Cognitive Tapered Slot Circular Array Antenna for Lunar Surface Communications

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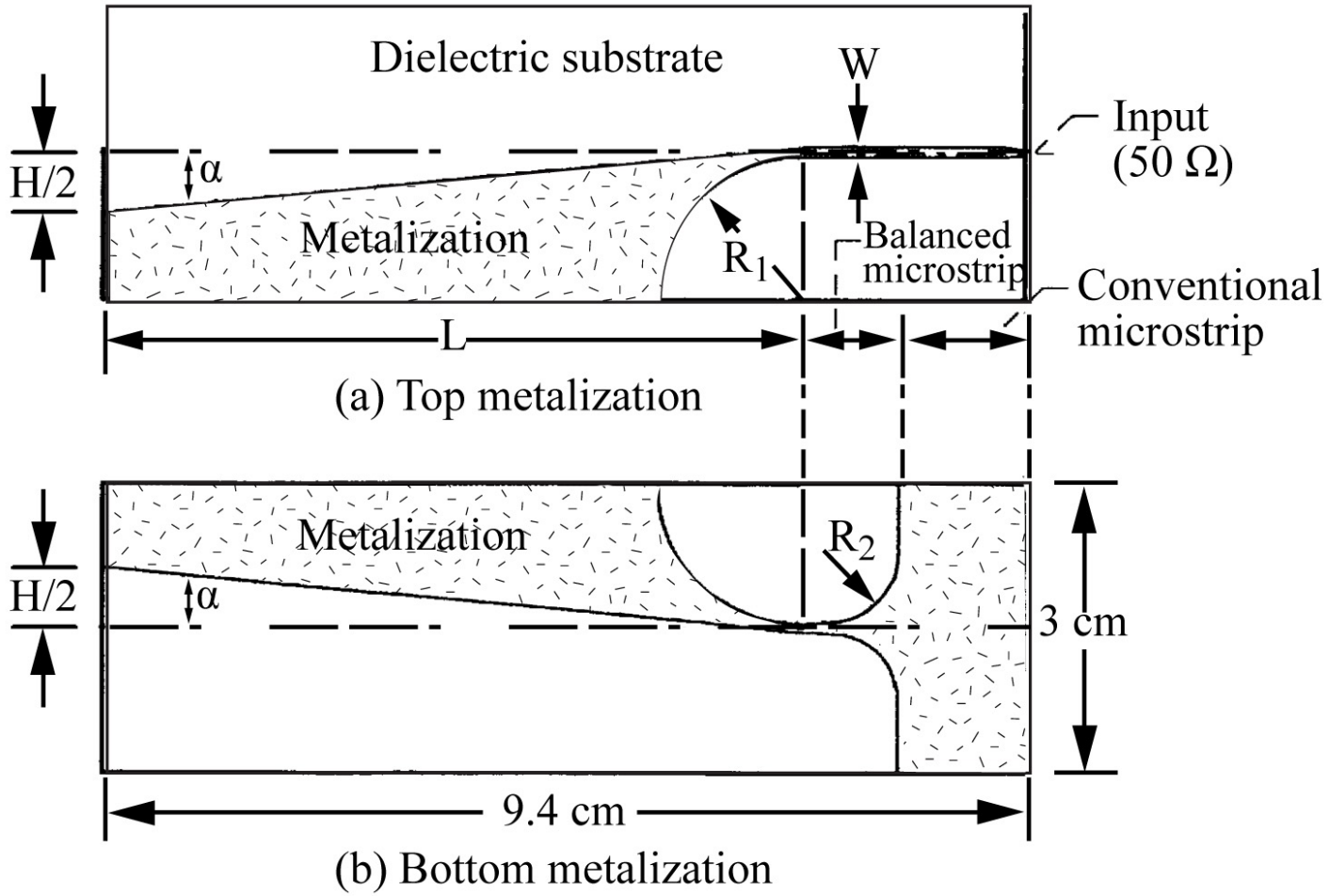
Introduction

