



High-Speed Radio Options

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CubeSat Developers' Workshop

Cal Poly, San Luis Obispo

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CubeSat High-Speed Downlink Communications

- NSF CubeSat High-speed Downlink Communications Group
 - Started in 2009, sporadic meetings
 - Aim is to provide high-speed options for NSF CubeSats
 - Group expanded to include any small satellites
- Last CHDC meeting held at SmallSat 2013
 - 20 participants
 - Discussions focused on radio hardware only
 - Summary of meeting to follow

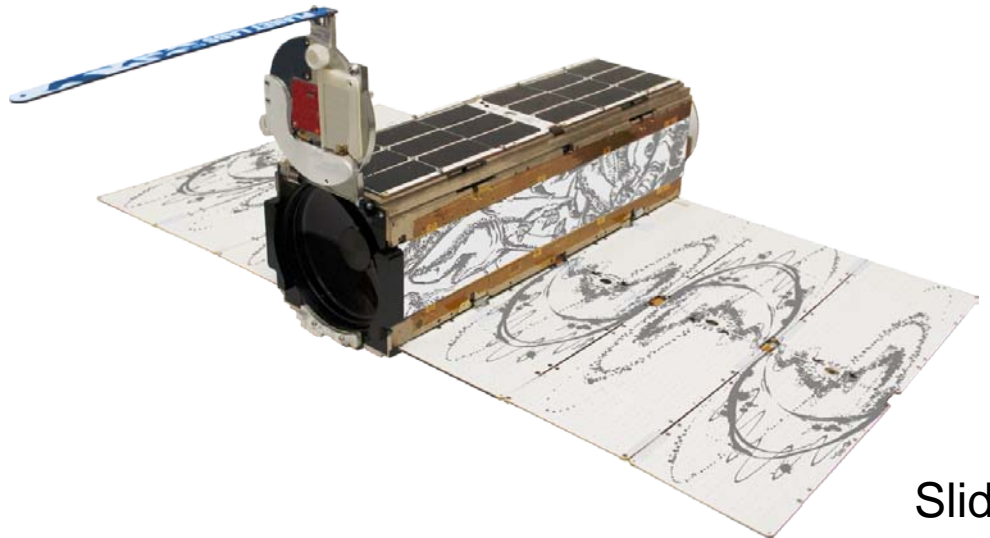
High-Speed Flight Qualified Radios

- L3-Cadet UHF
 - DICE
- Emheiser
 - 1 Mbps FSK at S-band
 - CINEMA
- ISIS S-band radio
 - Delfi-n3xt
- Innoflight SCR-100
 - 2.0 to 2.1 GHz, up to 4.5 Mbps B/QPSK
 - Flying on SENSE mission
- Custom Planet Labs
 - 8.2 GHz downlink, up to 120 Mbps
- Custom Japanese Radios
 - Hayato
 - KSAT-2



