ECE 4012 AN10A Proposal Presentation

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Agenda

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- Motivation
- Goals
- Technical Specifications
- System Design
- Schedule and Milestones
- Project Demonstration
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Introduction

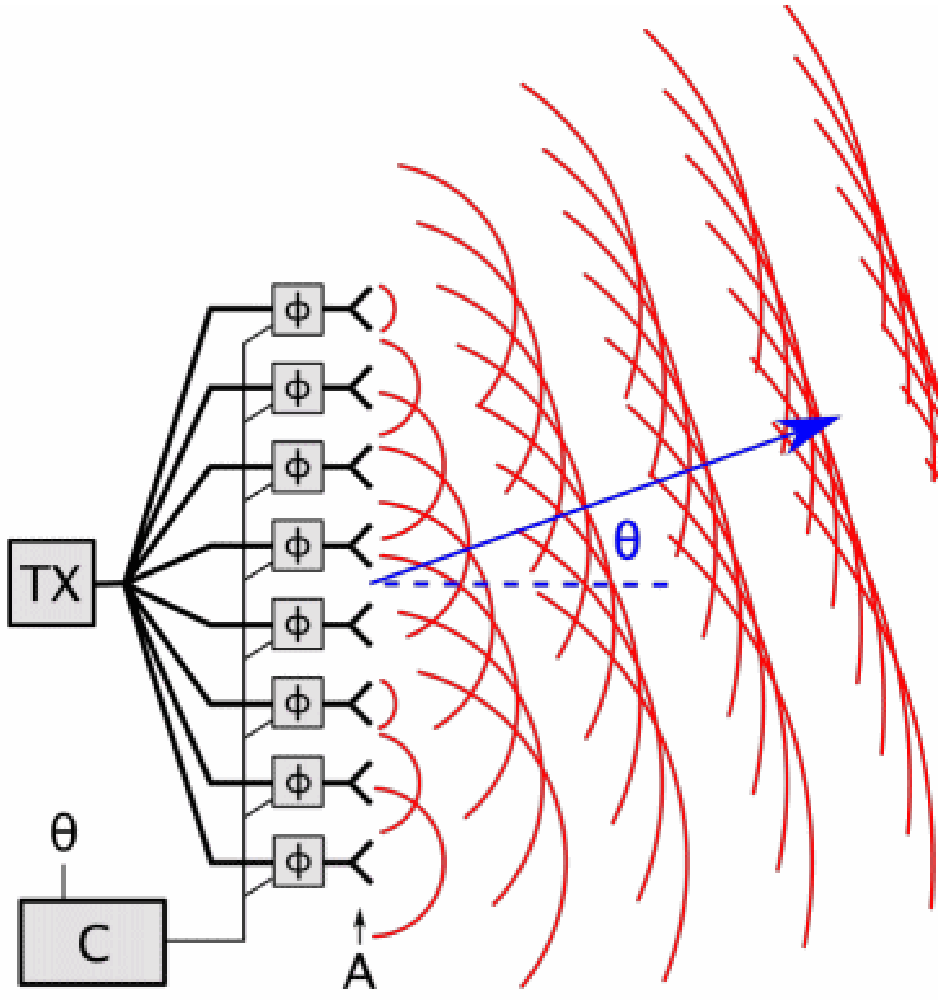
- This project is inspired by NASA's upcoming Artemis mission.
- NASA seeks to send back astronauts to the lunar surface.
- To be used as a gateway for interplanetary exploration.
- With the advent of this program, lunar surface communication systems have attracted attention.

Motivation

- 2.4 GHz Wi-Fi links are used for EVA communications on the lunar surface.
- Compared to VHF links, 2.4 GHz links introduce 18 dB more path loss.
- This severely limits the range of communication devices on the lunar surface.
- Current NASA goal for EVA range is 0.5 km.
- A phased array can be used to increase the gain in the azimuthal plane and surpass this goal.

Goals

- Develop a phased array system to be deployed on the lunar surface in the space environment.
- Spatially-reconfigurable and reliable communication links
- Easily deployable
- Lightweight
- Cheap
- Compatible with NASA and IEEE standards

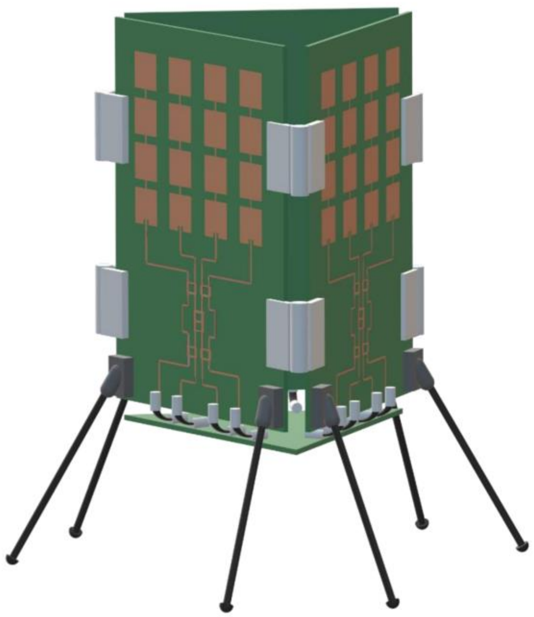


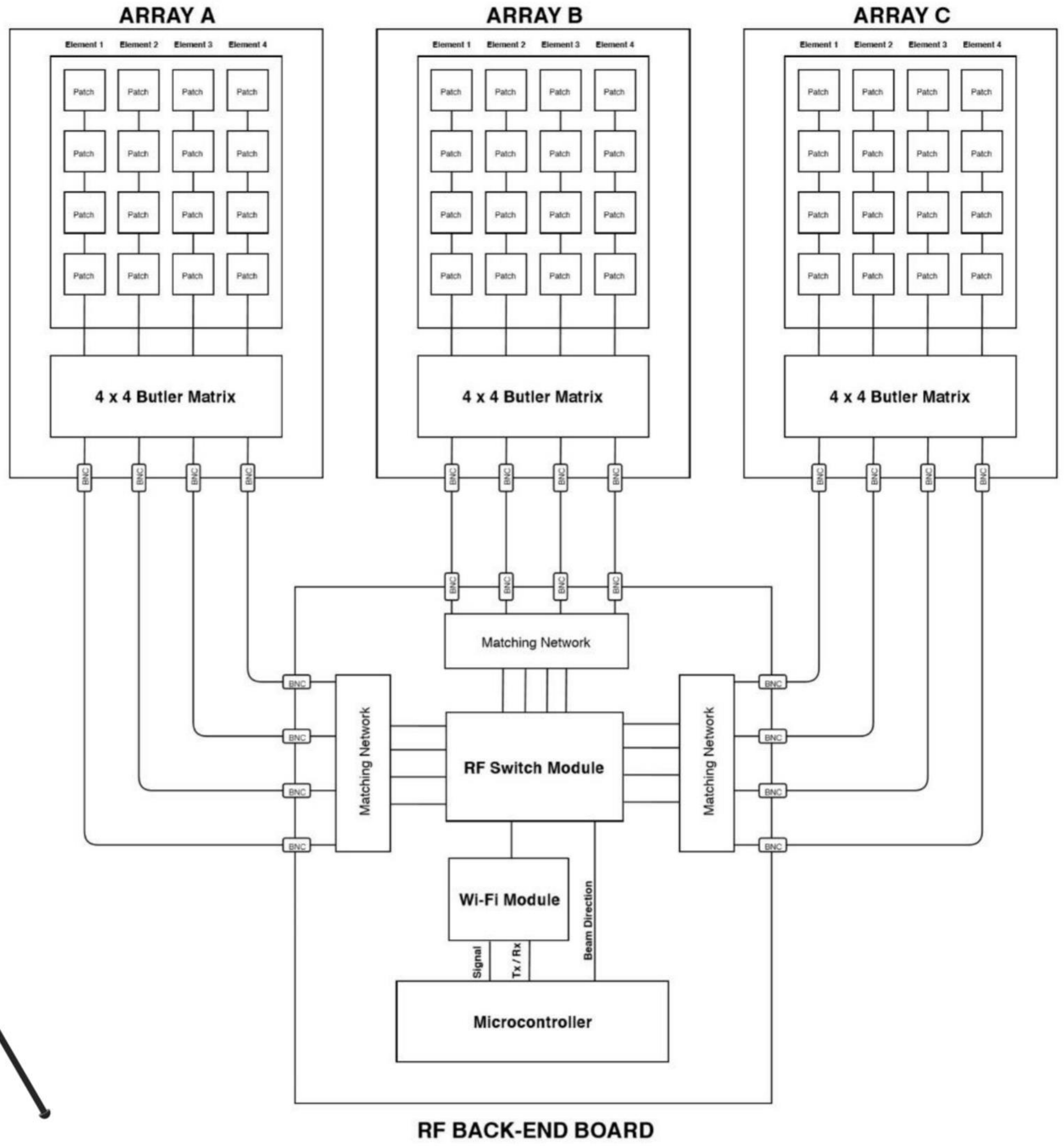
Technical Specifications

- 2.4 GHz frequency
- 0.5 km or greater range
- 2 lbs.
- -70 dBm minimum received signal strength
- 30-degree electrical beam steering resolution
- 70 mW gross power consumption

System Design

- Front end:
  - ➢ Series-fed linear patch antennas
  - ➢ Butler matrices
- Back end:
  - ➢ RF switch module
  - ➢ Wi-Fi module
  - ➢ MCU
- Mechanical Fixture:
  - ➢ BNC connectors
  - ➢ Hinges
  - ➢ Mechanical supports





Schedule and Milestones

Task Building Blocks	Start Date	End Date	Task Lead
Design circuit topology for Butler matrix	November 9th	January 6th	Baris Volkan Gurses
Design/finalize patch antenna design	November 9th	January 6th	Lucas Wray
Simulate/optimize Butler matrix	December 15th	January 6th	Baris Volkan Gurses
