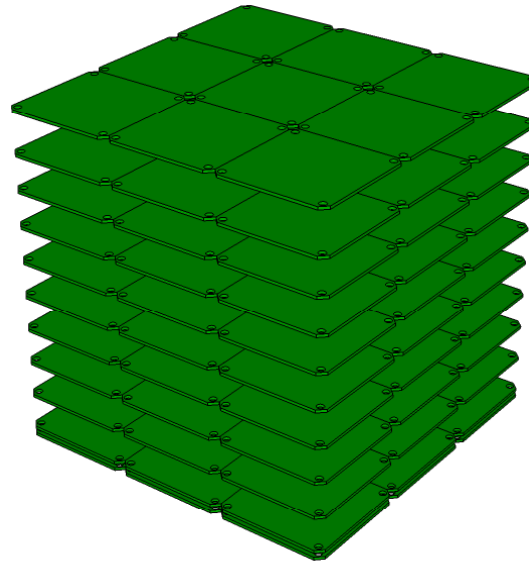


# CUBESAT-ON-DEMAND

a generic reconfigurable reusable spacecraft system



Michael Johnson  
michael@PocketSpacecraft.com

2011 CubeSat Developers'  
Summer Workshop

a  initiative

Logan, Utah, USA  
August 6-7, 2011

in association with

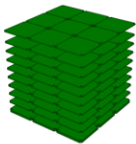


Cornell University  
Space Systems Design Studio  
Sprite Satellite Project

**POCKETSPACECRAFT**  
platforms for the personal space age

  
The CubeSat Cookbook  
cubesatcookbook.com  
  
myGroundStations.com

**QI OPTIQ**  
Photonics for Innovation



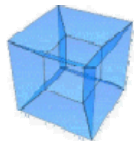
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# Open Source Space System

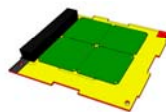
a  initiative



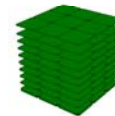
**SUPERSPRITE**



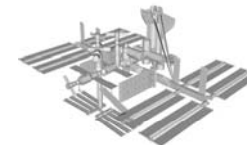
**MYPOCKETQUB.COM**



**POCKETPAYLOAD**



**CUBESAT  
ON DEMAND**



**SPACECRAFT  
ON DEMAND**

**O P E N C S S W**



  
**myGroundStations.com**



**+ 1 UNANNOUNCED  
CONSUMER TEXT**

**BOOKS / EDUCATION**



**OPEN MISSION  
CONTROL**



**OPEN MISSION  
DESIGN STUDIO**

**in association with**



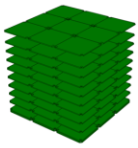
**Cornell University**  
Space Systems Design Studio  
Sprite Satellite Project



and many others with special thanks to Mason Peck, Sara Spangelo and Bob Twiggs  
plus ESA, NASA, STFC and the UK Space Agency

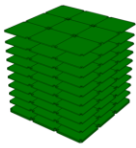
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Graphics courtesy: SSDL, Willis Michael



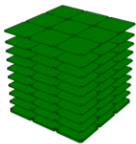
## Some observations

- CubeSats are typically single purpose
- Time on orbit and functional can greatly exceed mission requirements
- Development process is lengthy
- Costs still relatively high and often borne by a single group
- Launch process lengthy and frustrating
- Hard to try and iterate ideas quickly, easily and inexpensively



# What if...

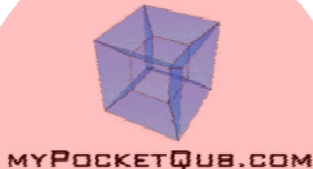
- General purpose reconfigurable CubeSats
- Launched regularly and speculatively to interesting places
- Consist of a mixture of standard subsystems and the ability to fly/launch custom subsystems / payloads
- Move as much of the problem into software / online as possible
- Provide project neutral hardware assembly, integration, verification and test bureau so designers can just design
- Open source to encourage professional and amateur collaboration
- Base on existing designs to get started quickly
- End result – generic CubeSats who's mission can be changed minute by minute, enabling just the combinations of subsystems they need for the task at hand to be enabled



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a generic reconfigurable reusable spacecraft system

# We already have most of the pieces...

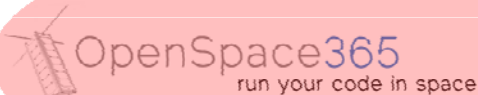
a initiative



**OPENCCSDS**



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CONSUMER TEXT  
BOOKS / EDUCATION**



