Naval Postgraduate School CubeSat Research Overview

Mobile CubeSat Command and Control (MC3) Ground Network

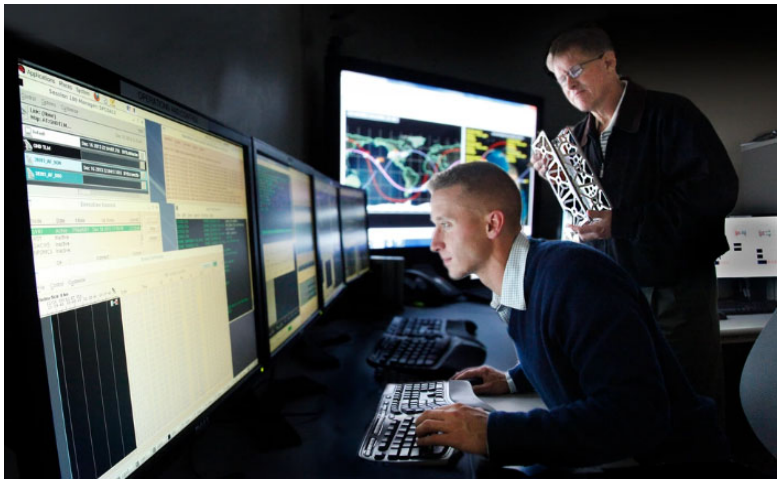
CubeSat Flight Opportunities

Giovanni Minelli, Ph.D. – Faculty Research Associate

Space Systems Academic Group

Hands-On Education

Design, build, test, launch, operate

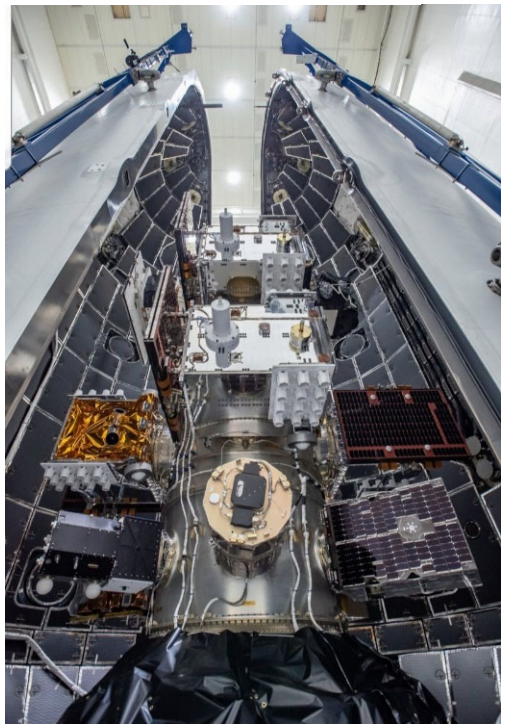


PANSAT (Petite Amateur Navy Satellite)

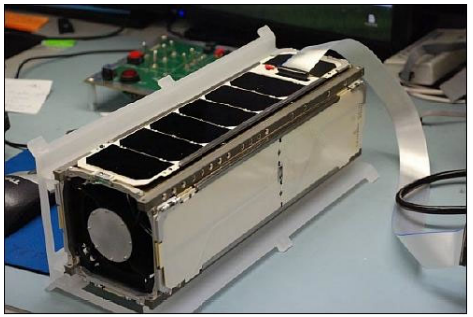
- Development began in 1990, led by Prof. Rudy Panholzer
  - 51 Masters Degrees
  - Structures, software, communications, deorbiting
- Deployed from Discovery on STS-95 (flight with Senator Glenn) in 1998

