Large European Deployable Reflector: RF Modeling and Measurement Correlation

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***Abstract*—We present the RF model and correlation with measurements in K band (18.7 GHz) of a 5.1 m diameter deployable reflector antenna in lightweight mesh technology. The RF model includes the manufactured surface shape, electrical properties of the lightweight mesh, a designed and non-circular rim as well as feed tower and truss. Good agreement between main beam shape as well as sidelobe and grating lobe positions between measured and predicted patterns is found.**

I. Introduction

European technological independence for large deployable reflectors (LDRs) has been on the agenda since 2017 when the Horizon 2020 LEA contract [1] was won by a large European consortium led by HPS in Germany, with the purpose to design, manufacture and test a 5.1 m diameter mesh-based LDR in X band (10.65 GHz).

In 2019, the same European consortium was awarded the Large Deployable Reflector for Earth Observation (LEOB) contract from the European Space Agency (ESA), also with the purpose to mature European LDRs and manufacture an 8 m mesh-based LDR, which could be a valid candidate for the EU-funded Copernicus Imaging Microwave Radiometer (CIMR) ESA mission, a conical scanning radiometer operating from L to Ka band. Due to lack of RF measurement facilities large enough to accommodate an 8 m reflector, it was decided to include in the LEOB project RF measurements and correlation with RF predictions of the 5.1 m LEA antenna at a frequency higher than the one considered in the LEA project and of practical interest for CIMR. The selected frequency was 18.7 GHz, and the correlation between RF measurements and predictions of the antenna at this frequency is the subject of this paper.

The paper is organized as follows: In Section II, the antenna and RF model of the antenna are presented. In Section III, measured and predicted pattern cuts and grids are compared, and, finally, in Section IV we conclude the work.

II. Antenna and RF Modeling

The LDR antenna consists of two tension nets with triangular facets, an RF reflecting lightweight mesh on the front tension net, and a deployable truss [2]. The bottom tension net (shown in the inset in Fig.1) is critical mechanically, but plays no role in the RF performance of the antenna. The front tension net determines the *shape* of the reflector, while the lightweight mesh determines its *reflectivity*. For this antenna, the front net is constituted by quasi-uniform triangular facets, which produces grating lobes at well-defined positions in the far field [3].

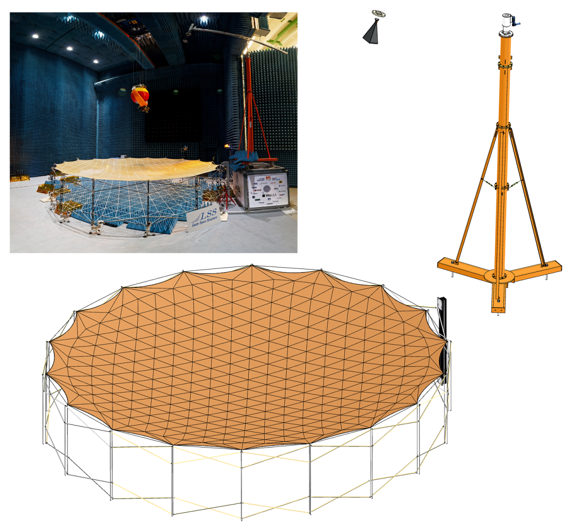

Fig. 1. Deployable reflector antenna with 5.1 m diameter: TICRA Tools RF model and manufactured antenna in Airbus measurement chamber (inset).

Laser measurements of the manufactured antenna are used in the GRASP [4] RF model to accurately represent the facetted surface together with a non-circular rim. Also, for validation, the truss and feed tower are included in the RF model. Reflection and transmission of the lightweight mesh were measured at normal incidence, and the mesh was modeled in GRASP using an equivalent wire mesh model, that yields fairly good agreement with the measurements.

The feed is a linearly polarized standard gain horn from Microwave Vision Group (SGH1800), and in simulations measured feed patterns are used as the source.

We have modeled the full antenna in the measurement chamber using MoM/MLFMM in ESTEAM [4] and compared this to the PO solution of the reflector in GRASP. Simulated MoM currents on the full antenna system are shown in Fig. 2. Patterns from the two approaches (not shown here) are in perfect agreement, except for small deviations at levels more than 50 dB below peak. On this ground, we concluded that PO analysis of the reflector alone is sufficient, and that truss and feed tower can be left out in the RF analysis.

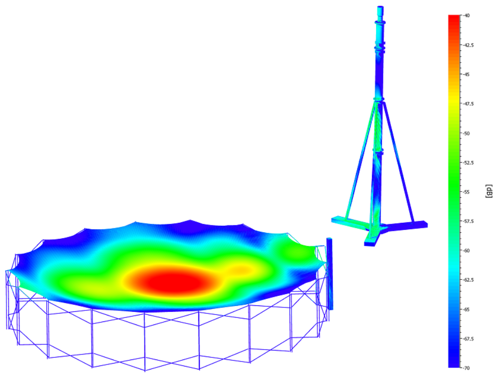

Fig. 2. Simulated MoM currents from ESTEAM on full antenna system.

III. RF Patterns

All patterns presented in this section are for a horizontally polarized feed and at 18.7 GHz. Similar results were obtained with a vertically polarized feed and at 18.6 GHz and 18.8 GHz, as well as with both polarizations in X band (10.4 GHz, 10.65 GHz and 11 GHz).