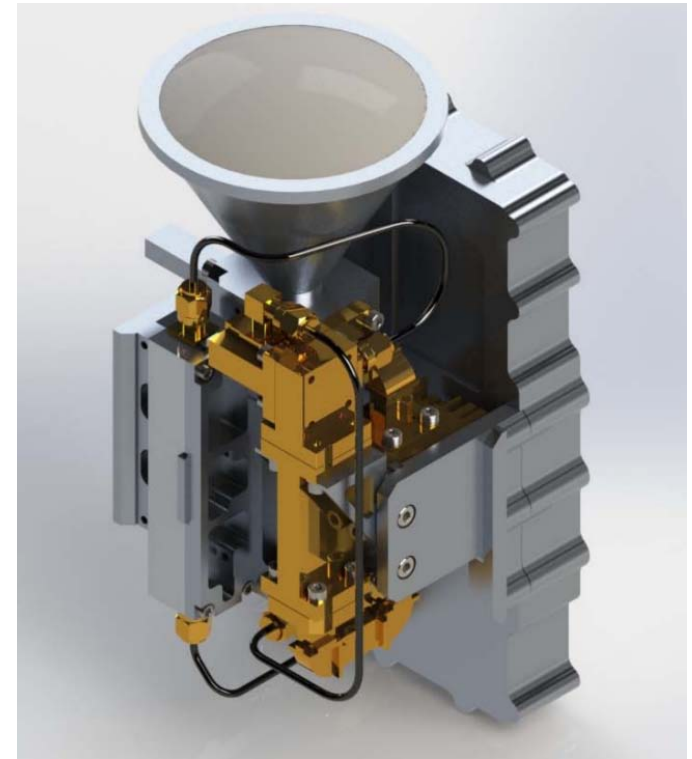
Flight-Qualified Radio: Planet Labs

- UHF telemetry channel based on a CC1110
 - 4800 baud duplex, plus ranging
 - 401 MHz Space Operations band
- X-band primary downlink
 - 66 MHz licensed spectrum
 - DVB-S2 variable bit rate, up to 120 Mbps max
 - 3 W RF TX power into patch or helical
- Earth-exploration Satellite Service commercial license
 - Initial filing fee: \$450k
 - Annual fee: \$150k
 - Good for 15 years
 - 1 year licensing process with public comment period
 - \$5M bond required (to prevent spectrum squatting)



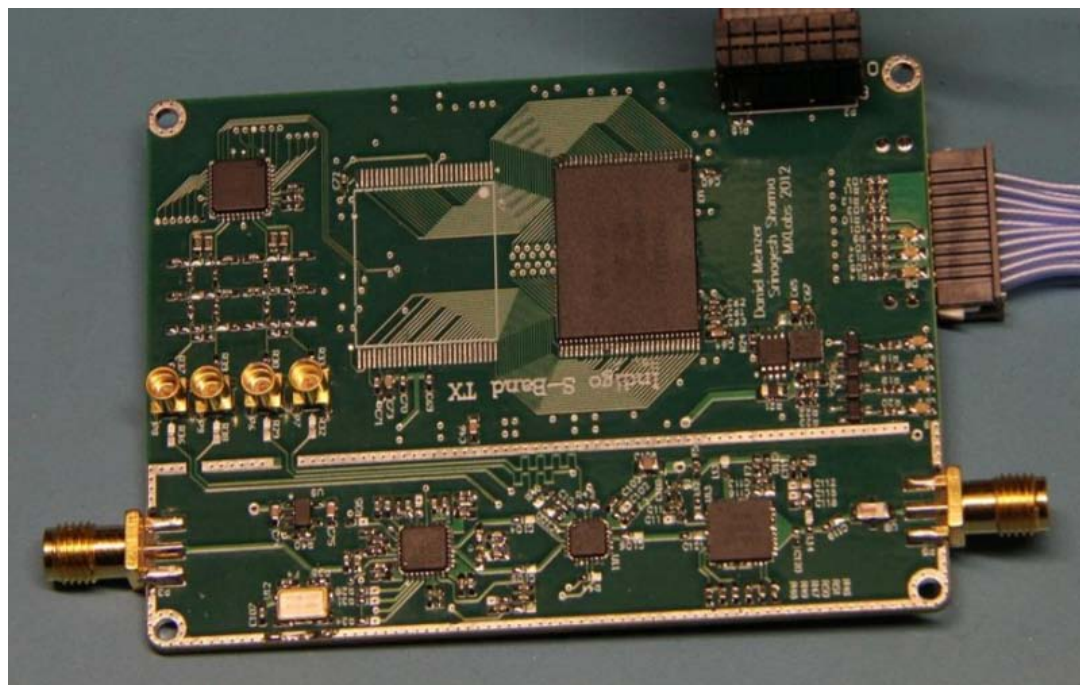
Canopus Systems

- Ka-band at 26.8 GHz
- Earth-Exploration Satellite Service
 - Experimental license for first launch
- 10 W DC for 500 mW RF TX
- DVB-S2 modulation, up to 40 Mbps
 - Cloud/rain fading
- Integrated 25 dB horn antenna
- 1U form factor
- Flight on the upcoming Dnepr cluster launch



