

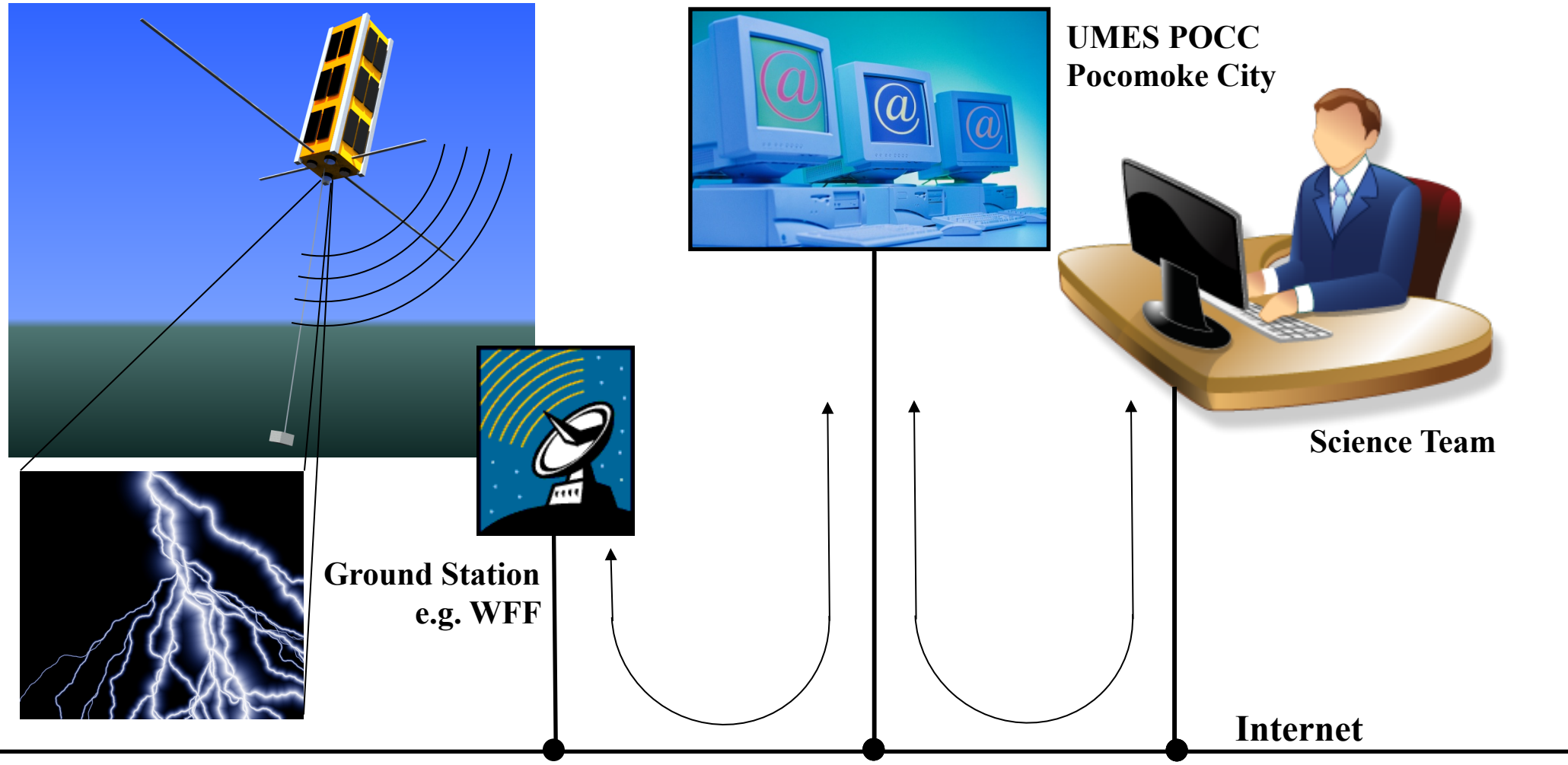


*Hawk Institute for Space  
Sciences*

# Firefly Comms Plan

*November 30, 2009*

# Firefly Operational View



# Comms Plan Overview

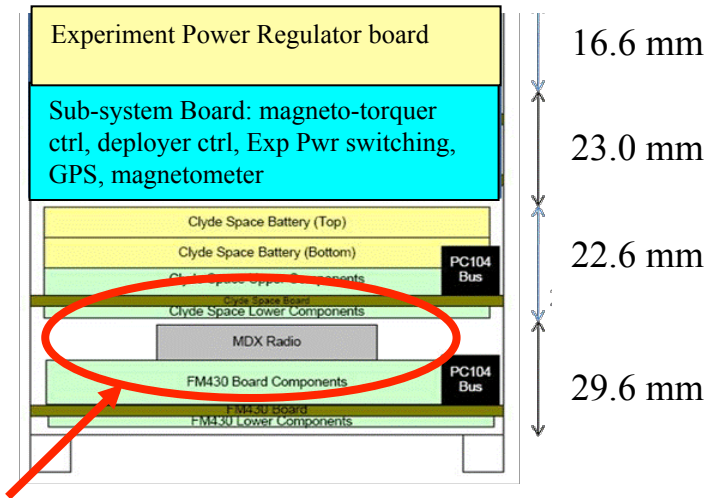
- MicroHard MHX-425 UHF Transceiver.
- 2W transmit power.
- Deployable half-wavelength dipole antenna with reactive balun.
- Meteorological satellite service frequencies in the 400.15 – 402 MHz band.
- UHF dish on the ground (baseline is NASA/WFF 36 dB gain UHF dish).
- MicroHard ground radio (matched to MHX-425) connected to UHF dish.

