Huge Power Demand...Itsy-Bitsy Satellite: Solving the CubeSat Power Paradox

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Outline

1. More utility = increased power demand
2. Power from a standard CubeSat
3. Configurations to improve OAP
4. Power Technologies
5. Conclusion

The engines cannæ take it, captain!
MORE UTILITY = INCREASED POWER DEMAND
‘I need more power!’

• Example recent requested requirement:
  – NRO QbX CubeSat program wants more power:
    • Steerable solar arrays
      – To enable 40 W average power
    • Flexible Power System
      – Can handle 1 to 12 strings of solar cells
      – Works in partial illumination

NRO with Colony 1 CubeSat (from Space News website)
Increased utility; Increased power demand

- CubeSat missions are becoming increasingly sophisticated.
  - Increasing payload power consumption and duty-cycles
  - More data storage and on-board processing
  - High downlink speeds
  - More sensors and actuators for attitude control.
  - Heaters, propulsion, etc.

Ye cannae change the laws of physics, captain!
POWER FROM A STANDARD CUBESAT
Assumptions

• 12noon LTAN, 600km Sun-synchronous orbit.
  – Worst case eclipse.
  – 180° + relative Sun position over Sunlit period.
• Nadir pointing, 3-axis stabilised (no BBQ roll).
  – Payload/RF determines pointing. Not Sun tracking.
• Spectrolab UTJ solar cells.
• Available technology (today)
3U CubeSat with Body Mounted Solar Panels

- 3U Panels have 7 large area UTJs
- Top Panel has 2 UTJs
Standard 3U Power Profile and Performance

- Orbit average power of 4.9W (including 10% Albedo).
- Peak power is 9W over the poles.
CONFIGURATIONS TO IMPROVE ORBIT AVERAGE POWER
Standard 12 Panel CubeSat

- **+X & -X** (Side) Solar Arrays **10W**
- **+Y & -Y** (Side) Solar Arrays **10W**
- **-Zlead & +xdep** Solar Arrays **10W**
- **-Ztrail & -xdep** Solar Arrays **10W**
- **-Zother & ydep** Solar Arrays **10W**
- **-Zother & ydep** Solar Arrays **10W**
- **USB Charge**

- **BCR1**
- **BCR2**
- **BCR3**
- **BCR4**
- **BCR5**
- **BCR6**
- **BCR7**

- **Separation switch**
- **Battery Bus**
- **Over-Current Protection**
- **5V REG**
- **3.3V REG**

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Standard 12 Panel CubeSat Power Profile and Performance

- Orbit average power of 12.9W (including 10% Albedo).
- Power profile consistently above 15W.
- Peak power is 22W.
Dart Config. with Skirt CubeSat

+Z & -Z (TOP)
Solar Arrays 10W

+Y & -Y (Side)
Solar Arrays 10W

USB +5V

Battery Bus

Separation switch

Over-Current Protection

BCR1

BCR2

BCR3

BCR4

BCR5

BCR6

5V REG

3.3V REG

Pull-Pin

Not used 3W

10W

10W

10W

10W

10W
Dart Config. with Skirt CubeSat
Power Profile and Performance

- Orbit average power of 7.3W (including 10% Albedo).
- Power profile shows high peak over equator.
- Peak power is 20W.
Side and Top Deployed Panel Config. CubeSat

- **BCR1**: +X & -X (Side) Solar Arrays **10W**
- **BCR2**: +Y & -Y (Side) Solar Arrays **10W**
- **BCR3**: -Zlead & +xdep Solar Arrays **10W**
- **BCR4**: -Ztrail & -xdep Solar Arrays **10W**
- **BCR5**: +xside & -xside (deployed one off) Solar Arrays **10W**
- **BCR6**: +xside & -xside (deployed one off) Solar Arrays **10W**
- **BCR7**: +Z & -Z Top/Bottom Solar Arrays **3W**

Additional Components:
- Separation switch
- Over-Current Protection
- Battery Bus
- 5V REG
- 3.3V REG
- USB Charge
- Pull-Pin
Dart Config. with Skirt CubeSat Power Profile and Performance

- Orbit average power of 20.8W (including 10% Albedo).
- Power profile more spread-out over orbit.
- Peak power is 40W.
POWER TECHNOLOGIES
EPS

• Over 140 Clyde Space CubeSat EPS shipped to date.
• 5\textsuperscript{th} Generation design.
• Zero current draw on launch vehicle
• 95-98\% efficient 5V and 3.3V Regulators redesigned:
  – Output current up to 2.5A nominal, 4A max.
• XUEPS variant can handle 12 Solar panels of 12W
  – For deployed panel systems and also 6U, 8U and 12U CubeSats.
Batteries

• 140-150Whr/kg
• Zero current draw from local circuitry
• Improved battery assembly method
  – Includes battery ‘clamping’
• New heater design
  – 200mW from 3.3V bus
  – Or 460mW from the 5V
• Tested and passed for shuttle launch
..and qualified to NASA GEVS
Solar Panels...

- Over 300 Clyde Space CubeSat solar panels supplied to date
- Traditional/Proven assembly methods and materials
- Non-traditional PCB substrate:
  - Embedded MTQ
  - Integrated sensors
  - Proprietary thermal transfer incorporating PCB vias
  - Easily customisable
  - No wiring!
- Two standard cell sizes
  - Large area and 2cmx2cm
  - Hold stock of cells for shorter lead-times
Problem solved?

- It is possible to achieve some impressive OAPs from a 5kg spacecraft.
  - Deployed panels are required
  - Careful consideration needs to be given to configuration with respect to target orbit/application.

- Larger solar panel areas does not necessarily mean better OAP.
  - Needs to be orbit and mission specific.

- More problems:
  - Thermal management!

The secret is to give them what they need, not what they want.
Questions?

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