Cal Poly CubeSat Conference 2013

Title: Advanced Communications for Small Satellites

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VULCAN WIRELESS INC.

Overview

- Company Introduction
- CubeSat Communications
- Current Products

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Company Background

- Located in Carlsbad California
- Formed in 1993, Incorporated in 1999
- Leverage COTS technology to Military Applications
- Digital Communications and Sensors
- Active Projects in SDR and Encryption Technology
- Focusing on Small Satellite Applications
- Markets
  - Military
  - NASA
  - Commercial

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CubeSat Communications

Advances in Communications for Small Satellites

- Migration from Single Point Designs to Existing Communications Infrastructure
  - Armature Band HF/UHF to UHF Military Standards or Commercial
  - S-Band from Point Designs to AFSCN/SGLS/TDRS or Commercial
- Multi Mission Radios Reduce SWaP
  - Multiple Waveforms, adaptive modulation, adaptive rates
  - Multiple Protocols for specific applications
  - Multiple Encryption required for variety of ground users
  - Multiple Antennas needed for required bands
  - Agile Frequency Tunability
  - Spectral Efficiency

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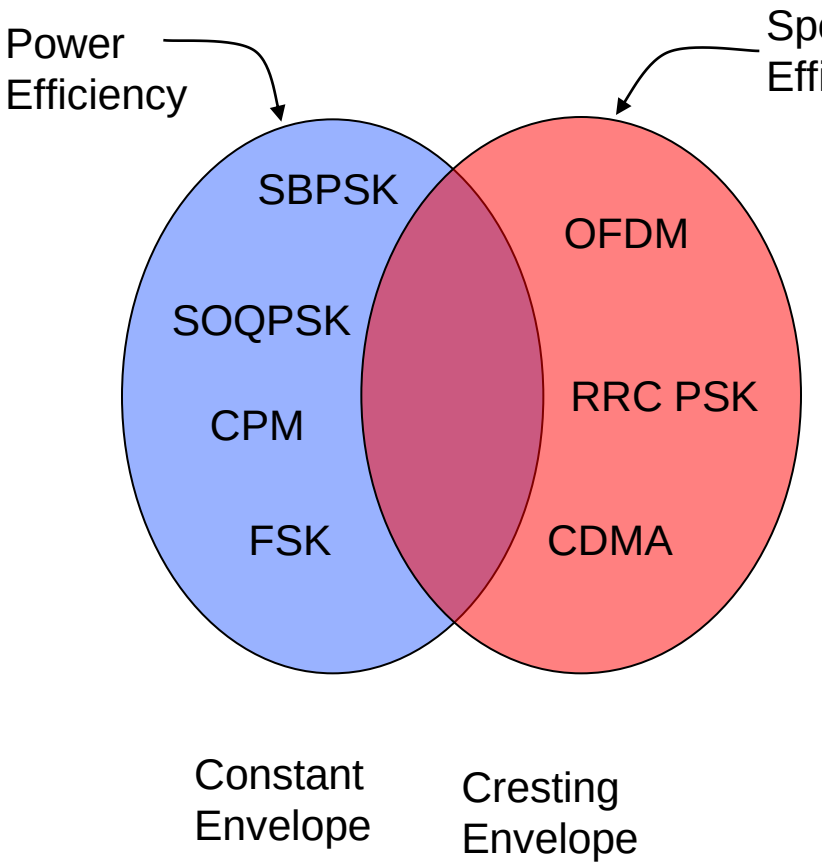
Waveform Power and Spectrum Efficiency



Ways to increase Power Efficiency

- **Use nearly constant amplitude waveforms**
- **Use amplitude variation along with PA efficiency algorithm**
  - **Feed-Forward**
  - **Feedback**
  - **Predistortion**
- **Power Limited Platforms Favor Const Envelope**
- **6U Vehicles will increase communication solutions**

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Waveforms

Constant Envelope

- MSK/FSK
  - Unfiltered and Gaussian Shaped
- BPSK/QPSK
  - Shaped
  - Shaped Offset (QPSK)
- Multi-H CPM
- MPSK
- Others

Spectrally Efficient

- BPSK/QPSK
  - Root Raised Cosine Shape
- 16 or 64 QAM
  - Root Raised Cosine Shape
- OFDM
- WCDMA
- Others

