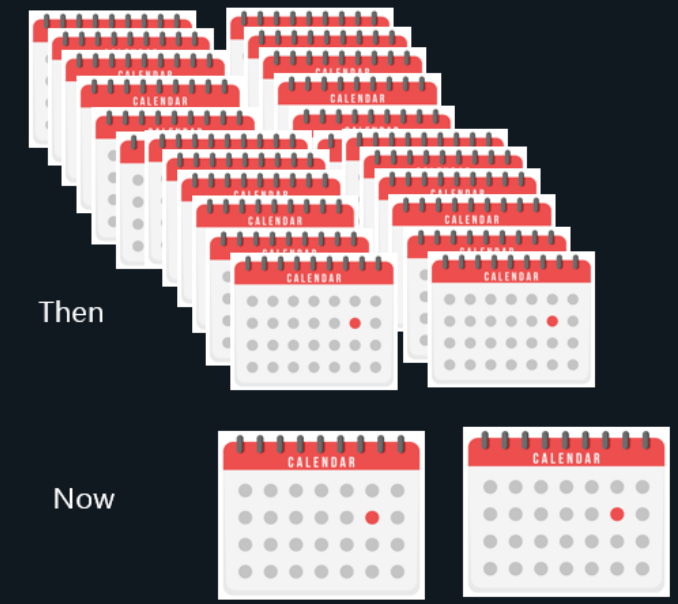
3D PRINTED BIU SATELLITE ANTENNA

Presentation Date | **November 2nd, 2022**

TABLE OF CONTENTS

1. Introduction

- A few decades ago at MDA (formerly SPAR), a simple space satellite antenna would take about **2 years** to design, build, and test
- Leveraging the maturity of additive manufacturing (AM), we have delivered a flight antenna within **2 months**
- This presentation, tells the story of how this is possible

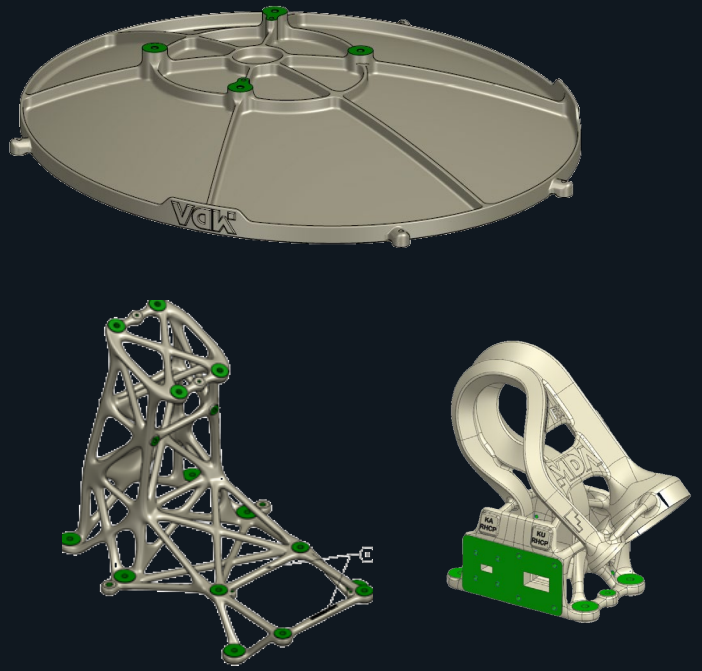


2. Requirements

- In the Summer of 2020, MDA was approached by one of its customers to provide 2 antennas for a January 2021 launch of a Bring-into-Use (BIU) Satellite
- We negotiated a simple antenna configuration consisting of a Transmit and Receive feed as well as a reflector and support structure
- RF, thermal, structural, programmatic, verification and documentation
  - Needed to transmit and receive suitably at the specified Ku and Ka frequencies to a target region from the specified orbit
  - Spacecraft was aluminum and the antenna was all-aluminum so no CTE mismatch or thermal concerns
  - Structural design environments were reasonable
  - One design review
  - Verification kept to a minimum
  - Bare bones documentation

