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Simulated 8x8 Ku-Band Array Antenna Performance on Airplane Door

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Abstract

An 8x8, Ku-band antenna array composed of circular patches was simulated both on an infinite ground plane and mounted on an airplane door. The radiated far field was calculated for both cases to determine the effect of mounting the antenna on the side of the airplane. It was found that the main beam was relatively unaffected, while the sidelobes were increased by 15 to 20 dB at angles more than 30° off boresight..

Introduction

The NASA Conformal Lightweight Antenna System for Aeronautical Communications Technologies (CLAS-ACT) Project designed and tested a Ku-band 8x8 patch array antenna for communication between an unmanned aerial vehicle (UAV) and a satellite. The follow-on activity, Antenna Deployment and Optimization Technologies (ADaPT), is funded by the Transformational Tools and Technologies (TTT) Project under the Transformative Aeronautics Concepts Program (TACP) of the NASA Aeronautics Research Mission Directorate (ARMD). The motivation for CLAS-ACT is described in [1], while the PLGRM measurement system and preliminary simulations are described in [2] and [3], respectively. In the current work, we compare the expected performance of the CLAS-ACT antenna under ideal conditions to the expected performance when mounted on an airplane. Ideal conditions are found when the array is mounted over an infinite ground plane; in the experimental case, the antenna was mounted on the luggage door on the side of a T-34C Navy trainer airplane. Both cases have been simulated using Feko software and the predicted far fields are shown.

Method

For the simulations, a 14.25 GHz circular patch antenna was employed. While simpler in design than the fabricated multilayer experimental patch, its behavior was expected to be quite similar and therefore helpful in understanding the array's behavior on an airplane. The patch was designed in Antenna Magus and imported into Feko, where a flat 8x8 array was created as shown in Figs. 1 and 2.

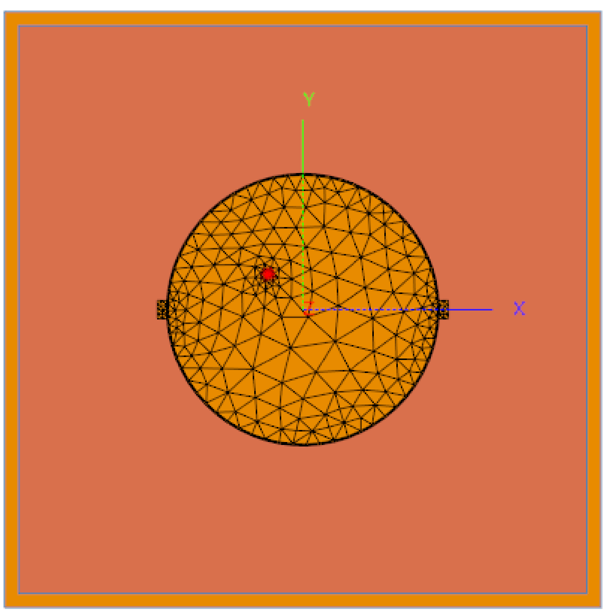

Figure 1. Circular patch.

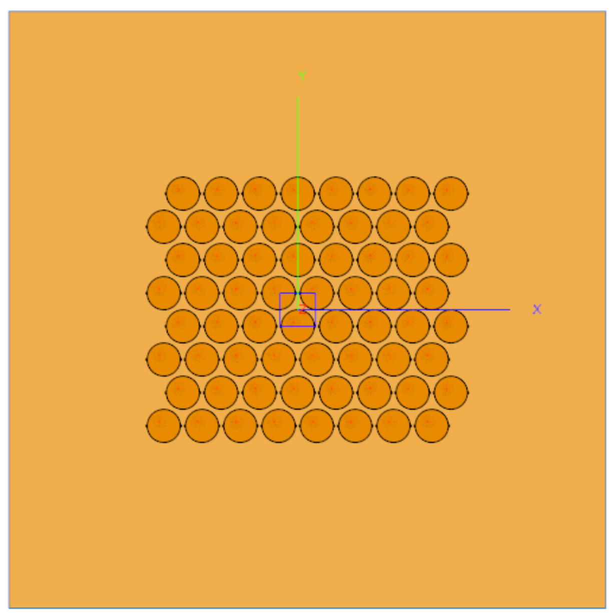

Figure 2. 8x8 array of circular patches.

