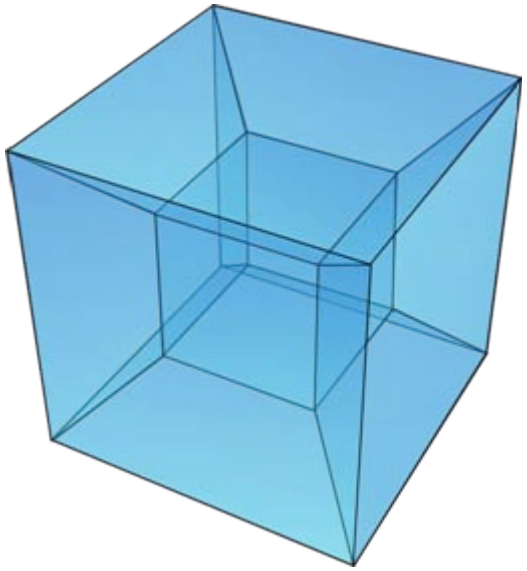

myPocketQub.com

an open source nano-satellite project

Michael Johnson

michael@myPocketQub.com

2010 CubeSat Developers' Summer Workshop

a JA initiative

Logan, Utah, USA
August 7-8, 2010

in association with

UKSEDS

SAPIENZA UNIVERSITÀ DI ROMA

The CubeSat Cookbook
cubesatcookbook.com
myGroundStations.com

Cornell University
Space Systems Design Studio
Sprite Satellite Project

CLYDE SPACE

open source initiative

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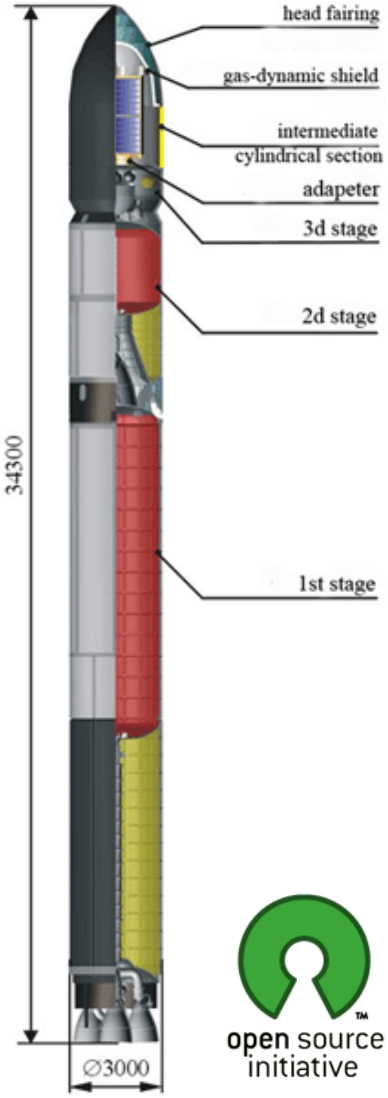
The mission

- Design and launch an open source satellite
- Use only open source or free tools
- Document every part of the process and make it freely available on the web
- Home hardware version to cost < GBP 100 / EUR 120 / USD 150
- Space hardware and launch to cost < GBP 10 000 / EUR 12 000 / USD 15 000
- Anyone can develop software on home hardware, and run on on-orbit space hardware for 24 hours for free
- Multiple inexpensive launch options



open source initiative

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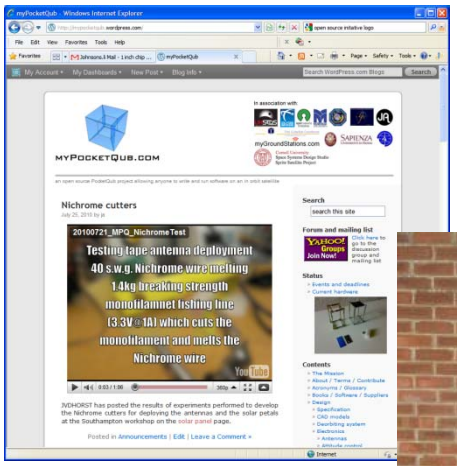
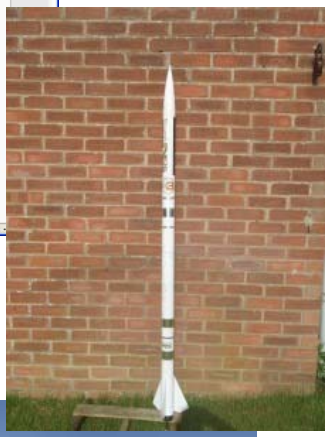
Develop and launch an open source satellite

- Team of >40 volunteers coordinated via web site
- Variety of launch options for all budgets and technical ability
  - Standardised weather balloon (up to 70 000 feet)
  - Standardised amateur rocket (up to 2 000+ feet in UK)
  - LEO launch kindly provided by UNISAT on DNEPR Nov. 2010 (700 km)
  - CubeSat / P-POD compatible deployer under development
- All welcome to participate!





