

CubeSatSim Project

An Educational Project Sponsored by AMSAT



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Topics

- CubeSatSim Team
- What is a CubeSatSim?
- Project Survey Results
- Technical Details
- Demo
- Get Involved
- Q & A
- Acknowledgements



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CubeSatSim Project Team

■ Hardware

- Alan Johnston, KU2Y
- Jim McLaughlin, KI6ZUM
- David White, WD6DRI

■ Educational Materials

- Paul Graveline, K1YUB
- Alan Johnston, KU2Y
- Fredric Raab, KK6NOW
- Mark Samis, KD2XS
- David White, WD6DRI

■ Beta Builders

- Bob Koepke ,AA6TB
- Kerry Bonin, KJ7HTG
- Jim Nagle, KF4OD
- Virginia Smith, NV5F
- Chris Thompson, G0KLA/AC2CZ
- Randy Standke, KQ6RS,
- Christine Mehner, MD, PhD, KO4EWG
- Sopwith, N1SPW
- Kai Ji, AC3EN

■ Students

- Villanova University, Villanova, PA
CubeSat Club and 2024 - 2019 ECE
1205 Freshman Projects classes
- Bishop O'Connell High School,
Arlington, VA DJO ARC students and
teacher Melissa Pore, KM4CZN

■ CAD

- Lindsay White, KI6LZN

■ Filter Design and Testing, RF Testing

- Randy Standke, KQ6RS

Thank You!



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What is a CubeSatSim?

- It is the core of an education program to evangelize the science and technology used in radio satellites.
 - University engineering programs
 - Amateur radio community
 - STEM programs
 - Libraries, Museums, Maker Faires, etc.



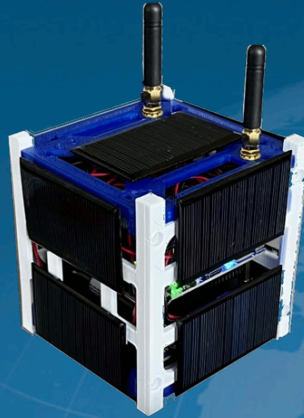
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What is a CubeSatSim?

- A low-cost satellite emulator that runs on solar panels, batteries, and transmits UHF radio telemetry



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What is a CubeSatSim?

- Uses a 3-board stack plus a Raspberry Pi Zero single board computer
- Includes a Raspberry Pi Pico microcontroller, rechargeable batteries, voltage/current sensors, and environment sensors.



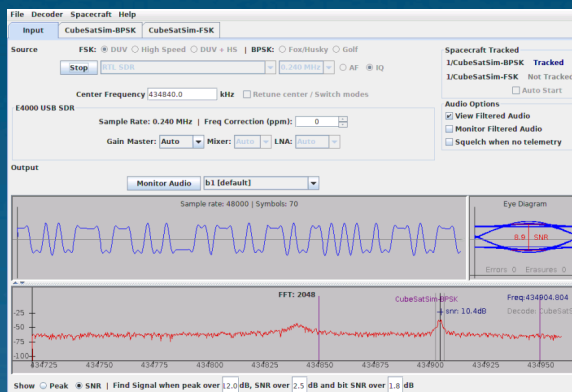
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What is a CubeSatSim?

- Transmits 70cm amateur band UHF radio housekeeping telemetry to a ground station in multiple formats - describing the operational location/health of the satellite.



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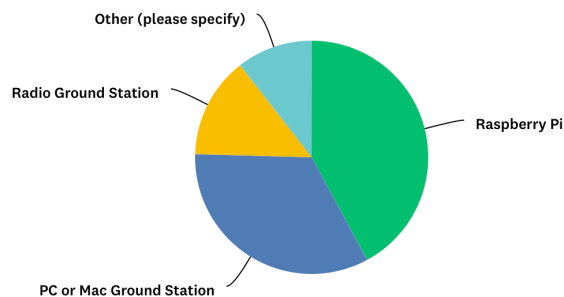
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CubeSatSim Project Survey Results

- Received 59 responses from builders or purchasers of PCBs
- Gathered Feb – May 2024
- Average rating of 9.0/10
 - How would you rate the CubeSat Simulator as a learning tool on a scale of 1 - 10 where 10 is best?
- Most issues fixed by Beta
- Ground Station question shows need for more support for PC or Mac Ground Station

What do you use as a Ground Station?

