January, 2014

The Design of the Open Prototype for Educational NanoSats

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Overview
The Open Prototype for Educational NanoSats (OPEN) is a framework, under development as part of the OpenOrbiter program [1], for a spacecraft that can be built for under $5,000 in parts costs [2]. The OPEN plans will be made freely available via the internet, when complete, along with fabrication instructions, operating software, a testing plan and other documentation to enable a rapid start to a CubeSat development program.

In addition to its low-cost, OPEN facilitates CubeSat development at institutions that may lack members of key disciplines via allowing modifications and innovation to be made where desired, leaving other areas untouched (or minimally modified). Program longevity is facilitated via removing the need to pay amortized development costs (either to a vendor or for self-development). This allows programs to produce a low-cost initial spacecraft and not incur another set of large costs when building a second (or third, etc.). Using low-cost parts also reduces risk [3] and allows greater student involvement and reduces impact of accidental damage.

Structural Configuration
The structure of the OPEN framework [4] (shown in Figures 1 and 4) is designed to maximize the volume available inside the P-POD (deployer) [5], which is shown in Figure 6. The primary structural members are the base and top plates and the side-rails which serve as the interface with the P-POD as well as holding the four circuit boards in place. The circuit boards themselves (shown in the Figure 5 exploded view and diagrammed in Figures 2 and 3) are also part of the structure, as they provide additional rigidity.

Electrical Configuration
The side panels interface with each other via PC-104-style connectors. Unlike their standard use, these connectors are placed at the top and bottom of each board (shown in Figure 6). Through the wiring in the baseplate, the boards are electrically stacked, while not being required to be physically stacked. Their position allows them to deploy components (e.g., the antenna shown in Figure 6) directly.

Spacecraft Operations
The OpenOrbiter (initial OPEN demonstration) spacecraft operations are shown in Figure 7. This demonstrates task division between primary and payload processing [6] centers.

Customization, Extension and Expansion
The OPEN framework is designed to enable users to design their spacecraft to suit their needs. The base design includes two primary areas for customization. It includes a 10 cm x 10 cm x 10 cm payload area (at the center of the CubeSat, as shown in Figure 1, and containing the CubeSat’s center of mass). Also, one of the side panels is reserved for payload components.

The availability of a complete set of designs also facilitates customization. Users can modify all areas as needed to enable their innovation.

Value Proposition
The value proposition of the OPEN is shown by Figures 9 and 10. Costs come from four primary sources: hardware, labor, launch and lab equipment. The OPEN can reduce many of these cost areas. It also removes the amortized vendor development cost that is repetitively paid when buying kits. It eases modifications and allows focus on the area of interest. It may also receive favorable export treatment from its university research heritage.

While typical design and development costs may be $250,000 or more [9], an OPEN-based spacecraft will be spared many, but not all (e.g., integration labor) of these expenses.

Enabling Activities

Education—enables single-investigator (or small group) projects, as faculty from all requisite areas are not required (or involvement can be minimized).

Developing nations—low cost, space-qualified technology enables the development of indigenous space program that is not dependent on foreign suppliers for continued success [11].

Small businesses—low price point enables space product development (space technology or space user) research that might otherwise be unaffordable.

References: