OPEN ORBITER: A PLATFORM FOR ENABLING PLANETARY SCIENCE

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Introduction: The Open Orbiter Initiative is creating an Open Prototype for Educational NanoSats (OPEN) which will be available to researchers worldwide to facilitate and enable technology development, planetary science and other research at lower cost levels. It is an open-hardware program (meaning that hardware designs are available and free-for-use to anyone that desires them) combined with open source software to operate and communicate with the spacecraft. The Open Orbiter spacecraft, a 1-U CubeSat form factor NanoSat, will serve as a testing and demonstration platform for the OPEN framework, demonstrating its capabilities and space qualifying it.

OPEN, among its many uses, is poised to provide significant benefit to the planetary science community in three ways. First, it enables lower-cost development of new technologies required for planetary science applications. Second, the platform can be utilized to support Earth or other planet (inclusive of minor planets) orbiting research. Finally, because of their small size and limited cost, a network of CubeSats based on the OPEN framework can be utilized to perform experimentation requiring concurrent data collection at multiple locations, simultaneously (e.g., many atmospheric science studies).

Background: Small spacecraft have a significant role to play in planetary science applications. In earth orbit, these spacecraft have been involved in atmospheric science, remote sensing and numerous other types of research. Small spacecraft represent a paradigm shift, as compared to the historically-implemented single-large-pristine-spacecraft approach. With small spacecraft, capabilities are spread across multiple craft (or between a craft and the ground station, etc.) which can be utilized separately or in concert, when required. In addition to cost benefits, the utilization of multiple small spacecraft also promotes a more risk-tolerant mission approach, as the loss of a single craft (in a multiple craft constellation) doesn't end the mission. These craft are also significantly less expensive to replace, if required, than a pristine-class spacecraft.

Two distinct approaches exist for creating a small spacecraft [1]. Under the first approach, components are procured from a kit manufacturer (e.g., Pumpkin or Tyvak) and integrated. Mission-specific payload components are built to interface with the pre-existing bus. Under the second, a spacecraft is designed from scratch. This allows maximum flexibility, but requires significantly more design and development expense.

Current Problem: From the aforementioned, it would seem like a prudent approach to small spacecraft development would be to begin with a kit-based solution and, upon successful completion of this first activity, gradually move to a internally-developed (lower cost) spacecraft. This, however, is problematic as it dictates that the vendor's (possibly proprietary) form factor be utilized for future work, to ensure intermediate-stage compatibility. Thus, to switch from the vendor kit approach to the in-house developed approach, a near-complete design process is required. This requirement can also be triggered by a vendor kit failing to support a mission need (e.g., insufficient space or an undesirable interface format). Again, with no way to modify the vendor-produced components, the user is left with the choice of paying the vendor to redevelop its standard component (if the vendor is even willing to do this) or to develop virtually the entire craft from scratch.

Proposed Solution: The proposed approach [2] for resolving this gap is to utilize a publically-available set of plans to build the spacecraft. An initial mission (or missions) can utilize the base configuration with only mission-specific payload elements added. The base configuration can be produced by a combination of third-party printed circuit board (PCB) fabrication and instructions-based assembly. This allows a prospective research group, as with the kit approach, to gain familiarity with techniques and procedures with a known-good starting point. As capabilities mature and knowledge increases, the research group can modify the standard components to fit their expanded mission needs. This capability is particularly import for researchers that require the ability to experiment with a spacecraft subsystem (e.g., building a more capable communications subsystem to facilitate more robust Doppler-based gravity modeling.

In addition to the flexibility that it offers, the OPEN framework has been designed to maximize the utilization of the CubeSat form factor. The design, shown in Figure 1, utilizes overhang space (created due to the configuration of the side-rails in the P-POD deployer [2]) to maximize the volume available for subsystem and payload elements. Figure 1 shows a top-down view of the spacecraft layout.