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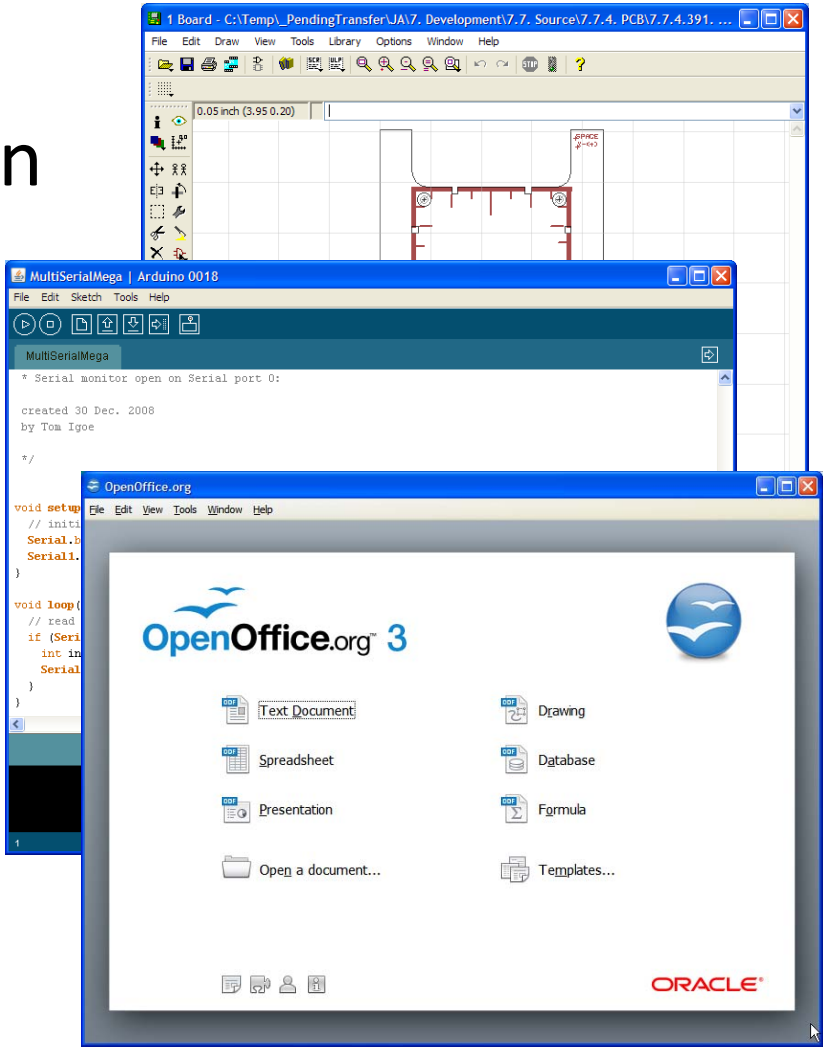
Use only open source or free tools

- Anyone should be able to help at home at no cost on Windows, Mac or Linux
- Hardware development
  - Arduino, EAGLE, Google SketchUp, RockSim, etc.
- Software development
  - Arduino IDE, GIT, etc.
- Documentation
  - InkScape, OpenOffice, etc.



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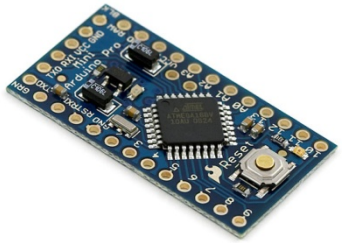
Home hardware to cost < GBP 100 / EUR 120 / USD 150

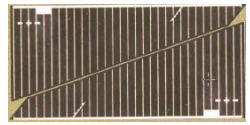


- Most parts available in Conrad/Maplin/Radio Shack etc
- Based on open source Arduino platform
- Inexpensive Bluetooth or GSM radio, solar cells, etc.
- Small dimensions allow simple/license free flight on balloons and three inch amateur rockets in many countries

Space hardware and launch
< GBP 10K / EUR 12K / USD 15K

- Hardware design exactly the same as home version with a few upgraded components
  - e.g. solar cells, radio, conformal coatings, etc.
- Small size (nominal 50mm x 50mm x 75mm) and mass (187.5g) allows inexpensive launch from new small orbital deployer MR-FOD

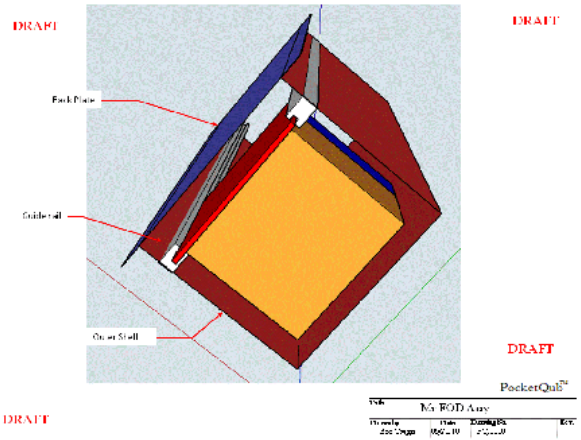
Radio Shack
USD 4.95

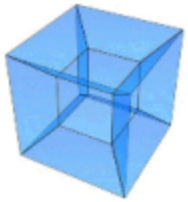


Spectrolab
USD 10.00

Roving Networks
USD 20.00

AstroDev
USD~1000





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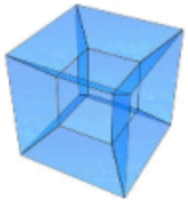
Run software in space