Simulate/optimize patch antenna	December 15th	January 6th	Sarah Deitke
Write project proposal/summary	November 9th	November 15th	All
Create the PCB layout	January 6th	January 20th	Lucas Wray
Design the mechanical fixture	January 6th	January 13th	All
Fabricate/populate the PCBs	January 20th	February 17th	Sarah Deitke
Build the mechanical fixture	February 3rd	February 17th	All
Characterize the system	February 17th	March 3rd	All
System field tests	March 3rd	March 30th	All
Write final report	March 30th	April 6th	All
Create/rehearse oral presentation	March 30th	April 6th	All
Create the design expo demo/poster	April 6th	April 20th	All
Project demonstration	April 13th	April 13th	All
Participate in design expo	April 20th	April 20th	All

Project Demonstration

Range Demonstration:

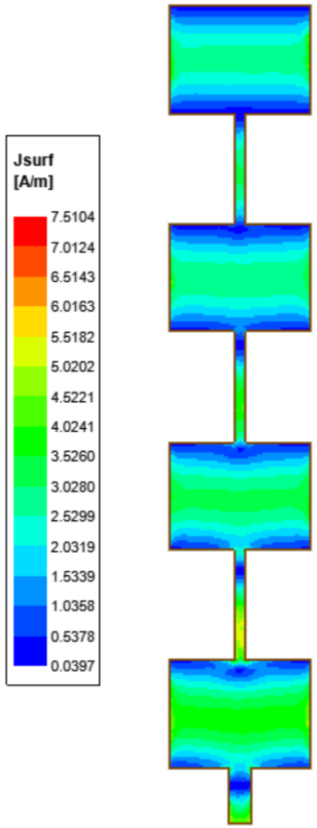
- Phased array and an off-the-shelf receiver with an isotropic gain of 17 dbm will be place 0.5 km apart.
- Successful communication link will be tested.
- Same test will be repeated by increasing the distance in 100-m increments.