In the array the elements were given a 0.6 λ spacing and illuminated with a 0.3 pedestal cosine taper. Far fields were calculated for a single patch and for the array on an infinite ground plane.

The airplane door had been modified to include a mounting surface for the antenna and this was also modeled. An array near-field Huygens box was calculated to fit within the mounting surface, as shown in Fig. 3. The near field then served as an equivalent source for calaculation of the array-on-the-door far field. Given that the experimental patch had been fabricated with a very low-permittivity aerogel substrate ($\varepsilon_r \approx 1$), the model was drawn with a free-space substrate as a further simplification for the final far field calculation, which was done by Adaptive Cross-Approximation (ACA).

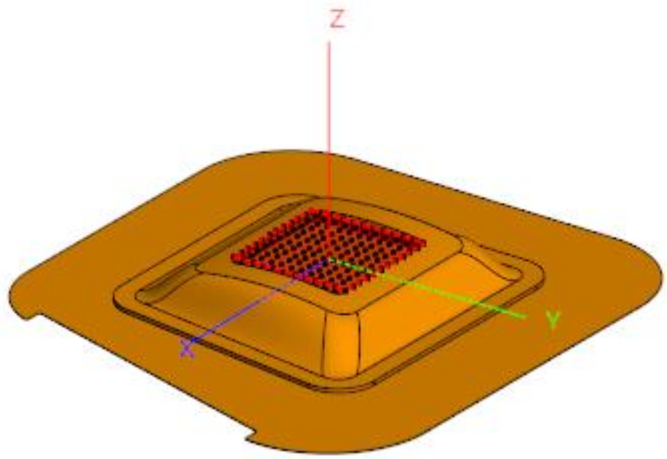

Figure 3. Near-field Huygens box (in red) situated over luggage door.

Results

The 3-D far-field simulation results are given below for a single circular patch, Fig. 4, for the array on an infinite ground plane, Fig. 5, and for the array on the airplane door, Fig. 6.

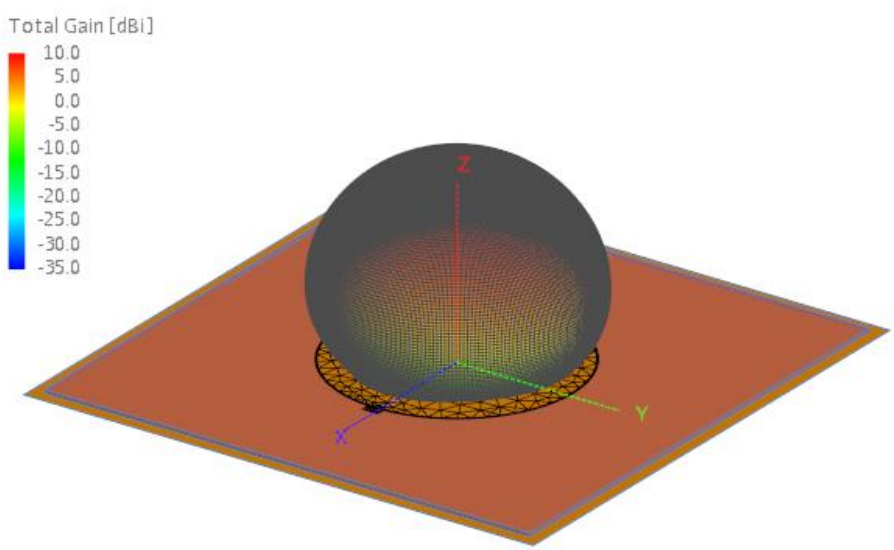

Figure 4. 3-D far field for a single patch.