- Arduino based SDK will allow anyone to follow along at home
- Homebrew code can run on space hardware
- Access accelerometers, magnometers, temperature sensors, video camera, etc.
- We hope to allow 365 people to have use of satellite for 24 hours for free via competition
  - Upload 32KB software
  - Download 1MB of results



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So, that's the grand plan – how to realise it?

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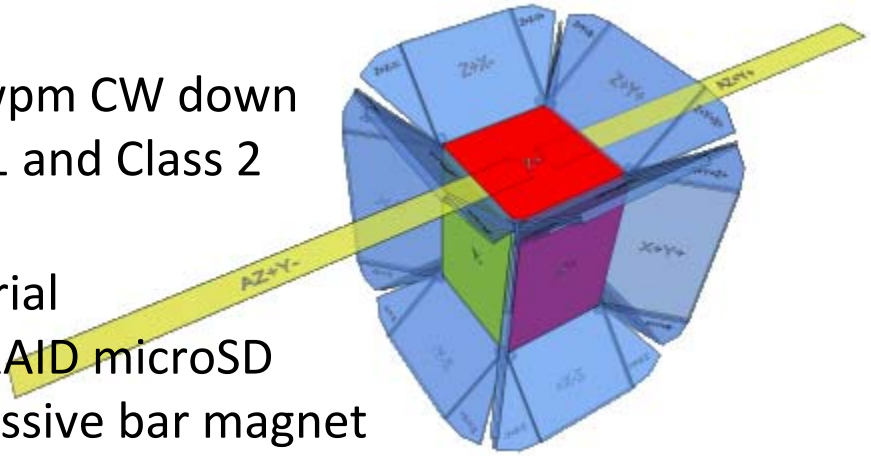
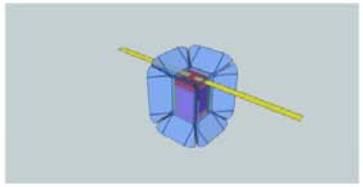
Specification

- System
  - 1.5Q PocketQub (50mm x 50mm x 75mm, 187.5g)
  - Must deorbit within 25 years from 700km sun synchronous LEO
- Power
  - 3.3V system, 900mAh Li-Poly battery, up to 2W popped solar petals
- Communications
  - 70cm, 1200bps data up/down + 1wpm CW down
  - myGroundStations.com LEO Class 1 and Class 2
- Structure / flight computer / ADCS
  - 1.6mm FR4 PCB as structural material
  - 3.3V 8MHz Arduino with sensors, RAID microSD
  - three axis PCB magnetorquer or passive bar magnet
- Payload
  - Public programmable 3.3V 8MHz Arduino with video camera
  - 2x Sprite ChipSat





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- Radio
- Antenna
- Flight computer
- Electrical power system
- Peripherals and sensors
- Attitude determination and correction
- Payload
- Solar cells

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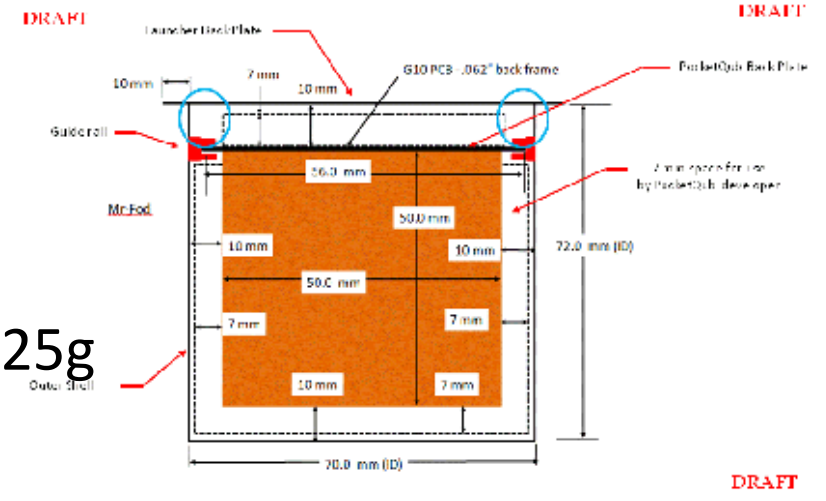
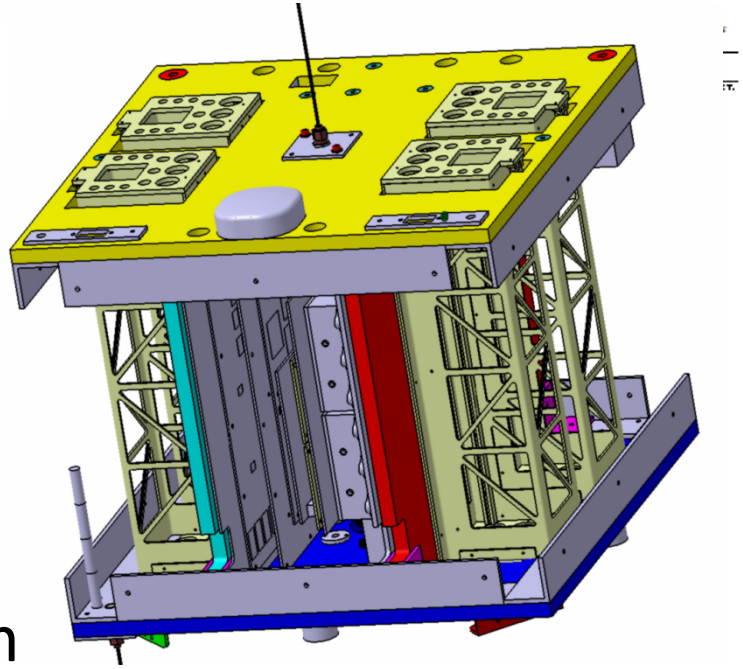
System : PocketQub

- PocketQub standard
  - 1U CubeSat = 8Q PocketQub (2 x 2 x 2)
  - 1Q = 50mm x 50mm x 50mm, 125g
  - 1.5Q = 50mm x 50mm x 75mm, 187.5g
- PocketQubs launched from 3Q MR-FOD (Morehead Roma – Femtosat Orbital Deployer) installed on UNISAT
- CubeSat / P-POD compatible deployer under development so myPocketQubs actually
  $1_{my}Q$ = 45mm x 45mm x 45mm
  $1.5_{my}Q$ = 45mm x 45mm x 67.5mm





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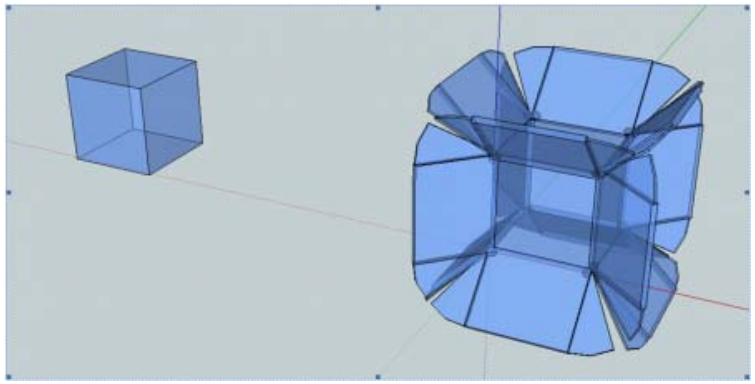
System: Deorbiting

- Need to be good space citizens
- IADC and space agencies requiring deorbiting within 25 years
- PocketQub has low ballistic coefficient
- Pop, like popcorn, a 1Q or larger PocketQub to the same volume as a 1U or larger CubeSat



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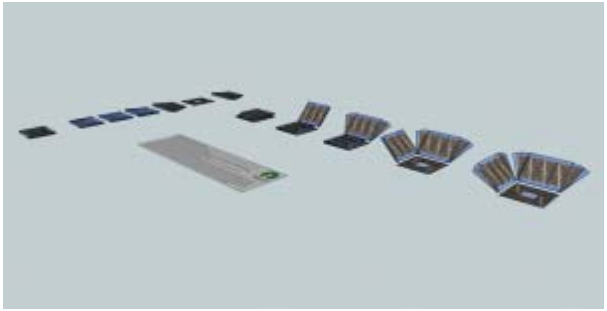
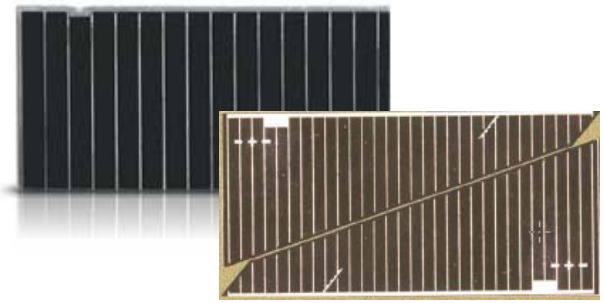
Power

- Popped structure increases surface area 5x for solar cells
  - Mix AzurSpace, Spectrolab and RadioShack cells to test cost / benefit
  - Springs from petals bring power in
  - Petals single or double sided
- 123A Li-Poly camera battery
- 3.3V power system





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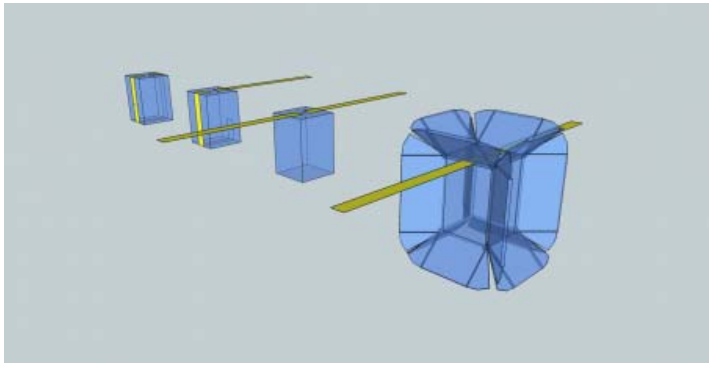
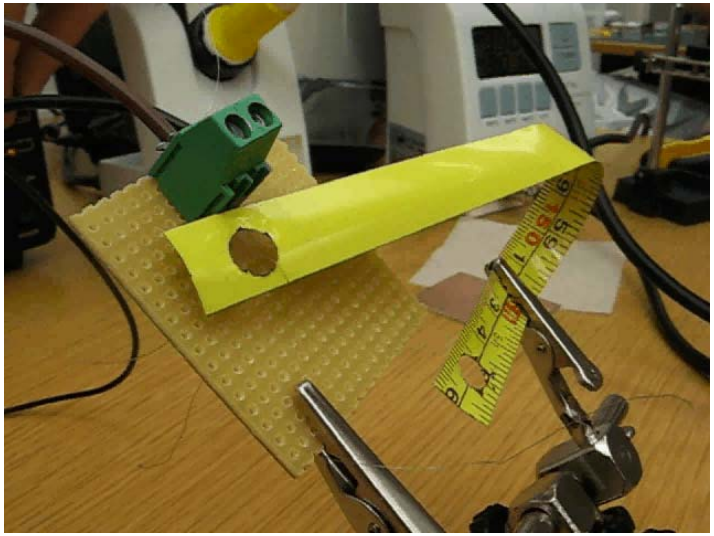
Communications

- 70cm up/down, 1200 bps GMSK, up to 3.5W
- 2m up/down, 1200 bps BPSK, up to 400mW (provisional)
- 2x 70cm down, 10 wpm CW (ChipSat) / 0.1 wpm CW (myPocketQub emergency mode), up to 11mW
- Radar resonator dipoles (provisional)
- Tape measure and spring wire antennas

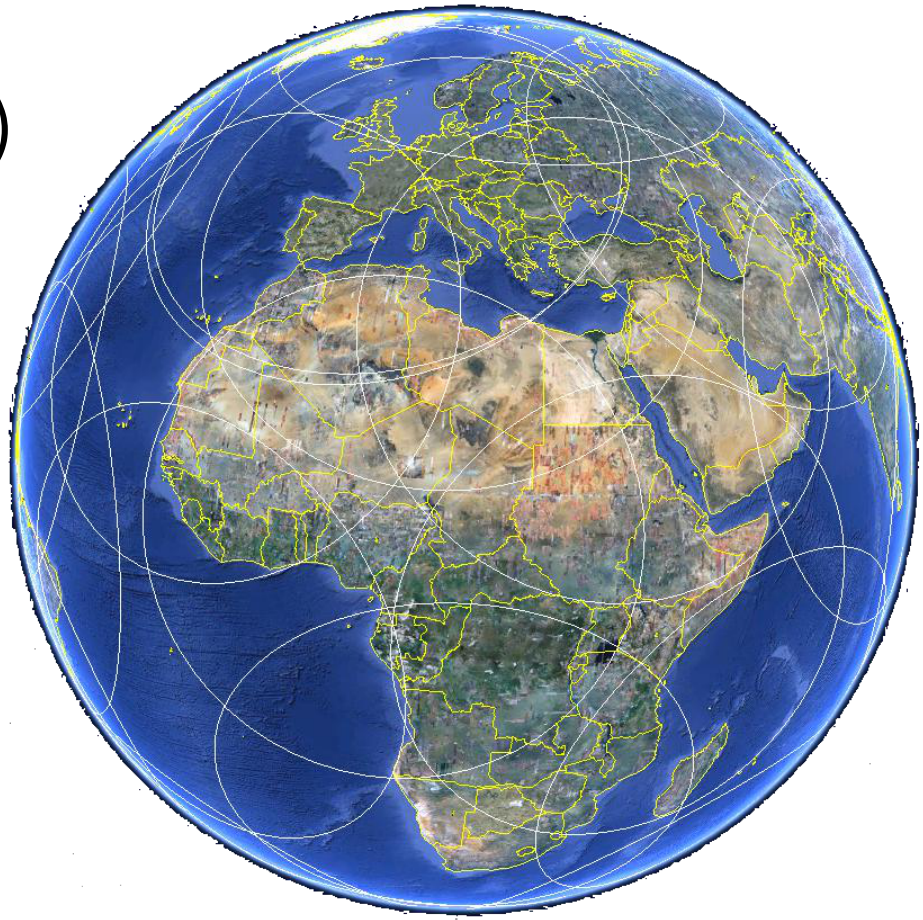




myPocketQub.com

myGroundStations.com

- 3+ LEO Class 2 (AU/UK/US)
  - 2m/70cm up/down link
  - S/X band up/down link
  - COTS transceivers
- 30+ LEO Class 1 (Global)
  - 2m/70cm down link
  - custom low cost soft radio
  - RAIGS (redundant array of inexpensive ground stations)
  - volunteer sites wanted! need to have clear view of sky, WiFi internet and room for a small omni antenna
- GENSO compatible (alpha)



Could you host a LEO Class 1 site?
If so, please email:
new.sites@mygroundstations.com

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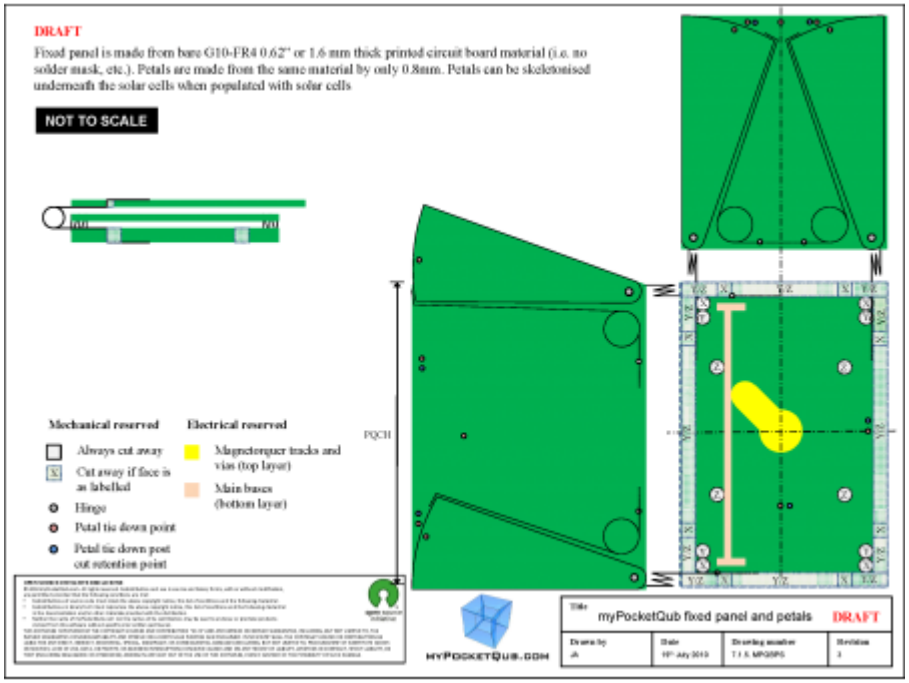
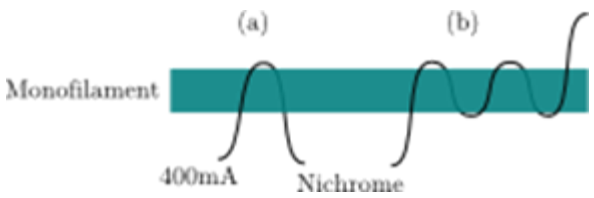
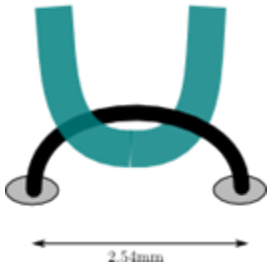
Structure

- 1.6mm FR4 PCBs double up as structure
- 40mm x 40mm x 60mm core held together in compression
- Flight systems embedded in walls of myPocketQub allows 32mm x 32mm x 32mm payload
- 4 / 24 layer (home/space)
- 0.8mm FR4 for petals
- Nichrome cutters cut monofilament, torsion springs deploy petals







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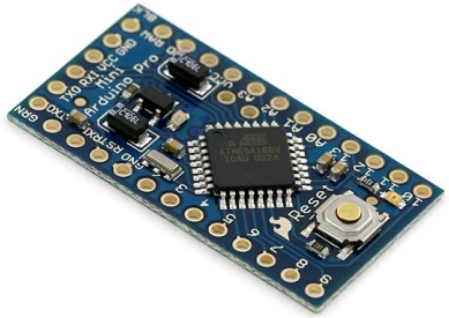
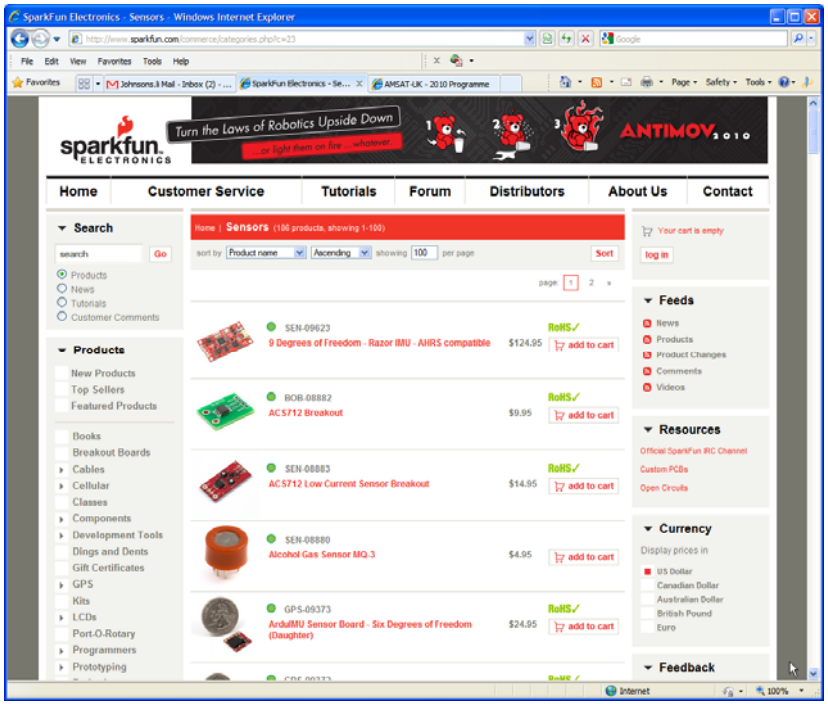
Flight computer

