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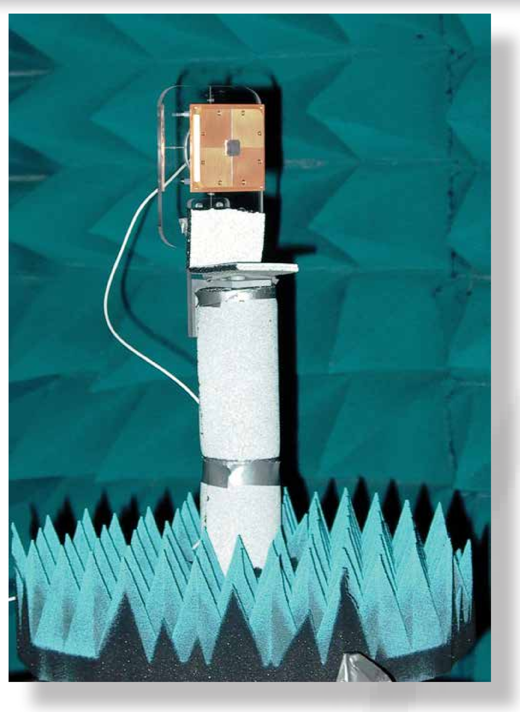
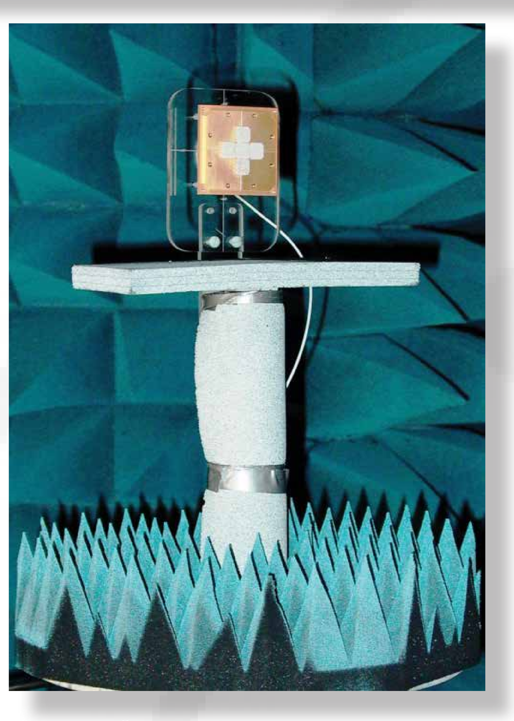
Antenna Characterization for the Wideband Instrument for Snow Measurements

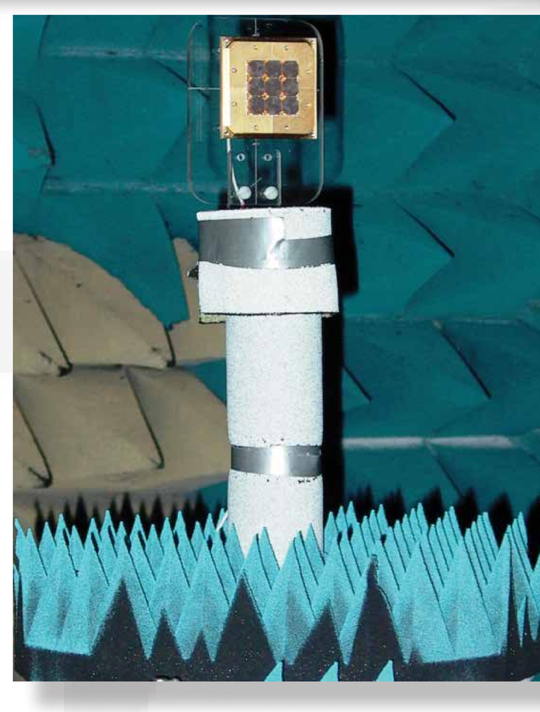
Kevin M. Lambert[†], Félix A. Miranda[††], Robert R. Romanofsky[††], Timothy E. Durham[†††], and Kenneth J. Vanhille[††††]
[†]Vantage Partners, LLC, Cleveland, OH; [††]NASA Glenn Research Center, Cleveland, OH; [†††]Harris Corporation, Melbourne, FL; [††††]Nuvotronics, Inc., Durham, NC