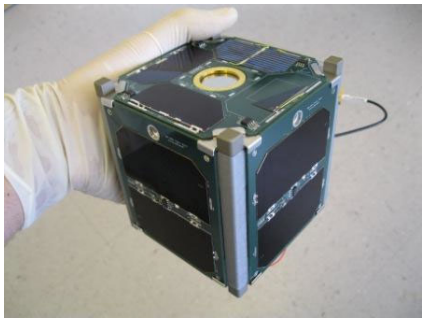
NPS Small Satellites

NPSAT-1

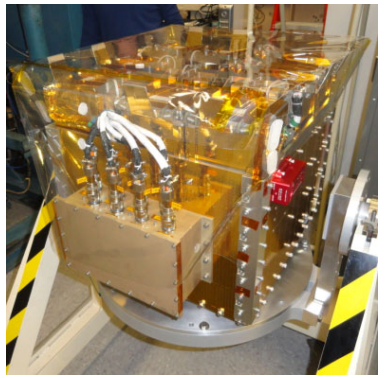


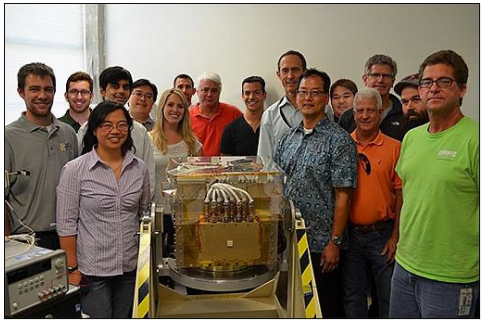
CubeSats

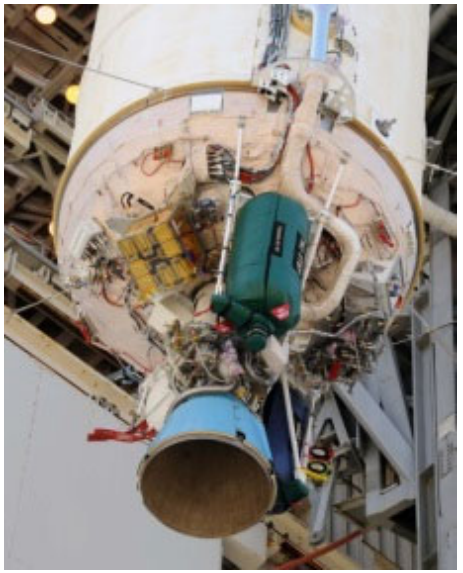




NPSCuL







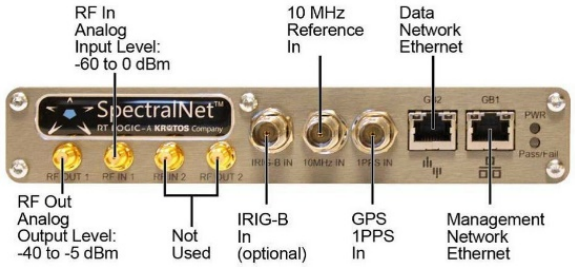
Hands-On Education

Balloons, drones, rockets

https://www.youtube.com/watch?v=1Vdfc1_DPTA

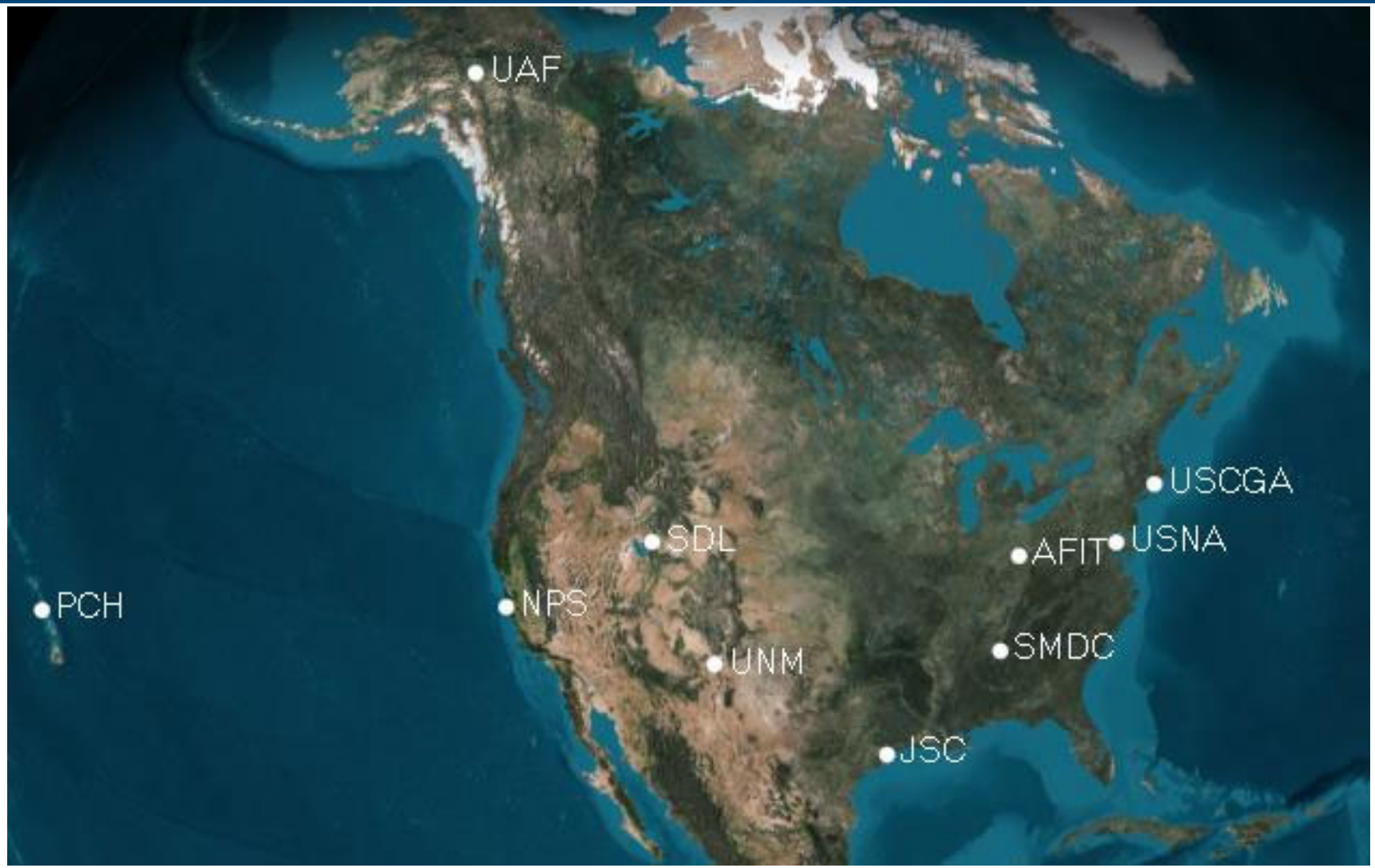
https://www.youtube.com/watch?v=9PpD1Z2MTZI

Community-based US government ground infrastructure for SmallSats



satTRAC Signal Converter Front View (1200 MHz Gen 2)

MC3 Network



PCH – Naval Information Warfare Center Pacific
UAF – University of Alaska Fairbanks
NPS – Naval Postgraduate School
SDL – Space Dynamics Laboratory
UNM – University of New Mexico
JSC – NASA Johnson Space Center
AFIT – Air Force Institute of Technology
SMDC – Space and Missile Defense Command
USCGA – US Coast Guard Academy
USNA – US Naval Academy

