Qualification of Additive Manufacturing for Antenna Application (3DPAN2)

GSTP Study (2020-2024)

3DPAN2-HPSD-RP-050, issue 2, Executive Summary

(ESA/ESTEC Contract N° 4000130490/20/NL/AR/idb)

Prime Contractor:

HPS GmbH (DE)

Subcontractor:

Fraunhofer IWS (DE)

The new process Additive Manufacturing (AM) has been in use in more and more technical areas for several years in order to manufacture lightweight and cost-effective parts. In the space industry it is used in institutional programs for non-critical components and only after acceptance by the customer chain, including the respective agency e.g. ESA/DLR.

In order to standardize the AM of space components, ESA developed a new process verification standard i.e. ECSS-Q-ST-70-80C. HPS applied this standard to verify and qualify the AM technology for Antenna Applications.

In the frame of the activity, called 3DPAN2, two antenna applications were identified to be manufactured using the AM technology. One application was a X-band reflector antenna with a diameter of 30 cm with integrated feed and interface brackets. The aluminum alloy Scalmalloy was selected as material. The second application was a Feed Tower made of the Titanium Alloy Ti-6Al-4V.

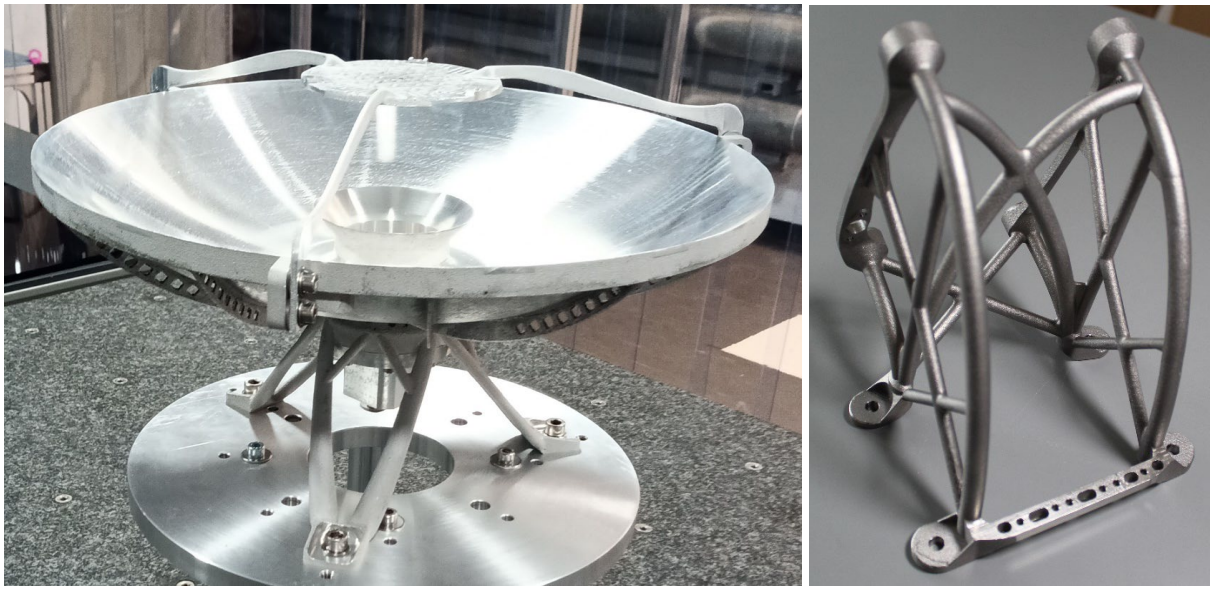

Figure 1: Left: 3DPAN2 antenna after assembly process, right:3DPAN2 Feed Tower, concept by HPS