➢Background and Use Case

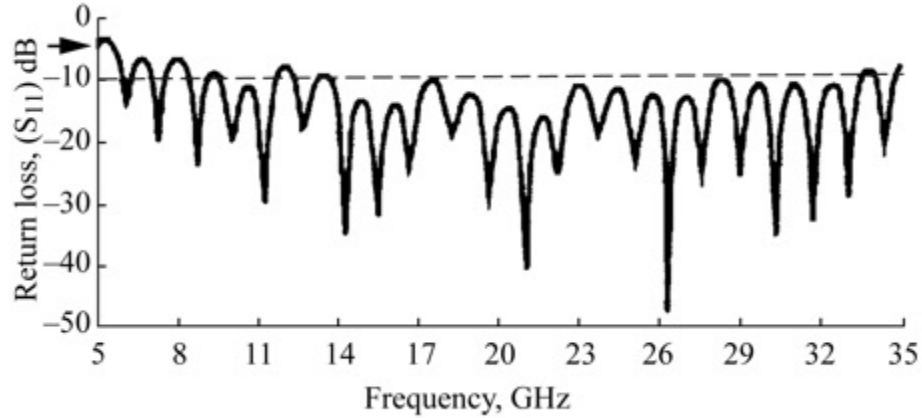
✓NASA's Human Lunar Exploration Program

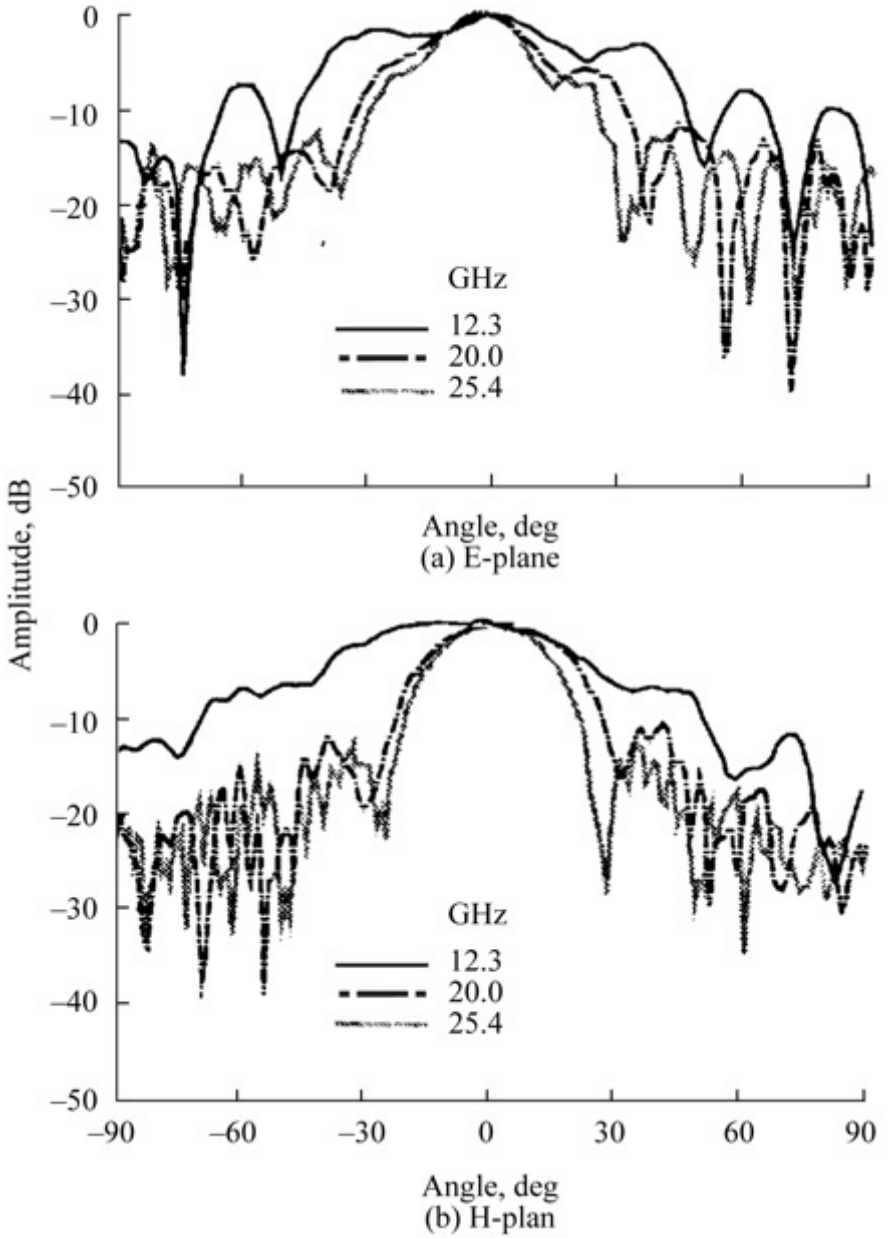
- Commercial Lunar Payload Service (CLPS) for delivering scientific instruments & technology demonstrations to the lunar surface
- Lunar surface network consisting of diverse nodes including landers, rovers, astronauts, science instruments/demonstrations, and towers for data communications are essential for success
- A lunar surface network based on wireless technologies is much more efficient than point-to-point communications
- However, the terrain profile of the lunar surface is highly irregular with craters and RF propagation models for lunar surface-to-surface links indicate high path loss
- A cognitive communication system architecture that works in unison with cognitive antennas to mitigate interference, share spectrum, and optimize the link performance is an enabling technology

