Design, Development and Testing of NASA's Europa Clipper High Gain Antenna

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***Abstract*—The design, development and testing of NASA's Europa Clipper High Gain Antenna (HGA) is discussed. The HGA is a 3 meter diameter Axially Displaced Ellipse (ADE) geometry with a dual X/Ka-band feed. Following the fabrication and testing of a full sized Electrical Test Unit (ETU) of the HGA, a flight model antenna was recently build and tested at NASA's Goddard Space Flight Center (GSFC) and Langley Research Center (LaRC).**

Keywords*— *Europa Clipper, Axially Displaced Ellipse, X-band, Ka-band, NASA, High Gain Antenna

I. INTRODUCTION

The Europa Clipper mission is a NASA Flagship mission in joint development by the California Institute of Technology Jet Propulsion Laboratory (JPL) and the Johns Hopkins University Applied Physics Laboratory (APL) [1,2]. The primary science downlink antenna is a 3 m dual X/Ka-band Axially Displaced Ellipse (ADE) High Gain Antenna (HGA). Following initial RF design studies [3], an Electrical Test Unit (ETU) was fabricated to test the RF performance of the feed in the reflector as well as perform RF boresight metrology [4-5]. The ETU RF testing was performed at a newly refurbished NASA LaRC ETR [6]. Following validation of the ETU performance, the flight antenna was fabricated and tested at NASA GSFC and LaRC.

II. RF DESIGN AND DEVELOPMENT

The initial sizing of the antenna system was determined by a telecom study resulting in a 3 meter dual reflector system. An ADE geometry for the reflector system was selected for it high efficiency. The first feed design effort for the antenna was based on an array feed with a central Ka-band horn surrounded by 4 X-band antennas [3]. This system was extremely efficient at Ka-band. It was designed as a low cost alternative to dual X/Ka-band feeds; however, it compromised X-band performance because of its low aperture efficiency.

A dual X/Ka-band corrugated feed horn topology for Europa Clipper was introduced in [4]. This horn geometry was inspired by the HGA on Cassini and used a similar transverse slot coupled rectangular branch waveguide to couple an X-band signal into the feed horn. Several RF design iterations were performed with the feed fabricator Microwave Engineering & Manufacturing Corporation (MEMCO) to ensure that the feed system could be made using standing machining operations.

An ETU reflector system was fabricated by the Applied Aerospace Corporation (AASC). All of the electrical surfaces of the ETU including the main, subreflector and strut face skins are composite representing the flight design. For cost and handling, the structure of the ETU was fabricated out of aluminum honeycomb [5].

During the testing of the ETU it was noted that the Ka-band quiet zone fields of the Experiment Test Range (ETR) at NASA LaRC had larger than desired variability. An effort was put forward to resurface the compact range reflector to improve the quiet zone at higher frequencies [6]. The improvements did not change the peak gain measurements because of the large size of the Europa Clipper HGA and the methodology used to measure the gain use a large plate as a gain standard [5]. This essentially integrated the quiet zone fields over a large area smoothing out variations in the fields. However, the resurfacing improved cross-pol and measurements off the main lobe of the beam.

III. FLIGHT FABRICATION AND TESTING

Following testing of the ETU, the flight fabrication of the HGA began. During the fabrication of the antenna it was discovered that the internal electrostatic discharges in the carbon composite of the reflector was potentially at a large enough level to necessitate mitigation [7]. After a tiger team study and a program pause, it was determined that the reflector should be painted with a dissipative paint and flight fabrication resumed.

Flight HGA testing began in the Spring of 2022. A simplified testing flow for the HGA is presented in Figure 1.

Figure 1. HGA Acceptance Testing Flow

Radiation pattern testing was performed in the ETR at NASA LaRC. Following pre-environmental RF testing, the HGA went through vibration, acoustics and thermal vacuum testing at NASA GSFC and was then transported back to LaRC for post-environmental RF testing. Figure 2 shows a photograph of the HGA in the acoustics chamber at GSFC. Figure 3 shows a photograph of the HGA in the NASA LaRC ETR with the compact range reflector in the background.

Figures 4-6 show an overlay of the pre-environmental and post-environmental radiation patterns at X-band downlink (8.424 GHz), X-band Uplink (7.17 GHz), and the Ka-band (31.86 GHz) RHCP port respectively. Both the co-polarized and cross-polarized radiation patterns aligned well before and after environmental testing.

Figure 2. Flight HGA in Acoustics at NASA GSFC

Figure 3. Flight HGA in NASA LaRC ETR

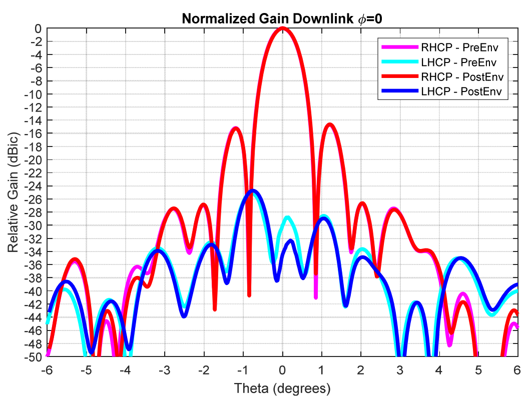

Figure 4. X-Band Downlink Radiation Pattern Cut

IV. Final HGA Work

The HGA is currently slated to be installed on the Europa spacecraft in the middle of 2024. One integrated, functional testing of the HGA signal path will be tested using a shorting plate over the feed aperture which reflects the high power signals to power sampler for telemetry and a load for dissipation.

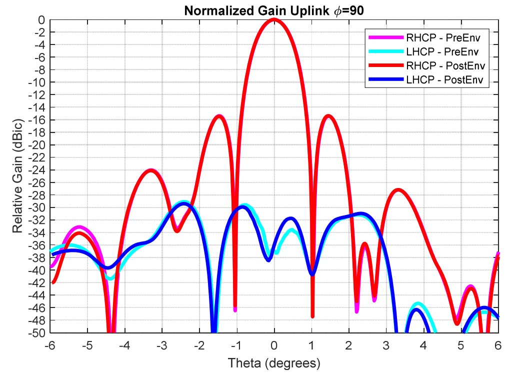

Figure 5. X-Band Uplink Radiation Pattern Cut

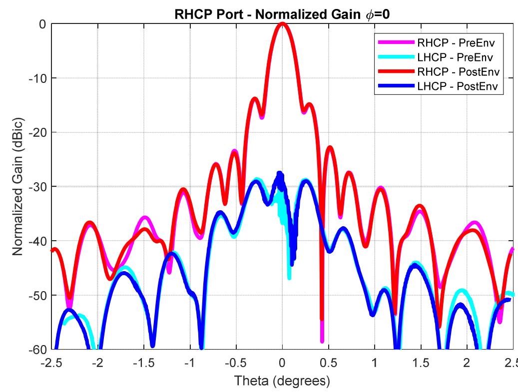

Figure 6. Ka-Band RHCP Port Radiation Pattern Cut

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