Novel Design of the Functional Structure of an 8U CubeSat to be 3D Printed in Thermoplastic

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Abstract

Additive manufacturing is changing the way of designing structural parts. It offers the following benefits: design for need instead of design for manufacture paradigm, fast prototyping, reduced environmental impact, process optimization, mass reduction and applicability to new materials, among others. In the space sector mass reduction is a major challenge. Structural components require the use of materials which have to resist very demanding conditions during launch and during operation in orbit. In addition, those materials shall have reduced mass in order to reduce launch costs. The introduction of new materials such as termoplastics with high resistance and low density can dramatically reduce the total mass of a spacecraft by fulfilling the requirements provided by launching authorities and by guaranteeing operability in the space environment. In this work, a novel design of an 8U CubeSat structure is proposed to incorporate the benefits of additive manufacturing in thermoplastic polyetherimide (PEI) with the objective of qualifying it to be used in Low Earth Orbit. The design incorporates the lessons learned from the mechanical qualification tests and analysis of a previous structure in PEI proposed by the research team. This study is being part of the H2020 European Project ReDSHIFT (Project ID 687500). ***Keywords: Polyetherimide, ULTEM, CubeSat, additive manufacturing, 3D printing, FDM, satellite structure, satellite design.***

1. First design of the structure and mechanical qualification

Thanks to the high level of standardization achieved with CubeSats, the availability of commercial components for all the relevant subsystem's simplifies the spacecraft design.

The structure of the satellite was designed to resist the mechanical loads during the launch. Then, a structural model of the satellite was manufactured. The structure (including the central tray and the bracket for the star trackers) was 3D printed on thermoplastic ULTEM™ 9085. Equivalent dummy masses with similar mechanical characteristics to the satellite equipment were manufactured in aluminum alloy AA-6082 T651 with classical CNC milling. The structure was qualified to fly in a PSLV launcher [1]. More details on the qualification campaign can be found in [2].

Later, the structure was redesigned and optimized to qualify at GEVS levels [3] in random vibration load and Arianne 5 quasi-static, sine and shock loads [4].

