National Aeronautics and Space Administration

Compact Low-frequency, Wide-bandwidth Antennas for Ice-sheet Ground Penetrating Radar

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Program: Innovated Spontaneous Concepts

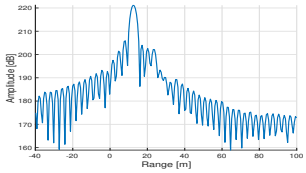
Project Objective:

1. Complete the fabrication of two compact low-frequency GPR antennas with 120-400 MHz bandwidth fits under the rover.
2. Conduct transmission tests with the antennas and a software defined radar.

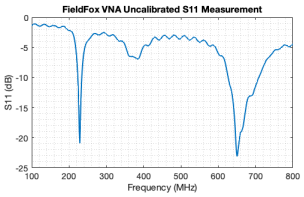
Background:

- In-situ ground penetrating radar (GPR) investigations of terrestrial ice-sheets are need to better understand temporal variability in sub-ice shelf melt rates that modify rates of ground ice flow.
- Multi-static measurements of subsurface ice using inexpensive radar units is an emerging area because of the potential for high spatial and temporal retrievals of ice thickness and basal topography.
- DASHER (Deployable Antarctic Sheet Exploration Rovers) was designed and fabricated to conduct subsurface imaging of changing melt channels beneath floating ice-sheets using a herd of autonomous rovers with multi-static synthetic aperture radar (SAR).
- Compact low-frequency rover-mounted antennas are essential for field testing:
  - Antennas dictate the operating frequency and thus penetration depth in ice of the radar.
  - Critical for conducting field-tests and acquiring science data.

Software Defined Radar transmission pulse:
Center frequency: 405 MHz
Bandwidth: 50 MHz
Range resolution: ~3 m



Vector Network Analyzer reflection coefficient of final antenna.
Resonances at 225 MHz, 405 MHz, and 650 MHz.



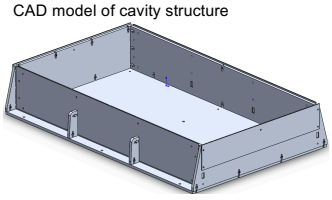
FY19 Results

- HFSS design of cavity-backed bow-tie patch antenna.
- Successfully fabrication of two GPR antennas.
- Successful outdoor tests to characterize antenna performance
  - Vector Network Analysis (VNA) S11 and S21 measurements
  - Software Defined Radar transmission tests
- Rover mounted antenna is ready for field tests

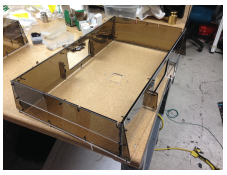
Conclusions

- The bow-tie patch antenna in free-space could achieve 150 MHz center frequency.
- Conducted a modeling effort on the feed design and experimented with the 8:1 balun feed structure.
- Improvements to the matching network are needed to realize the full bandwidth of the antennas.

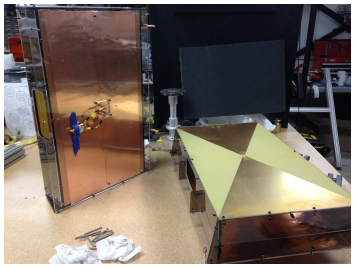
CAD model of cavity structure



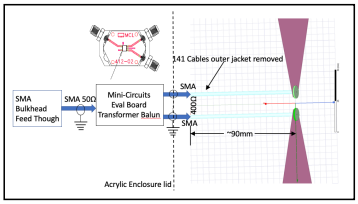
Rapid prototyping and construction of laser-cut acrylic cavity structure



Fabricated cavity-backed bow-tie patch antennas antennas

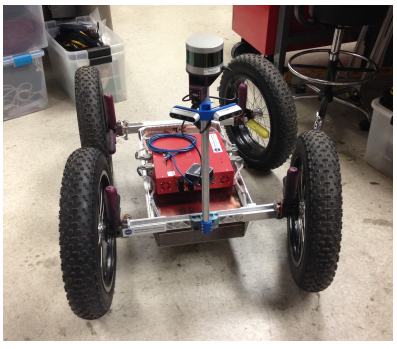


Schematic of antenna feed structure



CAD underside view of belly-mounted GPR antenna

Cavity-backed bow-tie patch antenna integrated on the belly of the DASHER prototype.



End-view and ground clearance of GPR antenna on DASHER prototype

Benefits to NASA and JPL:

- Accomplished 1-week assembly and testing of both antennas. Made possible by the design of the cavity structure, Section 347 rapid prototyping, and field-ready software defined radar.
- We will solicit field-work opportunities with external colleagues for bistatic radar tests over deep glaciers in Spring of 2020 (e.g., Norwegian Polar Institute for Svalbard, and Stanford for Greenland).
- Antennas can be used for other rover GPR concepts such as imaging dry regolith on the Moon or in-situ subsurface imaging of the Mars polar ice caps.

Publications:
NTR 51380: "Compact Low-Frequency, Wide Bandwidth Antennas for Ice-sheet Ground Penetrating Radar"
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