**OPEN MISSION  
CONTROL**



**OPEN MISSION  
DESIGN STUDIO**

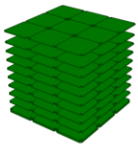
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**Cornell University**  
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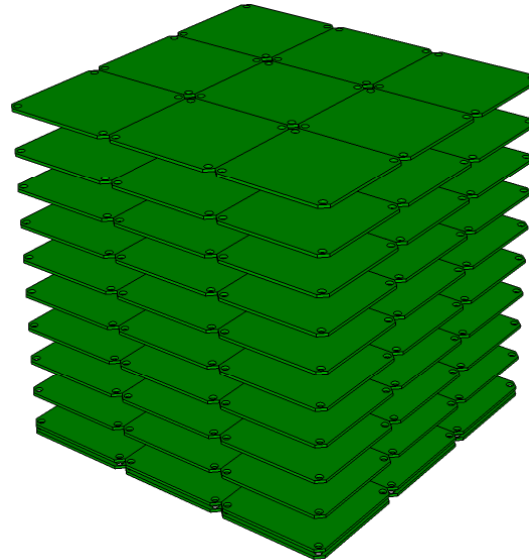
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**CUBESAT-ON-DEMAND**  
a generic reconfigurable reusable spacecraft system

...so let's give it a go

a  initiative

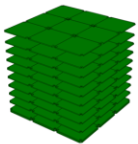


**CUBESAT-ON-DEMAND**

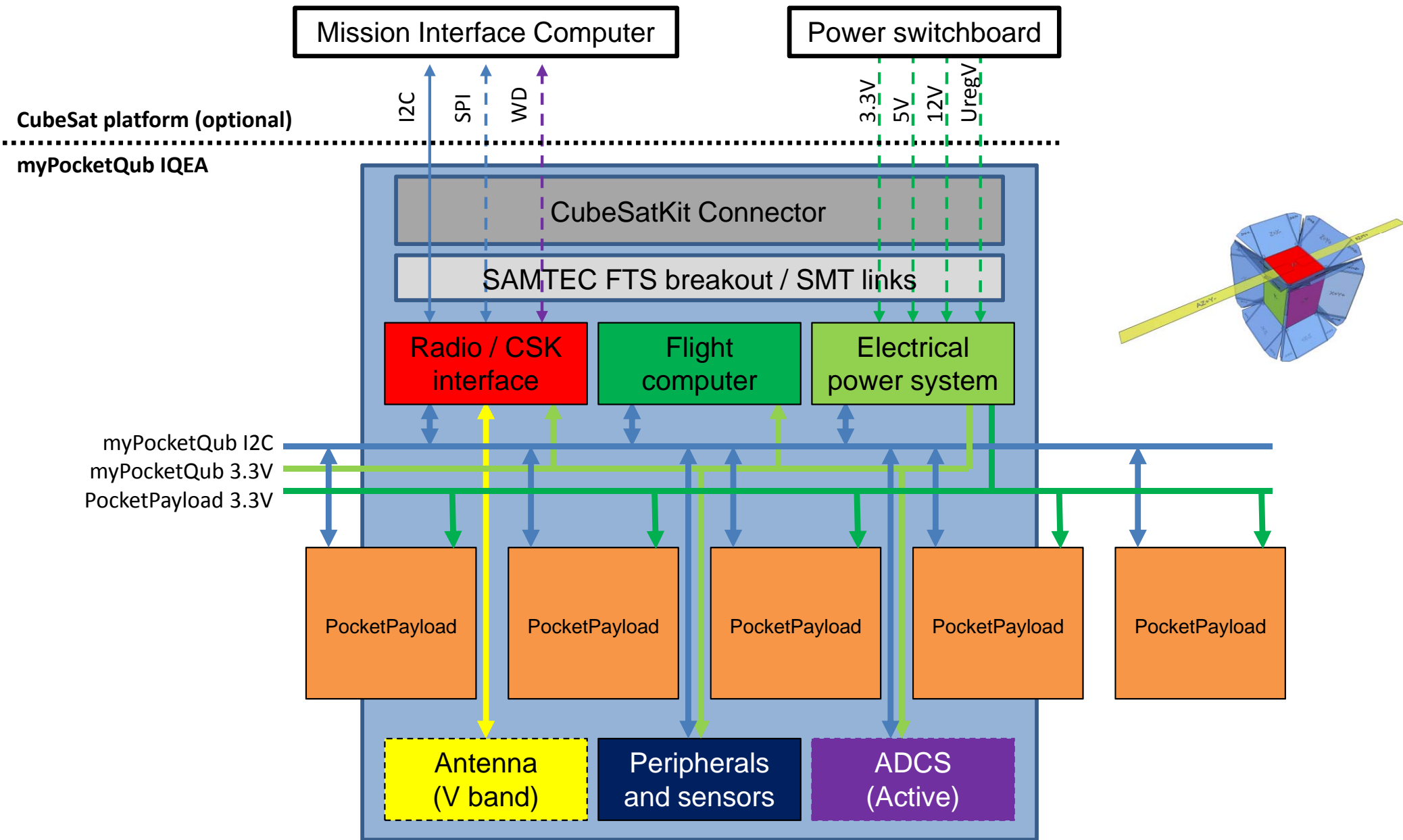
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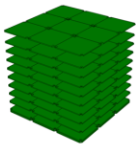
a generic reconfigurable reusable spacecraft system