University of Michigan: Indigo

- Transmitter only, 3.4 GHz
- Up to 5 Mbps OQPSK, 1W RF
- 128 MB of on-board storage
- Initial flight on CADRE



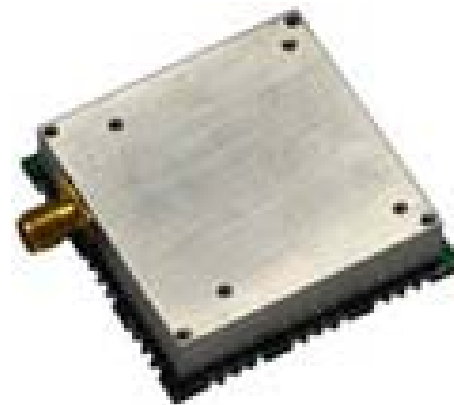
Prototype Unit

NASA/JPL: IRIS

- X-Band up/down, 62.5 to 256k bps BPSK
 - Expected to go up to 4 Mbps
- 13 W DC for transmit 500 mW RF, 7 W RX
- Designed for INSPIRE, earth-escape CubeSat in 2015?
- DSN-compatible with CCSDS
- Full duplex communications out to 5 M km
- Doppler and ranging up to 50 M km (limited by DSN)
- Presentation by Courtney Duncan later today

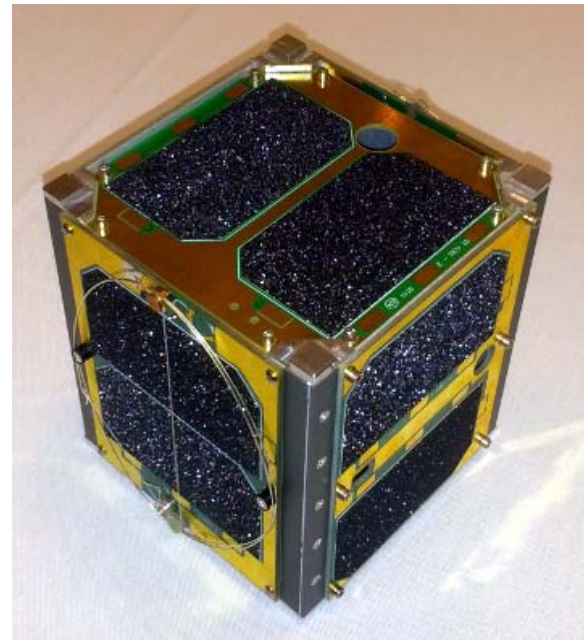
Other High-speed Radios

- University of Colorado
 - In collaboration with GSFC, WFF, and MSFC
 - S-band up, X-band down at up to 10 Mbps
 - Designed to communicate with NEN
 - 5 W DC for 1 W RF TX
 - Prototype this summer
- Astrodev Beryllium
 - 10 kbps to 2 Mbps GFSK at S-band
 - Flew on ArduSat-2 (DOA)
 - Upcoming launch later this year
- Tethers Unlimited SWIFT
 - Wide variety of frequencies



Future AMSAT CubeSats

- Fox-1
 - To be launched on GRACE or UltraSat
 - Tony Monteiro AA2TX, SK
 - On time for an October delivery this year
 - FM transponder: 435.180 MHz uplink, 145.980 MHz downlink
 - 15 kHz wide, 400 to 800 mW
 - Vanderbilt radiation experiment
 - VT camera experiment
 - Penn State MEMS gyro experiment
- RadFxSat (Fox-1B)
 - ELaNa Approved
 - Vanderbilt radiation experiment
 - RIT MPPT experiment



Fox-1 mock up

Conclusion

- Various high-speed options for future flights
 - Some teams above have expressed interest in selling/giving away designs
 - For those teams that can't throw money at the problem, low cost options exist
- Thanks to:
 - Courtney Duncan
 - Mike Safyan
 - Jamie Cutler
- Planning another meeting at SmallSat 2014
 - Contact me if interested

Thank You



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