Supporting the Flock

Building a Ground Station Network for Autonomy and Reliability

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A LINESCANNER FOR THE PLANET

- Sun synchronous orbit
- 475 km altitude
Mission 1 End-To-End System

100+ SATELLITES
3-5M RESOLUTION 4 BAND IMAGERY

26 GROUND STATIONS
9 SITES
150+M KM² PER DAY

1000s OF VIRTUAL MACHINES
5+TB DOWNLINKED DAILY

API FOR DATA PIPELINE AND PLATFORM ACCESS
12 Ground Station Sites

Automatic passes and scheduling for 60+ CubeSats
Geographic diversity decreases time between image capture and downlink
Two Types of Ground Stations

**UHF - TT&C**
- Yagis on Yaesu rotors
- 4800 baud GFSK
- Ranging for better OD when not taking passes

**X Band - Downlink**
- Primary image downlink
- 4.5-8m dishes
- COTS DVB-S2 receivers
- Adaptive Coding for variable datarate up to 120 Mbps
Current Flock Status

- 12 satellites successfully launched on PLSV-C34 on 22 June 2016
- 62 satellites in space
Ground Station Status

- 12 sites with 36 antennas
- More sites on the way

- About 1 TByte downlinked daily across entire network
  - All data uploaded to AWS for picture rectification and log analysis
  - Approximately 1M sq km per day
Ground Stations as IT Assets

- Use open source IT tools to check services, processes, and possible faults
- Alert and notify an on-call engineer
- Enables hands-off automation
Troubleshooting from Afar

- Radio gives us RSSI, enabling noise plots (right), and comparisons between sites
- Co-tracking shows differences in performance
- Co-tracking can diagnose transmit or receive chain problems remotely
Troubleshooting Tools

• Remote power distribution units cycle AC power and display current draw
• Managed ethernet switches show network status to each device
• Cameras show antenna movement and equipment access
Predictive Capacity Modeling

- Open-source software modeling shows needed ground station and satellite requirements for daily coverage
  - pyephem, R, ggplot, matplotlib
  - Customizable output and avoids vendor lock-in
Agile Approach to the Ground

• Redundancy in the network, as well as within each site
  • We can move passes from antenna to antenna at a site to reduce missed passes during a fault condition
• Uniform interfaces allows hardware swapping and stockpiling backups
• Iteration enables operation early and improvements as time allows
Questions?

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Credit: http://ozzophotography.com/