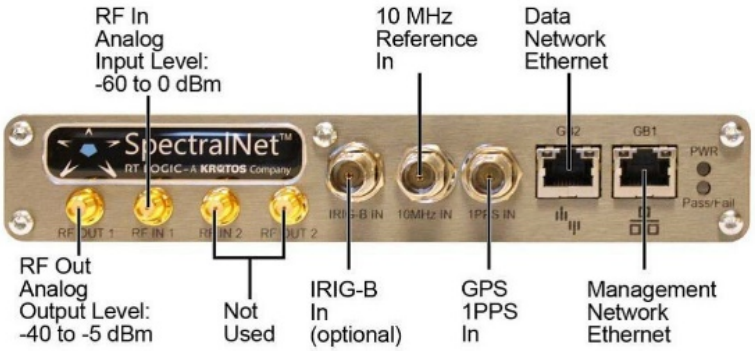
Radios Supported

USRP 2922

- UHF & S-band
- GNU Radio
- Titan (SDL)
- Innoflight GSDR
- All stations

Newtec MDM6000

- X-band, DVB-S2 & DVB-S2X
- 4x units on-hand
- Not yet implemented



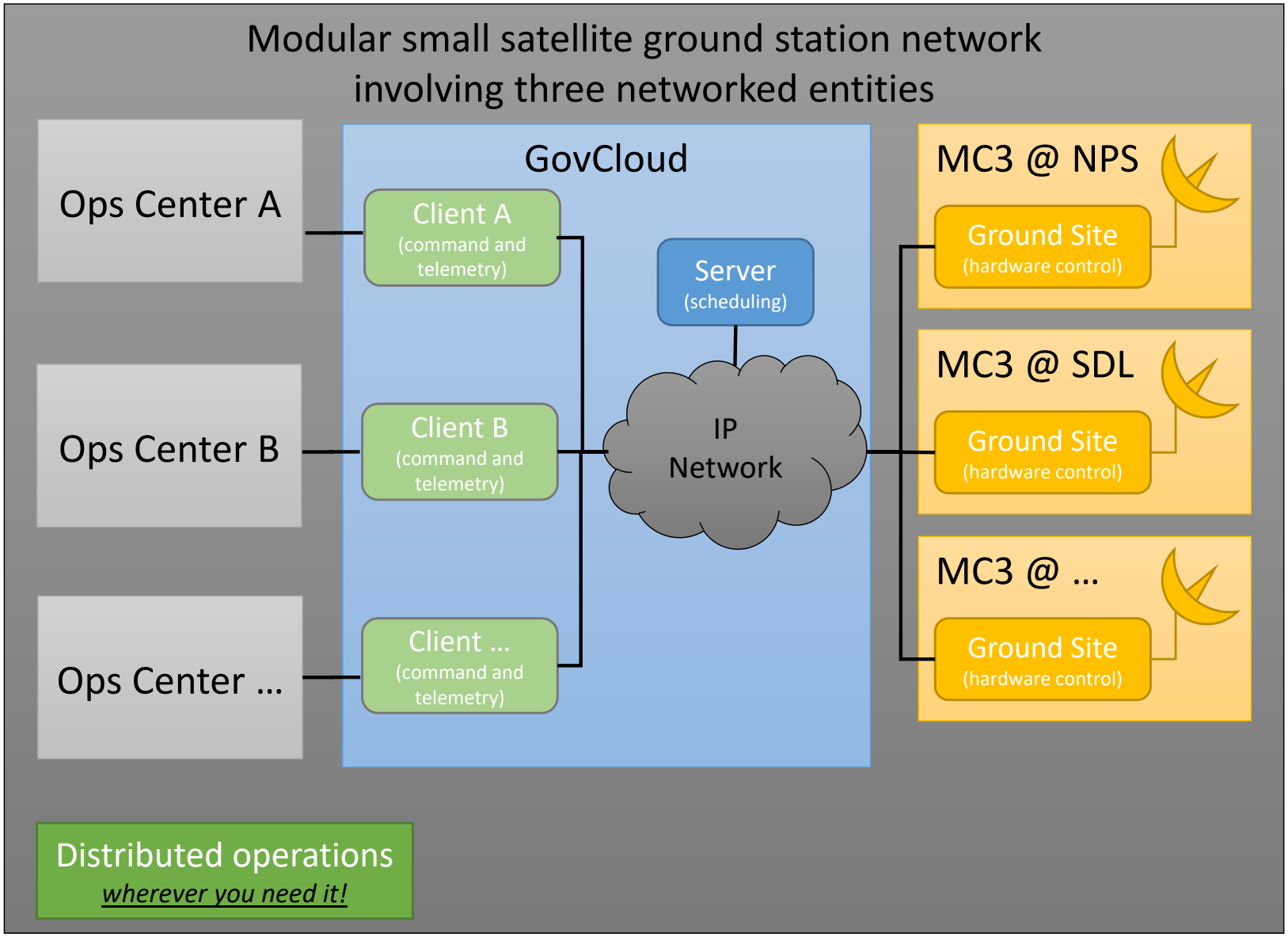
Kratos qRadio & SpectralNet

- Narrowband-only
- S-band
- GNU Radio
- Titan (SDL)
- Innoflight GSDR
- 7 stations

Amergint satTRAC

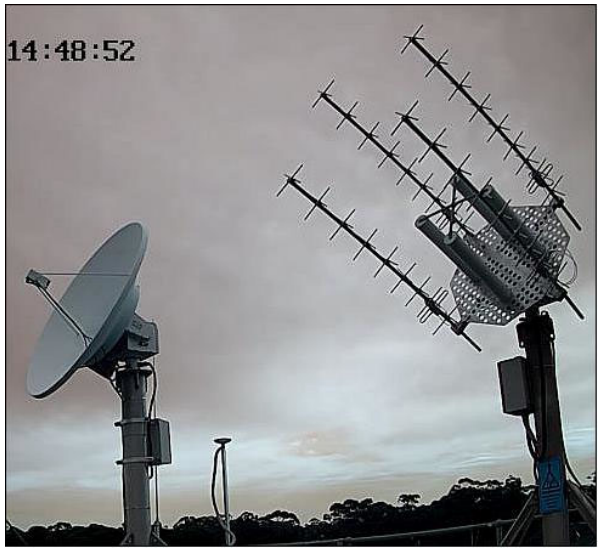
- S-band and X-band
- 2x radios on-hand
- Not implemented

SATRN Overview / Status



FVEY International Smallsat Command and Control Network (ISC2N)

