Extrapolating the Results of DICE to Constellation CubeSat Missions for Space Science

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Dynamic Ionosphere CubeSat Experiment (DICE)

Last Known Photograph

If Found Please Return to
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- DICE 70 Hz Science
  - 10.28 kbits/s
- DICE 35 Hz Science
  - 5.24 kbits/s
Red Book Regulations on 460 to 470 MHz

- 5.289 Earth exploration-satellite service applications, other than the meteorological-satellite service, may also be used in the bands 460-470 MHz and 1690-1710 MHz for space-to-Earth transmissions subject to not causing harmful interference to stations operating in accordance with the Table.

- US201 In the band 460-470 MHz, space stations in the Earth exploration-satellite service may be authorized for space-to-Earth transmissions on a secondary basis with respect to the fixed and mobile services. When operating in the meteorological-satellite service, such stations shall be protected from harmful interference from other applications of the Earth exploration-satellite service. The power flux-density produced at the Earth’s surface by any space station in this band shall not exceed -152 dBW/m²/4 kHz.

10 MHz Bandwidth available
DICE Telemetry Systems (3 Mbit/s)

With FEC the Downlink
Data Rate is 2.63 Mbps
Telemetry COT: L3 Cadet Radio

- UHF or S-Band
- Downlink: 1-20 Mbps
- Uplink: Up to 250 kbps
- Size: 2.7" x 2.7" x 0.53"
- Weight: 7.6 oz
- Transmit: 8-12 Watts
- Receive: 0.3 Watts
- Memory: 4 GB Flash

Source: http://www2.l-3com.com/csw/ProductsAndServices/DataSheets/Cadet_Nanosatellite_Radio_WEB.pdf
Telemetry System

WBX 50-2200 MHz Rx/Tx

LNA/BPF/Switch

Ettus Research

USRP N200

10 Msamp/s I/Q data

Software Radio

MYSQL Database

Ethernet
Interference at Wallops Site

Interference at SRI Site

Signal

460 to 470 MHz Band

With Interference Cancelation

460 to 470 MHz Band

Interference

460 to 470 MHz Band

Power Spectral Density

Power Spectral Density

Frequency [MHz]
DICE Results

DICE Database (launch to 12/1/2012)

Total
Yahtzee 1.46 GBytes
Farkle 2.19 GBytes

DICE Database Launch to 12/1/2012

TOTAL
Yahtzee 1.46 GBytes
Farkle 2.19 GBytes
DICE Magnetometer Data

Farkle Science Magnetometer 05/22/2012 22:19:24.212984 UT

Magnetic Field (nT)

Time (Sec) since 22:19:24.212984

400 nT
Extrapolate to Constellations

120 Satellites
Random CubeSat Constellation

Single Ground Station At Wallops, VA

- 500 km Circular Orbit
- 85 Degree Inclination
- 5° Horizon at NASA Wallops
Moving Forward

• Cadet-U
  – Bulk Builds to keep cost down
  – 450 up 460-470 MHz down

• Cadet-S
  – In fabrication
  – 450 up S-band down

• Cadet-SS
  – In concept
  – S-band up
  – S-band down

• A Turn Key Cadet System
  – Cadet Radio
    • Flight + Engineering
  – Cadet Ground Station
  – Ground Station Software

• How the 460-470 MHz band
  – Wallops/Morehead
  – NTIA Table Mountain and Colorado
  – Paul Allan
  – Alaska
Conclusion and Next Steps

• Conclusions
  – A single ground station with a “High Speed” data link is very effective way of operating a constellation mission.
  – Relatively large constellation missions could be operated from NASA Wallops “now” using the DICE telemetry systems.

• Next Steps
  – Work with the ITU and NTIA working groups to secure bandwidth and allocation procedures for CubeSat communications.
  – Develop a community ground station that is automated.
    • Upgrade Wallops
  – Continue to work on interference mitigation strategies so that the 460-470 MHz band can be fully utilized at SRI and other locations.
  – Find “under utilized” antennas in a Radio Quiet zones and work to develop them into a community resource.