I. Introduction

This poster describes experiments implemented to baseline the performance of the antenna used for the Wideband Instrument for Snow Measurements (WISM). WISM is under development for the NASA Earth Science Technology Office (ESTO) Instrument Incubator Program (IIP). A current sheet antenna, consisting of a small, 6x6 element, dual-linear polarized array with integrated beamformer, feeds an offset parabolic reflector, enabling WISM operation over an 8 to 40 GHz frequency band.

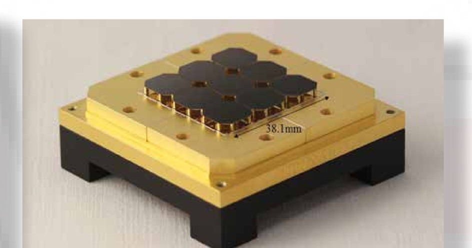

First prototype.


Second prototype.


Final design.

II. WISM

The WISM featured the application of an innovative feed antenna design for use in a reflector system (see companion poster in this session titled "Design of an 8-40 GHz Antenna for the Wideband Instrument for Snow Measurements (WISM)," by Durham, et al.). NASA Glenn Research Center supported development of the feed design by providing characterization measurements of two prototypes and two final design versions in a far-field range. The reflector system was tested in a planar near-field range.


Photograph of the final WISM antenna feed design. Outer dimensions of the antenna are 71.1 by 71.1 mm, although the PolyStrata (Nuvotronics, Inc.) portion is 38.1 mm on each side.

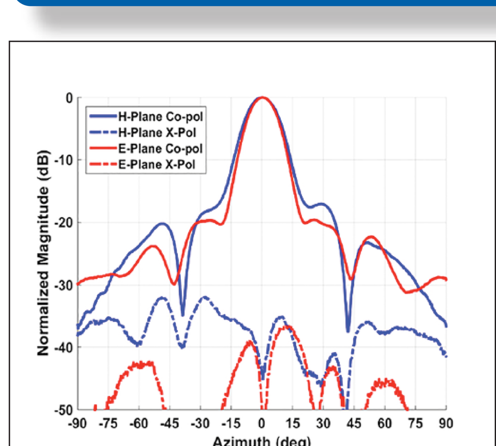
III. Summary of Far-Field Tests Performed on the Final Design Versions

⇨ *Radiation Patterns*
- Four frequency bands
  - X-band (9.5 to 10.0 GHz)
  - Ku-band (16.95 to 17.45 GHz)
  - K-band (18.6 to 18.8 GHz)
  - Ka-Band (36 to 37 GHz)
- Principal and intercardinal planes
- Four ports
  - Dual linear antenna
  - Two ports per orthogonal polarization
- Co-polarized and Cross-polarized, each port
- Magnitude and phase

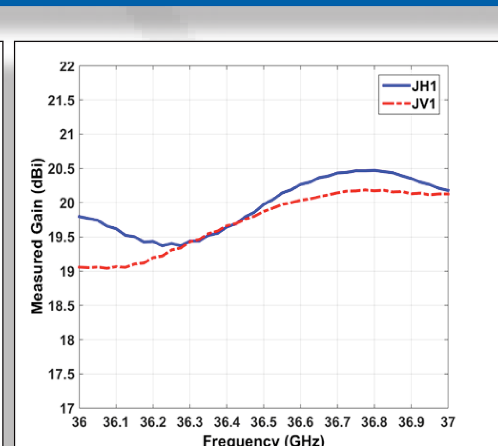
⇨ *Gain*
- X, Ku, K, and Ka frequency bands
- Each port