DTA – Auckland, NZ - UHF, S/X-band

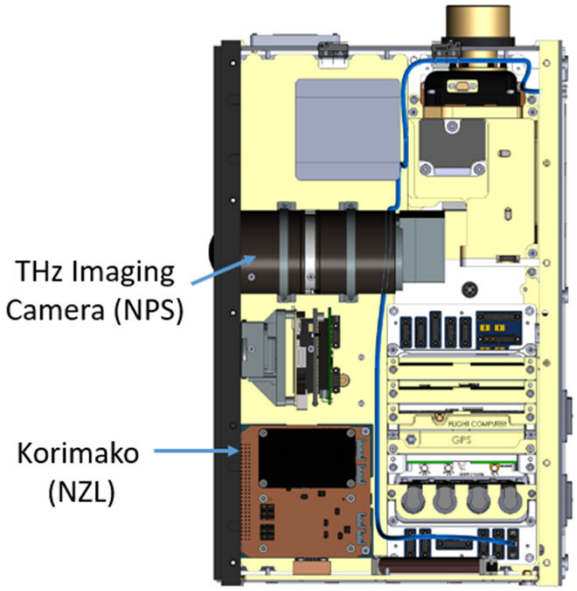


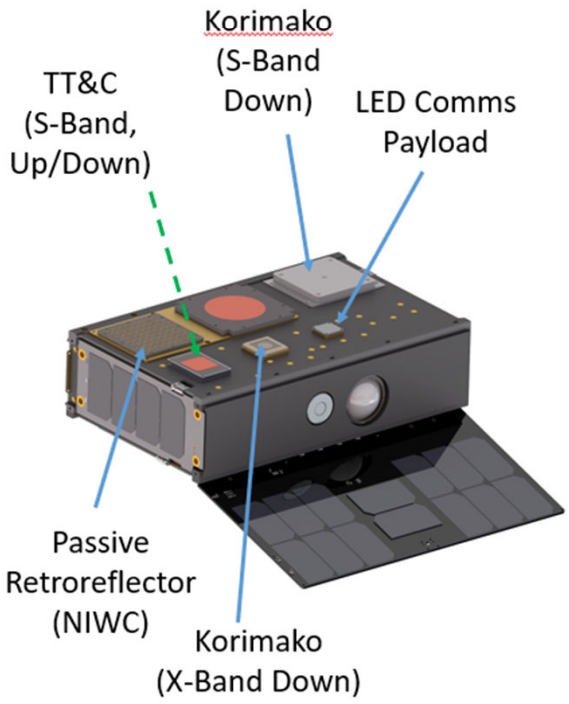
DSTG – Adelaide, AUS
UHF / S-Band

DSTL – Portsdown West, UK
S/X - Band

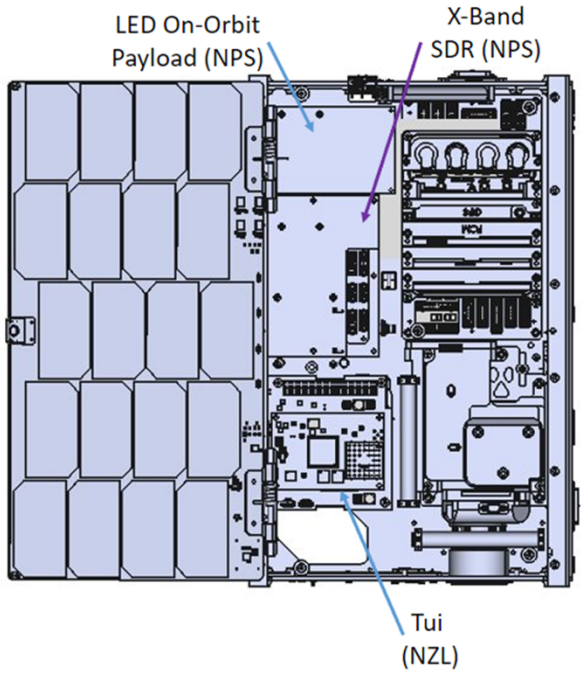
Mola and Otter CubeSats

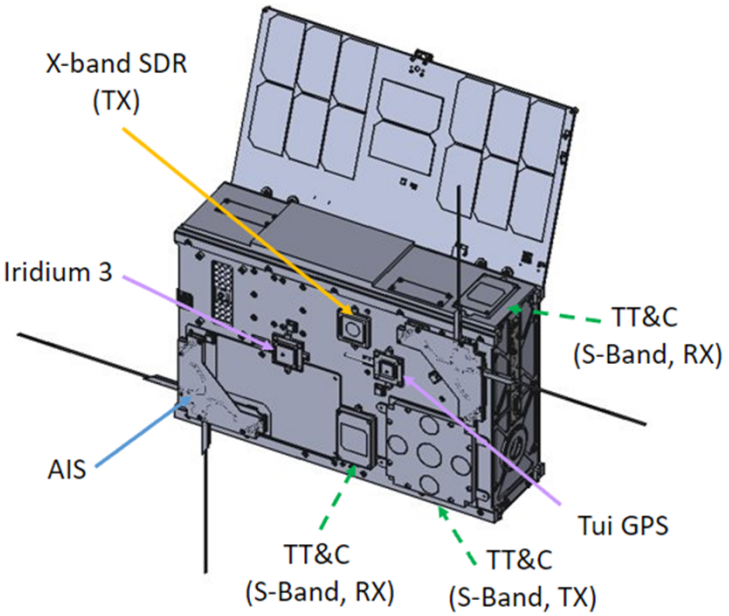
Mola



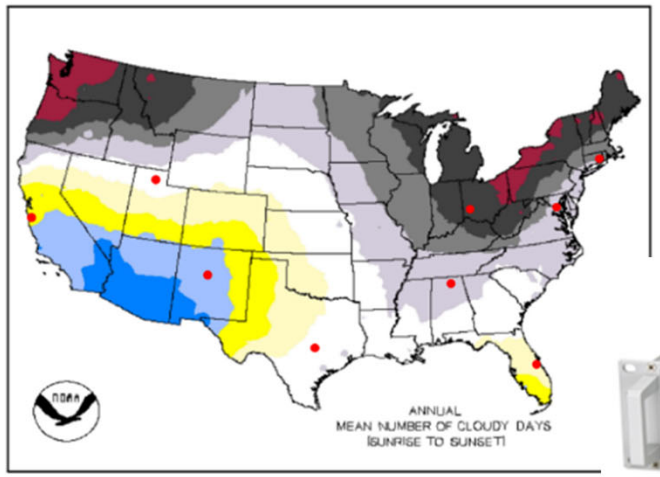


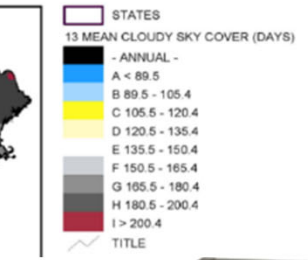
Otter

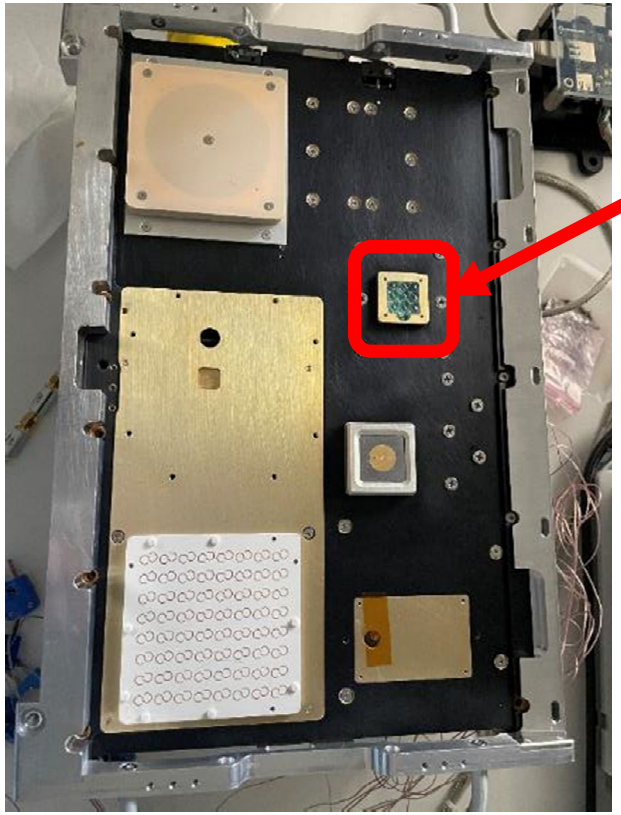




Optical Tracking/Comms







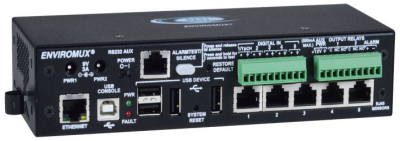
Mola LED Payload

- **9 green LEDs for optical terminal tracking**
- **Plan to track using 70 cm optical terminal**
