



# High-Speed Radio Options

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CubeSat Developers' Workshop

Cal Poly, San Luis Obispo

23 April 2014

# 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

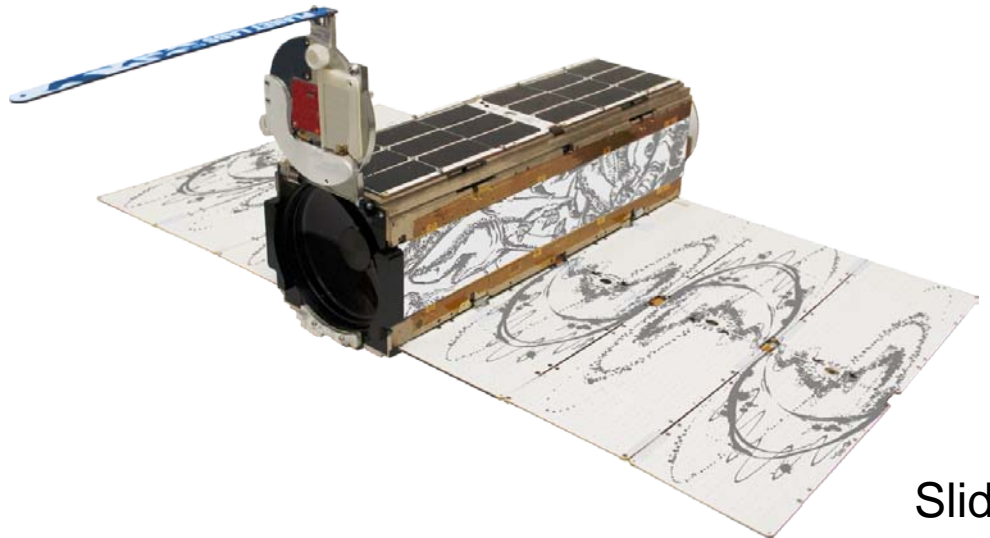
# High-Speed Flight Qualified Radios

- 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



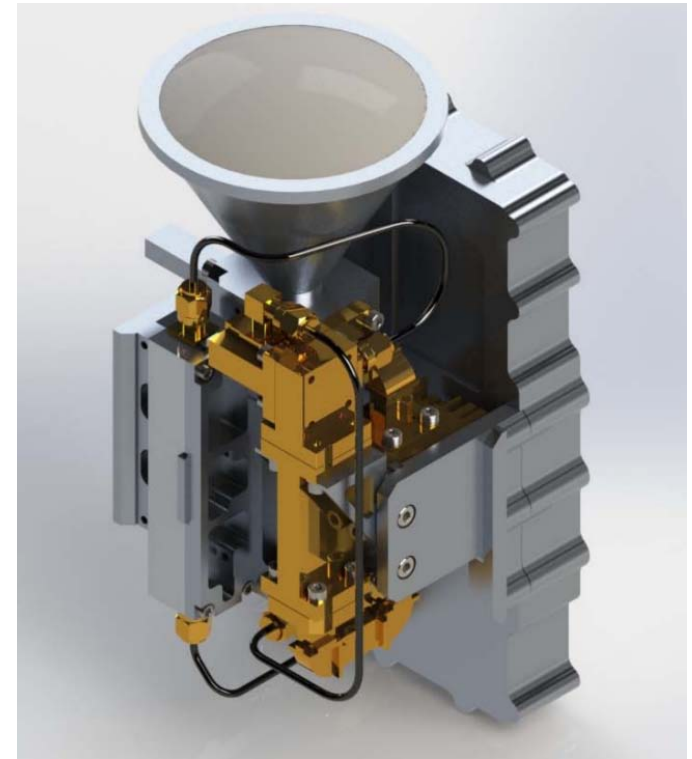
# Flight-Qualified Radio: Planet Labs

- 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)



