The Use of Additive Manufacturing for CubeSat Design and Testing

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**Introduction**

In developing a small spacecraft, the integration of numerous systems in a small area is a key challenge. It is easy to overlook how various component parts will integrate or have multiple sub-groups utilize unfilled space without realizing that they are creating a resource conflict. Additionally, the manufacturability of the final design is a key consideration. For all of these reasons, developing low-cost and incremental prototypes is a engineering “best practice” for small spacecraft development.

The use of additive manufacturing technology (commonly called 3D printing) as part of the development of the Open Prototype for Educational Nanosats (OPEN) CubeSat design [1] is discussed herein. OPEN is working to make spacecraft more affordable through the creation of publicly available designs for a 1-U CubeSat that can be produced with a parts cost of under $5,000 [2]. Reduced cost will make CubeSat development possible at numerous institutions [3].

**Additive Manufacturing at UND**

The UND Department of Computer Science has a state-of-the-art additive manufacturing and 3D scanning laboratory which features a human-size 3D scanner, capable of nearly instantly capturing imagery to create a digital model of an individual [4, 5]. It also has five 3D printers (shown in Figures 1 and 2), including one with dual filament extrusion capabilities, and a laser-based small object scanner.

In addition to supporting research into 3D scanning, numerous community outreach and instructional activities and work on assessing the quality of 3D printed objects [6], the laboratory can produce parts on demand for other projects. The OpenOrbiter Small Spacecraft Development Initiative has been fortunate to have access to these technologies (in addition to a student-assembled metal-capable CNC mill [7]) to facilitate its mechanical design, fabrication and testing.

This equipment has been used to produce all of the 3D printed objects shown in Figures 2, 3, 4 and 7. In addition to the models shown, numerous other interim models have been created to test out various part designs, component assembly and configurations.

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**OPEN Structure Design & 3D Printing**

Four OPEN structure designs are shown. Figure 2 (left) shows a 3D printed model of one of the earliest designs. This design was limited in that single use attachment mechanisms were used to retain the rails to the top and bottom plates, making disassembly to correct issues very difficult. Figure 5 (right) shows an interim design, which facilitated the use of the corner posts to support batteries; however, it was prohibitively expensive to fabricate. Figure 5 (left) shows an interim design, prior to enhancement. Finally, Figure 6 shows the current believed-final design. Additive manufacturing has also been used to create a high altitude balloon testing unit (shown in Figure 7).

**Conclusion**

Additive manufacturing has been an integral part of the OpenOrbiter program’s mechanical design process. In addition to design visualization benefits, it has been used to build prototypes to engage student participants and facilitate community outreach.

In future work, we aim to explore the usability of 3D printed parts in some areas of CubeSat design. We will look at ways to prevent the problems, such as pressure-created structural failures, discussed in [12].

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**References**