Single Tapered Slot Antenna Element with Endfire Radiation Pattern

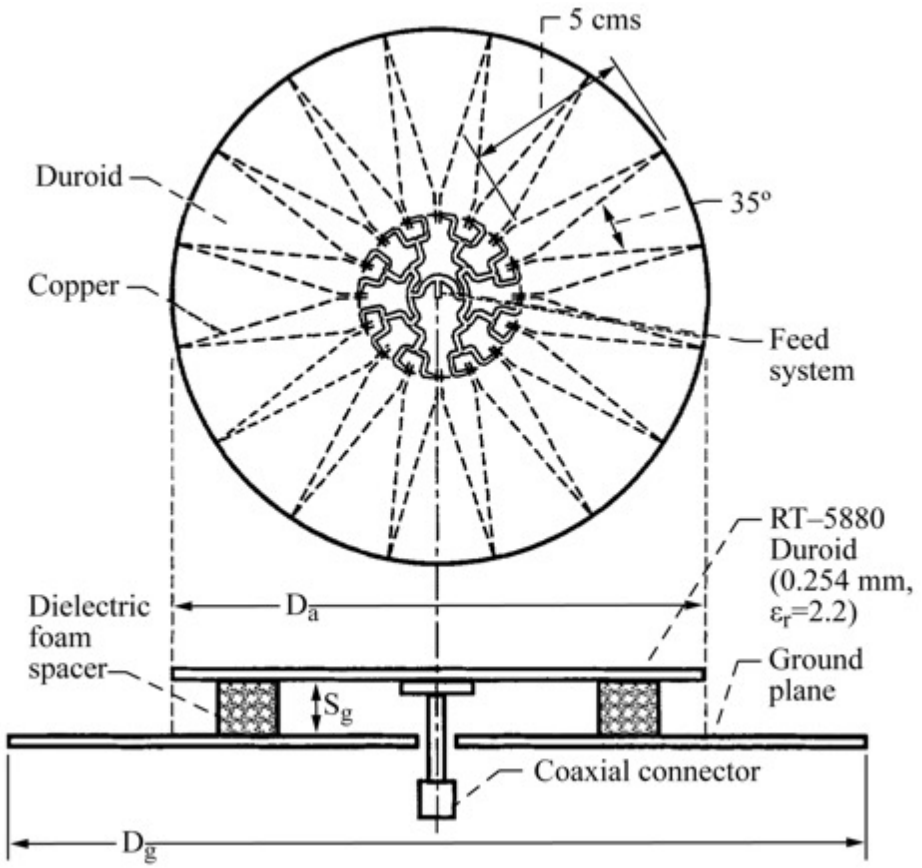


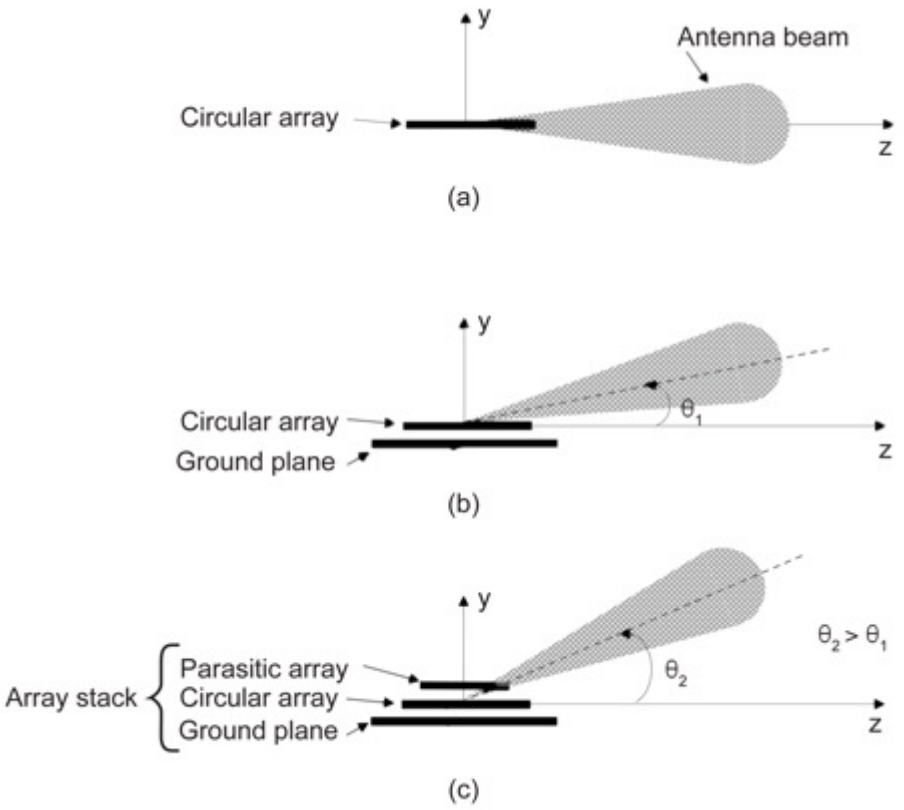
Single Tapered Slot Antenna Element
Return Loss & Radiation Patterns



