Achieving Global Awareness via Advanced Remote Sensing Techniques on 3U CubeSats

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A need for affordable data is stimulating innovation.
How can we improve on environmental monitoring within financial limits
Ninja imaging...

- This conceptual sequence evoked further development of imaging concepts within the UK for CubeSat platforms...
Deployable mirror concepts

- Work with the UK Astronomy Technology Centre established feasibility of photon enhancement using deployable mirror systems
- Defines ROM ADCS imaging concept & specification
Resizing the aperture

2.1m resolution
(10 cm aperture at 500 nm wavelength and 350 km altitude)

0.7 m resolution
(30 cm aperture at 500 nm wavelength and 350 km altitude)
Derived ADCS concept

• 3-axis reaction wheel based control
• Sun and Earth sensing attitude knowledge

CRUISE MODE
1. Maintain off-set nadir pointing +/- 30 deg
2. 2 sigma 0.1 deg pointing knowledge accuracy
3. Periodic desaturation of wheels (> 15 orbits worst case)

IMAGING MODE
1. 30 s slow slew about pitch axis to facilitate TDI +/- 20 deg, c. 0.6 deg.s-1
2. Stability driven over pointing knowledge
3. Deactivation of ADCS actuation during imaging (70 x TDI period)
Towards fine pointing @ CSL

- Magnetorquer desaturation
  - Current CSL product
- ADCS motherboard
  - UKube-1 heritage
- Space-grade GPS
  - UKube-1 payload
- Horizon sensing
  - 3rd party off-the-shelf
- Fine sun tracking
  - Coarse sensor iteration
- Reaction wheels
  - Smallsat evolution
Other required platform improvements
Reference app: Wildfires

- Affects 30% of the global land surface
- Majority 30°S and 20°N
- Peaks 1-4 pm local time
- Imaging
  - 4 and 11 µm typical IR
  - Low res visible imager
  - onboard fire detection algorithms
End user needs

• Detection & geolocation
• Fire intensity
• Damage assessment
• Fire front evolution
Spatial vs temporal

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<th>Need</th>
<th>Spatial</th>
<th>Temporal</th>
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<tr>
<td>Detection &amp; geolocation</td>
<td>High</td>
<td>V High</td>
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<tr>
<td>Fire intensity</td>
<td>Moderate</td>
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• Given the significant cost for a full high spatial high temporal resolution constellation
  – What can be achieved by supplementing current capability with CubeSats?
Regions of interest
3U Medium Resolution Optics

- Payload design for the 3U CubeSat mission platform would use an uncooled dual-band Medium Wave / Long Wave InfraRed detector with optics.
Adhoc constellation

• Lower cost to orbit solution
• Evaluated 3-4 satellites in 4-5 planes with orbit parameters distributed based on likely future launches
• Parameter dependent but approximately 80:20 rule against Walker constellation
Real time links

• Typical RT needs
  – Detection alerts
  – RT firefront evolution

• Supplement to
  – End user transmissions (handheld radio)
  – Data dump over ground station
Further work

- Ongoing ADCS developments at Clyde Space
- Payload prototyping for subsystem characterisation using identified OTS sensors
- Continuing crossover capability with existing in-orbit capability
  - Synergy between early detection, and monitoring of fire front evolution with higher resolution small satellites (e.g. ESA / DLR FireBIRD concept)
- Developing framework agreements for end users, and refinement of the cost models c. 1.4 MGBP.yr-1
The goal: ‘LIVE’ Google Earth

• ‘Live maps’ will be the next evolution of online satellite EO images.
• To do this needs constellations of imaging spacecraft.
• CubeSats can enable this:
  – Starting with medium resolution imagery.
  – Deployable optics could provide hi-res imagery in 2-3 year timeframe.
  – (also has interesting military possibilities)
questions?

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