COWVR Instrument Antenna, Performance Verification and Test Results

Paolo Focardi, David Gonzalez, Jefferson A. Harrell and Shannon T. Brown
Jet Propulsion Laboratory, California Institute of Technology,
4800 Oak Grove Dr., Pasadena, CA 91104
Paolo.Focardi@JPL.NASA.gov

***Abstract*—This paper describes the test campaign and the results used to verify the performance of the Compact Ocean Wind Vector Radiometer (COWVR) instrument antenna. Developed as a proof-of-concept technology demonstration mission, it's planned for launch in 2016. Using small mass and low power, when compared to other instruments with similar capabilities, COWVR promises to obtain the same wind vector retrieval accuracy. COWVR was designed and developed at Jet Propulsion Laboratory (JPL) in collaboration with the US Air Force Space Missile Command.**

Keywords—reflector antenna; horn antenna; off-set reflector; radiometer; scanning antenna; anechoic chamber measurements; radiation patterns.

I. Introduction

COWVR is a low-cost, low-mass, low-power, fully-polarimetric imaging radiometer system operating at 18.7, 23.8 and 33.9 GHz. The fully-polarimetric observations enable retrieval of ocean surface wind vector, as well as other key environmental parameters such as precipitable water vapor, cloud liquid water, precipitation rate and sea ice. Its compact size is well suited for implementation on an ESPA-class satellite, enabling low launch costs as a secondary payload. The COWVR system utilizes a novel design to reduce the system complexity which in turn significantly reduces the cost, mass, power and volume from the heritage WindSat sensor [1], yet is predicted to maintain the same wind vector retrieval accuracy. An image of the COWVR instrument antenna is shown in Fig. 1 during radiation pattern measurements.

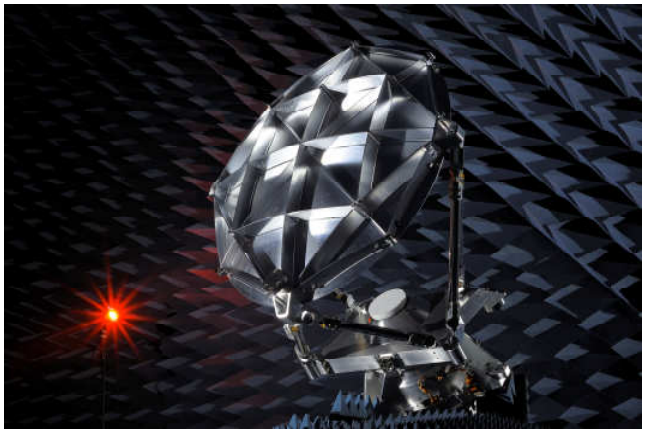

Fig. 1, The COWVR instrument antenna during tests at JPL.

This paper describes the COWVR instrument antenna geometry and its operation, but not the radiometer capabilities or its unique features. For more information about the radiometer see [2]. We also give an overview of the measurement set-up used to test the antenna at Jet Propulsion Laboratory. Lastly, we present an example of the obtained results and comment about their accuracy when compared to predictions obtained with RF models.

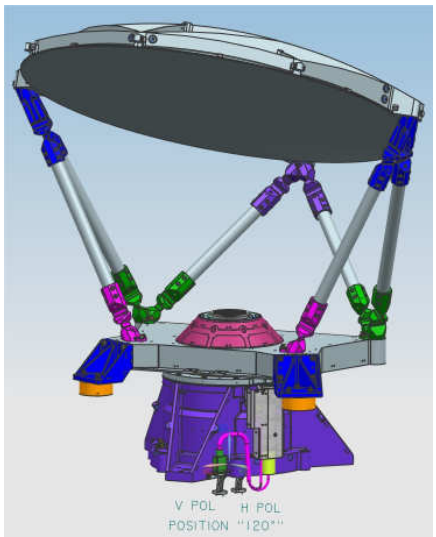

Fig. 2, CAD Model of the COWVR instrument antenna in its 120° position including (in purple under the top deck) the Spinning Mechanism Assembly (SMA).

II. COWVR Antenna Description

The COWVR antenna, shown in Fig. 2, is comprised of a non-rotating circularly corrugated feed-horn connected to the radiometer electronics through an Ortho-Mode Transducer (OMT) to separate the two linear polarizations. The feed-horn illuminates a spinning top deck which includes the reflector, the supporting struts, the top deck itself and a conical baffle all around the feed-horn. The reflector is an off-set configuration with a 75cm diameter and a focal length of 43cm. The phase center of the feed is located at the focus of the reflector with no edge offset, therefore putting the horn and part of the top deck in the direct field of view of the reflector. Not shown in Fig. 2 is the Expanded Poly-Styrene (EPS) radome that covers the feed-horn which is visible in Fig. 1. Also shown in Fig. 2 are the two waveguide ports that connect the antenna to the

radiometer electronics. The nominal pointing of the secondary beam for this configuration is 47.12° from Nadir.