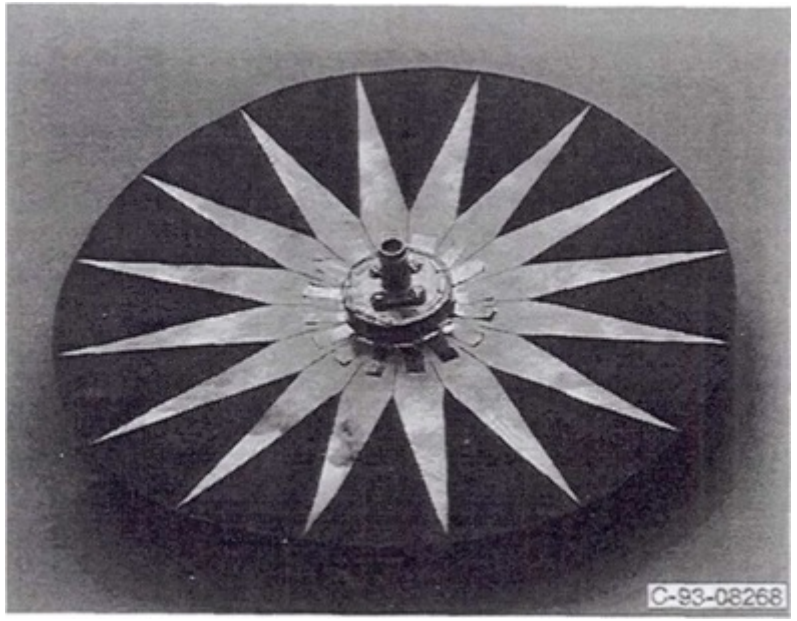


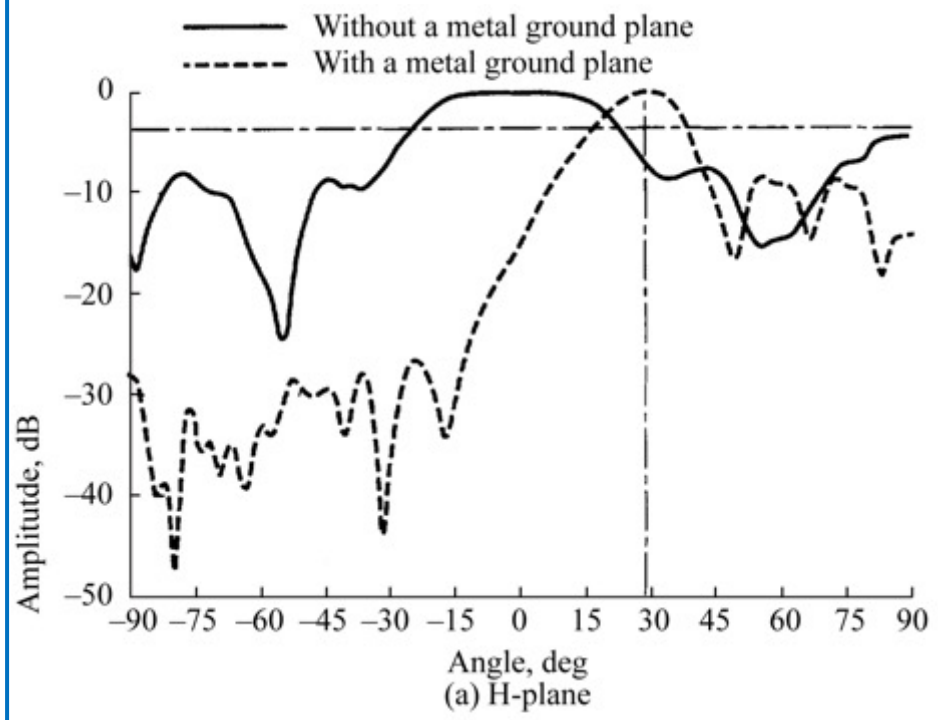
TAPERED SLOT CIRCULAR ARRAY (TSCA) ANTENNA WITH OMNI DIRECTIONAL RADIATION PATTERN