A. RF Measurements

RF testing of the LDR antenna was performed using Airbus' Portable Antenna Measurement System (PAMS) in Ottobrunn, Germany, with the antenna pointing towards the ceiling and supported by gravity compensation devices. PAMS provided the far-field pattern in the range $-20^\circ \leq \theta \leq 20^\circ$, which was obtained from irregular near-field sampling by a crane-based gondola probe on a plane normal to the antenna boresight.

The uncertainty of the measured patterns of the electrically large antenna (diameter of $\sim 318\lambda$) was estimated to be ± 0.4 dB on the peak gain and ± 5 dB at -30 dB below peak.

B. RF Pattern Correlation

A comparison of measured (black) and simulated (red) pattern cuts in the $\phi = 90^\circ$ plane is shown in Fig. 3. For the co-polar component, good agreement is found in the main beam shape as well as in the position of sidelobe peaks and nulls, with levels that are well within the estimated measurement uncertainty. Also, positions of the first- and second-order grating lobes around $\theta = 3.4^\circ$ and $= 6.8^\circ$, respectively, are in good agreement. This grating lobe position corresponds to a tension net facet side length of approximately 300 mm [5]. For the cx-polar component, positions of lobes and levels are in fairly good agreement for the higher-lying parts.

In Fig. 4, we compare the co-polar pattern grid from measurements (left) and RF simulations (right). The position of the stronger grating lobes are in good agreement between the two, also with levels that are well within the estimated measurement uncertainty. From approximately fourth order, grating lobes in some directions do not appear in measurements due to the limited dynamic range of the measured data, while they do appear in the simulations.

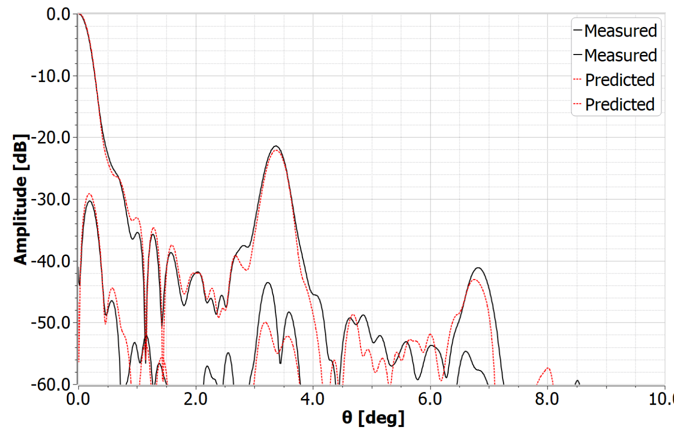

Fig. 3. Pattern cuts: Measurements (black) and RF simulations (red).

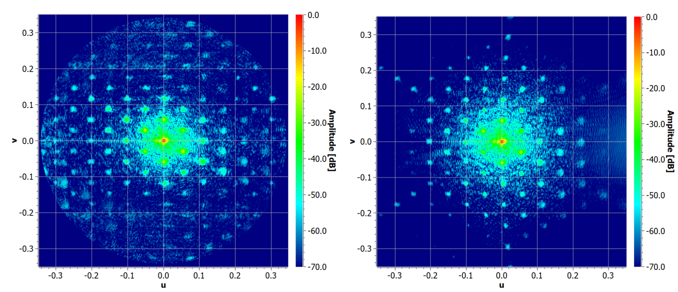

Fig. 4. Co-pol pattern grids: Measurements (left) and RF simulations (right).

IV. Conclusion

We have introduced the Large European Antenna, a 5.1 m diameter deployable reflector antenna, that has been designed, manufactured and measured. We have presented the RF model of the antenna, and correlated far-field patterns from measurements and RF simulations, with good agreement in main beam shape as well as in sidelobe and grating lobe positions.

Acknowledgement

LSS manufactured the antenna, HPS measured the reflector surface and contributed to feed and reflector alignment, Airbus performed the RF measurements, and TICRA did the RF modeling and correlation with RF measurements.

References

[1] Large European Antenna, http://www.welea.eu/.

[2] L. Datashvili, N. Maghaldadze, M. Friemel, T. Luo, L. da Rocha-Schmidt, C. Cappellin, J. R. de Lasson, R. Jørgensen, J.-C. Angevain, A. Ihle, and L. S. Drioli, "Large deployable reflectors: Enhancing the mesh reflector RF performances," in *3rd International Conference "Advanced Lightweight Structures and Reflector Antennas"*, September 2018.

[3] J. R. de Lasson, C. Cappellin, R. Jørgensen, L. Datashvili, and J.-C. Angevain, "Advanced techniques for grating lobe reduction for large deployable mesh reflector antennas," in *Antennas and Propagation Society International Symposium*, July 2017.

[4] GRASP and ESTEAM Software, TICRA, Copenhagen, Denmark, www.ticra.com.

[5] C. Cappellin, J. R. de Lasson, R. Jørgensen, L. Datashvili, J. Pauw, N. Maghaldadze, M. Migliorelli, and J.-C. Angevain, "Large mesh reflectors with improved pattern performances," in *37th ESA Antenna Workshop*, November 2016.