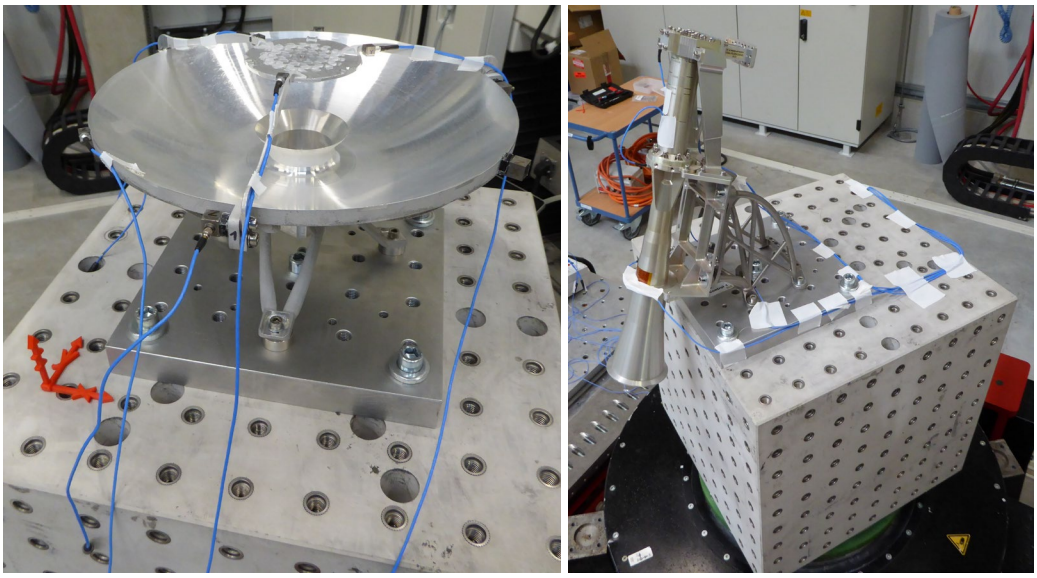

Figure 2: Left: 3DPAN2 X-band antenna on shaker table,
right: 3DPAN2 Feed assembly on shaker table, concept by HPS

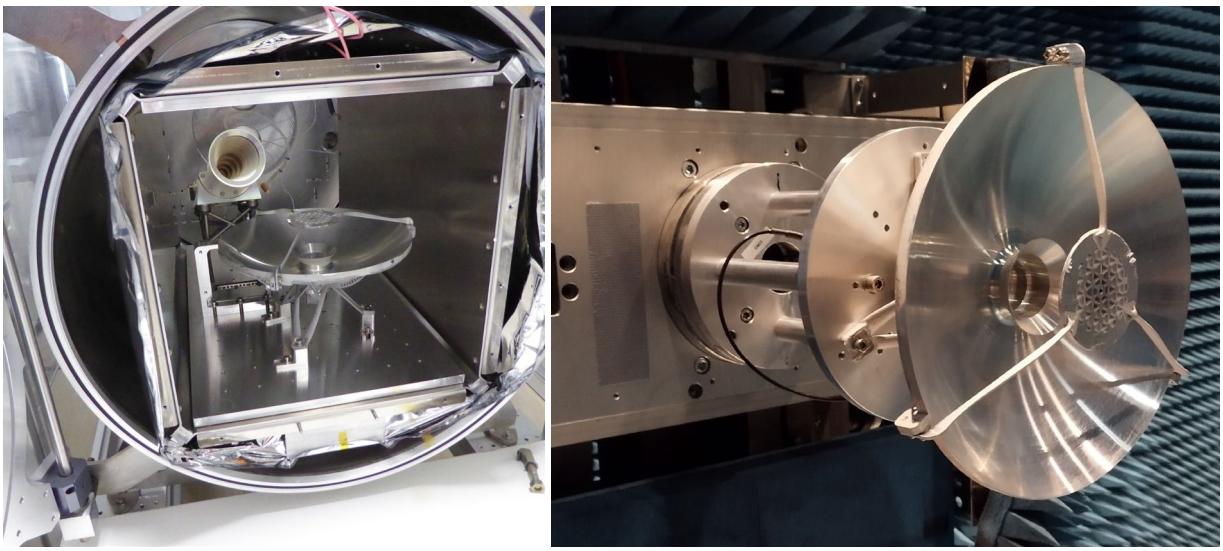

Figure 3: Left: 3DPAN2 X-band antenna and Feed assembly in TVAC chamber,
right: 3DPAN2 X-band antenna in RF test chamber, concept by HPS

Following objectives were part of the 3DPAN2 activity:

- Establish an overview of company specific applications and select two RF-related parts (including requirements) suitable for Additive Manufacturing (AM)
- Application of the AM process described in ESA standard ECSS-Q-ST-70-80C on the selected parts
- Definition of the Additive Manufacturing Process Specification (AMPS) for the demonstrator parts

- Manufacturing and testing of material samples and generation of a database for the design and analysis of future AM flight hardware
- Manufacturing and testing of breadboards (BB) and demonstrators
- Drawing Lessons Learnt for future development of AM parts by improving existing engineering guidelines
- Raise the manufacturing technology from TRL4 to TRL5 or better taking into account the AM technology and AM produced antennas.

The general conclusion of the GSTP activity is:

1.) The AM production of antennas with integrated feed and interface brackets is feasible using an AM suitable design. This allows the minimization of the number of mechanical interfaces and RF flanges which improves both the mechanical and RF performances of the antenna.

2.) The RF test performed on the antenna has shown a good agreement between predictions and measurement results, demonstrating that the accuracy of the reflective surfaces, machined after AM process, was fully compatible with the frequency band of the antenna.

3.) The material database for additive manufactured Scalmalloy has been defined, and the one for the titanium has been extended.

4.) The existing engineering design guidelines for AM components were improved.

5.) Both demonstrators were tested in a vibration and TVAC test campaign under an environment relevant for low-earth orbits (LEO) without any damages or deformations including sine and random vibration and a temperature range of +120°C to -120°C.

The following table presents the improvements identified in the main key factors achieved through Additive Manufacturing (AM) technology compared to conventional machining (CM) technology.

Key factor	Improvements achieved through Additive Manufacturing (AM) technology compared to conventional machining (CM) technology.
Mass	-20% to -25%
Cost	-25% to -35%
Delivery time	Approx. -50%

Munich, 04.12.2024