- **Otter with have 1550 nm optical comms package**

Machine Learning

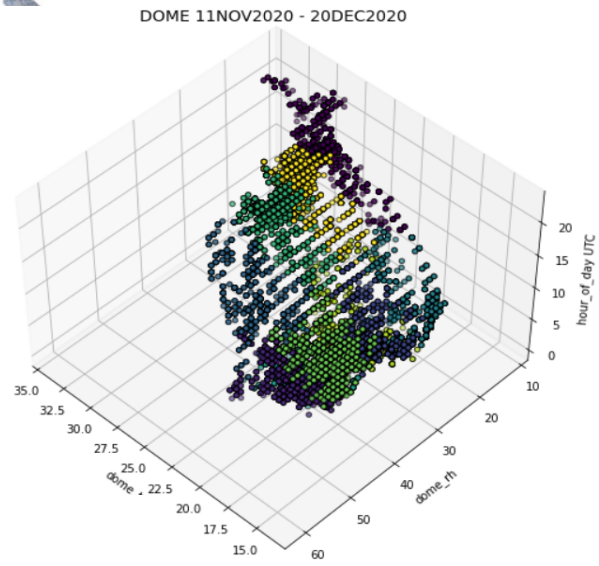
Treat MC3 nodes as “satellites”

- Collect health and environment telemetry
- Introduce autonomous issue detection and classification
- Remove operator involvement through autonomous issue resolution



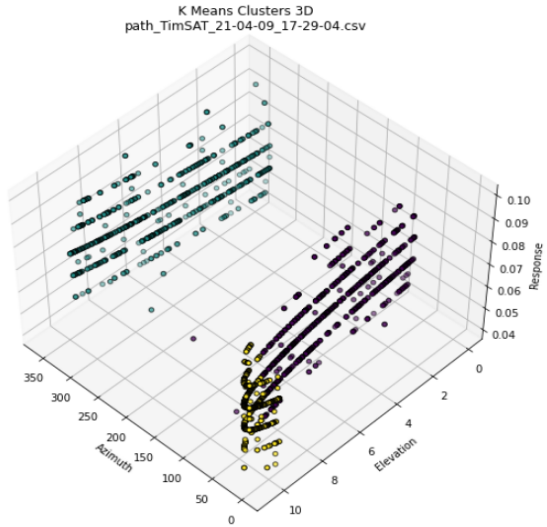
Health and Environmental Monitoring System (HEMS)

- Voltage, current, temperature, humidity telemetry
- Device-level power and network controllability
- Inductive monitoring system (IMS)
  - Algorithm for real-time telemetry interpretation
  - Trains on healthy ground station data

