NISAR Flight Feed Assembly Measurement Campaign

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***Abstract*—NISAR (NASA ISRO SAR, National Aeronautics and Space Administration, Indian Space Research Organization, Synthetic Aperture Radar) is an Earth science project currently in its final development phase at NASA Jet Propulsion Laboratory (JPL) and at ISRO. Due for launch in 2022, it will assess how our planet changes overtime by measuring differences in the Earth's solid surface due to factors like climate change, movement and melting of glaciers, earthquakes, land-slides, deforestation, agriculture and others. The enabling instrument for this mission is a dual band radar (L-Band and S-Band) that feeds a 12m deployable mesh reflector. This paper describes the antenna measurement campaign of the L-Band feed array developed at JPL. The S-Band feed array is developed by ISRO and is not part of this paper. While Measurements of the Engineering Model have been published before, this paper focuses on the first measurements done with the Flight Model.**

***Index Terms*—reflector antenna, feed array, patch array antenna, deployable reflector, near field antenna measurement.**

I. Introduction

NISAR is a collaboration between NASA and ISRO, with JPL developing the L-Band radar and ISRO developing the S-Band radar. By employing a repeat pass interferometry scheme while using a sweep SAR technique, NISAR will image the entire planet solid surface with a 12-day repeat pass strategy over the course of a 3-year mission. The L-band feed is an array of 12 dual-polarization (horizontal and vertical) elements. Each array element is composed by 2 patches radiating in phase. Each patch is configured in a stacked patch configuration to broaden the bandwidth and is fed by two feeding points for each polarization. Overall, the L-Band feed is a 2x12 patch array where each patch pair forms a single array element. Two patch pairs make one LFTA (L-Band Feed Tile Assembly) or tile, so the full array, or L-FRAP (L-Band Feed RF Aperture), is made by 6 tiles [1].

Each LFTA is built with a supporting aluminum frame, a dielectric feeding network board with 4 independent connectors (2 for V-Pol and 2 for H-Pol), and 4 stacked patches in an air-patch configuration. The assembly is completed with a radome made by a rigid shell covering a foam insert. Since the feed array is exposed to space while in flight, the radome was added to the design in order to limit the temperature gradients across the feed. Given the 12-day repeat strategy employed by the mission, performance stability over time and under all operating conditions was one of the key driving requirements.

Fig. 1 shows a sketch of the NISAR observatory with all its major components and sub-systems.

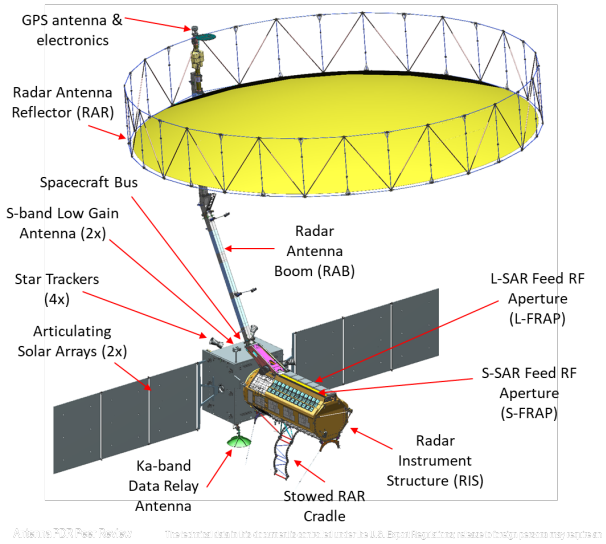

Fig. 1, View of the deployed NISAR instrument. The 6-tile L-Band feed array is visible on the top deck of the IRIS (Integrated Radar Instrument Structure).