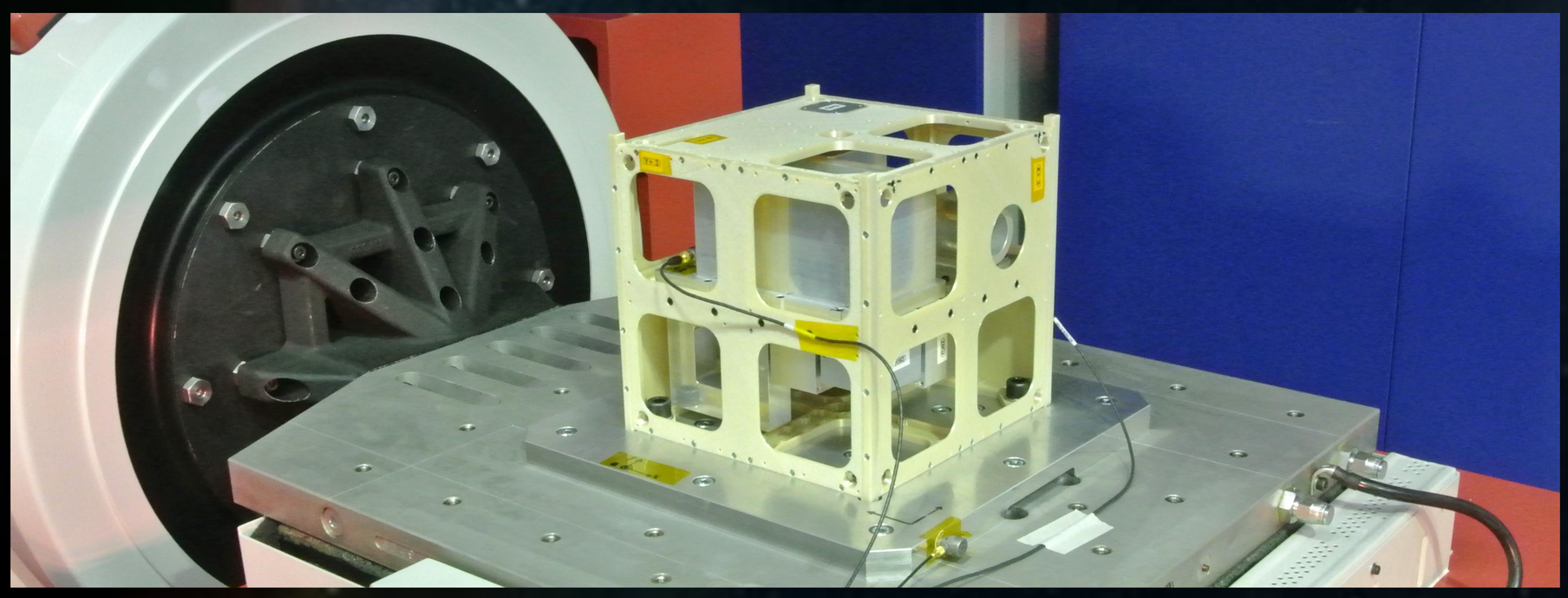

Figure 1: Structural model with 3D printed on top of the shaker during the mechanical qualification tests.

2. Redesign of the structure

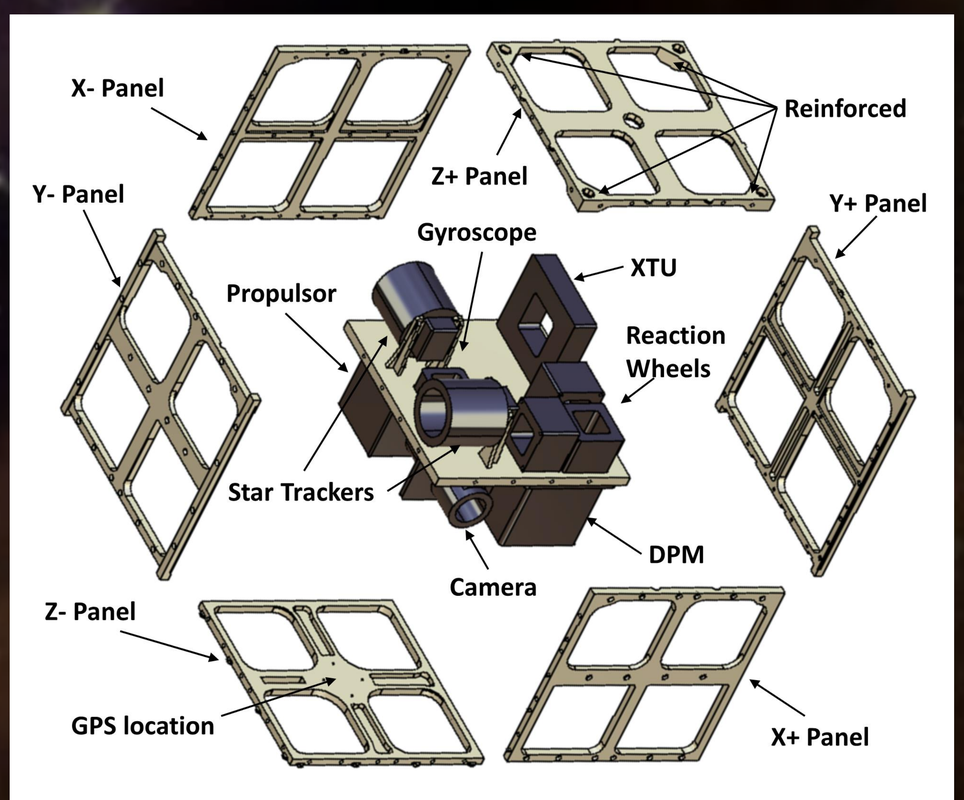

Figure 2: New structural design.

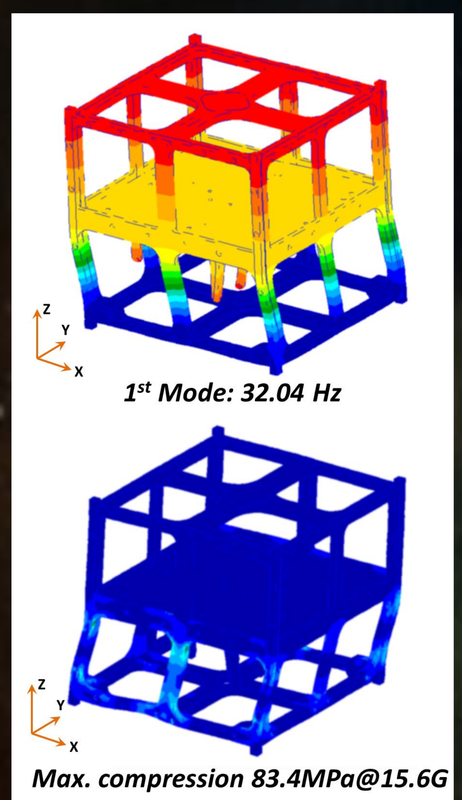

Figure 3: Mechanical analysis.