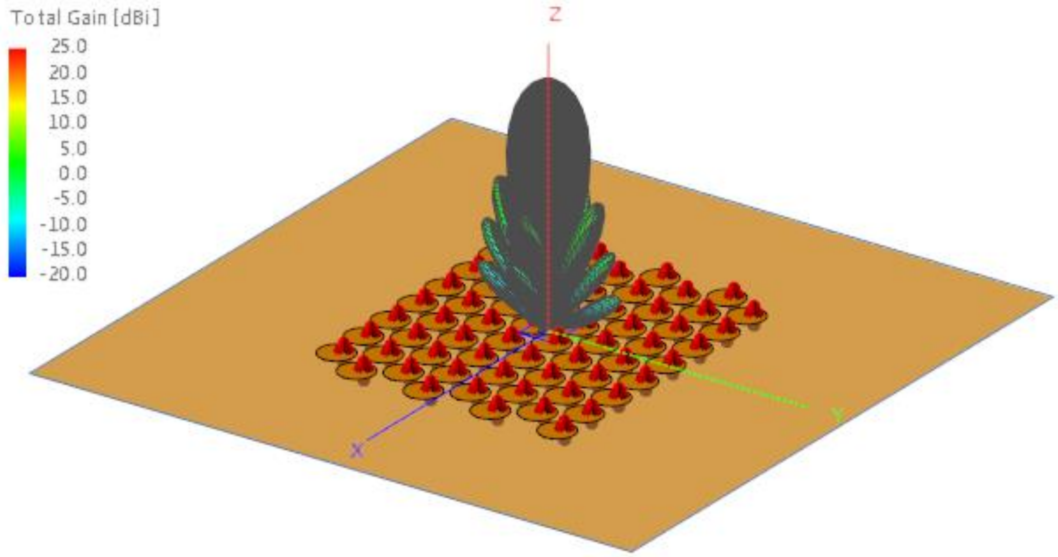

Figure 5. 3-D far field for 8x8 array on an infinite ground plane (ideal case). Feed points are shown in red.

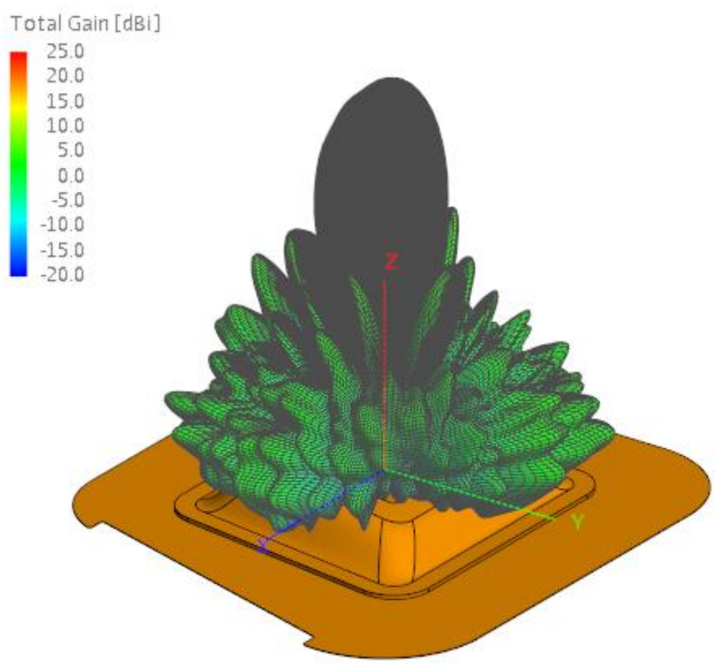

Figure 6. 3-D far field for 8x8 array on the airplane luggage door.

In Figs. 7-9 the far field of the door array is compared to that of the ideal array in the principal planes.

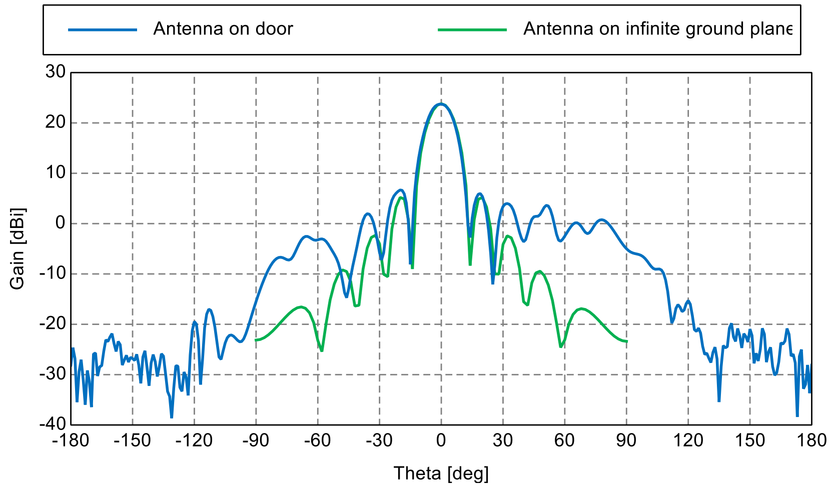

Figure 7. Total gain in the X-Z or phi = 0° plane.