- 3.3V 8MHz Arduino Mini Pro
- Connects to system I2C bus
- Peripherals include
  - Accelerometers
  - Magnetometers
  - Altimeter(home)
  - RAID1 2GB microSD cards
  - Vibration sensors
  - Voltage and current sensors
  - All based on off the shelf SparkFun open source I2C designs





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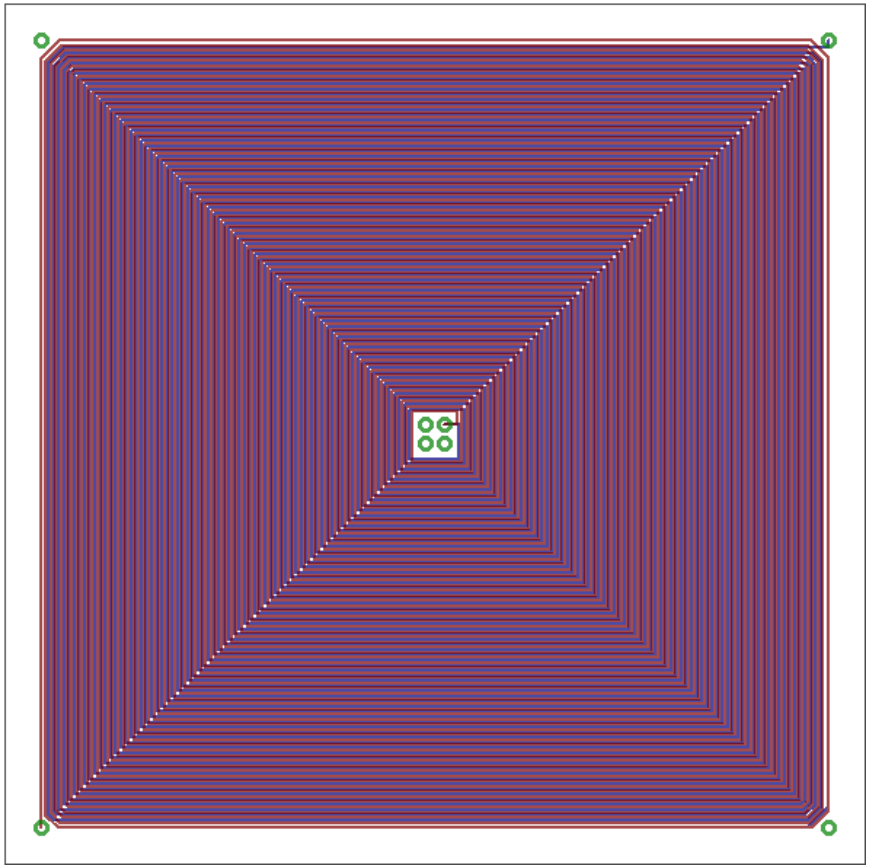
Attitude determination and control system

- Three axis magnetorquer design based on SUSAT / OpenCubeSat ADCS design and software
- PCB magnetorquers – 24 layer board allows 600 turns – almost 50m long track
- Pseudo bar magnet backup mode
- Some users may be allowed to run experimental ADCS algorithms
- May fly with passive system this launch if run out of development time



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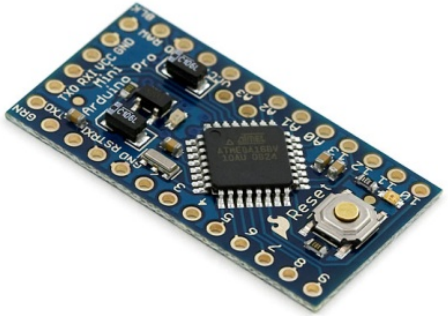
Payload 1: Qubduino

- Computer in space that up to 365 people can use for 24 hours each
- 3.3V 8MHz Arduino Mini Pro
  - 2GB microSD
  - Video camera
  - Access to main system sensor data via dual port I2C RAM to protect main systems from rogue software
- 32KB program uploaded, 1MB data downloaded
- Public access to space – try to replicate microcomputer revolution with bedroom space hacking



