



DESIGN, DEVELOPMENT, AND OPERATION OF CUBESAT-BASED HF SATCOM

USNA Small Satellite Program

April 26, 2017

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Team Organization



1/C Evans
-Team Lead



1/C Scheiner
-Comms



1/C Giornelli
-ADCS



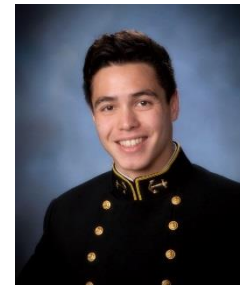
1/C Randell
-HF Systems



1/C Cho
-EPS



1/C Gray
-Build



1/C Scigliano
-Operations



1/C Walker
-Software &
Safety



1/C Misch
-Structures/
Mechanical



1/C Williams
-Telemetry

Overview

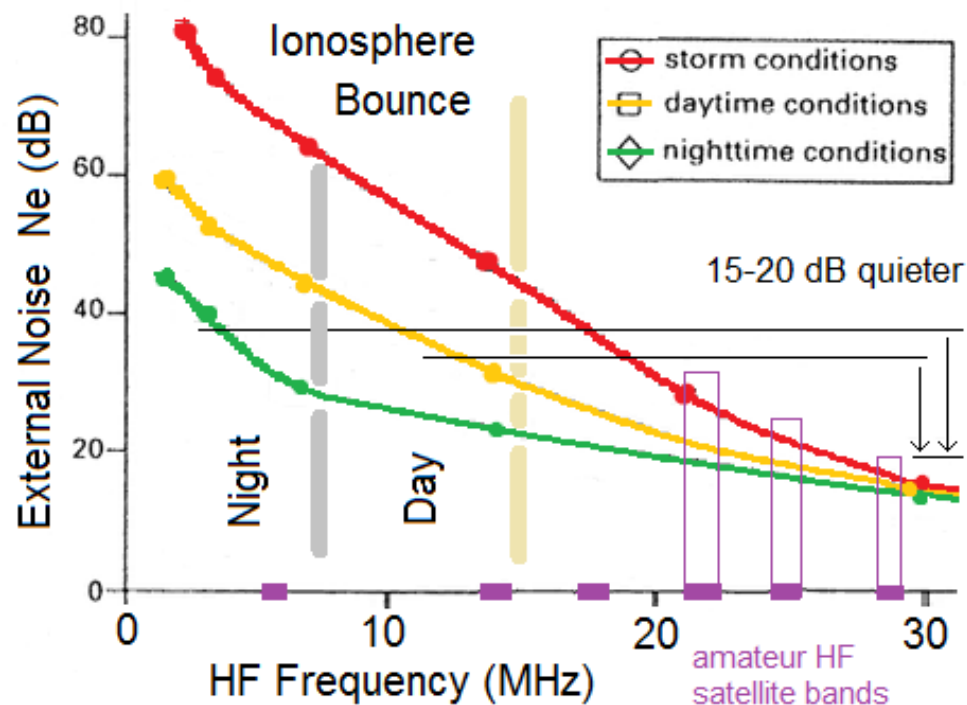
- Team Organization
- HF Justification
- Motivation
- Mission
- Mission Objectives
- CONOPS
- Satellite Design
- Conclusion

Main Objective: HF SATCOM

- Provide an alternative form of SATCOM
- 1.5 U CubeSat with HF Transponder payload
- Utilize Radio Amateurs to test and determine useful range of operations
- If successful, implement fleet of similar CubeSats to provide worldwide coverage