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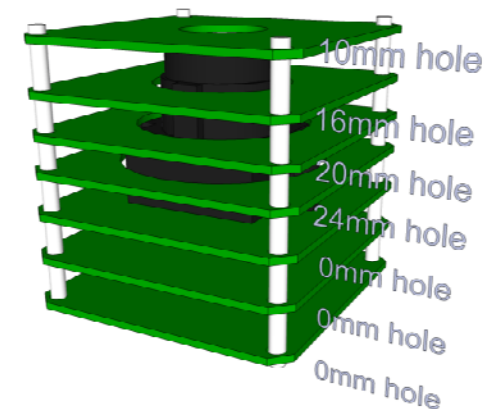
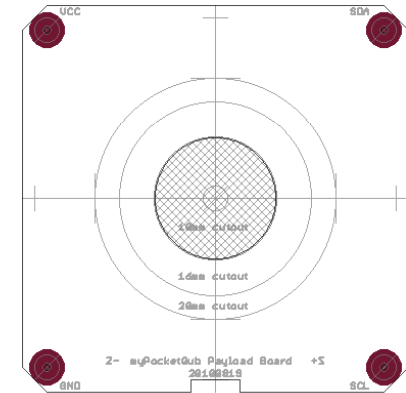
# myPocketQub IQEA



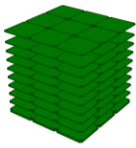


# PocketPayloads

- Elements:
  - 1PP = 32mm x 32mm x 8mm card
- Electrical interface:
  - PocketPayload 4 wire (I2C + 3.3V)
  - Optional Bluetooth or WiFi (preferred fast data)
  - Optional unified ISP/JTAG/Spy-Bi-Wire connector
  - Optional custom inter-board connectors via slot
- Mechanical interface:
  - Up to 20mm diameter central cut out for deployables
  - Free flying configurations:
    - 1Q: 4PP stack via M2 pillars enclosed by walls
    - 1U: 99PP (3 x 3 x 11) unshielded array for LEO
    - 1U: 28PP (2 x 2 x 7) shielded array for GTO
    - 3U: up to 288PP unshielded array for LEO
    - 3U: up to 76PP shielded array for GTO

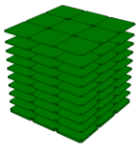






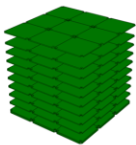
# Virtual mission design process

- Web based tool used to select the combination of subsystems required and required operations schedule
- System then gives online access to the appropriate software and hardware tools to configure each subsystem
- User develops software in normal way
- If any custom hardware (best avoided):
  - PCB and BOM is submitted online
  - PCB and parts automatically sourced
  - Board assembled by flight hardware partner
  - Verified on engineering model
  - Integrated on next suitable flight
- Software is uploaded to ground based engineering model and a virtual mission is run on the engineering model
- Results returned, verified and if passed, uploaded to flight hardware on orbit otherwise returned to designer for refinement