III. Radiation Pattern Measurement Set-up

The instrument antenna was mounted on a pedestal in an NSI planar near field range at JPL with its main beam pointed directly into the plane of the scanner as shown in Fig. 1. Given the high gain of this antenna (>40dB) it was the perfect application for a planar near field scanner. The main goal of the measurement campaign was to verify the accuracy of the RF model predictions and then use the model rather than the measurements for on orbit radiometer calibration. From an instrument performance perspective, a key aspect of the range validation was also to verify that the model accurately predicts the variations of the pattern as a function of reflector rotation angle. Previous flight missions (AQUARIUS and SMAP) had already proven the high level of accuracy achievable with today's RF models by measuring the performance of scale models. With COWVR we had the opportunity to measure directly the actual flight hardware and get an accurate evaluation of the latest version of tools like HFSS™ and GRASP™. Since the top deck spins around Nadir, the pedestal had the capability to rotate the SMA but keep the reflector accurately pointed directly at the scanner. Rotations in 30° steps were achievable, but measurements were done only at 90°, 120° and 180° since they were the most critical positions of the top deck from an RF scattering point of view. One more measurement was done at the 180° position of the top deck with aluminum foil distributed on the top deck in order to simulate the presence of Multi-Layer Insulation (MLI) thermal blankets.

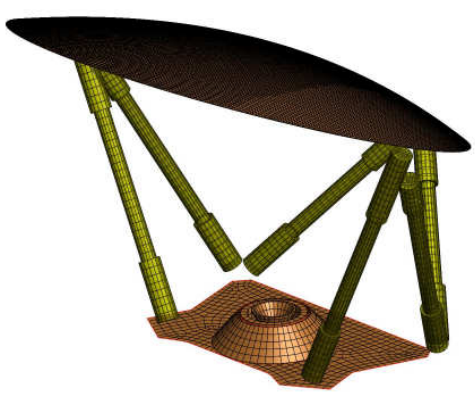

Fig. 3, Simplified RF Model used in GRASP™ to generate the calculated results.

IV. Comparing Measurements with Predictions

The performance of the COWVR instrument antenna was predicted by an RF model made of a hybrid between HFSS™ and GRASP™. HFSS™ was used to calculate the feed pattern including the effect of the conical baffle around the horn and the phase delay between polarizations introduced by the OMT. A Spherical Wave Expansion (SWE) of the HFSS™ radiation pattern was then used as a source in a simplified GRASP™ simulation which includes the top deck, the horn, the baffle, the struts and the reflector. The reflector was described by a tabulated surface with the measured "as-built" shape and position of the parabolic surface. Fig. 3 shows the simplified RF Model used to compare with measured results.

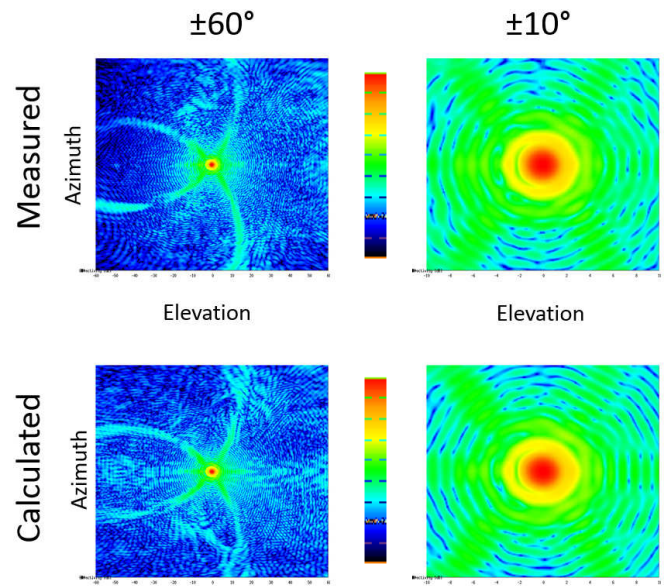

Fig. 4, Comparison between measured (top) and calculated (bottom) 2D radiation patterns in Elevation/Azimuth format at 23.8 GHz for co-polar vertical polarization.

Fig. 4 shows an example of how measured and calculated radiation patterns compared for the co-polar vertical component at 23.8 GHz. Similar agreement was found at all frequencies and polarizations, including for Cx-Pol. It is important to note that in Fig. 4 the green and light blue colors are respectively 45dB and 60dB below peak. A larger RF model is currently being developed in order to assess the impact of solar panels protruding into the field of view of the reflector, once the instrument is mounted on the spacecraft. All relevant results will be presented including those accounting for the presence of thermal blankets.

Acknowledgment

The research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

References

[1] Gaiser, P.W.; St Germain, K.M.; Twarog, E.M.; Poe, G.A.; Purdy, W.; Richardson, D.; Grossman, W.; Jones, W.L.; Spencer, D.; Golba, G.; Cleveland, J.; Choy, L.; Bevilacqua, R.M.; Chang, P.S., "The WindSat Spaceborne Polarimetric Microwave Radiometer: Sensor Description and Early Orbit Performance," *Geoscience and Remote Sensing, IEEE Transactions on* , vol.42, no.11, pp.2347,2361, Nov. 2004.

[2] Brown, S. T.; Focardi, P.; Kitiyakara, A.; Maiwald, F.; Montes, O.; Padmanabhan, S.; Redick, R.; Russell, D. and Wincentsen, J., "The Compact Ocean Wind Vector Radiometer: A New Class of Low-Cost Conically Scanning Satellite Microwave Radiometer System", 94th American Meteorological Society Annual Meeting, Atlata GA, Feb. 2-6, 2014.