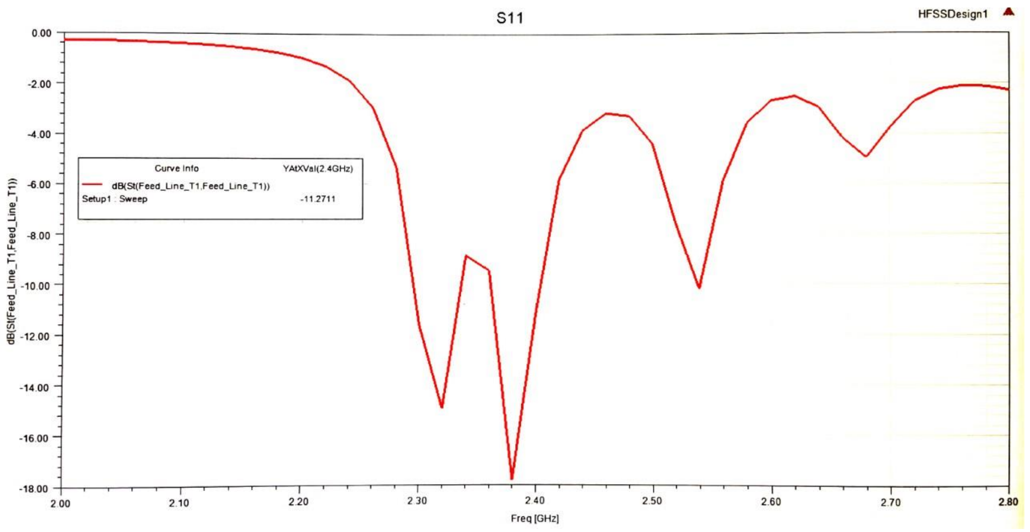
Coverage Demonstration:

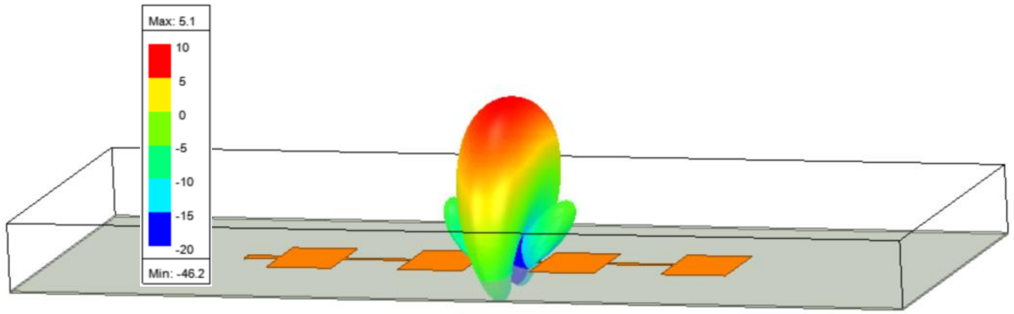
- Off-the-shelf receiver will be placed 50 m away from the phased array.
- Receiver will be moved around the phased array.
- Successful communication link will be tested at each location.

Current Status
Patch Antenna Design

- Optimize dimensions (gain, S11)
- Chebyshev width tapering (SLL)
- If BW < 100 MHz, explore other feed options