⇨ Return loss
- 8 to 40 GHz
- Each port

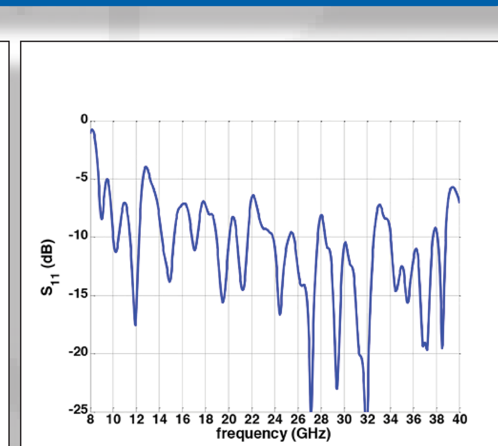
IV. Characterization Results of Final Design WISM Antenna Feed Versions



Feed principal plane patterns at 36.5 GHz.

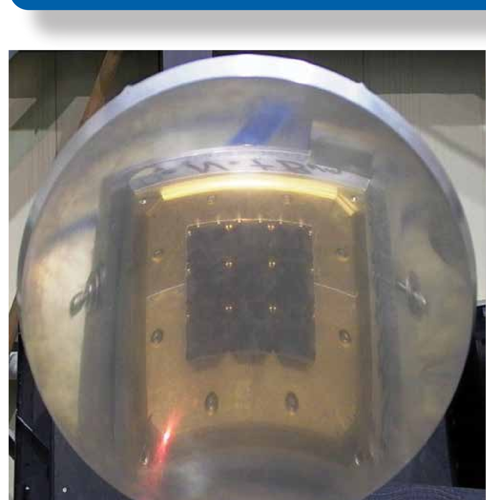


Feed Ka-band gain.

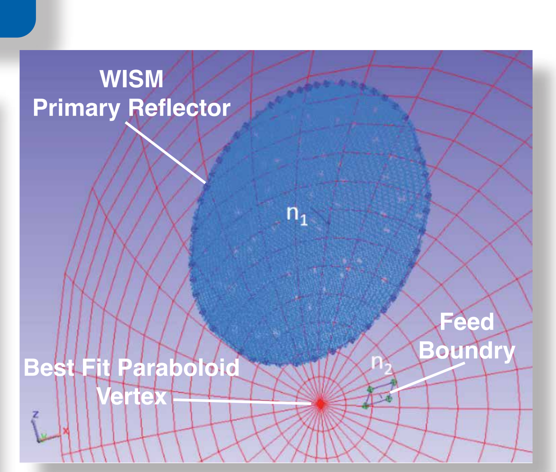


Feed return loss.

V. Reflector System Integration and Alignment


Laser radar used to ensure proper feed alignment.


WISM reflector antenna with WISM antenna feed.



Primary reflector surface map, feed plane, and parent parabola; n_1 is the normal to the WISM reflector, centered at the vertex, and n_2 is the normal to the feed plane.