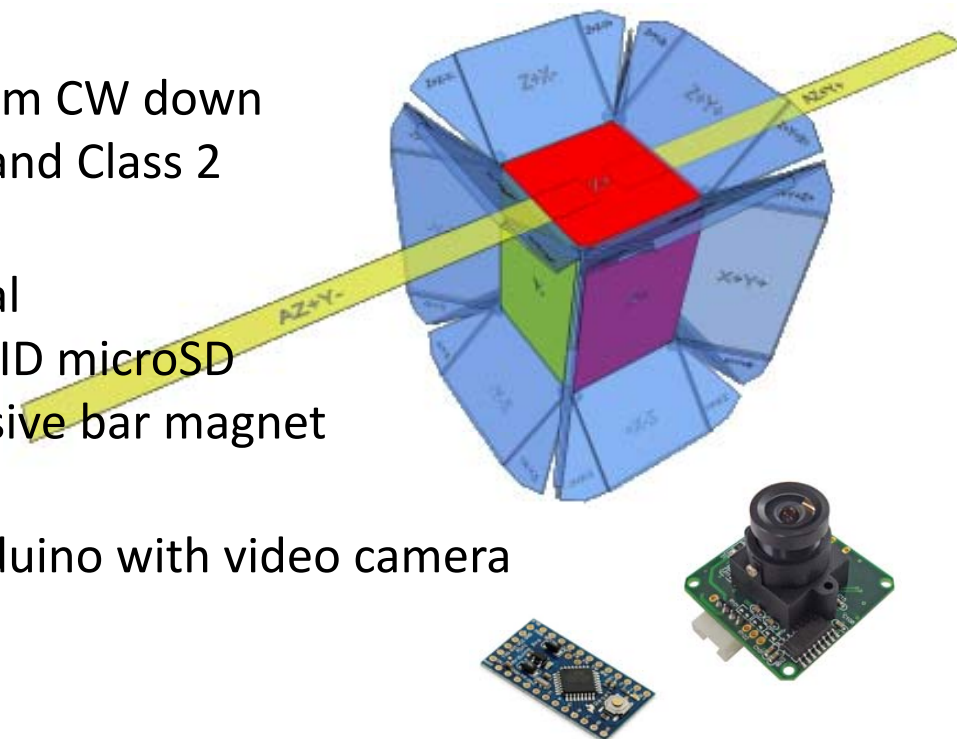
# Sample day in the life

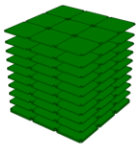
- AIS tracker (10 minutes)
  - Enable motorised dipoles, OBC, FPGA, SDR and EPS
- ADS-B tracker (10 minutes)
  - Adjust motorised dipoles, leave other subsystems as is, update firmware
- OpenCCSDS CFDP revision 123 (360 minutes)
  - Enable X-band patch and transceiver, OBC, EPS
  - Test implementation over four orbits simulating Earth/Mars delay by alternating uplink and downlink every orbit with DSN antennas for a full system test
- ADCS test (1060 minutes)
  - Enable OBC, magnetorquer drivers, gyros, EPS
  - Test novel ADCS algorithm in-situ for hours or days



# Test 1: myPocketQub 391

- myPocketQub 391
  - launch on DNEPR 2012
  - open source, open access
- System
  - 1.5Q PocketQub (50mm x 50mm x 75mm, 187.5g)
  - Deorbits 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





# Test 2: myPocketQub IQEA



- UKSEDS UKube-1 payload myPocketQub 442  
– 96 mm x 96 mm x 28 mm, 310g; launch 2012

myPocketQub IQEA + vRadio + 5x PocketPayloads:

- **OpenSpace365**

Arduino with sensors allowing 365+ school pupils, university students and hobbyists to develop and fly virtual software payloads on-orbit for a day each

- **OrbitView**

Imaging payload to capture 360 degree panoramas from multiple points on-orbit to allow anyone to 'look out of the window' of UKube-1

