CONSTRUCTING A PROBABLISTIC SEISMIC HAZARD ANALYSIS FRAMEWORK FOR THE MOON.

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Introduction: Global coverage with high resolution images and altimetry data from the Lunar Reconnaissance Orbiter (LRO) spacecraft have enabled detailed mapping of tectonic features on the Moon, including wrinkle ridges, graben, and over 3500 young lobate scarps [1–3]. The locations of young fault scarps can now be combined with newly developed seismic ground motion shakemaps [1] and data from the Apollo-era seismic network on distributed seismicity and the nature of the near-surface structure [6–8]. These components collectively offer inputs to develop a preliminary seismic hazard analysis (PSHA) for the Moon, which includes a seismic source model, a ground motion model, and a site response model (Fig. 1).

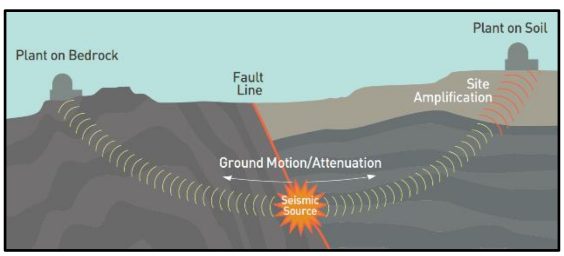

Figure 1. PSHA components [9].

In this study we explore preliminary applications and extensions of existing PSHA methods (e.g., as utilized in the nuclear industry [10] and more broadly) to probabilistically assess seismic hazard on the Moon and other planetary bodies. A preliminary seismic source model can be constructed using the location of potential fault sources (i.e. global distribution of lobate scarps) [1–7] and distributed seismicity data from the Apollo era seismic catalog. We develop the ground motion model using information from lunar shakemaps, as developed in [1]. Finally, for the site response model we derive a velocity profile of the upper 30 m in the near-surface using seismic waveforms measured from seismic instruments deployed during the Apollo era [7–9] and the horizontal-to-vertical spectral ratio method to estimate the fundamental resonance peak [11–12].

The results of this study will provide a useful resource for evaluating seismic hazards on the lunar surface, both globally and at high priority landing sites. Such a hazard evaluation is essential to support the future design and construction of structures, systems, and components [13] (especially possible nuclear-based power source options) that are being explored. This study is particularly timely in lieu of renewed interest in the lunar surface operating environment and NASA's Artemis lunar exploration program.

The results will also aid in the development of future lunar seismic monitoring networks and help target areas where additional orbital and in-situ data may be needed to develop a more robust PSHA for design purposes for future exploration. Specific astronaut led field activities could include geophysical investigations that could constrain scarp geometries, near-surface characteristics, and ground motion attenuation to more accurately characterize the seismic hazard at future landing sites of interest (i.e. permanently shadowed regions (PSRs) in the south polar region)

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