Interference to NASA GPS Applications: Lunar Missions & Climatology

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Background

GPS is required for everything from cellphone communication to weather forecasting to navigation. However, GPS is vulnerable to interference from other signals, which may threaten its functionality and reliability, thus impacting all the systems that rely on it. Ligado Network's recently approved use of 1526-1536MHz for their 5th Generation Broadband Mobile Telecommunications (5G) network base stations, aims at providing private 5G networks for the energy, manufacturing, health care, and transportation industries and poses a potential for interference with GPS receivers in the L1 band (~1559-1610MHz). This project investigates the potential interference and impacts on GPS receivers caused by Ligado base stations on two (2) specific NASA uses of GPS – 1) for lunar navigation in support of the Artemis Program, and 2) for the use of GPS signals directly performing scientific measurements for climate science and monitoring applications.

Methods

Investigations into lunar navigation systems is performed by modeling and simulating the interference that may be seen by a GPS receiver en route and on the lunar surface. Research into Ligado and other similar systems is used to develop a list of assumptions for the parameters of the simulation. The project pulls from existing MATLAB modeling and simulation code, which will be modified to reflect the specific use-case deployment scenarios of the Ligado interference and will include a modification of the GPS receiver characteristics. The parameters are then altered to account for multiple deployment scenarios and run as a Monte Carlo algorithm that will provide results mimicking various Ligado deployments. Various internal and external NASA database as well as academic papers were searched to find missions that used GPS for climate science

Objectives

- Develop a list of assumptions for currently unknown parameters for the study
- Modify existing MATLAB code to meet the specifications and methodologies for study
- Perform multiple iterations of the modelling & simulation, while varying various assumptions using Monte Carlo algorithms
- Obtain modeling & simulation results to inform the developers of lunar GPS receivers

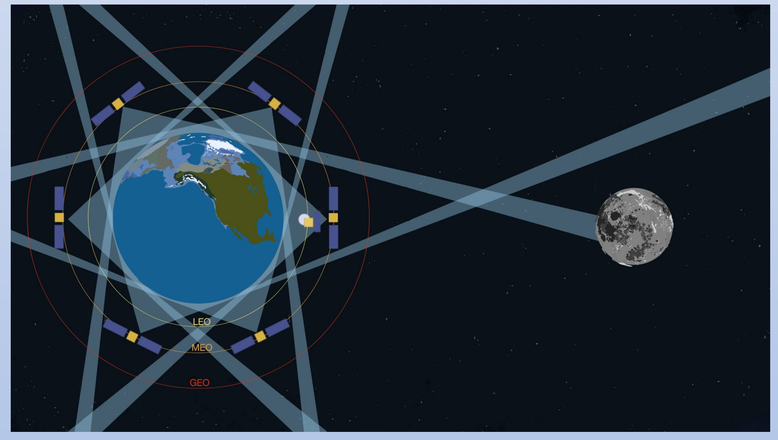


Illustration of "traditional" GPS set up. Six GPS satellites are represented with extended service volumes

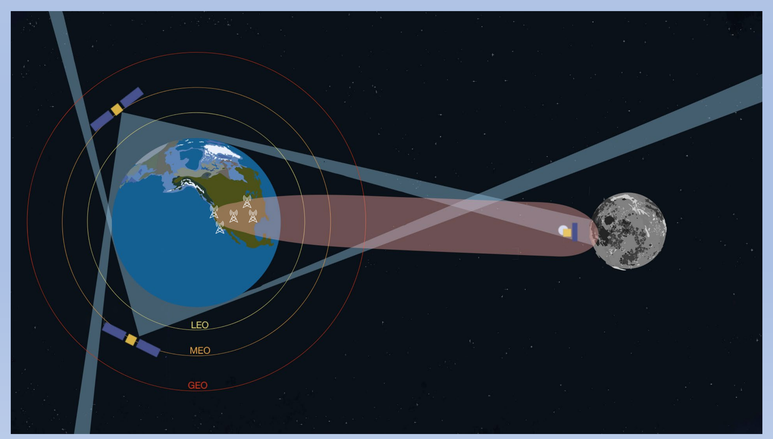
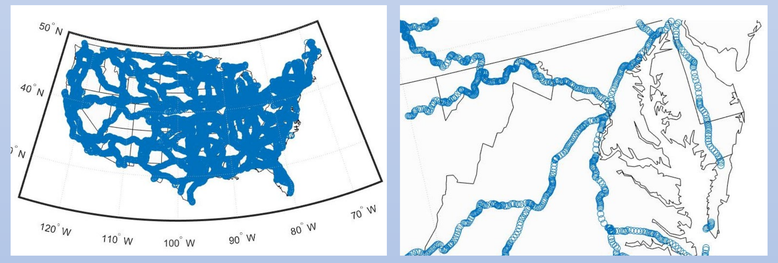


Illustration demonstrating use of GPS extended service volumes (blue) at lunar surface with interference from 5G base stations (red)

Results

- Compiled a collection of 13 missions, 10 of which are currently active, currently utilizing GPS for climate science
- Analyzed mission specifications and data: most common GPS-climate uses are Radio Occultation, Reflectometry, and precise timing and location
- Modelled scenarios for 4,000 – 40,000 base stations placed along railroads in the continental United States
- Developed MATLAB code to simulate interference from Ligado base stations at lunar surface
- In process of creating Monte Carlo simulations



Maps of railroad base station deployment over (1) the continental US and (2) Maryland, where each circle represents a 5G base stations

Future Work

- Continue develop the simulation to include up to 200,000 base stations and more locations to measure interference along the path to the moon
- Use findings to understand the feasibility of using extended service volumes for GPS navigation
- Inform GPS receiver designs for future systems
- Inform discussions on legislative and regulatory processes

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