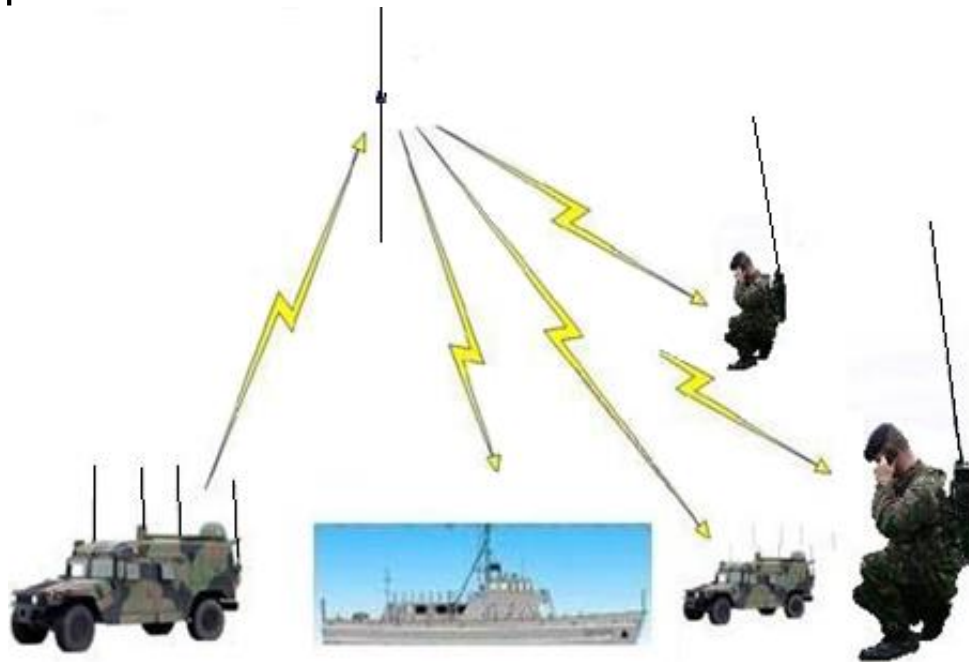
Why HF?

- HF is significantly simpler than other SATCOM bands
 - Non-Tracking Antennas
 - Lower noise in satellite bands



HF SATCOM Applications

- Most small DoD assets are already equipped with HF radios
- These same assets often don't have SATCOM access
- Provides alternative in emergencies to assets that do have SATCOM



Motivation

- Improve Communications
 - Demonstration of HF Radio Satellite Communication
 - Utilize Amateur Radio Operators
- Educate USNA Astro-track Midshipmen on Satellite Development Process with Hands-On Experience