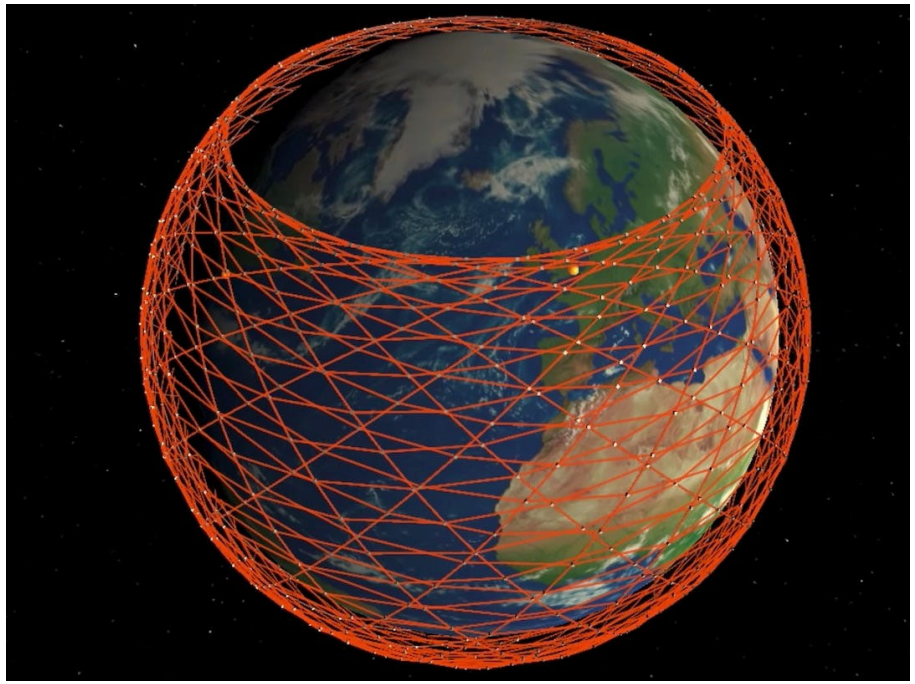


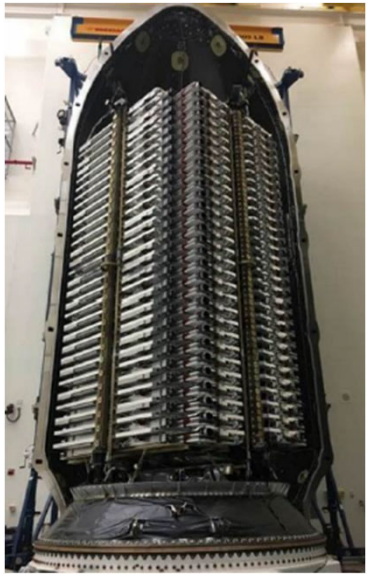
Automated G/T measurements in development

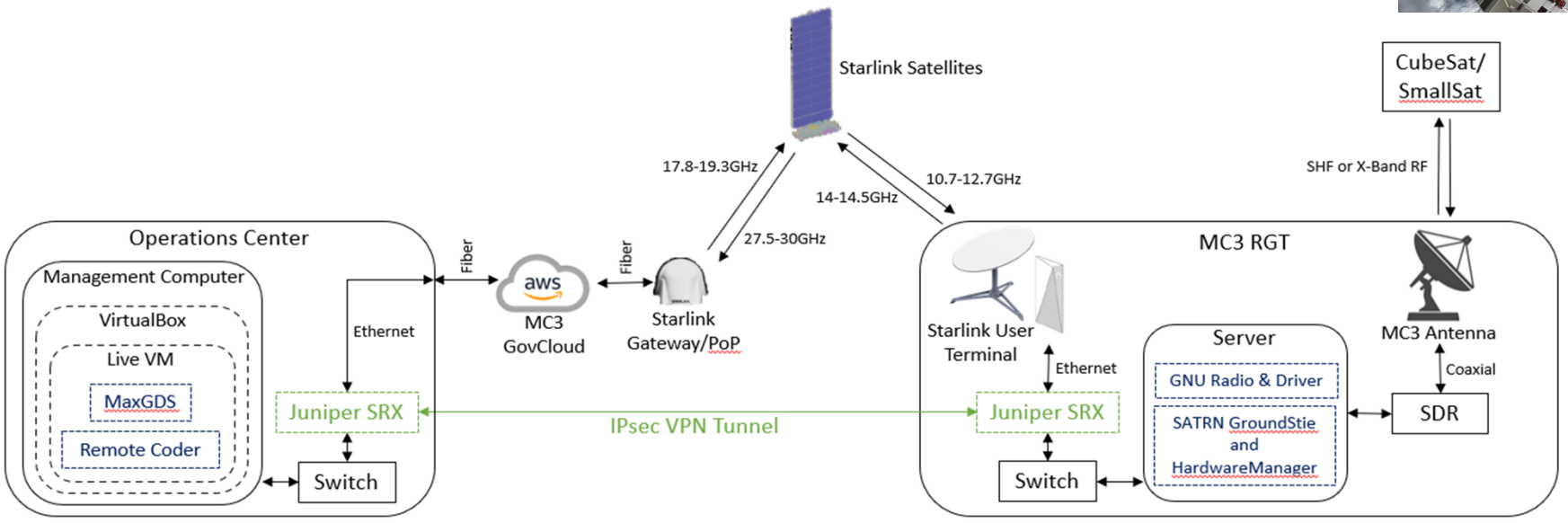
- Trending for ground system performance