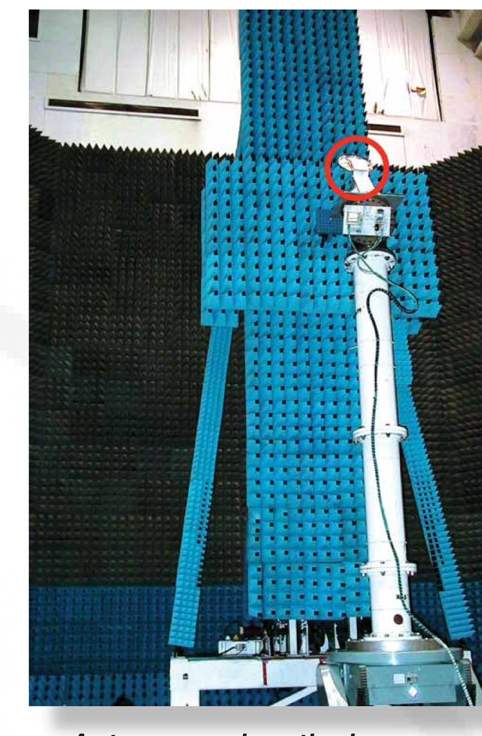
⇨ *Leica Geosystems LR200 Laser Radar*

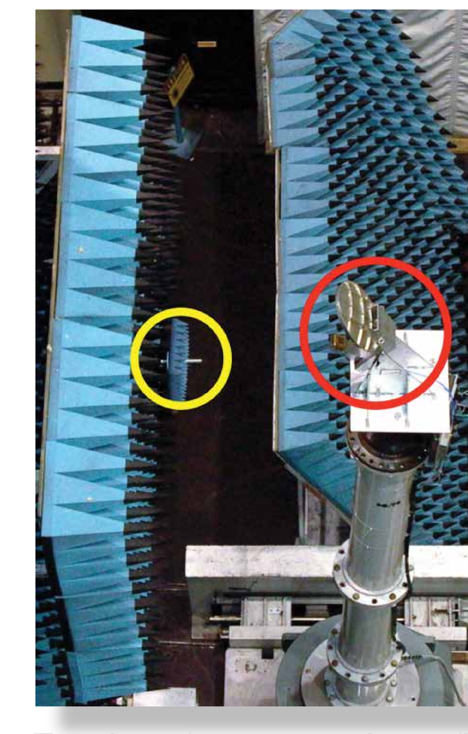
⇨ *Surface mapping and data analysis*
- Provides best-fit paraboloid
- Focal point location

⇨ *Feed integration*
- Feed phase center known from design and RF measurement
- Feed position mapped relative to reflector surface

⇨ *Feed alignment*
- Iterative process spanning Sept. 9 to 24, 2014
- IGES models from laser measurements submitted to Harris Corporation
- Analysis and discussion produces recommended adjustment
- Final position: phase center 0.013 in. from focal point (0.044 λ at 40 GHz)


Antenna being raised to test position.


Antenna and vertical scanner.


Top view of antenna and near-field probe.

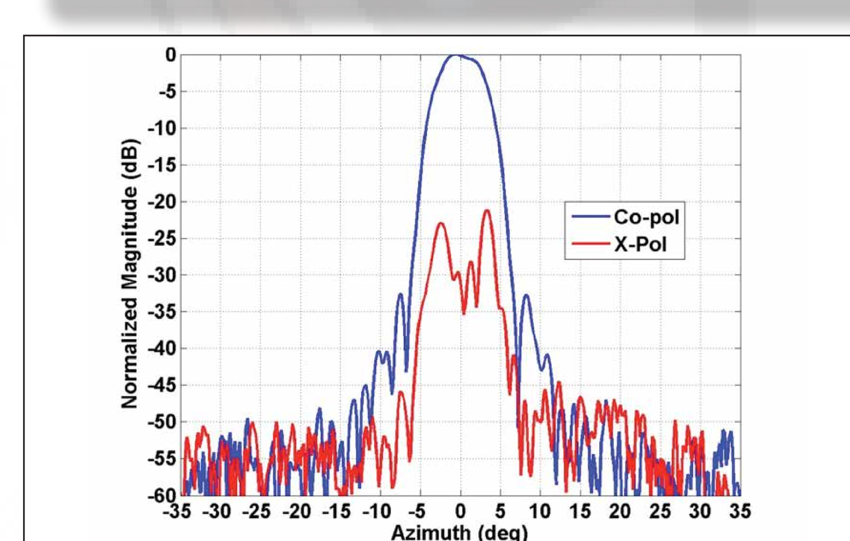
VI. NASA GRC Planar Near-Field Range

- ⇨ *40 by 40 by 60-ft test volume*
- ⇨ *Vertical Scanner with 22 by 22-ft scan plane*
- ⇨ *15 ton capacity azimuth over elevation pedestal*
- ⇨ *Removable sidewall, bridge cranes, and drive-in dock*
- ⇨ *Nearfield Systems, Inc., transceiver, motion control, and experiment and data processing software*
- ⇨ *Transceiver frequency range 2 to 50 GHz*
- ⇨ *Probe rotational stage for automated polarization control*

