LUNAR SURFACE OPERATIONS WITH DUAL ROVERS

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INTRODUCTION: Lunar Electric Rovers (LER) are currently being developed that are substantially more capable than the Apollo vehicle (LRV). Unlike the LRV, the new LERs provide a pressurized cabin that serves as short-sleeve environment for the crew of two, including sleeping accommodations and other provisions that allow for long term stays, possibly up to 60 days, on the lunar surface, without the need to replenish consumables from some outside source, such as a lander or outpost. As a consequence, significantly larger regions may be explored in the future and traverse distances may be measured in a few hundred kilometers (1, 2).

However, crew safety remains an overriding concern, and methods other than "walk back", the major operational constraint of all Apollo traverses, must be implemented to assure –at any time- the safe return of the crew to the lander or outpost. This then causes current Constellation plans to envision long-term traverses to be conducted with 2 LERs exclusively, each carrying a crew of two; in case one rover fails, the other will rescue the stranded crew and return all 4 astronauts in a single LER to base camp. Recent Desert Research and Technology Studies (DRATS) analog field tests simulated a continuous 14 day traverse (3), covering some 135 km, and included a rescue operation that transferred the crew and diverse consumables from one LER to another; these successful tests add substantial realism to the development of long-term, dual rover operations. The simultaneous utilization of 2 LERs is of course totally unlike Apollo and raises interesting issues regarding science productivity and mission operations, the thrust of this note.

ISSUES: One of the major, outstanding questions is the possible separation distance of the 2 vehicles. The latter is substantially dictated by the LERs' energy budget, as each LER must be able to reach the disabled partner at any time. Both LERs will charge their batteries via portable photovoltaics and the separation distance may thus vary with the battery status on a daily, possibly hourly basis, resulting in a "drive-to" envelope akin to the Apollo walk back constraint. Separation distances of tens of km seem optimistic and 10 km may be more reasonable; close proximity operations are obviously optimal from a safety point of view. Depending on how these currently open energy and safety considerations will ultimately manifest themselves in firm "flight rules", the two rovers may or may not be allowed to operate independently. We assume in this note that separation distances will be < 10 km and that both rovers essentially explore, to first order, the same terrain and geology.

This then raises the question: how are the two vehicles and crews best utilized to maximize the science return? On one hand one can postulate an end-member case in which both crew and vehicles are configured in identical fashion, primed to conduct identical exploration tasks via modestly different (or identical?) traverses and EVA stations. The other end-member case would have LERs A and B configured such that each pursues dramatically different tasks. Obviously, both LERs have to complement each other in all cases, yet it seems likely that potential redundancy will be reduced, by design, in the latter case. The following expands on the idea to have substantially different capabilities on board each rover, with both rovers operating on occasion within kilometers of each other, yet mostly in close proximity as a tandem, if not as a single unit; we dub this the "Tandem Mode" of rover operations.

THE TANDEM MODE: Most surface exploration scenarios define geologic observations by the crew, the acquisition of samples, and geophysical investiga-

Fig.1: Protopype LER during field test at Black Point Lava Flow, in the vicinity of Flagstaff, AZ

tions as the prime objectives. This already suggests, that one LER may do all of the geophysical investigations via such instruments as ground-penetrating radar, active and passive seismic experiments, magnetometers, heatflow probes, gravimeters, soil penetrometers etc. The other LER would then specialize in geologic field observations and the acquisition of samples. Obviously, the crews of LER A and LER B would have different, yet complementary, skill mixes. Geophysical investigations and sample acquisition could proceed simultaneously at the same station or at modest (<5 km) separation distances. Based on Apollo it seems fair to assume that the geophysical investigations will be less frequent and time-consuming than the sample acquisitions, and LER A should have time to somehow support the acquisition of samples, the primary task of LER B.

LER A could be designed and manned such that it specifically contributes to the "high grading" of the sample collection. The latter relates to the reduction of sample mass collected in the field such that it becomes compatible with the allowable mass for Earth return; this "high grading" will occur in a number of phases and places as detailed by (4), yet it is most efficiently done in the field, as there is ultimately also a sample-related mass limit on each LER. Based on Apollo, it can be expected that future 4-men crews on long-duration missions may collect many times the allowable Earth return sample mass, and suitable "high grading" becomes a major science issue (5). We define "high grading" (see also 4 and 6) as employing some instrument(s) which can augment the field- and hand specimen-descriptions of an experienced and well trained observer. The instrument(s) may either reveal petrographic, mineralogic, or compositional information beyond that generated by the unaided eye of the field workers, thus providing critical information to identify the scientifically most valuable samples. Such instruments based on XRF, XRD, Raman and IR spectroscopy, laser ablation etc are currently under development and suitable devices for inclusion into an LER should mature within a decade. We envision these high-grading operations to be conducted outside the pressurized cabin, yet data display and synthesis may very well occur inside. An accurate scale will be part of the instrument suite and the crew will know the stored sample mass at any given time. Another useful tool to be mounted on LER A would be a rock splitter inside a containment box, which would allow the safe and purposeful fracturing and subdivision of homogeneous rocks or the isolation of specific clasts or matrix of polymict breccias (see 4).

The simple point here is: LER mounted devices seem capable to assist in the high grading of the field collection; this high grading would complement that achieved by hand held instruments operated by the field workers (4); the total sample mass carried on board the rover would be minimized and the final high grading in the Outpost's GEOLAB (6) could be more focused. The LER A crew seems in a position to devote substantial time and effort to this activity, thus complementing the efforts of LER B and that of the science "backroom" on the ground.

CONCLUSION: The use of 2 rovers provides substantial challenges to science operations. This even includes the possibility of 2 Science Support Rooms on the ground, if both rovers were to conduct substantially identical operations. We suggest that the rovers should be configured such that they conduct complementary investigations, as this seems more productive scientifically. One rover could shoulder the tasks of geophysical investigations and sample high grading, the other of geologic field observations and basic sample acquisition.

References: (1) Weisbin, C.R. *et al*., (2008), LPSC 40th, Abstract # 1054; (2) Clark, P. E. *et al*. (2008) LPSC 40th, Abstract # 1135; (3) Evans, C.. *et al*; LPSC 41st, this volume; (4) Lofgren, G. E. *et al*., LPSC 41st, this volume; (5) LEAG http://www.lpi.usra.edu/leag (6) Calaway, M.J., *et al*., LPSC 41st, this volume.