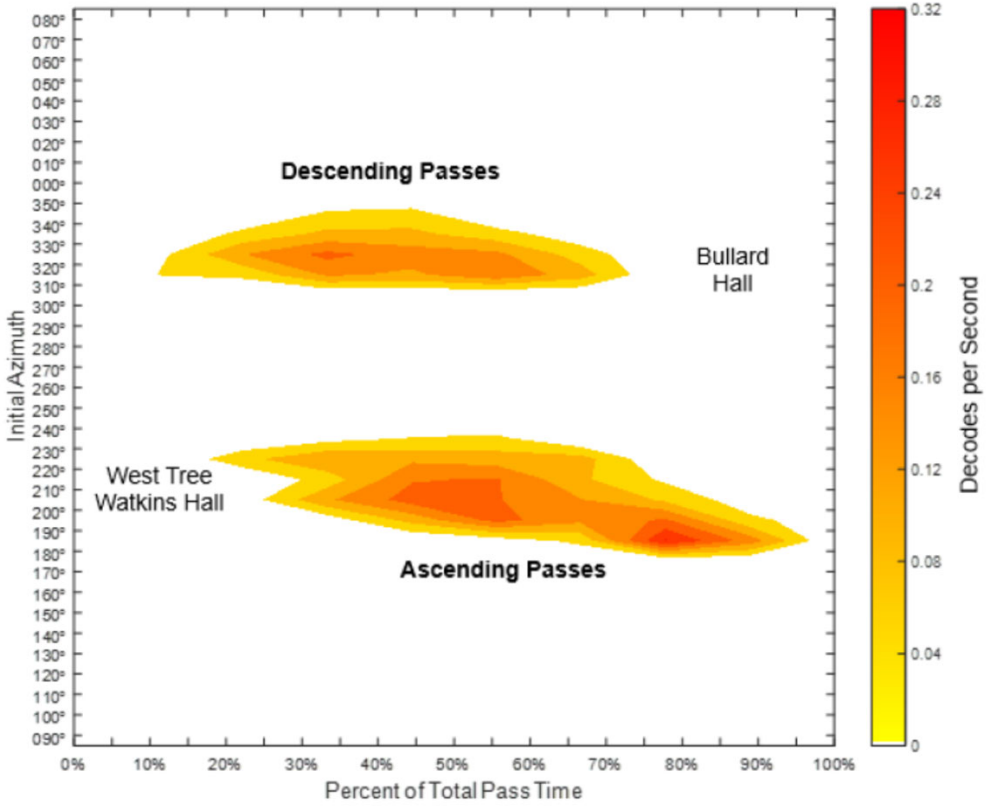
SpaceX Starlink





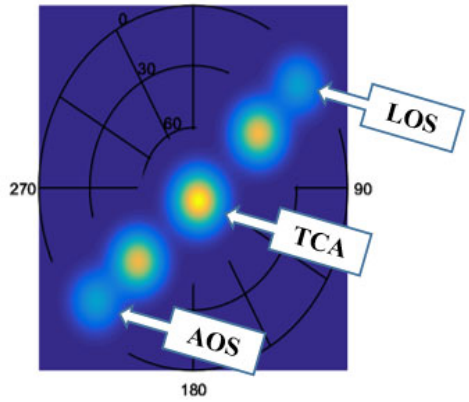


Schedule Optimization



Define: Objective, Dynamics, Constraints

$$
\begin{cases}
\text{Minimize} & J[x(\cdot), \mathrm{u}(\cdot), t_f] = E(x(t_f)) + \int F(x(t), u(t))dt \\
\text{subject to} & \dot{x}(t) = f(x(t), \mathrm{u}(t)) \\
& x(t_o) = x^0 \\
& t_o = t^0 \\
& t_f = t^f \\
& e(x(t_f)) = 0
\end{cases}
$$



Leone, J., "CubeSat Pass Quality Analysis and Predictive Model", M.S. Thesis, Naval Postgraduate School, Monterey, CA, June 2018

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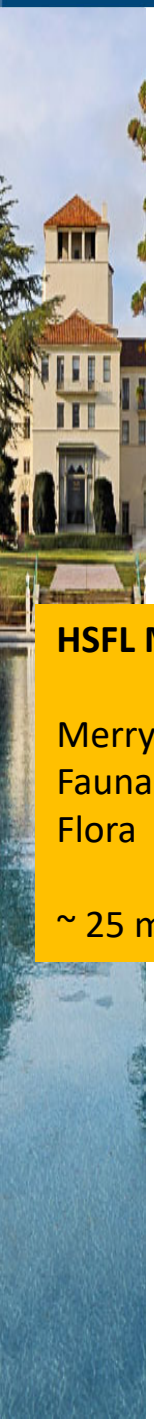
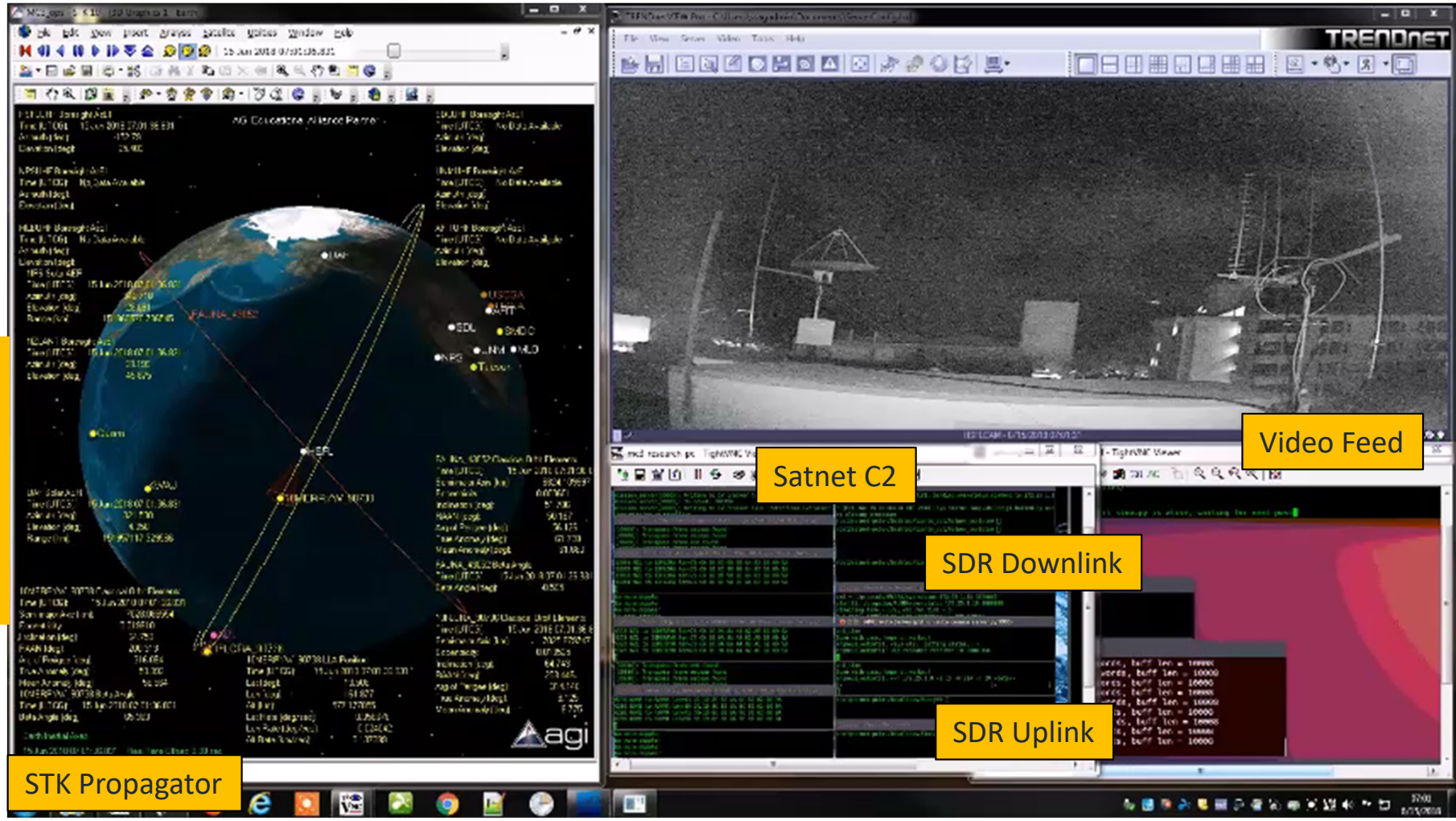