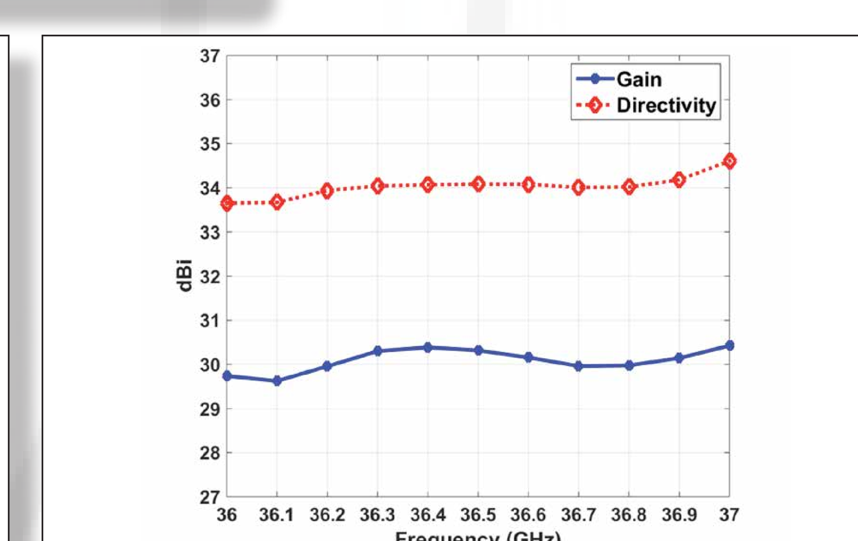
VII. Summary of Near-Field Tests Performed

Test #	Band Description	Frequency (GHz) Start	Stop	Increment	Max θ	Probe	Port	Co-Pol	X-Pol	Actual Test Time (hrs)
1	Ku-Band (Radar)	16.95	17.45	0.05	50°	WR-42	JV1	X	X	8.5
	K-Band (Radiometer)	18.60	18.80	0.05						
2	Ku-Band (Radar)	16.95	17.45	0.05	50°	WR-42	JH1	X	X	8.5
	K-Band (Radiometer)	18.60	18.80	0.05						
3	Ku-Band Lower (Radar Enhanced)	13.35	13.85	0.05	50°	WR-62	JV1	X	X	3.5
4	X-Band (Radar)	9.50	10.00	0.05	60°	WR-90	JV2	X	X	9
	X-Band (Radiometer Enhanced)	10.55	10.75	0.05						
5	X-Band (Radar)	9.50	10.00	0.05	60°	WR-90	JH2	X	X	9
	X-Band (Radiometer Enhanced)	10.55	10.75	0.05						
6	Ka-Band (Radiometer)	36.00	37.00	0.10	35°	WR-28	JH1	X	X	10.2
7	Ka-Band (Radiometer)	36.00	37.00	0.10	45° (Back/spillover lobes)	WR-28	JH1	X	X	17.5
8	Ku-Band (Radar)	16.95	17.45	0.05	45° (Back/spillover lobes)	WR-42	JV1	X	X	6.8
	K-Band (Radiometer)	18.60	18.80	0.05						
9	Ku-Band (Radar)	16.95	17.45	0.05	45° (Back/spillover lobes)	WR-42	JH1	X	X	6.8
	K-Band (Radiometer)	18.60	18.80	0.05						
10	Ku-Band Lower (Radar Enhanced)	13.35	13.85	0.05	50°	WR-62	JH1	X	X	3.5