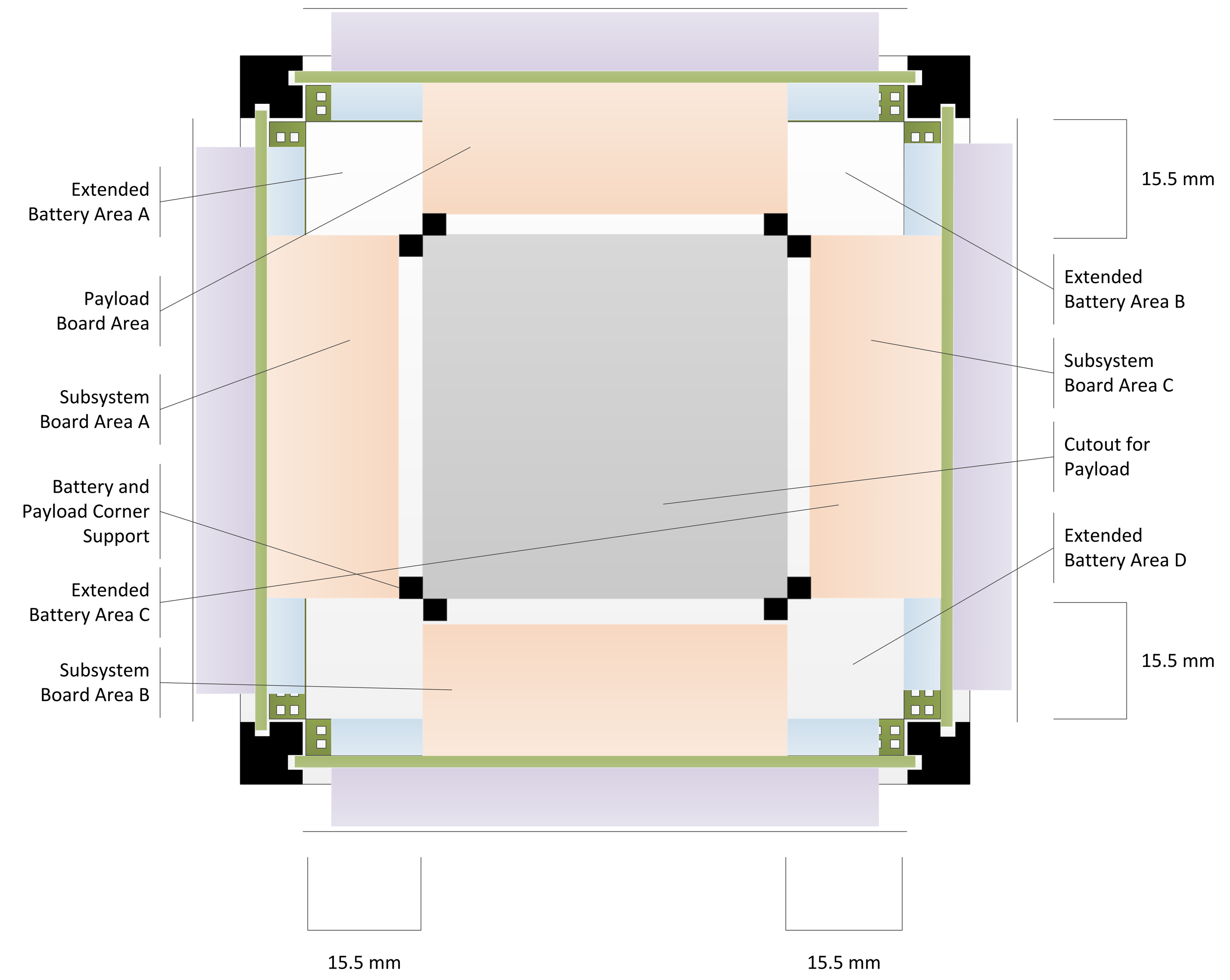

Figure 1. Open Prototype for Educational NanoSats Spacecraft Design [2]

Conclusions & Future Work: The OPEN framework is poised to provide a significant benefit to educational and researcher users. By allowing lower-cost access to the designs required to build a small spacecraft, and lowering the prospective component cost (excluding payload) of the craft to only $5,000 USD, OPEN is poised to allow greater work on the development of the critical technologies required to advance planetary science research and the missions required to advance Earth and planetary science.

References:

[1] Straub J. (2012) "Cubesats: A Low-Cost, Very High-Return Space Technology" Proc. Reinveting Space 2012.

[2] Straub J., Korvald C., Nervold A., Mohammad, A., Root N., Long N. and Torgerson N. (2013) OpenOrbiter: A Low-Cost, Educational Prototype CubeSat Mission Architecture" Sumitted for pulication in Machines.

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