Mission

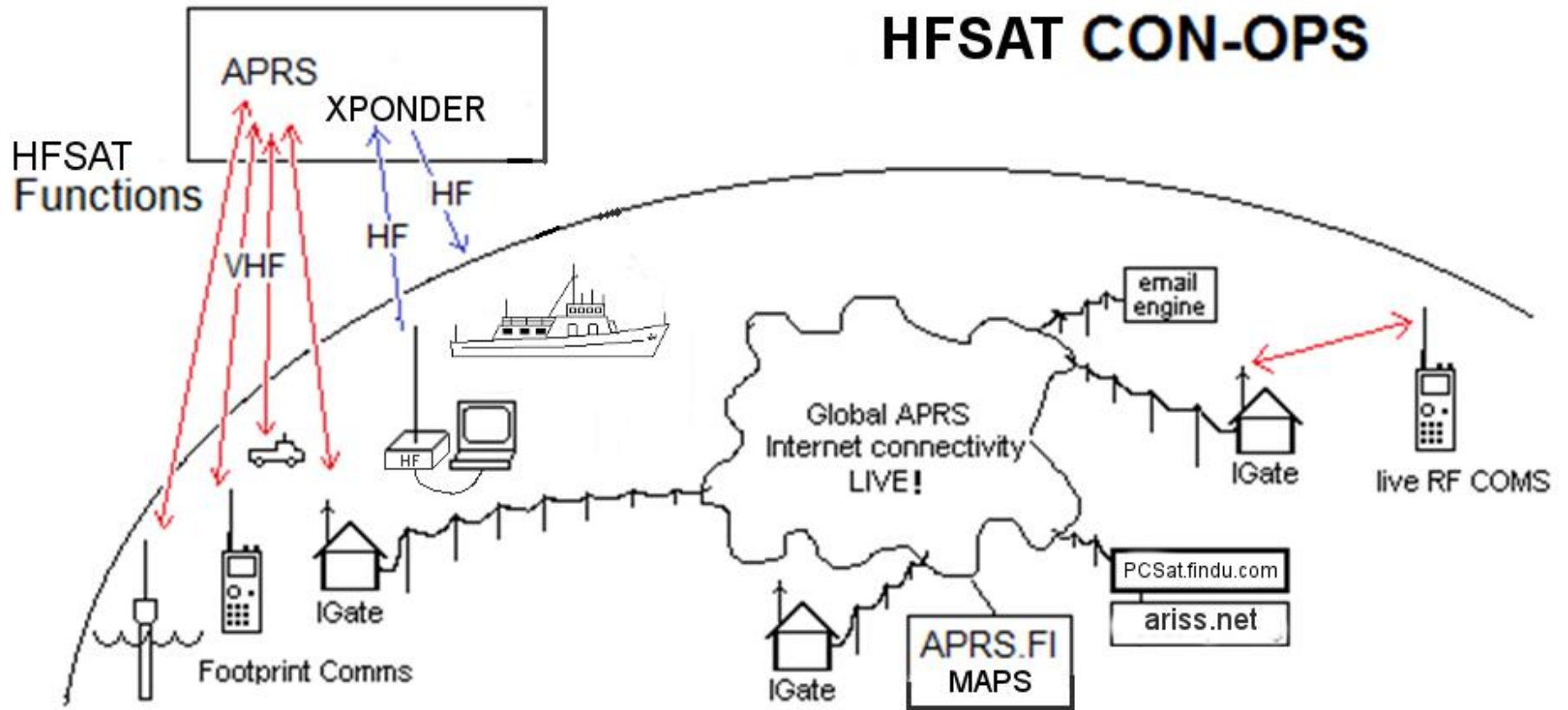
- Design and build a HF-band communications Satellite which is compatible with existing operational DoD radio equipment. By utilizing the HF-band for both uplink and downlink, HFSAT will greatly **increase the range of the primary means of communication** between small DoD assets for HF radio. This 1.5U CubeSat would be used to explore the **potential for wide-spread implementation** use of SATCOM for HF radio relay.

Mission Objectives

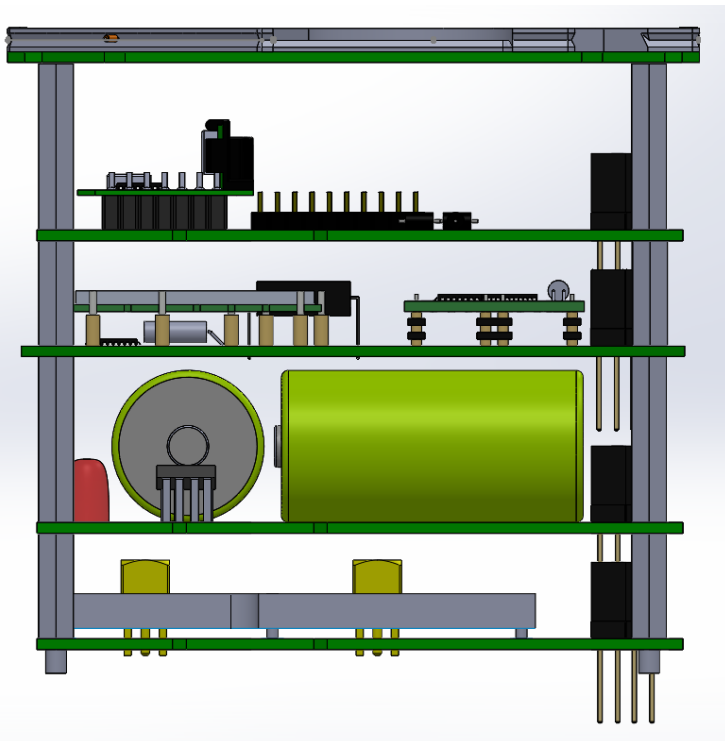
- Test HF Radio Satellite Communication Capabilities
 - Utilize Amateur Radio Band and Operators
 - Educate Midshipmen on Satellite Development Lifecycle
-
- Our Solution: Build CubeSats with HF SATCOM to fill gap
 - Inexpensive
 - Quick



