Notes on Discussions with Companies SmallSat Conference 2018

Mariusz G.

Overall impression: CubeSat business is now aggressive and very competitive. More claims and stakes are higher. Good deal with LeafSpace if we go for them?

CubeSat Vendors

NanoAvionics

See separate meeting minutes

Blue Canyon Technologies

Talked with the former ADCS lead @ Ball Aerospace

- Claims they can achieve pointing accuracy of 0.002 deg (1 sigma) - achievable through 2 star-trackers being orthogonally mounted to each other (90 degrees).
    - Claim that this number comes from orbit, not in lab environment!
    - Claims this accuracy translates directly from subsystem to c/s system level (no loss of accuracy from star-tracker to cubesat). I challenged him on thermal and structural limitations being different on c/s – he said solution is to have a model for this and system indentification
    - 3U and 6U can achieve same accuracy, doesn't matter
    - Example CubeSat mission: HaloSat
    - Marc Murbach @ NASA Ames does not agree – you can get accuracy of perhaps 2-5 degrees at best. That's what they work with on optical communications
    - My message to them: I don't believe it until seen it tested in lab with my own eyes.
    - NanoAvionics does not believe them.
- Best star-trackers in the conference?
    - Attitude model runs primarily on the startrackers so we don't get random noise from other sensors
    - When actuating, the S/C uses the startrackers for knowledge only, noise not present since the signal is averaged. Skeptical?
    - Acts as small telescopes with very fine pointing
    - Calibration in-orbit necessary per orbit at best
    - $75,000 per star tracker
- Their reaction wheels are superb? They scale from small to medium to large
    - Have dampers and pre-flight lubrication. Lubrication lasts for 10 years with very low performance degradation. Microvibrations down to 10^-8 Hz.
    - Nonlinear programming and time optimal control (this is aligned with what Marco Ciarcia did research about in Naval Postgraduate School and doing in his lab now). Time optimal control, settles in a couple of seconds (max 4-5 seconds).
    - Sets reference viewing angles (start and finish), then a slew rate which it should hold constantly as for our mission
- After-launch dislocations and dismounting, varying CG, is identified through calibration (system identification, inertia estimation).
- They offer that they can build a 6U cubesat bus (incl. trackers) for $800,000
- BCT uses Ball Aerospace COSMOS for Mission Operations Software

Ground Station

Infostellar – a scalable ground network (side-meeting)

"What does it take to build a truly scalable ground station network? In this session, the Infostellar team will present how we are answering this question through the development of StellarStation, a cloud-based platform that aggregates ground stations around the world.

When scaling from one technology demonstration to a full commercial operation with potentially hundreds of satellites, the ground segment challenge is how to incrementally increase ground station capacity with minimal integration and regulatory cost. To test our approach to this challenge, over 2017-18 we deployed an experimental version of StellarStation: a free ground station network for amateur frequencies.

We will share our experience of creating this amateur ground network, discuss regulatory challenges and pitfalls to avoid during frequency selection and coordination, and announce future commercial plans for StellarStation."

- In-house servers vs. cloud (like Azure, Amazon, Google) – they use cloud based service
- Scalability = delta Coverage /delta cost
- Compatibility assessment (EIRP/GT, link budget, cost, location, transceiver)
    - This is done to match the right satellite you want to uplink/downlink with
    - Virtual loopback for testing
    - Test compatibility with communicating in the cloud, done on-demand
    - Automated -> satellite will find a matched Ground Station
- Contracting
    - Infostellar acts as a single window with single contract (no matter how many GS, just work with them through their cloud)
- They can do technical integration if you are interested in HW
    - ACU for tracking
    - Baseband equipment and modem (for data RX/TX)
- Cloud approach
    - Pull all GSs into a single cloud
    - Developed a completely public API for this in github
    - When you write SW in monitoring/tracking & control → this goes directly to the cloud (GS scheduler and data ingestion API between cloud and GS HW
    - Owner marks where the GSs are available
    - There is a GUI to reserve passes and to allocate duration of the passes (scheduling for each Ground Station)
- StellarStation Amateur
    - Collected in the GS block diagram
    - Publicly available info on satellites operating on amateur bands
    - Developed interface for the most popular/sought configuration
    - Tracks 11 satellites daily
- Good support case for LEOP service upon request (for free)
    - Irazu-Sat, UbakuSat, Enduro-Sat 1 used this
    - They can demodulate the IQ
    - Telemetry viewer, monitoring if everything is in place or not

