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Hardware Architecture for Evolutionary SmallSat Pedagogy and Space Workforce Development

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Abstract

This paper presents an evolutionary pedagogy for training small satellite developers with an example hardware architecture that implements progressive learning with emphasis on inexpensive COTS hardware, culminating with work on actual flight articles. Small satellite development involves two parallel paths – hardware and software. Although learners may not have access to flight hardware during the early stages of their curriculum, it is a fairly simple matter to integrate a common software programming environment throughout. The proposed architecture uses a coding environment entirely in Python throughout the curriculum. In its MicroPython and CircuitPython implementations, it can be used as a microcontroller language, replacing C-based languages quite effectively. Hardware training still benefits from an incremental approach. The proposed architecture is a three-tiered approach to hardware training, gradually transitioning from working with a fully integrated spacecraft simulator to component fabrication and integration with a flight-ready vehicle. An example Tier 1 spacecraft simulator would be the A^{3}Sat device that is based on a Raspberry Pi processor and can easily be assembled by mid-to high-school students. A Tier 2 device is an Adafruit Metro M4 microcontroller board, which can run MicroPython or CircuitPython natively through its onboard ARM microcontroller. An ideal Tier 3 device is the PyCubed CubeSat open-source architecture, which is a flight-ready CubeSat avionics package in the $200 (USD) range. Learners would then finally have the opportunity to train on the same hardware they can use to implement their flight vehicle. At this tier, learners would focus on payload development, designing and building their own components while using the skills learned previously to integrate the hardware and software with the PyCubed bus. This paper will detail the hardware architecture at the three Tiers and propose how they can be integrated effectively into space system education pedagogy.

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