CONOPS



Satellite Overview



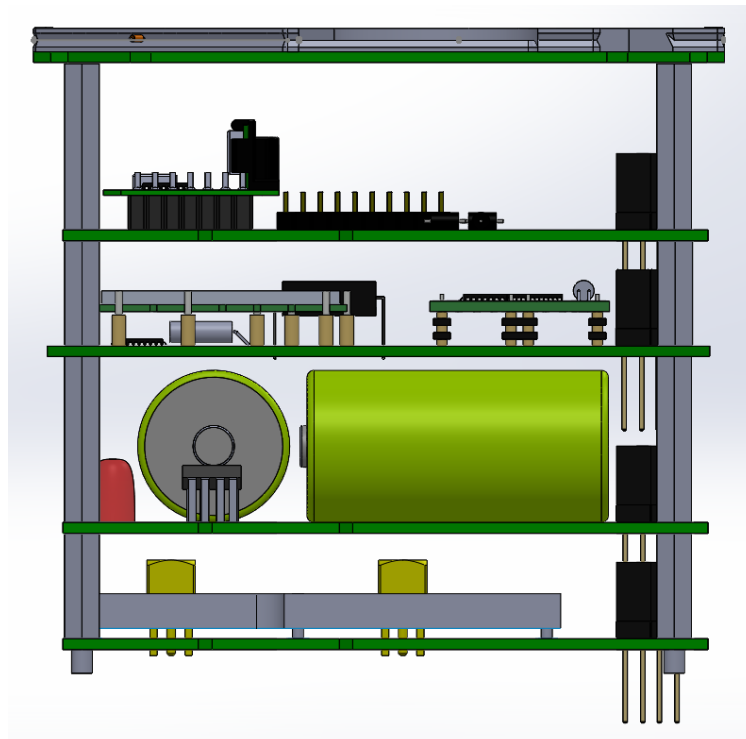
Satellite Specifications

| | |
|------------------|-------------------------------------|
| Mass | 2200 g |
| Size | 1.5 U |
| Power Generation | 2.75 W in Sunlight |
| ADCS | Gravity Gradient Magnetotorquers |
| Comms HF | 21.4 MHz Up 29.42 MHz Down |
| VHF | 145.825 MHz (Up & Down) |