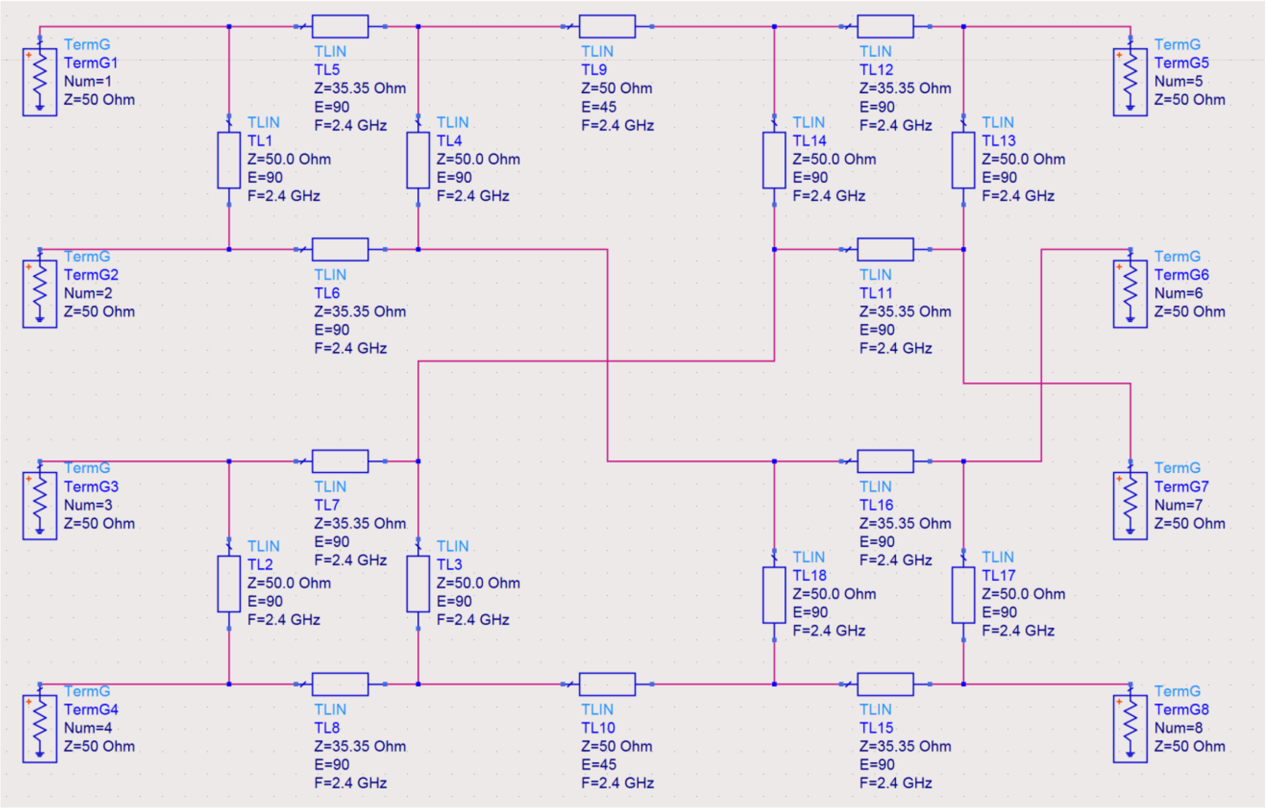


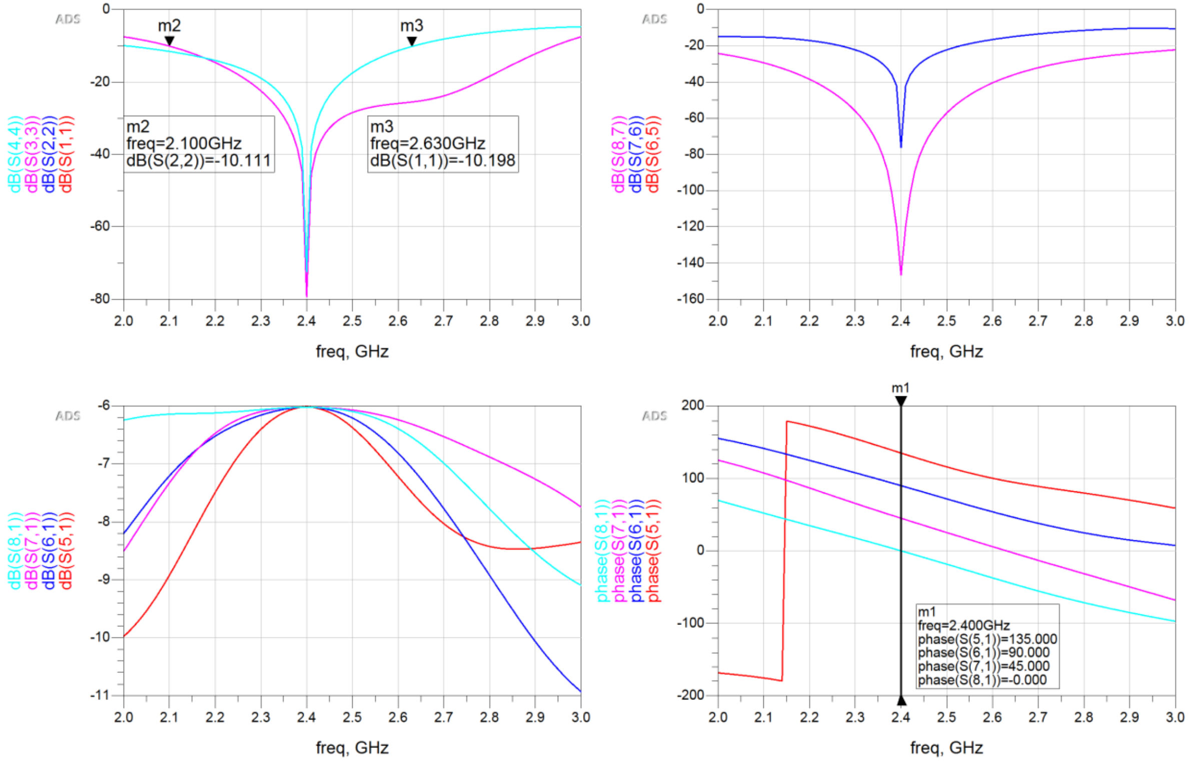




Current Status

Butler Matrix Design





Current Status
Lunar Propagation Model

- d^4 path loss exponent
- Longley Rice Irregular Terrain Model modified to lunar surface
- Recommended margin 15-20 dB of additional power

