LTE Coverage Analysis Using TEMPER and Wireless InSite

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While recent science missions, such as NASA Lunar Reconnaissance Orbiter (LRO), have collected valuable selenic data, little is known about Earth's moon, especially its far-side and poles. The NASA Artemis Program will further our understanding by enabling human exploration of the lunar South Pole. The Artemis mission will require high-data-rate communications to minimize exposure of human and robotic explorers to extreme environmental effects. Rugged terrain in this region will makes surface-to-surface communications difficult. To design a communications system that meets the above specifications requires accurate electromagnetic wave propagation modeling over the lunar regions of interest.

JHU/APL examined the coverage of a Long Term Evolution (LTE) communication system at the lunar South Pole using multiple models. The Tropospheric Electromagnetic Parabolic Equation Routine (TEMPER) is a JHU/APL-developed software, which uses a Fast Fourier Transform to solve the 2D electromagnetic parabolic wave equation. While TEMPER has an extensive pedigree for accurately modeling radio frequency (RF) refraction within the marine-air boundary layer, it has also been adapted to model propagation over terrain, which JHU/APL leveraged for this analysis. Remcom, Inc.'s Wireless InSite (WI) is a 3D ray-tracing software suite for modeling the effects of terrain, buildings, and foliage on site-specific RF propagation. JHU/APL employed the WI X3D shooting and bouncing ray propagation model, which accounts for reflections, transmissions, approximate diffraction, and atmospheric absorption.

The methodology outlined in this work enables a high-fidelity representation of propagation effects to construct an accurate estimate of coverage of the lunar South Pole region. Each model offers significant advantages over a simple line-of-sight coverage solution. TEMPER accurately captures the effects of shadowing, 2D multipath, and diffraction, whereas WI captures the effects of 3D scattering and multipath. Merging the results of both models allows for a conservative estimate of performance, while still accounting for higher order propagation effects. Furthermore, this methodology can be easily extended to other coverage analyses.