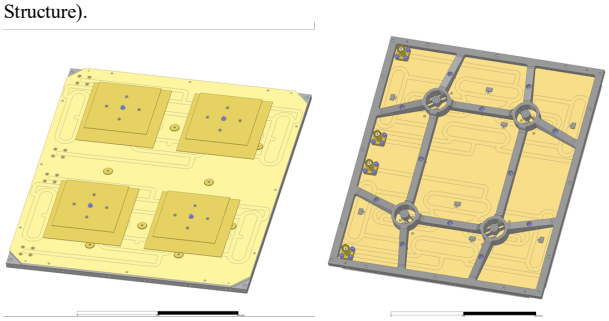

Fig. 2, Top (left) and bottom (right) view of a single LFTA without radome. At left the 4 stacked patches are visible. At right, the supporting frame and the 4 TNC connectors can be observed on the bottom side.

Fig. 2 shows a single LFTA without radome, while Fig. 3 shows a cross section of a complete LFTA with the details of the patch stack-up. The two patches in Fig. 3 are fed in

phase, at both polarizations, and radiate as one element of the array. In [3] some of the design changes that were implemented during the development of this feed antenna design are highlighted.

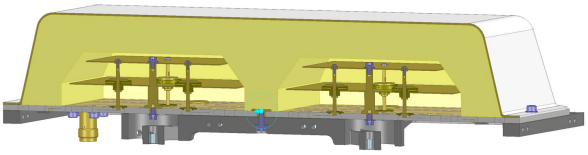

Fig. 3, Cross section of one LFTA exposing the geometry of a patch pair composing one element of the feed array. The radome foam (yellow) is covered by a rigid shell painted white.

II. Antenna Measurements

At the time of writing, all flight units are in the process of being assembled, so no data from these units is available yet. As shown in [2], extensive measurements were performed with the EM units both at JPL and at ISRO Space Application Centre (SAC) in India. All measurements matched the calculated predictions well both at JPL and at SAC. We expect the same level of accuracy from the flight units. Only minor design details were changed between the EM and the FM units. The three areas that were modified are the TNC connector, the supporting frame attachment to the board and the upper patch attachment points.

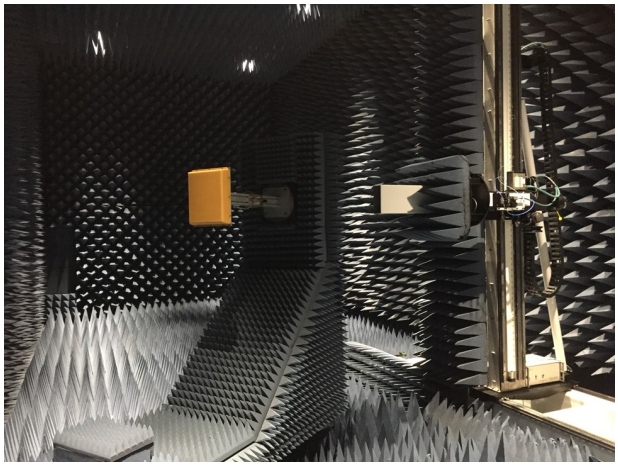

Fig. 4, One EM LFTA being measured in the spherical near field range at JPL.

None of the design changes should have any significant impact on the radiation pattern of these antennas and therefore the RF performance of the flight units is expected to be very similar to the EM units. Eight flight units are being built; six will be mounted in the array and two will be spares. Once the assembly is completed, in order to verify mission requirements and RF performance, each LFTA will be first measured in a spherical near field range. This first measurement will be used to verify the general pattern of a single tile to make sure it behaves as expected. Measurements will be done at both polarizations (H & V) and at 9 frequencies across the L-Band operating range. Since the band is relatively narrow and the near-field range is capable of multiplexing the measurements, all frequencies will be measured in one pass of the scanner.

The near field spherical range will also be used to measure the gain of each LFTA. During the EM measurement campaign, we demonstrated that, as expected, spherical near-filed measurements produce better directivity results compared to those from a planar near-field scanner with the full array configuration. In fact, since the beam-width of each array element is relatively wide, the spherical range is better suited for a measurement of the single array elements than the planar one. EM directivity measurements were within 0.1 dB of the predicted values when measured in the spherical range. We believe we will obtain similar results from the flight units.