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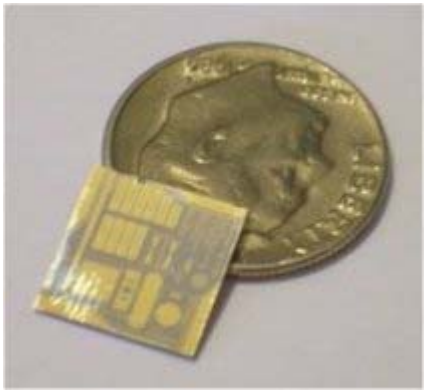
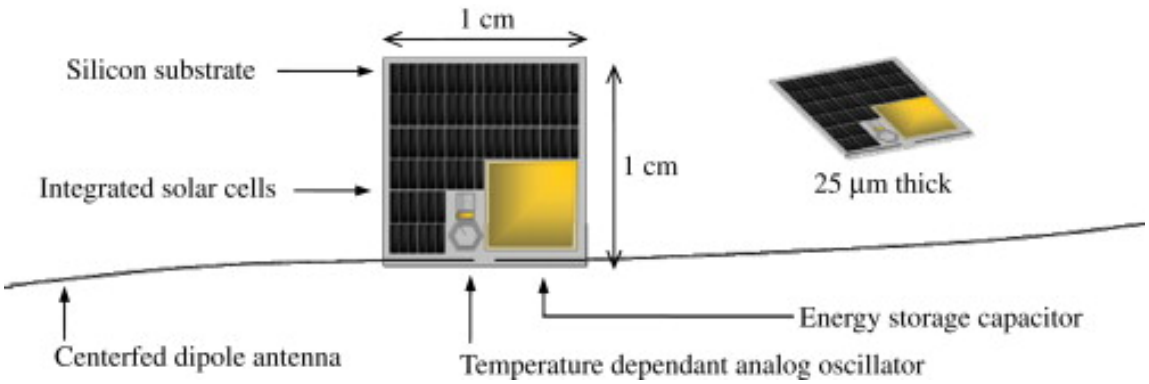
Payload 2: Sprite ChipSat

- Secondary payload is two Sprite ChipSats – satellites on a chip
- Two of the major petals attached to myPocketQub 391 Z-face will have Sprite ChipSats attached

Cornell University
Space Systems Design Studio
Sprite Satellite Project





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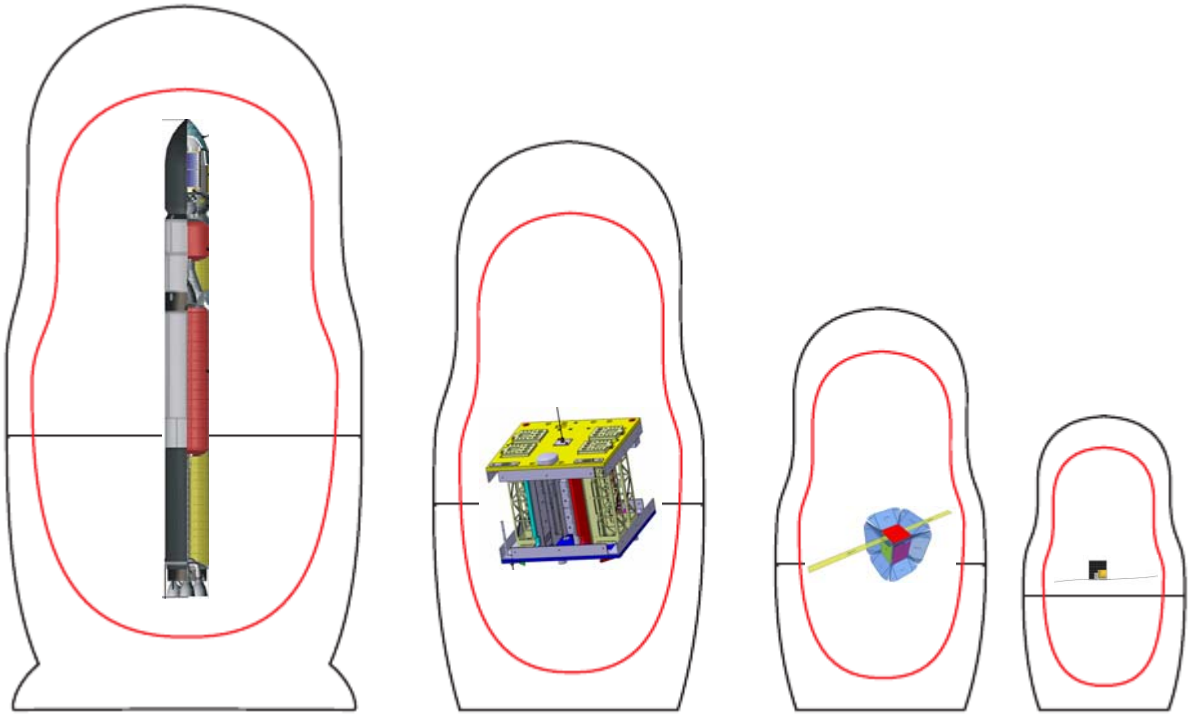
Small is beautiful!



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