- **Qubduino**

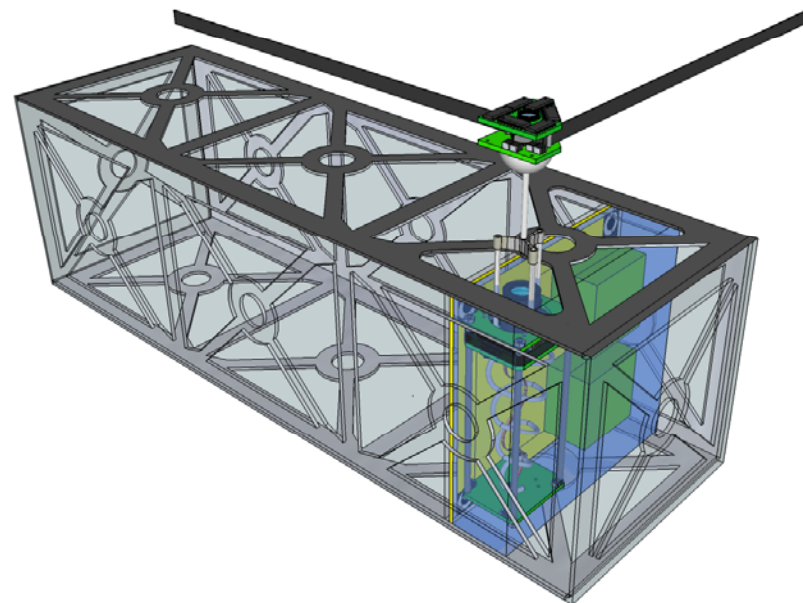
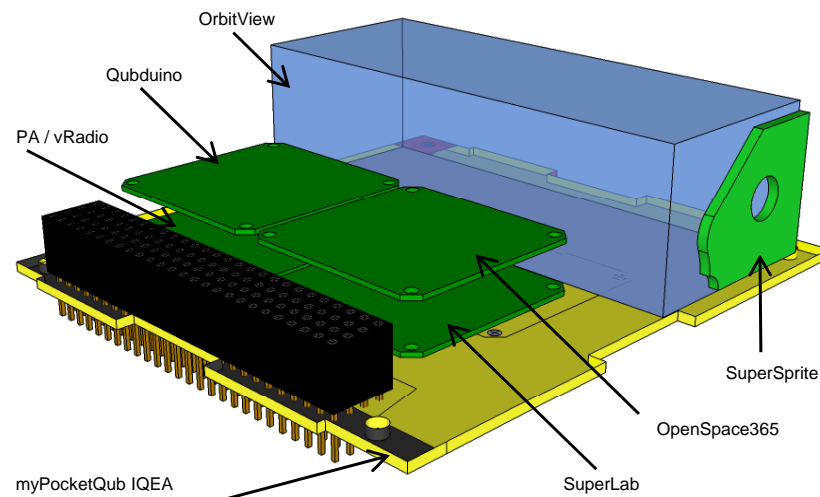
Arduino with Field Programmable Gate Array (FPGA) to space qualify GBP 10 FPGA, test self repairing algorithms and host advanced virtual payloads

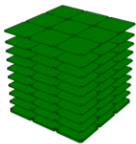
- **SuperLab**

Physics experiment to characterise thin film superconductor materials

- **SuperSprite**

Satellite on a chip proof-of-concept with solar cells, energy storage, micro-controller and transceiver

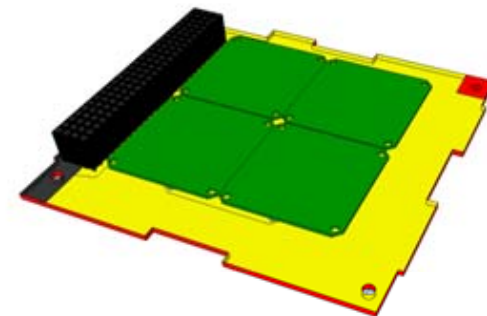




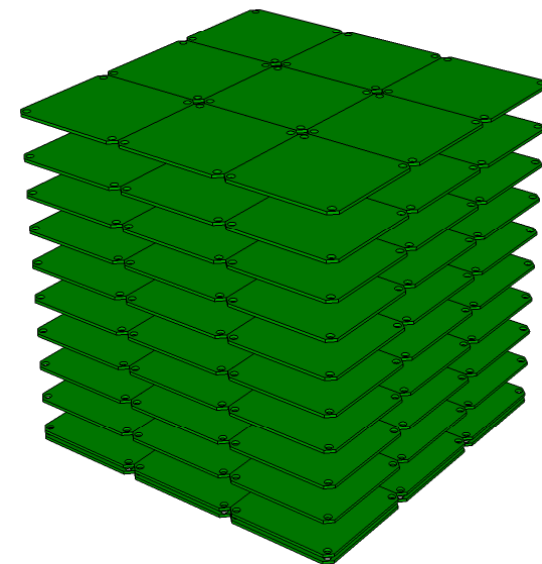
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# Test 3: CubeSat-on-Demand 394 (COD394) a initiative