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CubeSat SDR Communications

- Software Defined Radio Provides Multi-Mission Functionality
- 6U Form Factor will increase available electrical and thermal environments to increase the capacity of SDRs
  - Increased RF Power Amplifiers are needed
  - Increased DC power for higher performance radio architectures

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CubeSat SDR Communications

Cognitive Radio Functionality

- Enables SDR to communicate with a variety of target radio
- Each target radio requires specific waveform parameters
- Each target radio requires specific protocols

Waveform Protocols

- The protocol controls physical layer behavior based on state of the channel
  - Full Duplex
  - Half Duplex
  - Burst Data
  - Streaming Data
- Protocol controls flow of data packets

CubeSat Communications

Encryption

- Protocols often integrate defined encryption
- Encryption Algorithms and keys change with waveform & protocol

Examples

- NSA Type -1 encryption
  - Pegasus/Cardholder
  - NSA Suite B, AES 256
- NIST FIPS-140
- COTS Encryption

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CubeSat Communications

Frequency Agility

To conduct multiple communication mission RF needs to be tunable

RF Front Ends need to be configurable

Antenna Systems

Multiband antenna systems need to be integrated with the SDR to conduct multiple missions

Single Feed System may require duplex filters

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CubeSat Communication Products

Active Software Define/Cognitive Radio Products

- CSR-SDR-U/U
- ORS-SDR-U/U
- CSR-SDR-S/S
- LPR-SDR-S/S
- NSR-SDR-U/U

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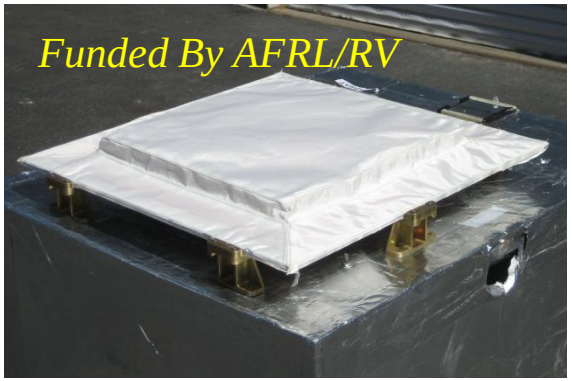
MBT-R2 PnPSAT

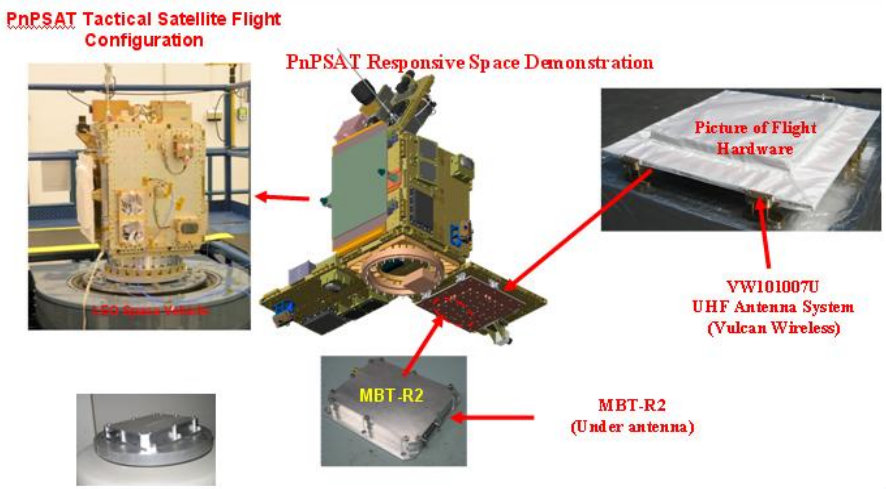
MBT-R2 Tactical SDR



PnPSAT UHF Flight Antenna

GTX117 Ground Terminal

- Developed for PnPSAT
- UHF Tx/Rx Half Duplex
- Software Defined Radio Flexibility
  - TT&C
  - Direct to War Fighter
- Integrated 28V Power Supplies
- Provided Turn Key Data Link with:
  - SDR (Tested to TRL-6)
  - Flight Antenna
  - Tracking Ground Terminal (Kwaj)