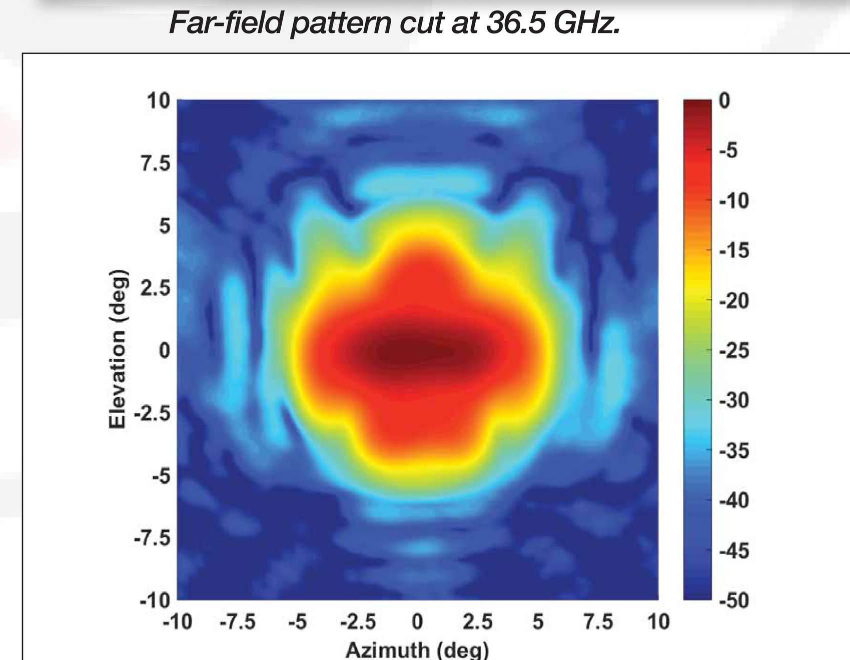
VIII. Characterization Results of Integrated Reflector System



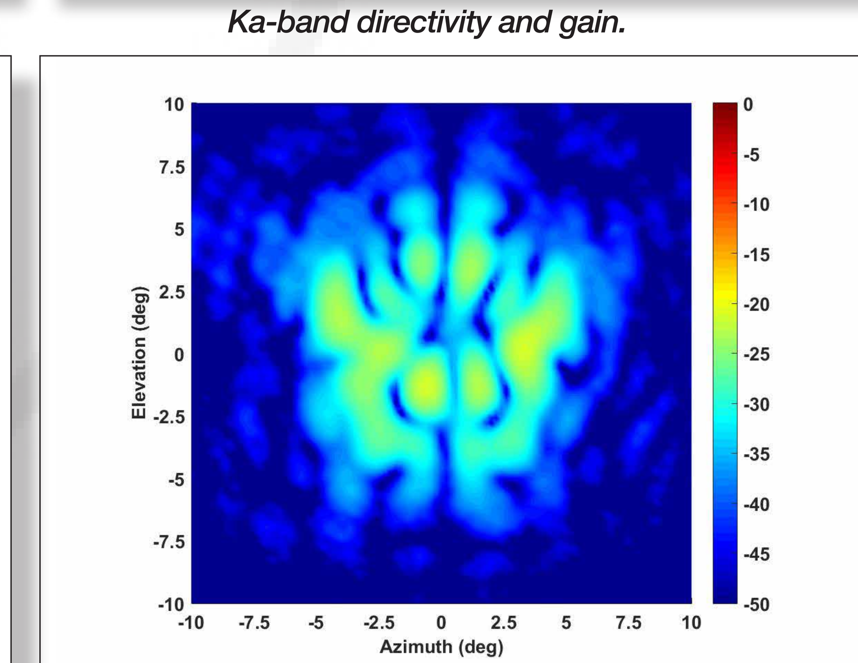
Far-field pattern cut at 36.5 GHz.



Ka-band directivity and gain.



Co-polarized far-field pattern at 36.5 GHz.



Cross-polarized far-field pattern at 36.5 GHz.

IX. Concluding Remarks

Testing of the feed and reflector antenna for the WISM demonstration has provided necessary system information and shown their suitability for the proposed purpose.

X. Acknowledgments

The authors acknowledge the support of NASA's Earth Science Technology Office (ESTO) Instrument Incubator Program (IIP) in furthering the "Enhancement, Demonstration, and Validation of the Wideband Instrument for Snow Measurements (WISM) work.