The AMSAT CubeSat Simulator: A Satellite in Your Hand

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Why a Simulator?

- To demystify and reveal the inner workings of a Satellite
- To support educators and provide demonstrations to the public
- To help CubeSat builders / developers be successful

One Small Step (at a Time)

- PROBLEM: Too Many CubeSats "DOA" upon LEO deployment *
- SOLUTION: Build Levels of Competence & Confidence in Satellite Technology

CRAWL	...	Amateur Radio: opportunities & benefits
WALK	...	AMSAT CubeSat Simulator
RUN	...	Engineering Model (EM) or Test Unit (ETU)
FLY	...	Flight Model (FM), Flight Spares & Testing

Original ARRL ETP CubeSat Simulator

Built by Mark Spencer, WA8SME, ARRL Education & Technology Program Coordinator

Described in The AMSAT Journal September/October 2009 and November/December 2009 issues

http://www.arrl.org/files/file/ETP/CubeSat/CubeSat-Pt1-SepOct09.pdf
http://www.arrl.org/files/file/ETP/CubeSat/CubeSat-Pt2-NovDec09.pdf


Education with a Satellite Simulator

ETP CubeSat Simulator (Part 1, the technical part)
by Mark Spencer, WA8SME, mspencer@arrl.org
ARRL Education and Technology Program Coordinator

During my interaction with classroom teachers involved in the ARRL's Education and Technology Program (ETP), I encourage the teachers to develop a portfolio of space related activities for use in their classrooms. These activity suggests include, for example, the use of Amateur Radio satellites, NOAA weather satellites, an ARISS contact, Radio JOVE, INSPIRE, and radio astronomy. During the Teachers Institute (http://www.arrl.org/FandES/tbp/ti.html), one afternoon of the 4-day institute is dedicated to bring space into the classroom with hands-on demonstrations of these suggested portfolio activities.

In preparation for the TI-2, I wanted to develop an affordable classroom resource that teachers could add to their portfolio of space related activities to demonstrate satellite fundamentals in a controlled and predictable way so that the more tenuous live on-the-air satellite activity would be more effective as an instructional tool. The result of this effort, the CubeSat Simulator, is described here. This article, part one of the description of the simulator, will focus on the technical side. . In part two of this article, I will list a growing list of possible CubeSat Simulator activities that can be used in the classroom.

The criteria upon which the CubeSat Simulator was developed include:

1. A resource that simulates a satellite operating in orbit as closely as possible in a classroom environment.

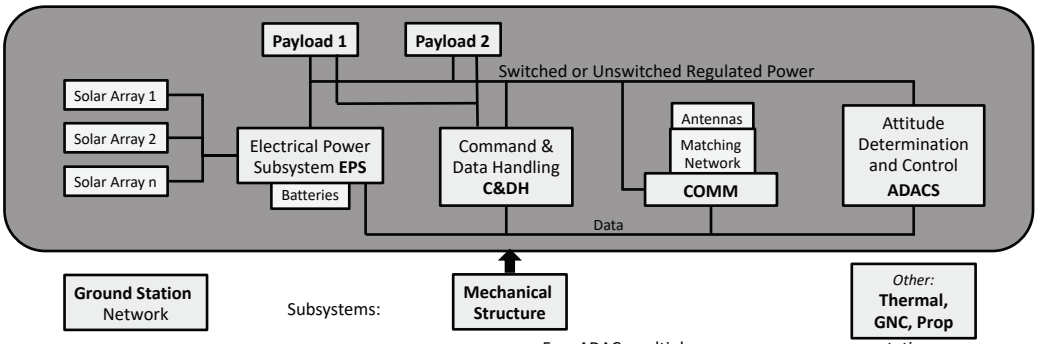
Top 5 Reasons: Why a Simulator is Better than a Real Satellite

1. You can build your own in far less time and for less than $400!
2. You don't have to pay a lot of money and wait years for a launch -- a Sim can be "launched" in any classroom or hamfest on the spot!
3. A Sim is available anytime, not just on certain passes at certain times of day
4. You don't need a full ground station to receive telemetry, just a PC with an SDR dongle
5. You can keep a Sim on your desk or shelf to show off, and it will never burn up on re-entry

Who will use a Satellite Simulator?