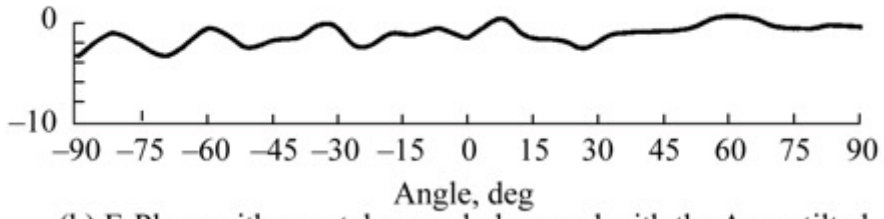


TAPERED SLOT CIRCULAR ARRAY (TSCA) ANTENNA & RADIATION PATTERNS



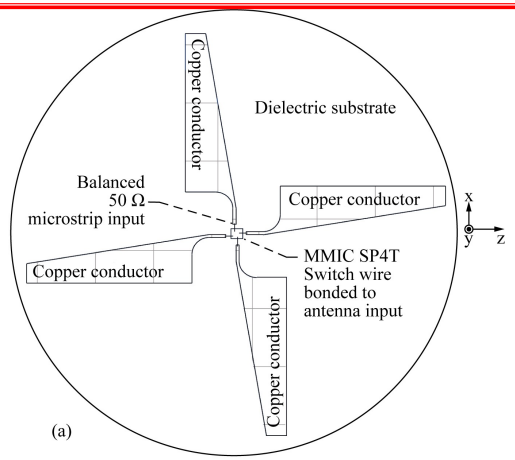


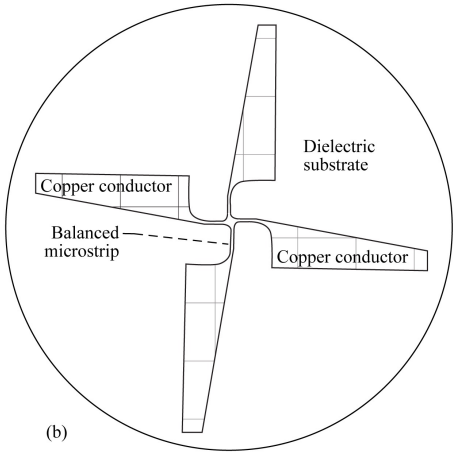
(a) H-plane

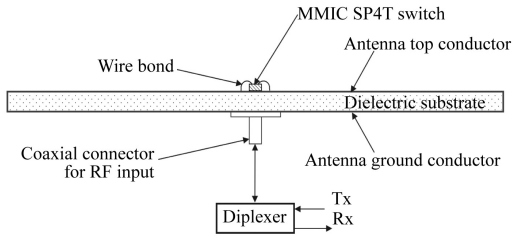


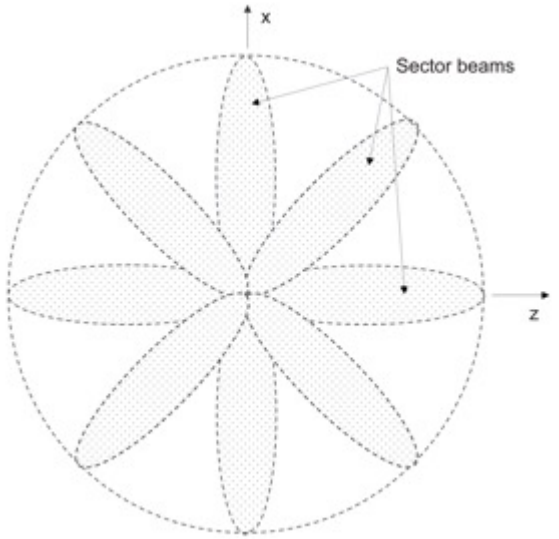
(b) E-Plane with a metal ground plane and with the Array tilted