Satellite Design

ADCS and C&DH

Batteries

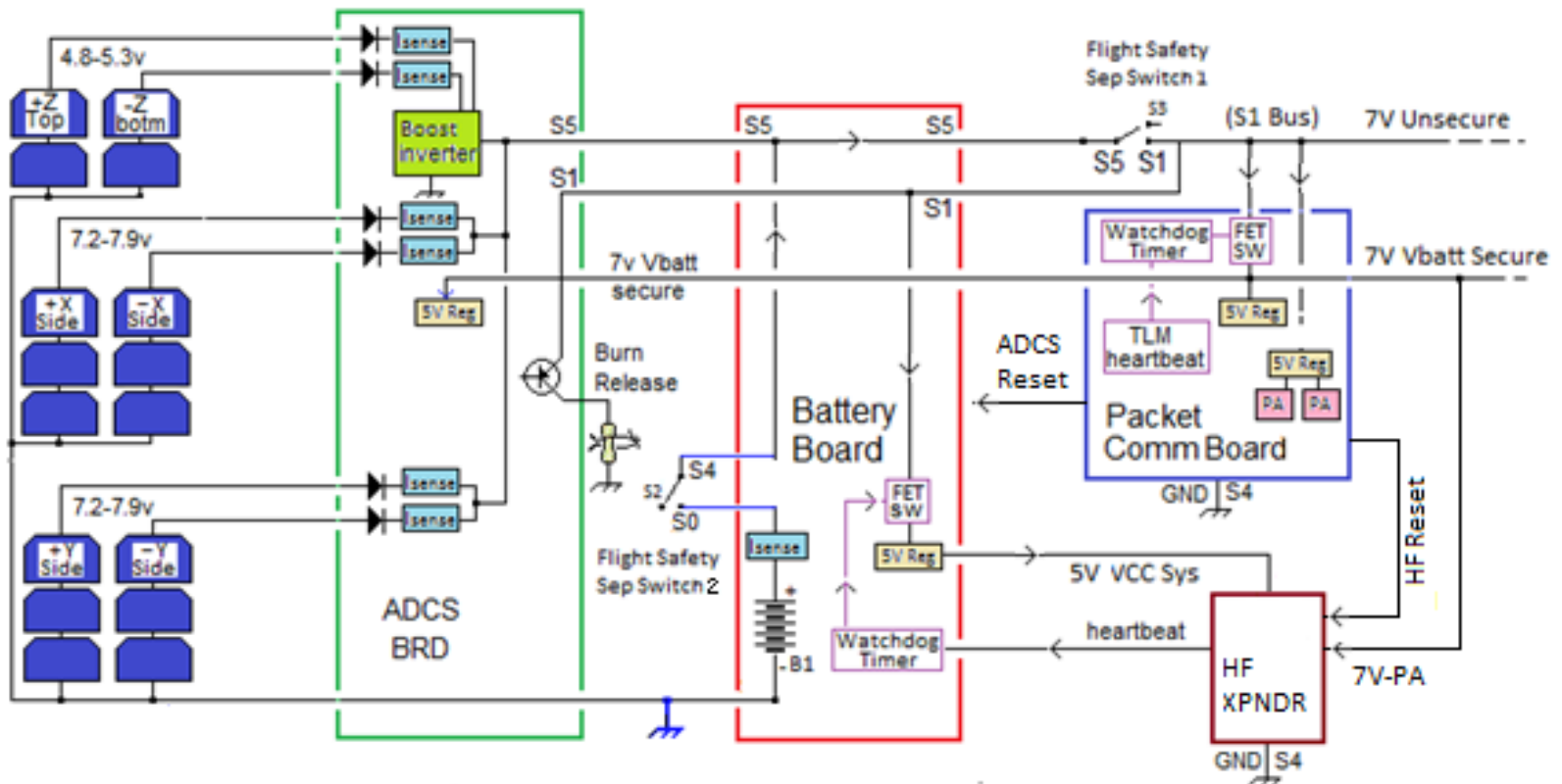


Antenna Deployment Mechanism

Communications

HF Transponder

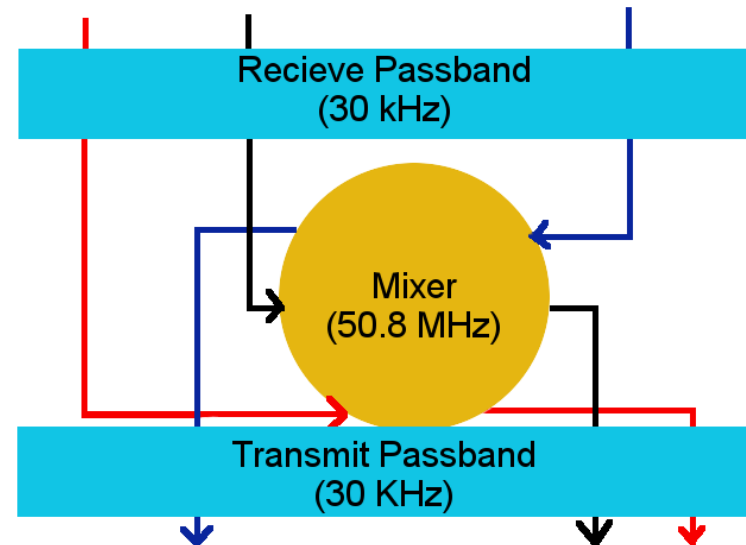
Power System



Outputs: $V_{batt} \sim 7V$, Regulated 5V

Unique Satellite Features

- Half Wavelength-Dipole HF Radio Antenna
 - Also utilizes tip mass for gravity gradient stabilization
- Linear Inverting Transponder
 - 21.4 MHz Uplink
 - 29.4 MHz Downlink
 - 30 kHz Passband
 - Allows 10 simultaneous users