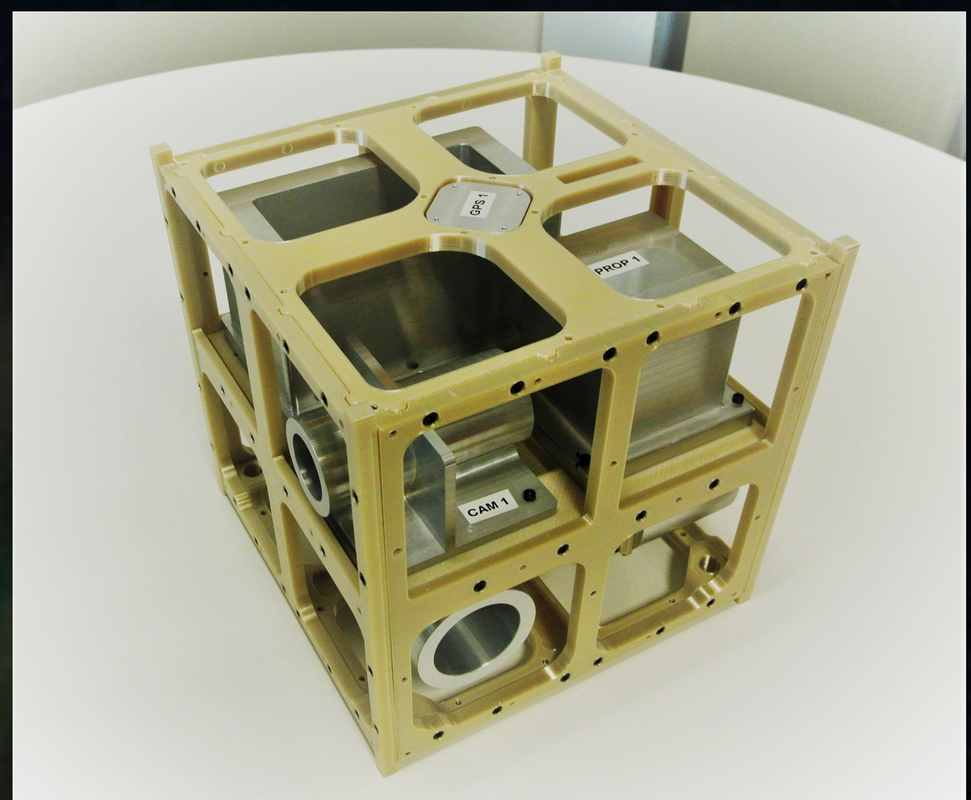

Figure 4: New structural model ready to qualify.

3. Conclusions

An 8U CubeSat structure was 3D printed in ULTEM™ 9085 and mechanically qualified for space flight: quasi-static loads, random and sine vibration at PSLV launcher levels as stated in PSLV user manual. A redesign was done by considering GEVS and Arianne 5 mechanical qualification levels. Robustness testing of the first design and mechanical analysis of the new design indicate that the structure will pass the new established qualification requirements. Preliminary Thermal Vacuum tests indicated that the structure can withstand with the space environment. Final results of TVAC testing and new mechanical testing will be provided in the near future.

4. References

[1] Department of Space Indian Research Organisation. Polar Satellite Lauch Vehicle. Government of India. (n.d.) Retrieved from: https://www.isro.gov.in/launchers/pslv on 2018/07/06.

[2] Becedas, J., A. Caparrós, A. Ramírez, P. Morillo, E. Sarachaga and A. Martín-Moreno. In press. “Advanced Space Flight Mechanical Qualification Test of a 3D Printed Satellite Structure Produced in Polyetherimide ULTEM”. In Advanced Engineering Testing. IntechOpen. United Kingdom. ISBN 978-953-51-6706-8. Ali, A. editor.

[3] NASA Goddard Space Flight Center. General Environmental Verification Standard (GEVS) for GSFC Flight Programs and Projects. NASA Goddard Space Flight Center, Greenbelt, Maryland, (2013).

[4] Lagier, R. “Ariane 5 User’s Manual”. Arianespace. Issue 5, Revision 2. October 2016.

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Background source: NASA