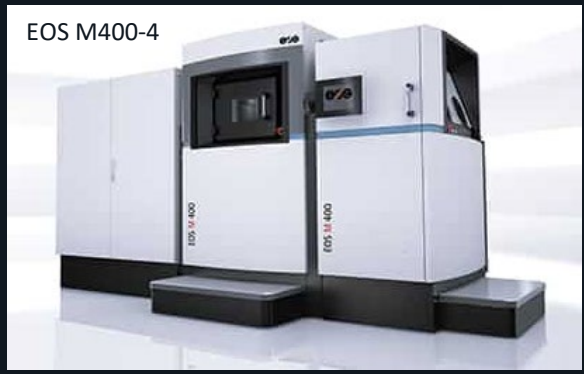
3. Design

- To reduce assembly time each antenna was consolidated into three AlSi10Mg parts bolted together.
- Parts were designed to minimize the need for AM printing supports, while still achieving optimal RF, structural, and mass performance (**2 weeks**)
  - Feeds designed so they could be printed with few supports
  - As-printed surface roughness of RF active surfaces taken into consideration to maximize RF performance
  - To minimize mass and provide optimal stiffness, support structure was designed using good “organic” engineering principles based on topological optimization of heritage structures
  - Parts were heat treated without sacrificing dimensional stability
  - Minimized post-machined surfaces (highlighted in **green**)
  - Minimized bolted interfaces (qty=8) to reduce assembly time



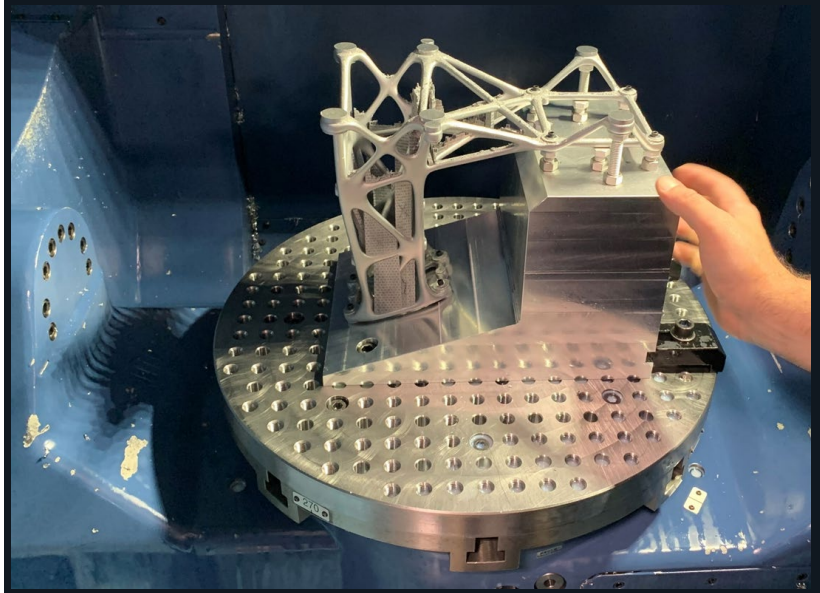
4. Build

- 3D printing performed on two printers (Trumpf 2000 and EOS M400-4) using qualified processes
  - Reflector back-surface printing-supports designed to provide a compliant RF surface profile, yet be easily removed
- Precision post-machining only performed at interfaces
- Grit blast and chemical rinse performed to ensure cleanliness of bare surfaces



4. Build (continued)

- Burloak Technologies Incorporated (BTI), our AM partner, is a fully space-qualified 3D-printing production facility and NADCAP certified
  - Documented processes, paperwork, traceability, and all other standard QA and PA provisions
  - Successfully audited by MDA and MDA primes
- All aspects needed to produce and validate 3D printed parts are under one roof – this provides schedule, cost, quality, logistics and risk management – very efficient
  - Vertically integrated value stream - Printers, heat treatment furnaces, machining, inspection, grit blasting and cleaning, as well as material testing
- Requirements on Burloak are controlled via the drawing, purchase order, and the Source Control Document (SCD – i.e. specification), reflected in Burloak's standard operating procedures and specific program travelers