HFSAT Linear Inverting Transponder

Power System: Solar Panels

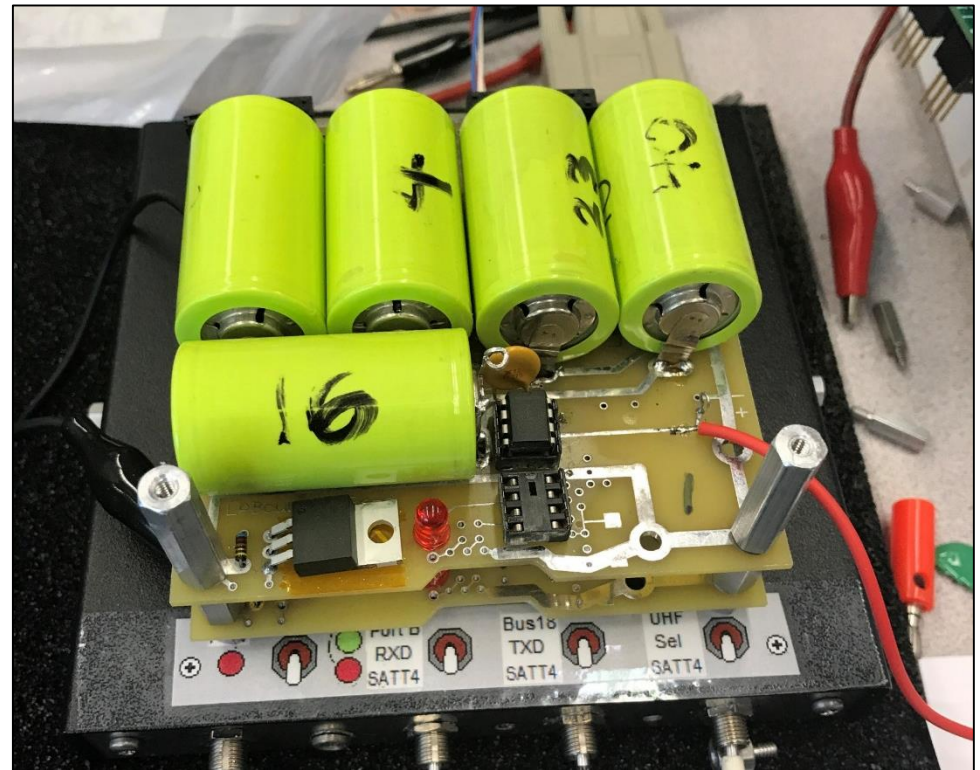
- 6 side panels composed of UTJ Solar Cells
- 2.75 W generated in sunlight
- Also act as Magnetotorquers