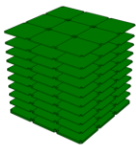
- 1U planned to launch to SSO LEO 2012/2013
- System
  - Pumpkin structure
  - 1x myPocketQub IQEA in CubeSat-on-a-Board mode
  - 5x myPocketQub IQEA in Solarpanel-Magnetorquer-Antenna mode
  - 54 general purpose PocketPayloads including EPS, OBC, FPGA, SDR, cameras, antennas, etc.
  - up to 45 custom payloads possibly including novel sensors, ChipSat and myPocketQub deployer and plus **your** PocketPayload?
- Virtual payloads
  - looking for beta testers with interesting ideas for virtual payloads and willing to suffer version one development tools
  - ideal mission length ranges from a few minutes to a few tens of hours
- Custom payloads
  - 59 of 99 PP already allocated
  - < USD 2000 per PocketPayload to LEO
  - (< USD 8000 per PocketPayload to GTO/GEO)



0.2U-3U / 4-288PP myPocketQub IQEA



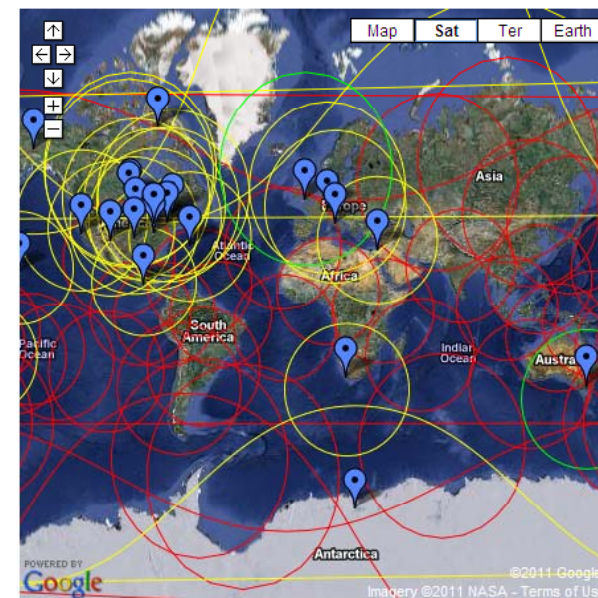
1U / 99PP CubeSat PP-POD



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

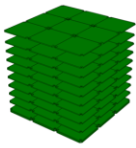
- Software
  - OpenMissionControl.org
  - OpenCCSDS CFDP

myGroundStations.com



**Could you host a LEO Class 1 site?**  
**If so, please email:**  
[new.sites@mygroundstations.com](mailto:new.sites@mygroundstations.com)

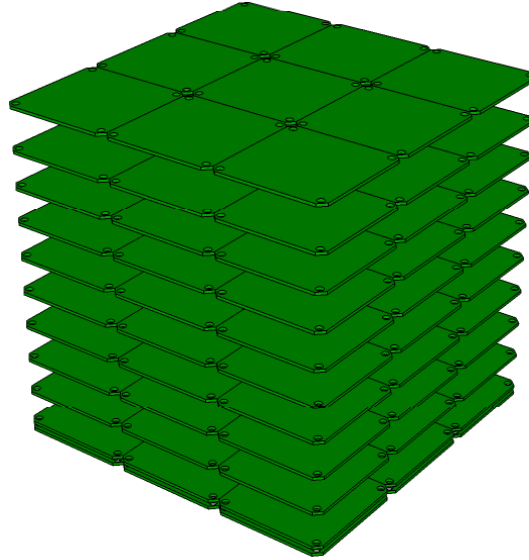




## Future work

- Pipeline of launches to GTO, GEO, LLO, etc.
- Enable simultaneous virtual payloads, power budget permitting
- Optimise the standard and custom PocketPayload mix based on real world experiences
- Remove myPocketQub IQEA from the control role – move to a swarm/cloud of self organising and regulating payloads
- Open source open access project – where would you like it to go?

# Questions?



## **CUBESAT-ON-DEMAND**

a generic reconfigurable reusable spacecraft system

**Michael Johnson**

michael@PocketSpacecraft.com

**Would you like to launch a virtual payload or  
custom PocketPayload on COD394?**

**If so, please email:**

**COD@PocketSpacecraft.com**

**Could you host a myGroundStations.com  
ground station?**

**If so, please email:**

**New.Sites@myGroundStations.com**