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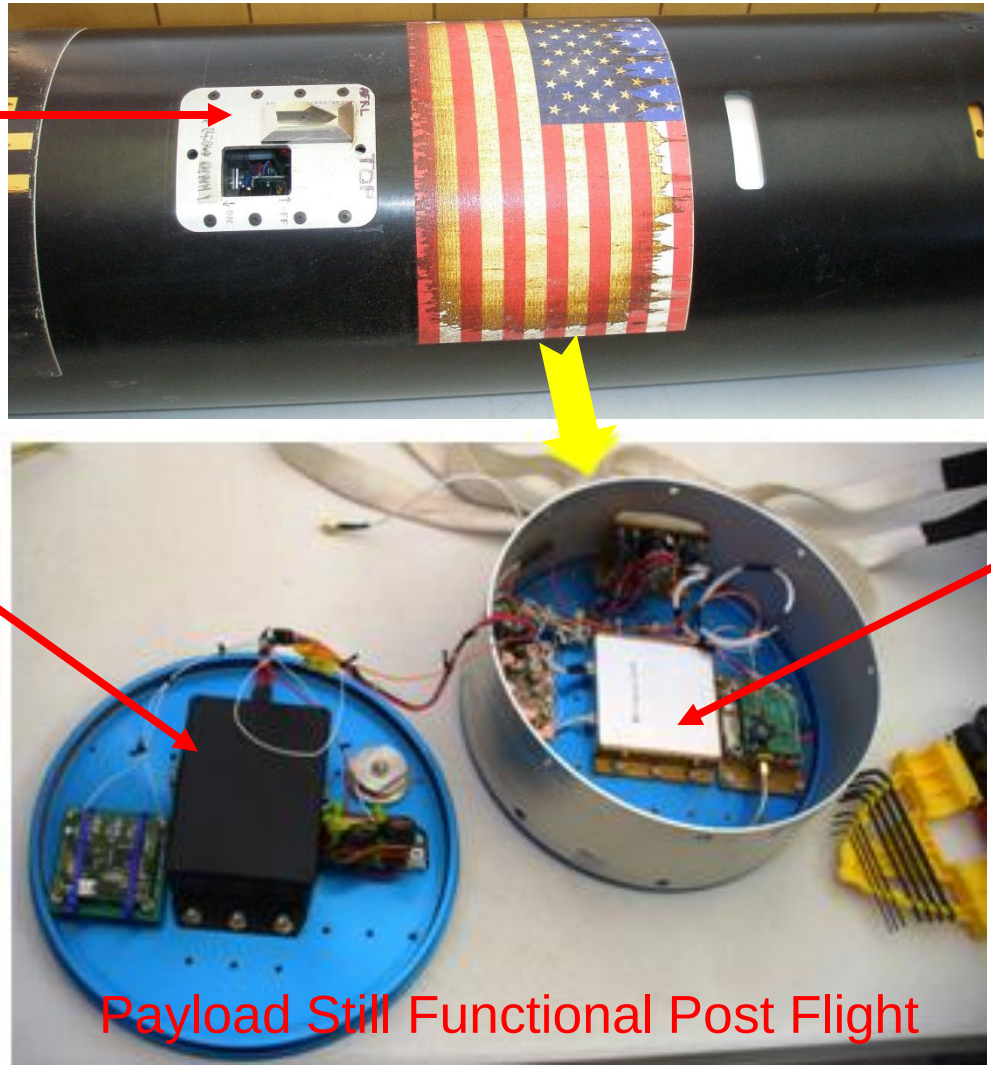
Sounding Rocket Experiment

Objective of Experiment

- CubeSat Software Defined Radio
- Host on Hypersonic Flight Vehicle
- Demonstrate Space Vehicle Black Box Transponder Capability
- Close Link to GEO TDRS-MA
- Provided Real-Time Payload Telemetry to Ground
- S-Band Frequency

CSR-SDR-S Flown on Sounding Rocket



Continued Evolution

CSR-SDR-U/U

2010

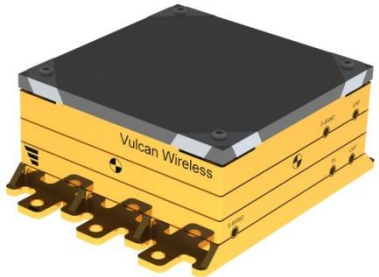
- Low Power design for CubeSats
- Half Duplex
- 5Watts RF
- 10.6Watts DC Draw on Tx
- Variety of Interfaces