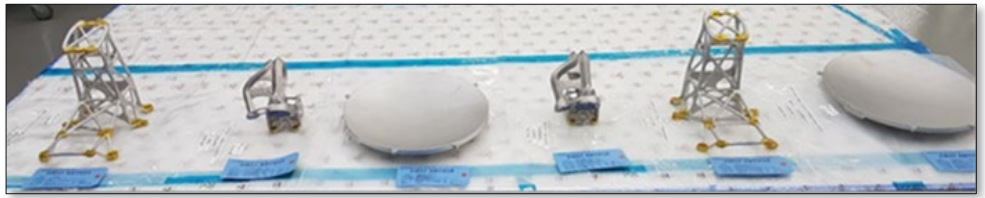


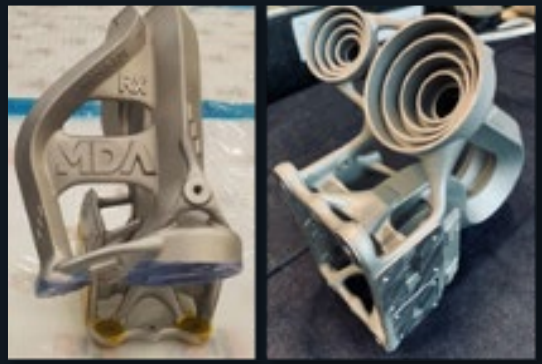
4. Build (continued)

- Inspection, validation, and Work in Process (WIP) tests performed at Burloak were reduced to the bare minimum
  - Powder chemical composition, size, tap and apparent density
  - Heat treat Certificate of Conformance (CofC)
  - Dimensional inspection report
  - Surface roughness measurement
  - Chemical composition (post heat treatment campaign)
  - Tensile yield, ultimate, and elongation (post heat treatment campaign)
- Results were provided in an End Item Data Package (EIDP)

4. Build (continued)

- Burloak delivered the 3D printed antenna parts **within 1 month**
  - AM AlSi10Mg flight parts on Trumpf 2000 (Feeds) and M400-4 (Reflector and Support Structure)





4. Build (continued)

- The Ku/Ka Tx and Rx antennas, composed of only 3 parts, were bolted together with only 8 screws:
  - Feed/waveguide, structure and reflector

5. Test

- RF verification, structural vibration, packing, and delivery were performed in **2 weeks**, successfully meeting the 2 months schedule from contract award to delivery
- Both antennas were mounted in the compact antenna range test facility at MDA; S-parameters and RF pattern tests were performed – all compliant
- Afterwards, random vibration testing of both antennas was performed in all 3 axes successfully

6. Launch

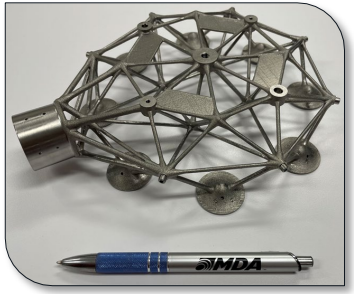
- The antennas were assembled onto the spacecraft, the launch (Jan 20, 2021) was flawless
- The satellite is currently operational, with the antennas performing perfectly

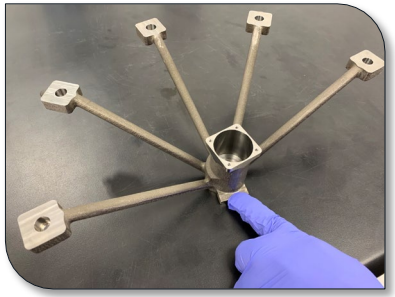
7. Conclusion

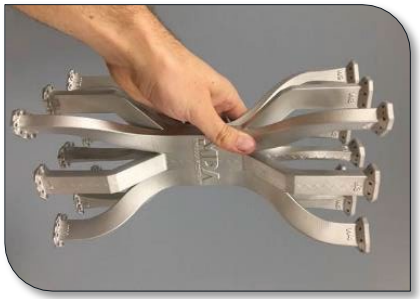
- This presentation summarized the MDA BIU satellite antenna program that was successfully executed from contract award to delivery in 2 months, which was only possible by leveraging 3D printing and post processing services from our partners at Burloak

8. Future

- Presently, MDA uses this AM technology for numerous on-going space programs, including a follow-on BIU program currently underway.







THANK YOU