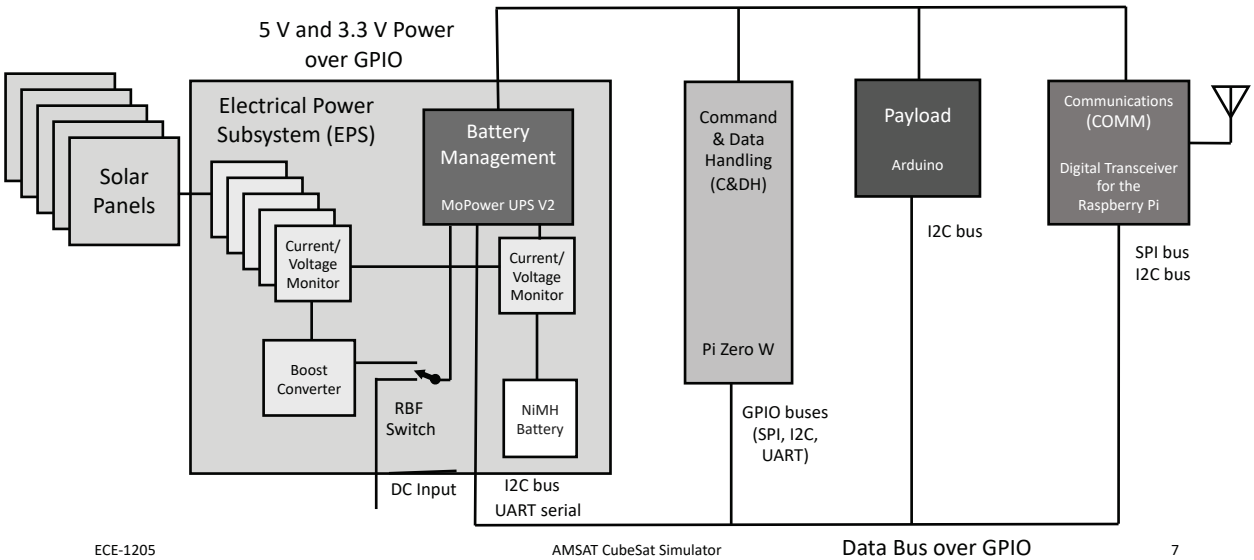
- Educators
  - In a classroom setting to do exercises that teach aspects of STEM and encourage technical careers
- Presenters
  - Those who wish to do public demonstrations and training, including AMSAT at Hamvention
- Builders
  - Teams who desire an early risk-reducing step in building a CubeSat flight model
- Makers
  - Hobbyists who just like to build things and enjoy the Raspberry Pi single board computer and the related simple interfaces

Typical Spacecraft Block Diagram

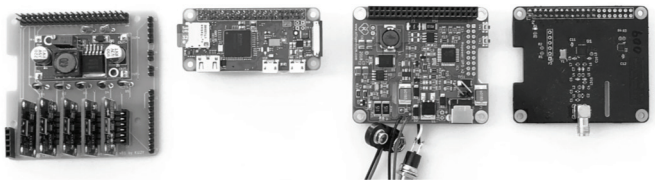


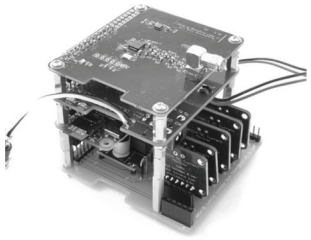
1. Mechanical Structure: PC/104 standard, PCB stack, interlayer connections, standoffs, fasteners, microswitches, deployables
2. EPS: solar cells, batteries, recharging, power regulating, distribution, grounding, fusing
3. C&DH: On Board Computer (OBC), FSW processing, scheduling, Housekeeping, storage
4. COMM: receivers, transmitters, processor, memory, TT&C, beacons
5. ADAC: multiple sensors, memory, computation
6. Thermal: Temp sensing, heat transfer, computation, control
7. GNC: GPS, RTC, time-stamping data, timing/1 PPS, computation
8. Prop: Propulsion, if we are so lucky, for translation, possibly attitude rotation
9. Payloads: The reason for the mission: Cannot fly without these VIPs!
10. Ground Station: Some seemed as an afterthought. Don't ever let it happen to you!

AMSAT CubeSat Simulator Block Diagram



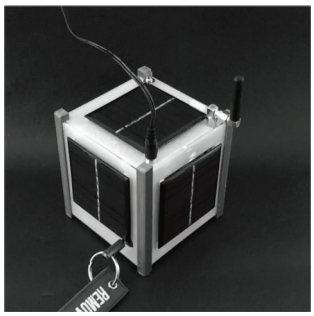
Boards in the Prototype





Solar Power Management (part of EPS)	C&DH	Battery Management (part of EPS)	Comm (Transmitter)
Custom Circuit Board	Raspberry Pi Zero W	MoPower UPS V2	Brandenburg Tech Digital Transceiver for the Raspberry Pi
Monitors solar panel current and voltages for telemetry. Boosts voltage to 15 V to charge batteries. Switches between DC input power and solar power.	Runs software to control simulator. Controls and communicates with other boards using the GPIO connector.	Manages charging of 9 V NiMH battery. Provides power on/reboot/shutdown button and automatically shuts down Pi if battery voltage is too low.	Transmits telemetry signal on 70 cm band using different modulation schemes.

1U CubeSat Spaceframe



3D Printed with PLA

Based on a design by TJEmsley

https://www.thingiverse.com/TJEmsley/designs

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Questions? Comments?

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https://github.com/alanbjohnston/CubeSatSim/wiki