AFRL

CSR-SDR-S/S

2012

- TDRS-MA Return
- USB Frequency Plan
- AFSCN/SGLS/TDRS/Commercial Waveforms
- Up to 6Mbps
- Compact



AFRL

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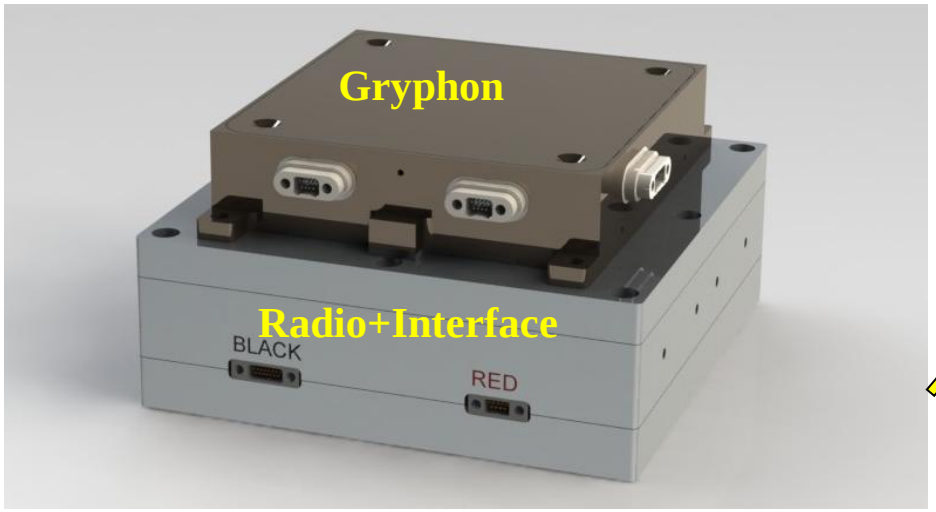
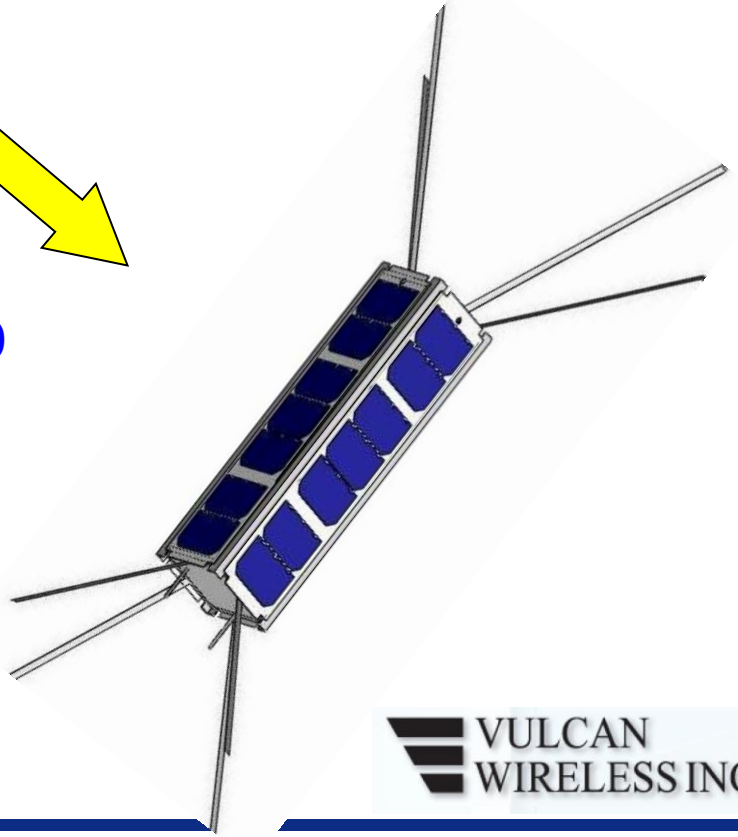
ORS ENABLER Payload



SMDC-1 Bus



Communications payload stack

- Gryphon AVE TYPE-1 Encryptor (NSA Suite B)
- Software Defined Radio (CSR-SDR)
- Direct to War Fighter Communications
- Cognitive Radio Architecture
- Antenna Phasing Circuit

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Conclusion

- Questions