiesinger et al [4]. It would be advantageous to include some type of teleoperated sampling system on the pressurized rovers to sample these units.

Marius Hills: The third landing site (figure 2) would be in the Marius Hills region, near a large, steep-walled pit described by Robinson et al. [5]. The scientific objective of this mission would be to sample the various volcanic cones and domes and associated lava flows, within rover range, and to use robotic probes to descend into the pit to better understand its formation and possible association with an underground lava tube. The traverse from Reiner Gamma to this location would be approximately 225 km, and would pass by numerous volcanic cones, domes, and sinuous rilles which could be observed and sampled to better understand their formation process and history.

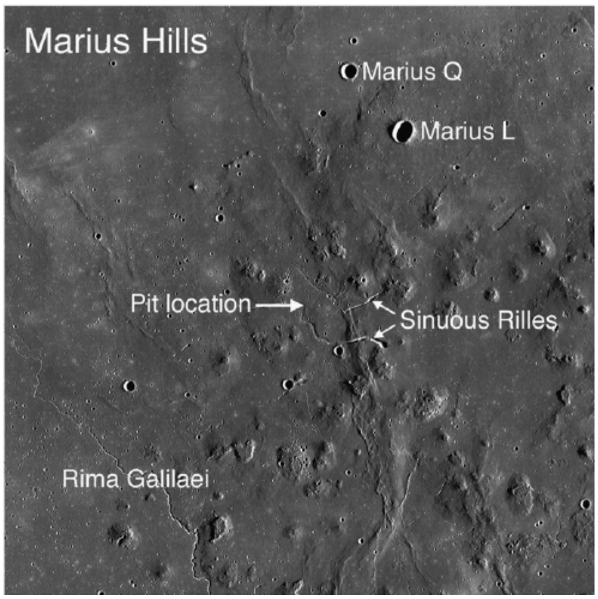

Figure 2 Marius Hills landing area (Robinson et al., 2012)

Aristarchus Plateau: The final two landing sites are associated with the unique and complex Aristarchus Plateau (figure 3). The fourth human mission would land on the mare plains adjacent to the southern boundary of the plateau. These plains are mapped as the youngest basalts on the Moon by Hiesinger ate al. [4], and are important to sample to understand the thermal and magmatic history of the Moon. A young volcanic vent is also in the exploration zone of the fourth mission. Another important scientific objective of this mission, would be to collect ejecta from both Aristarchus and Herodotus craters in radial collection patterns pointing back to the center of each crater. These samples could yield information from different depths of the Aristarchus Plateau, and also possibly yield ages for both impacts. This location is approximately 350 km away from the Marius Hills landing site, and the traverse is mostly over smooth, mare terrain.

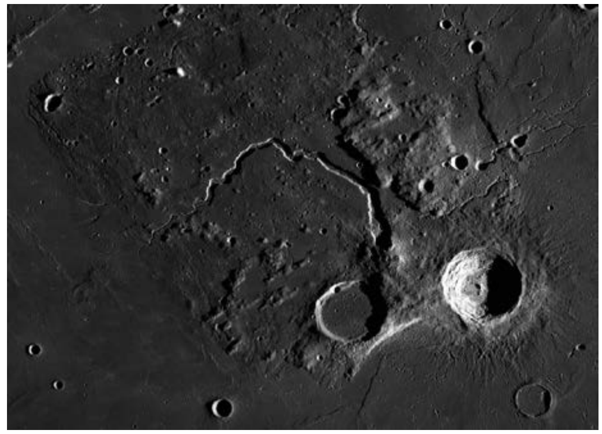
Figure 3 LROC WAC mosaic

The fifth and final human mission in this campaign will target the Aristarchus Plateau proper, near the source vent for Schröter's Valley. There are various paths that could be taken from the previous landing site, from the most direct, but possibly most challenging traverse directly up the southern boundary of the plateau (~ 85 km), to a traverse that circumnavigates Herodotus crater (~ 200 km). The scientific objectives at this final landing site would be to understand the formation, impact, and volcanic history of the very complex plateau.

Conclusion: Through this series of human missions, many of the important lunar science concepts and goals of the National Research Council could be addressed [6]. These include determining ages for the Kepler, Aristarchus and Herodotus impacts, determining the variability in chemistry, mineralogy, origin, and age for a number of mare units, determining the composition range and extent of the Aristarchus regional pyroclastic deposit, and determining the compositions and age of the rocks that make up the Aristarchus Plateau. Finally, the last landing site on Aristarchus Plateau could possibly transition to a mining operation, using the regional pyroclastic deposit as an 'ore body' to produce oxygen and other useful products for long-term human presence.

References: [1] ISECG (2013) *http://www.nasa.gov/sites/default/files/files/GER-2013_Small.pdf*. [2] Hufenbach B. et al. (2015) IAC-15, A5,1,1,X30756. [3] Öhman T. et al. (2012) *J. of Geophys. Res.*, 117, E00H08. [4] Hiesinger et al. (2011) GSA Special Paper, 477, 1-51. [5] Robinson M.S. et al (2012) *Planet Spa Sci*., 69, 18-27. [6] NRC (2007) National Academies Press.