# Firefly Comms Configuration

|                      |                           |   |
|----------------------|---------------------------|---|
| Volume 3: Spacecraft | FMB/MHX-425               | Flight Mother Board and radio                 |
|                      | EPS w/Batteries           | Power system                                  |
|                      | GPS/magnetometer          | Subsystem board                               |
|                      | EPR                       | Experiment Power Regulator                    |
| Volume 2: Instrument | ECB 0                     | Experiment Control Boards                     |
|                      | ECB 1                     |   |
|                      | GRD front End             | GRD electronics                               |
|                      | <b>GRD</b>                | Scintillation-based gamma-ray detector        |
| Volume 1: Instrument | <b>Ant/GGB mini-board</b> | Comm ant/balun, VLF ant, GGB deployment       |
|                      | Optical/VLF Front End     | Optical diode electronics, LNA, filters, etc. |
|                      | Photometers               | Photo-diodes & collimators                    |

Dashed = Gravity Gradient Boom (GGB)

## 1U Spacecraft Bus Layout



# Link Margin Calculation Summary

WFF link margin calculation shows link margin of at least +9.3 dB at 5° elevation:

## Method 1:

Transmitter gain (2W) = 33 dBm = 3 dBW

SC losses = 3 dB, SC Antenna Gain = 1.4dB

Free Space Loss = 151 dB (max slant range 1889 km at 5 deg elevation of tracking antenna)

UHF antenna at WFF gain = 36 dB with 15dB LNA, UHF antenna at WFF losses = 4dB

MHX-425 receiver sensitivity at 115.2kbps = -107dBm

Total:  $33-3+1.4-151+36-3+15+107 = 35.4\text{dB}$ , 20 dB required -> **15.4 dB margin worst case.**

## Method 2: (using antenna G/T – more accurate)

Downlink frequency 401 MHz, ground antenna size 18.3 m, Ground antenna G/T 6.9 dB/K

Data modulation Bi-Phase; carrier modulation PCM-PSK/PM, Data rate 0.1152 Mbps

Transmitter power 2 W (33 dBm), spacecraft passive losses 3 dB, spacecraft antenna gain 1.4 dB

Spacecraft EIRP (min) 31.4 dBm

Altitude 430 km, elevation angle 5 degrees, slant range 1889 km

FSPL -150.0 dB, atmospheric loss 1.0 dB, Received power -119.6 dBm

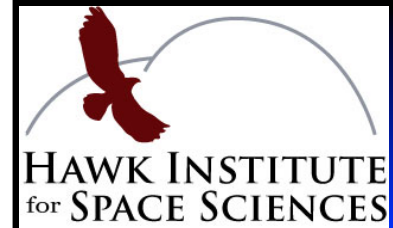
Ground antenna gain (effective) 35 dBi, ground station passive loss 3 dB

Received power at feed -87.6 dBm, System noise density -170.5 dBm/Hz, Carrier to noise 82.9 dB

Bit-rate level 53.6 dB-bps, Required Eb/No 20 dB, Required carrier to noise 73.6 dB-bps

-> **margin 9.3 dB worst case**

## Method 3 results in 11.3 dB link margin worst case



# Frequency & Licensing Status

- NTIA forms filled out with all available information.
- Missing information for NTIA forms requested from MicroHard; awaiting response.
- Once forms fully filled out, will review with GSFC Spectrum Manager and file request for frequency licensing.

# Comms Concept of Operations

- Antenna deploys autonomously 30 minutes after ejection from P-POD.
- Transceiver enters sleep/sniff mode until receives ground transmission.
- As backup, turn transceiver on and transmit when expect to be near ground station, possibly using GPS location.
- If no ground contact within 3 days (TBC), reboot transceiver.
- Up to twice daily ground-station overpass for data downlink.
- Weekly command uplink (more frequent if and as needed).
- Flight software designed for autonomous operations, self-diagnostics provides single-event upset (SEU) recovery.

# Comms I & T Plan

## ✓ Pre-Experiment Integration & Test – Passed

### Checkout of comm link between MHX-425 ETU and MHX-425 ground radio ETU

- Slave radio (on Pumpkin development board with other Firefly Spacecraft ETUs and Firefly Flight Software version 1)
- Master radio (on MicroHard development board)
- Purpose was to check out the flight software command and telemetry interface and validate the form fit and function of the radios

### • Spacecraft Flight Software Acceptance Test – NLT February 2010

- Check out all spacecraft flight hardware, and flight software with experiment ETUs (Experiment Control Board (ECB) and Experiment Power Regulator (EPR))

### • Pre-Environmental Comprehensive Performance Test (CPT) – NLT March 2010

#### Firefly in final flight configuration and tested with remote ground station

- Comm link will include test with at least 0.5 km between ground dish and satellite with attenuation between ground station antenna and receiver to simulate orbital slant range.

### • Environmental Test – NLT April 2010 at WFF

- Vibration
- Thermal vacuum & thermal balance
- CPT (between and after each environmental test)