LUNAR SURFACE GRAVIMETRY SURVEYING THROUGH THE LUNAR NIGHT. K.A. Carroll, Gedex Systems Inc., 407 Matheson Blvd., Mississauga, Ontario, Canada L4Z 2H2, kieran.carroll@gedex.com

Introduction: Making gravimetry measurements on the Lunar surface is a powerful technique for determining characteristics of the Moon's subsurface structure. The most useful types of measurements are long-term monitoring of the Moon's gravity at one or more static locations, and surveys over extensive lines and/or areas in which measurements are made at a large number of different locations. In both cases, limiting the data-taking to a single Lunar day-time significantly restricts the dataset sizes, limiting the science results that can be obtained. We discuss how Lunar landers and rovers capable of surviving the Lunar night would enhance the science achievable for Lunar surface gravimetry.

Lunar Surface Gravimetry Background: The well-known terrestrial geophysics technique of surface gravimetry surveying is one of the few techniques that can provide information about the composition and structure of the lunar subsurface. This has been used once on the Moon, with Apollo 17's Traverse Gravimeter Experiment (TGE) [1]. Gravimetry surveys carried out on the Lunar surface can achieve sub-km spatial resolution, far finer than the ~12 km resolution achievable by the best gravity measurements made from Lunar orbit [2]. New gravimeter technology opens the prospect of conducting lunar surface gravimetric surveys using small lunar rovers [3].

Gravimetry can be used to determine the size and extent of interesting subsurface features such as lava tubes [4][5], ice deposits, buried craters and boulders, and volcanic intrusive features such as those that may cause the magnetic anomalies associated with lunar swirls. They can augment and enhance interpretation of local and global seismological signals collected by Lunar Geophysical Network stations [6]. Long-term gravimetry monitoring at one or more static locations on the Moon may provide a means to probe the structure of the Moon's mantle.

Surveying Through The Lunar Night: One application for gravimetry on the Lunar surface is *gravimetry surveying*, in which a gravimeter is carried to a sequence of measurement stations, typically either along a traverse line (as in the TGE survey), or spread throughout a two-dimensional area (e.g., along a set of parallel survey lines). Such surveys aim to estimate density variations in the subsurface structure below the survey area, to help understand the local geology.

The more measurements that are made in such a survey, the larger the area that can be covered, and/or the finer the spatial resolution that can be achieved in the resulting geological models. Obviously, surveys that are carried out by rovers that can survive the Lunar night can make measurements at a greater number of stations, by making measurements over a period of multiple Lunar days, covering more survey area.

Modern Lunar rovers (; e.g., CNSA's Yutu rover) are expected to have a speed of ~0.2 km/hour, allowing up to ~70 km of travel during one Lunar day, Taking into account time that must be spent making each gravimetry measurement (expected to be 10-20 minutes per station), such a rover could traverse as much as 40 km of survey line length, with 100 m between stations, over the course of one Lunar day, allowing an area of 2x2 km to be surveyed with line spacing of 100 m.

A rover capable of surviving the Lunar night could cover more survey line length and/or area. E.g., over the course of 2 years (24 Lunar days) a total distance of perhaps 1000 km could traversed, allowing an area of 10x10 km to be surveyed at 100 m resolution.

Long-Duration Gravity Monitoring: Another application for gravimetry on the Lunar surface is *long-duration monitoring* of the gravity strength at one or more static locations on the Moon, to probe the structure of the Moon's mantle. As discussed in [7], some of the Moon's hemispherically asymmetric features may be explained by the Lunar mantle having a laterally inhomogeneous structure. Long-duration gravimetry measurements at a well-selected static location on the Lunar surface, using a gravimeter on a Lunar lander, could investigate this by detecting the non-degree-2 elastic response of the Moon to tidal forcing from the Earth and the Sun. Measurement series longer than one Lunar day will span multiple cycles of these signals, and produce more data points to fit to a Lunar elasticity model, resulting in improved estimates of mantle inhomogeneity parameters.

References: [1] Talwani M. (2003) The Leading Edge v.22 no.8, 786-789, doi: 10.1190/1.1605083. [2] Lemoine, F.G. et al. (2014) *Geophys Res Lett., 41,* 3382–3389. [3]. Jawin, E.R. et al., "Lunar Science for Landed Missions Workshop Findings Report," SSERVI. [4] Carroll, K.A. et al. (2015) *LPS XLVI*, Abstract #1746. [5] Urbancic, N. et al. (2017) *JGR: Planets, 122*, 1181-1194. [6] Carroll, K.A., "Lunar Surface Gravimetry Science Opportunities," poster at SSERVI/LEAG Lunar Science for Landed Missions workshop, NASA Ames Research Center, 10-12 Jan. 2018. [7] Zhong, S. et al. (2012) *Geophys Res Lett., 39,* 3382–3389.