- Requests for StellarStation, shows available passes, Infostellar calculates the orbit based on TLE. They suggest you should use the whole pass as it is scheduled to you, not segmented duration of the pass.
- TM streaming by default then you may store it. You may request for storing it.
- Product roll out
    - Cannot uplink in amateur bands
    - An operator needs to be present at the Ground station for this
    - Uplink and complete TT&C support is commercial
    - UHF, S-band, X-band for downlink
- UHF TT&C locations
    - Inuvik in Canada, Tokyo in Japan, Europe, South Africa, Rwanda
    - First-come-first serve for competing requests for access to passes and TM downlink, LEOP etc.
    - Before 12 hrs you can cancel for free, if you cancel after 12 hrs you pay penalty
- Uses standard encryption

LeafSpace (one-to-one meeting with CTO)

See separate detailed meeting minutes

Mission Operations

University of Pittsburgh/Space Micro:

An undergraduate student from University of Pittsburgh is doing daily operations (TM/monitoring/tracking) at the university. Experience:

- Upgrading and automating COSMOS ground station interface

- Developed a COSMOS ground station GUI for real time telemetry data visualization

- Added features to Buildroot using post-build scripts

- Calculated device metrics for computational density, power consumption, memory bandwidth.

He offered to help us and guide us how to do this. LinkedIn: https://www.linkedin.com/in/michael-adams-ba0170107

LASP - University of Colorado at Boulder

Talked about OASIS which is a mission operations SW

- Not for free. $10,000 for license (for 4 years) – it is not commercial though (basically fees). $2,500 per year. Included help desk/support. Student friendly since students operate satellites with this daily.
- They can help us develop our own software for extending OASIS capability as well as help us on the Flight Software.
- Full uplink-downlink loop. Includes data visualization, telemetry visualization as well as planning & scheduling and uplink.
- Encourages us to use their S-band ground station if we are interested. They are open to work with us on downlink.
- Will set up a Skype meeting with the developer and see how we match.

Products

Hyperscout Cosine

- Claim they can downlink Level 2 data directly from the sensor (geometrically, radiometrically calibrated and processed). They didn't know how to answer this properly ☺ confusion between what is science definition and "their" definition
- They work with S&T in Norway on the onboard processing
- SNR of 50-100:1 depending on wavelength
- Price: $30,000 per unit (excl. support and onboard processing training, operations training)
- Didn't have a good answer for "dead pixels" in space and degradation of optics. They only say it has been designed to withstand space radiation.. skeptical..
- $30,000 per unit

Hawkeye 360

- Talks about SAR and RF technology
- Uses RF to detect ships that e.g. turn off their AIS receivers

Syrlinks

- Annoying chat about their S-band transmitters and receivers (full duplex), 11 W consumption. Worth looking into.
- Constantly going off-topic and bragging about non-CubeSat form factor transceivers + advertising their Ku-band as well as X-band (not relevant).

Launchers

NanoRacks

- Ca. $180,000 to launch a CubeSat to ISS and deploy into orbit, depending on the launcher available
- Mounting payload/camera on ISS a bit more expensive but cheaper overall
- They already have a hyperspectral imager on ISS, may use gimbal and shielding.
- The mounted instruments cannot stay forever – will be operational on monthly basis (for a price) and dismounted if not in use.
- They arrange launcher and mounting on/deployment from ISS
    - Provide separation mechanism and deployer if we want to deploy cubesat
    - Documentation & requirements form
    - NanoRacks arranges this and tells us what is needed and is the channel between us and the launcher and ISS

Spaceflight Industries

- Price tag to be confirmed
- Deliver to launch 2 months prior to launch
- Initiate deals & discussions with Spaceflight Industries 6 months prior to launch
    - Documentation & requirements form
    - Spaceflight Industries arranges this and tells us what is needed and is the channel between us and the launcher

Swedish Space Coorporation

- Launch infrastructure discussions ongoing
- Planned first launch capability in 2021 to polar orbits and SSO