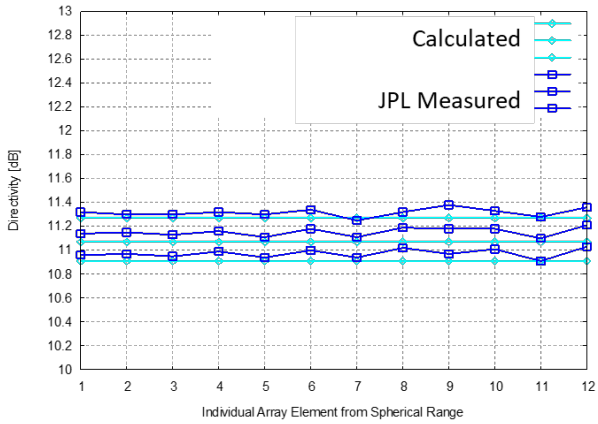

Fig. 5, EM measured vs. calculated directivity from the spherical range for V-Pol. The three sets of data are for increasing frequencies: 1.2175 GHz, 1.2575 GHz and 1.2975 GHz.

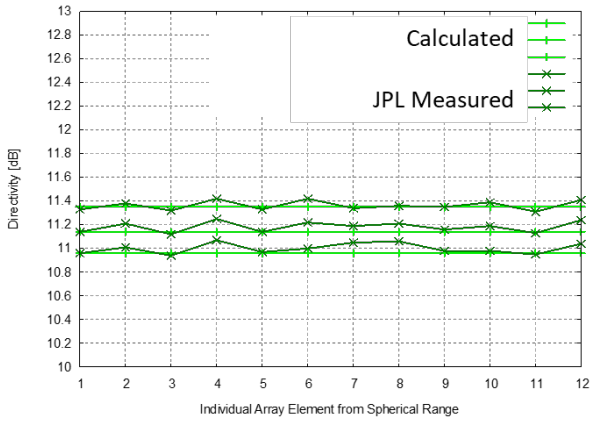

Fig. 6, EM measured vs. calculated directivity from the spherical range for H-Pol. The three sets of data are for increasing frequencies: 1.2175 GHz, 1.2575 GHz and 1.2975 GHz.

Once all LFTAs have been measured in the spherical range, they will go through a series of environmental tests such as thermal cycling and random vibration. At the end of these tests they will be tested again in the spherical range to make sure no degradation of performance has occurred.

This will conclude our measurement campaign at the single LFTA level. At that point six selected tiles will be mounted on the flight support structure for the array and then measured again in the array configuration with a planar range. But these measurements are beyond the scope of this paper.

III. Conclusions

The NISAR LFTA design has reached its final configuration and the flight hardware is being built. A measurement campaign in a spherical near field range will verify initial performance and will also confirm it after a series of environmental tests are concluded. While measured data for the flight units is not yet available, we are confident they will confirm again the good results obtained with the EM units as no significant RF changes were implemented in the final design. At the same time, the process used to verify requirements has been discussed based on the experience gained with the EM measurements.

Acknowledgment

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References

[1] P. Focardi, P. Brown, “Preliminary Design of the NISAR L-Band Feed Antenna Tiles”, Proceedings of the 11th European Conference on Antennas and Propagation, Paris, France, March 19-24, 2017.

[2] P. Focardi, Joseph D. Vacchione and Jefferson A. Harrell, “NISAR L-Band and S-Band Instrument Antennas: Compatibility Test and Results” Proceedings of the 12th European Conference on Antennas and Propagation, London, UK, April 9-15, 2018.

[3] P. Focardi and Joseph D. Vacchione, “NISAR Flight Feed Assembly: Evolution of the Design from Initial Concept to Final Configuration” Proceedings of the 13th European Conference on Antennas and Propagation, Krakow, PL, March 31 - April 5, 2019.