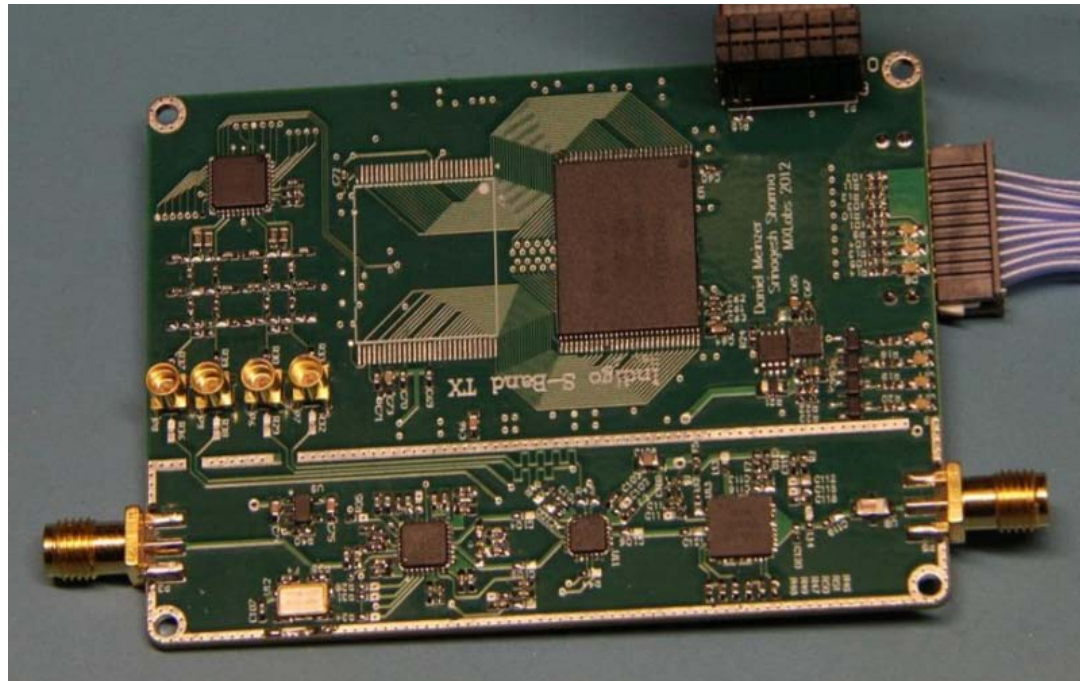
# Canopus Systems

- 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



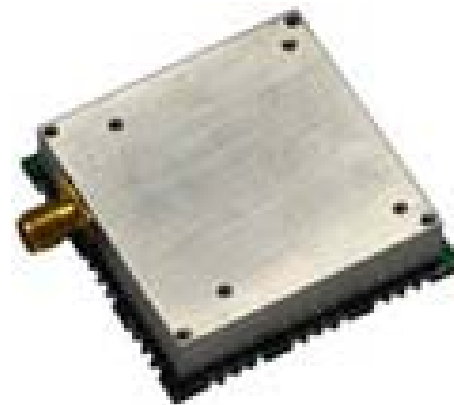
Prototype Unit

# 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

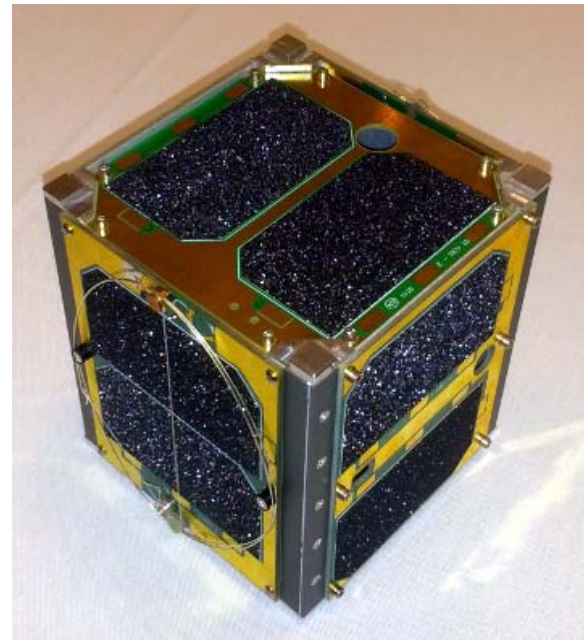
- University of Colorado
  - In collaboration with GSFC, WFF, and MSFC
  - S-band up, X-band down at up to 10 Mbps
  - Designed to communicate with NEN
  - 5 W DC for 1 W RF TX
  - Prototype this summer
- Astrodev Beryllium
  - 10 kbps to 2 Mbps GFSK at S-band
  - Flew on ArduSat-2 (DOA)
  - Upcoming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