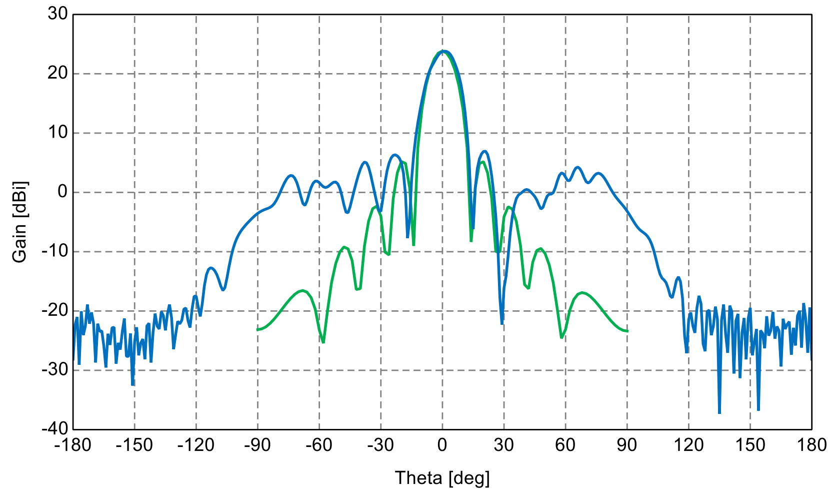

Figure 8. Total gain in the Y-Z or phi = 90° plane.

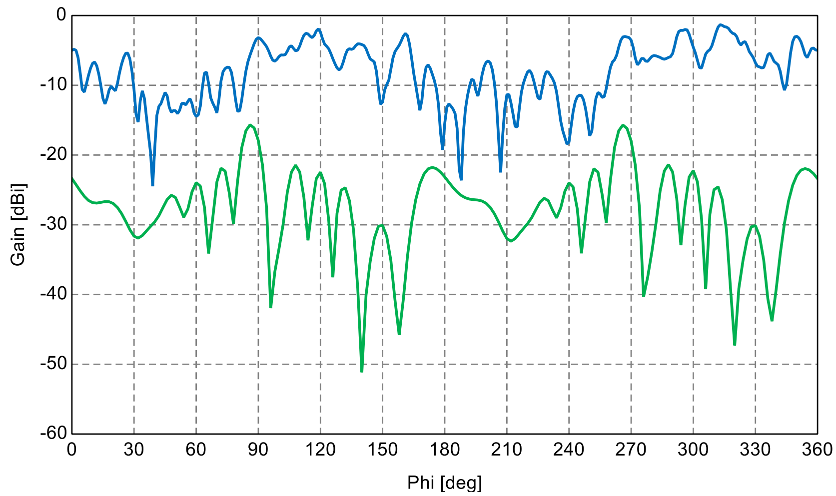

Figure 9. Total gain in the X-Y or theta = 90° plane.

Conclusions

Looking at the far field plots in Figs. 5-6, we see that mounting the antenna on the door produces many more sidelobes compared to the ideal situation on an infinite ground plane. The maximum gain in Figs. 7-8 is about 23 dBi for both cases, and the main beam is only negligibly widened by the presence of the door. However, the sidelobes for the antenna on the door are much higher beyond 30° off boresight, on the order of 15-20 dB higher at 90° off boresight.

These simulations have predicted the influence of the door mounting on the radiated far field of an 8x8 flat array antenna pointing in the boresight direction. The effect on phased array scanning has not been studied.

References

1. J. M. Downey, B. L. Schoenholz, M. T. Piasecki and R. J. Kerczewski, "Phased array antenna for the mitigation of UAS interference," *2018 Integrated Communications, Navigation, Surveillance Conference (ICNS)*, Herndon, VA, April 10-12, 2018, pp. 2D2-1-2D2-8, IEEE Xplore, doi: 10.1109/ICNSURV.2018.8384843.

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