- Built in-house



Power System: Battery Board

- 5 NiCd Cells
- Battery Capacity: 286 mAh @ 7V max

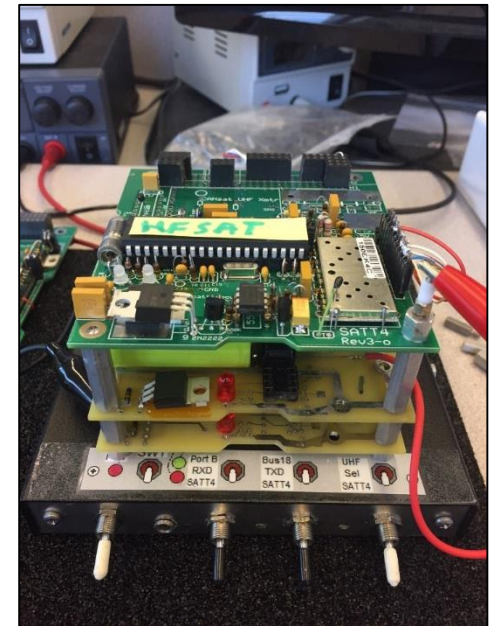


VHF Communications

- In addition to HF mission, HFSAT performs VHF packet radio communications
 - Telemetry
 - Command and control
 - User payload mission of APRS user digipeating.
- Uses modified Micro-Trak TinyTrak 4 communications controller (telemetry and command) and APRS digipeater combined with the radio transceiver.
 - Called the **SATT₄**
- Tx/Rx on **145.825 MHz**



MT-TT₄



USNA SATT₄ on its Test Set

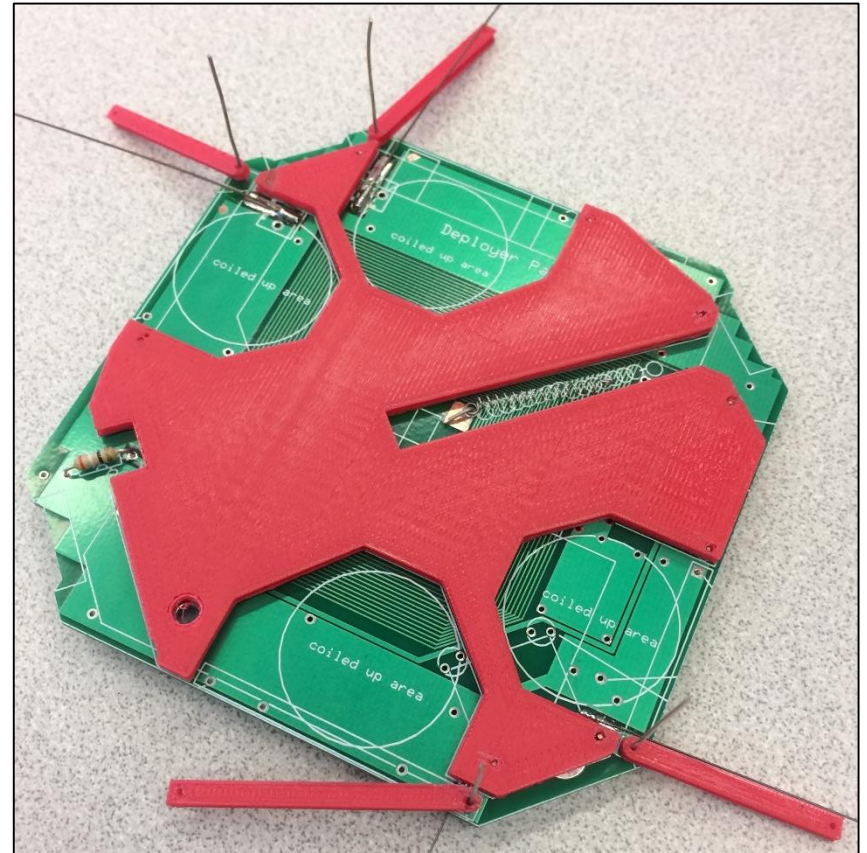
ADCS and C&DH

- Gravity-Gradient Stabilization
 - Dual-duty HF Antenna
- Magnetometers provide control for Solar Panel Magnetotorquers
- C&DH done by Arduino
- Current Sensors



Antenna Design & Deployment

- Nitinol Wire Antennas
- Mechanical Antenna Deployer
 - 3-D printed
- Burn Resistor for Release



Conclusion

Successful Means for Accomplishment of Mission Objectives:

- ✓ Test HF Radio Satellite Communication Capabilities
 - ✓ Utilize Amateur Radio Band and Operators
 - ✓ Educate Midshipmen on Satellite Development Lifecycle
-
- Predicted launch mid-2018

Questions?



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