Tapered Slot Circular Array Antenna with Switched Sector Beams

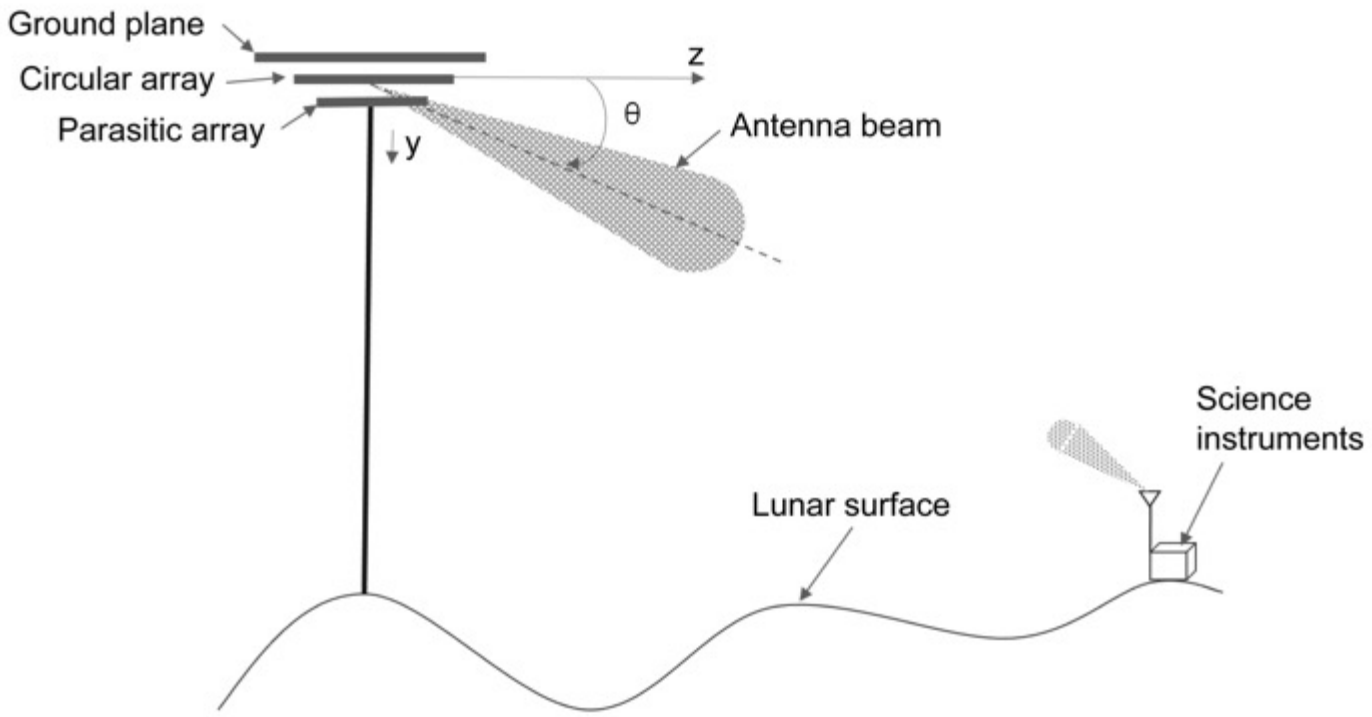








Application to Lunar Surface Communications



- The four-element TSCA antenna when placed above a ground plane and with a parasitic array on top can generate a beam displaced in the elevation
- The antenna when inverted and elevated above the lunar surface can generate switched sector beams pointed in the downward direction
- These beams are convenient for acquiring data transmitted by the science instruments dispersed across the lunar surface

DISCUSSIONS

- The wide bandwidth of the TSA is an advantage
  - ✓Because the frequency of operation, waveform, and data rates are different for each instrument since they perform different type of science (seismometer, spectrometer, UV/Visible camera, etc.)
- Instruments can come from different sources
  - ✓Government (NASA), commercial, universities, laboratories, and international partners; and currently there are on acceptable interoperability standards for lunar surface communications.

DISCUSSIONS (CONTINUED)

- Whether the cognition ability resides in the antenna or the antenna is part of a cognitive communication system depends on several factors
  - ✓The location of the early science instruments on the lunar surface will be known
    - The radio can instruct the antenna to point the beam at a given quadrant or sector. Very small amount of processing is required of the antenna controller and the cognition ability can reside on the software defined radio
  - ✓Future payloads may include rovers, astronauts with hand-held instruments, and other mobile assets to broaden NASA's scope of knowledge. These assets may have to be found or re-discovered each time
    - The radio architecture can be simplified by having the search conducted by the antenna. The radio would simply request to talk to a given asset and the antenna would be responsible for finding the asset. The antenna controller performs significant amount of processing. Hence, the cognition ability can reside on the antenna

DISCUSSIONS (CONTINUED)

- Finally, there is also the issue whether the antenna is compatible with a certain radio or is capable of working with a number of compatible radios. In the latter case, much more processing would be required by the antenna controller in order to achieve universal operation with many radio platforms.

CONCLUSIONS

- The design, fabrication, and characterization of a single TSA element with a balanced microstrip line feed and a sixteen-element circular array with a sixteen-way power divider as a feed has been briefly discussed
- The design of a four-element circular array antenna with switched sector beams is presented
- The architecture of the circular array antenna to enable lunar surface communications using a software defined radio has been briefly discussed