HSFL MC3

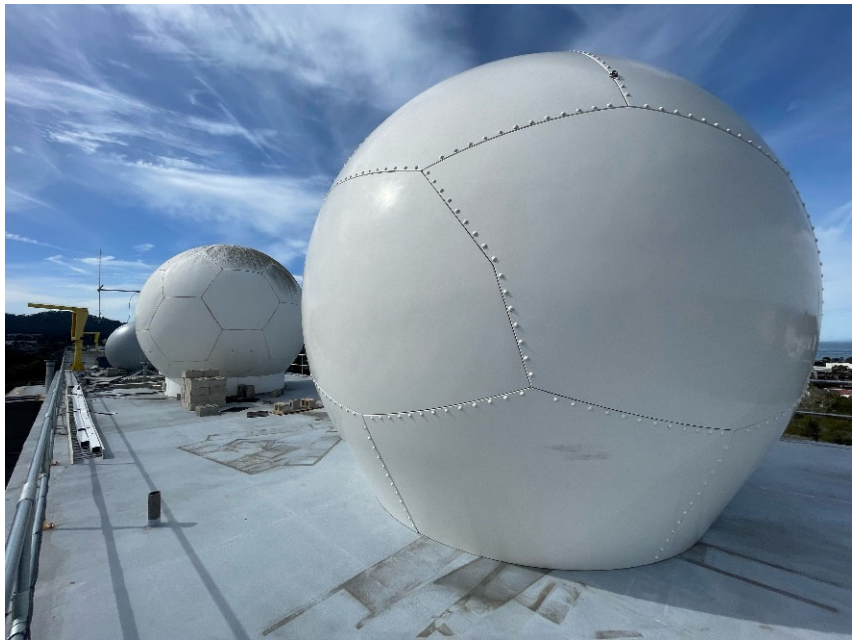
Merryweather
Fauna
Flora

~ 25 min



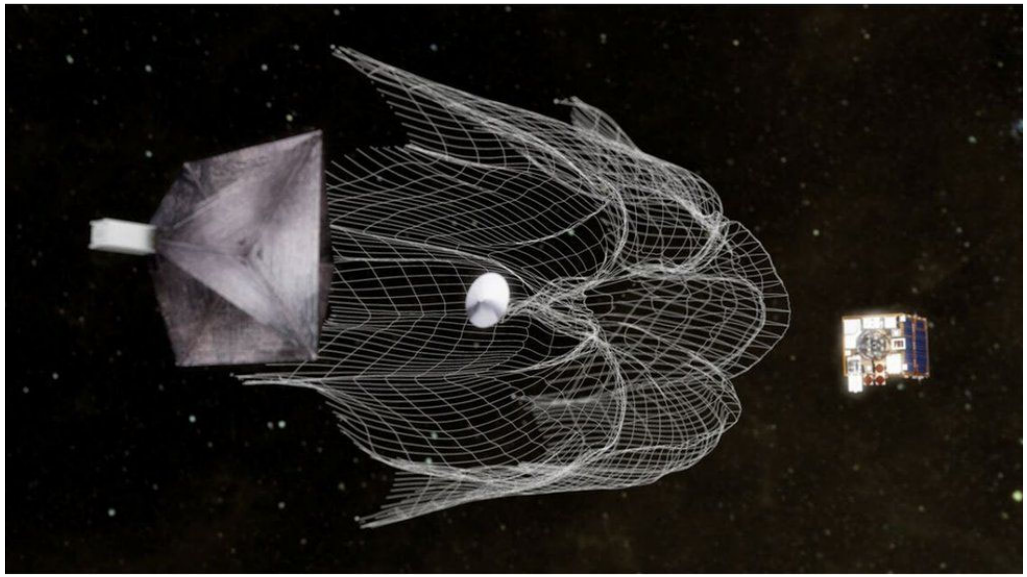
Sp-703 Radio Laboratory

- RF testing for spacecraft
- Jamming detection/ mitigation
- Software-defined radio research
- Waveform analysis



Orbital Debris Mitigation

- Formation flying maneuvers using differential drag
- Grappling, attaching, handling mechanisms
- De-orbit devices for small spacecraft



Call for Collaboration

Ground Segment

- Come fly with us! Still have capacity available for servicing orbiting spacecraft
- MC3 govt RF licensing process is 'fast'
- High speed communications applications (X-band, optical)
- Research in autonomous scheduling and operations
- Testing of novel aperture designs
- MC3 Program manages govt-owned SATRN software baseline and can distribute to other orgs

Flight Opportunities

- Space for payloads on follow-on CubeSats starting with 2025 flight (6U, 12U, maybe 27U)
- On-orbit experiments
- Operations training
- Workforce development courses

Contact Information

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