Answered: 57 Skipped: 2



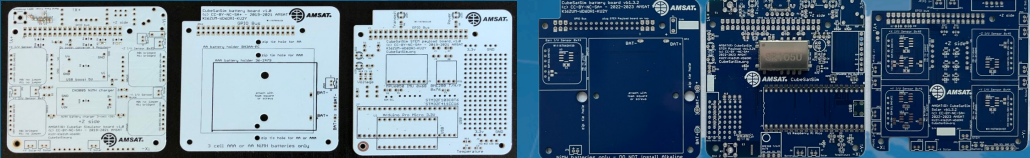
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CubeSatSim Beta

- CubeSatSim Beta v1.3 is a redesign for lower cost and easier to find parts plus some new features:
 - FM transceiver module with RF command and control
 - Raspberry Pi Pico microcontroller
 - Easy to add new sensors with Qwiic hardware connector and software extensions
- V1 still supported and available
- Will transition from Beta later this year





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Announcement: Limited Availability of Kits



- Everything you need to assemble a CubeSatSim in a few hours
- Some soldering: sensor pin headers and solar panel wires
- Assemble the 3D printed frame parts and attach solar panels
- Available at our booth and on the AMSAT Store in June



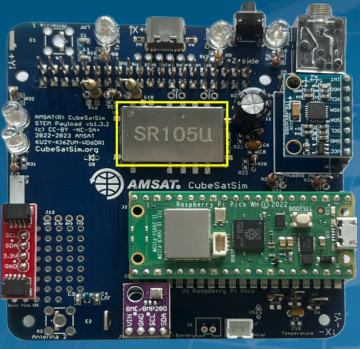
<https://www.amsat.org/cubesatsim-kits-available-at-hamvention/>

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Technical Details

- STEM Payload Board
 - Raspberry Pi Pico microcontroller and **FM transceiver SR105U**
 - Temperature/Pressure/Humidity Sensor BME-280 (purple)
 - 3-Axis Accelerometer/Gyroscope MPU-6050 (blue)



The image shows a STEM Payload Board, a blue printed circuit board (PCB) populated with various electronic components. A yellow box highlights the SR105U FM transceiver chip. Other visible components include a Raspberry Pi Pico microcontroller, a BME-280 sensor, and an MPU-6050 sensor. The board is labeled 'AMSAT Education' and 'AMSAT CubeSatSim'.



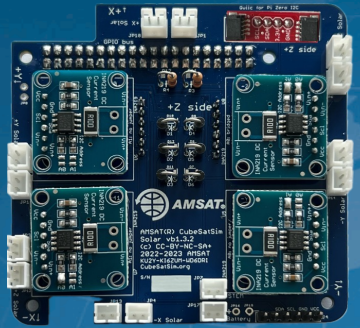
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Technical Details

- Solar Board
 - 6 Voltage/Current Sensors
 - Solar panels plug into JST 2.0 connectors
 - Uses low cost solar panels (\$1.50/panel)



The image shows a Solar Board, a blue PCB designed for monitoring solar panel performance. It features six JST 2.0 connectors for solar panels, several voltage and current sensors, and various electronic components. The board is labeled 'AMSAT Education' and 'AMSAT CubeSatSim'.