$$d_{max} = 10^{\left(\frac{G_{TdB} + G_{RdB} - P_{TdB} + P_{RdB} + 2(h_{TdB} + h_{RdB}) - M_{Total}}{40}\right)}$$

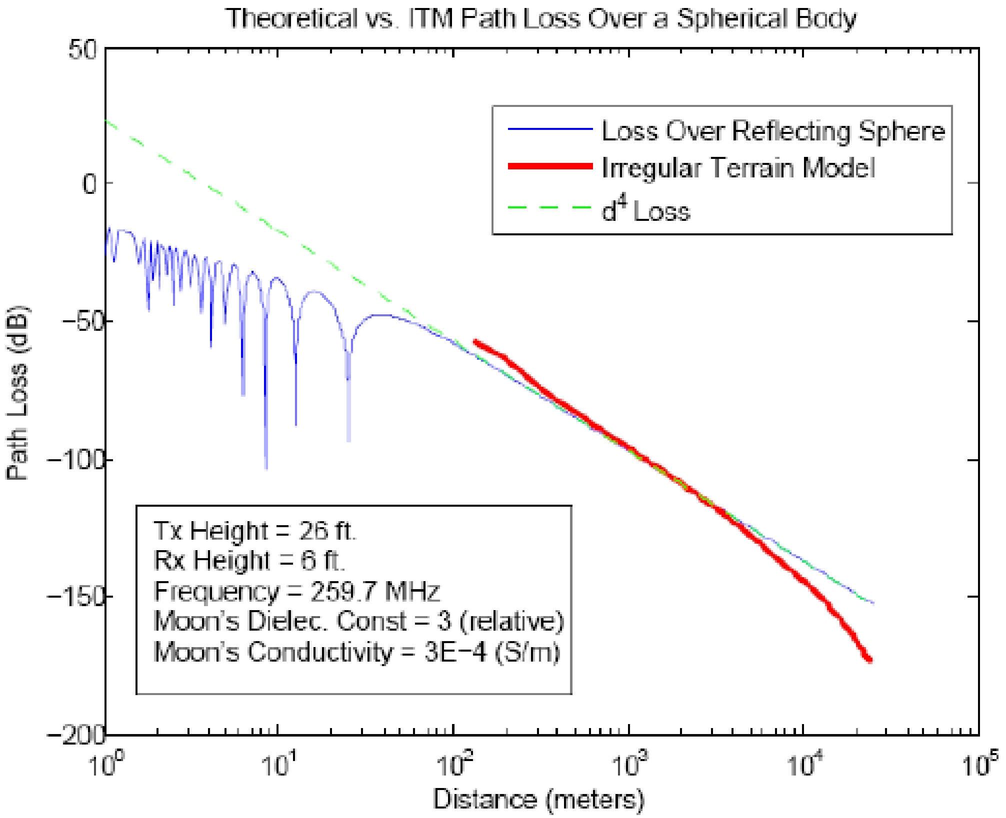


Figure 1.—Smooth Moon path loss.

References

- https://www.nasa.gov
- https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20070025224.pdf