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Technical Details

- Battery Board
 - 3 AA Nickel Metal Hydride (NiMH) Batteries for safety
 - Can operate in demo mode for 3 hours
 - Charged with solar panels or USB-C cable





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Technical Details

- Raspberry Pi Zero
 - Software on micro SD card – pre-imaged available on AMSAT Store
 - Runs C and Python software
 - Pi Camera for SSTV



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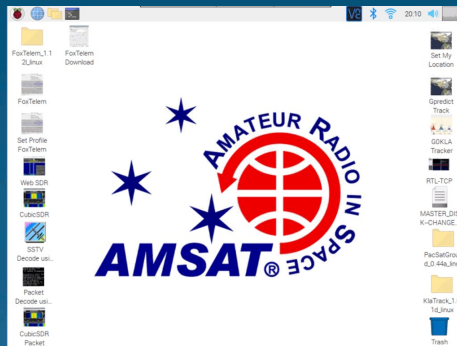
Technical Details

■ Ground Station

- Pre-built Software Stack (Fox-in-a-Box)
- Or, install on your own PC

■ Software:

- FoxTelem
- Direwolf
- QSSTV
- OpenWebRX
- CubicSDR
- RTL-TCP
- Gpredict
- KLATracker



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Technical Details

Blinks	Mode	Description	Decoding	Command	Audio	Waterfall (Cubic SDR)
1	APRS	Automatic Packet Reporting System. This digital mode sends a packet of data with AFSK or Audio Frequency Shift Keying modulation.	Windows: SoundModem or Direwolf Raspberry Pi/Linux: OpenWebRX or Direwolf with spreadsheet http://cubesatsim.org/telem	config -a	CubesatSim.org/a	
2	FSK	Frequency Shift Keying. This mode transmits a continuous signal that makes a rumbling sound that emulates the AMSAT Fox CubeSats such as Fox-1C or AO-95. Also known as DUV or Data Under Voice.	Windows/Raspberry Pi/Linux: FoxTelem	config -f	CubesatSim.org/f	
3	BPSK	Binary Phase Shift Keying. This mode transmits a continuous signal that sounds like noise that emulates the AMSAT Fox-1E or HuskSat-1 CubeSats. You need to demodulate using USB.	Windows/Raspberry Pi/Linux: FoxTelem	config -b	CubesatSim.org/b	
4	SSTV	Slow Scan Tele/Vision. This mode transmits stored images in Scottie 2 format which sounds like a series of tones.	Windows: MMSSTV Raspberry Pi/Linux: QSSTV	config -s	CubesatSim.org/s	
5	CW	Continuous Wave or Morse Code. This mode transmits a FM modulated tone at 20 words per minute Morse Code telemetry.	Windows/Raspberry Pi/Linux: fdigi with spreadsheet http://cubesatsim.org/elem	config -m	CubesatSim.org/m	

■ Telemetry Modes

- APRS (Automatic Packet Reporting System)
- FSK (Frequency Shift Keying DUV (Data Under Voice))
- BPSK (Binary Phase Shift Keying)
- SSTV (Slow Scan TV)
- CW (Continuous Wave aka Morse Code)



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CubeSatSim Command and Control

Ready for the Demo?



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Get Involved with the CubeSatSim Project

■ Borrow a CubeSatSim Loaner

- AMSAT members can borrow a loaner to show at an event or in a classroom
- Teachers can also borrow a loaner – contact me!

■ Build a CubeSatSim

- Fully open source – about \$300 to build

■ Limited availability of kits



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Questions?

Contact Alan at ku2y@arrl.net

<https://CubeSatSim.org>

<https://www.amsat.org>

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



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Acknowledgements

- Thanks to Mark Spencer, WA8SME, for his trailblazing work on CubeSat simulators for the ARRL and to Bob Bruninga, WB4APR, for ideas and inspiration from his undergrad “LabSat” developments.
- Pat Kilroy, N8PK, was instrumental in getting the CubeSat Simulator project going again.
- We would also like to acknowledge all the open source hardware and software that is a part of the AMSAT CubeSatSim.
- Finally, we would like to acknowledge the support of the AMSAT Board of Directors and the members of AMSAT for their support and encouragement of this project.



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