AMSAT OSCAR-E

AMSAT OSCAR-E Project
Fall 2003 Status Report

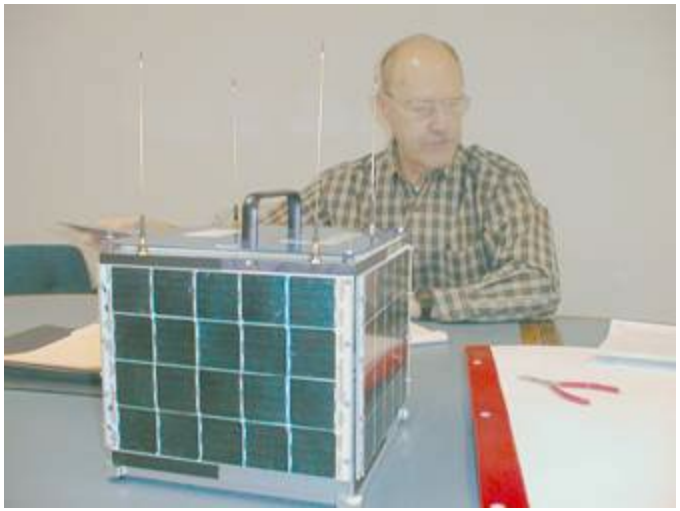
Report Presented by
Richard M. Hambly, W2GPS

21st Space Symposium and AMSAT-NA Annual Meeting

Saturday, October 18, 2003, 15:00 EDT
Toronto Airport Marriott, Toronto Ontario Canada

AO-E Introduction

- Microsat class spacecraft (~10 kg).
- Six solid aluminum trays stacked to form a 9.5-inch cube structure.
- Six solar panels, one on each side.



Dick Daniels W4PUJ at SpaceQuest 28_Feb-2002

- Antennas on top and bottom.
- Similar to original Microsats
  - » AO-16, DO-17, WO-18, LO-19
- Similar to the descendents of that legacy
  - » IO-26, AO-27, MO-30, SO-41.

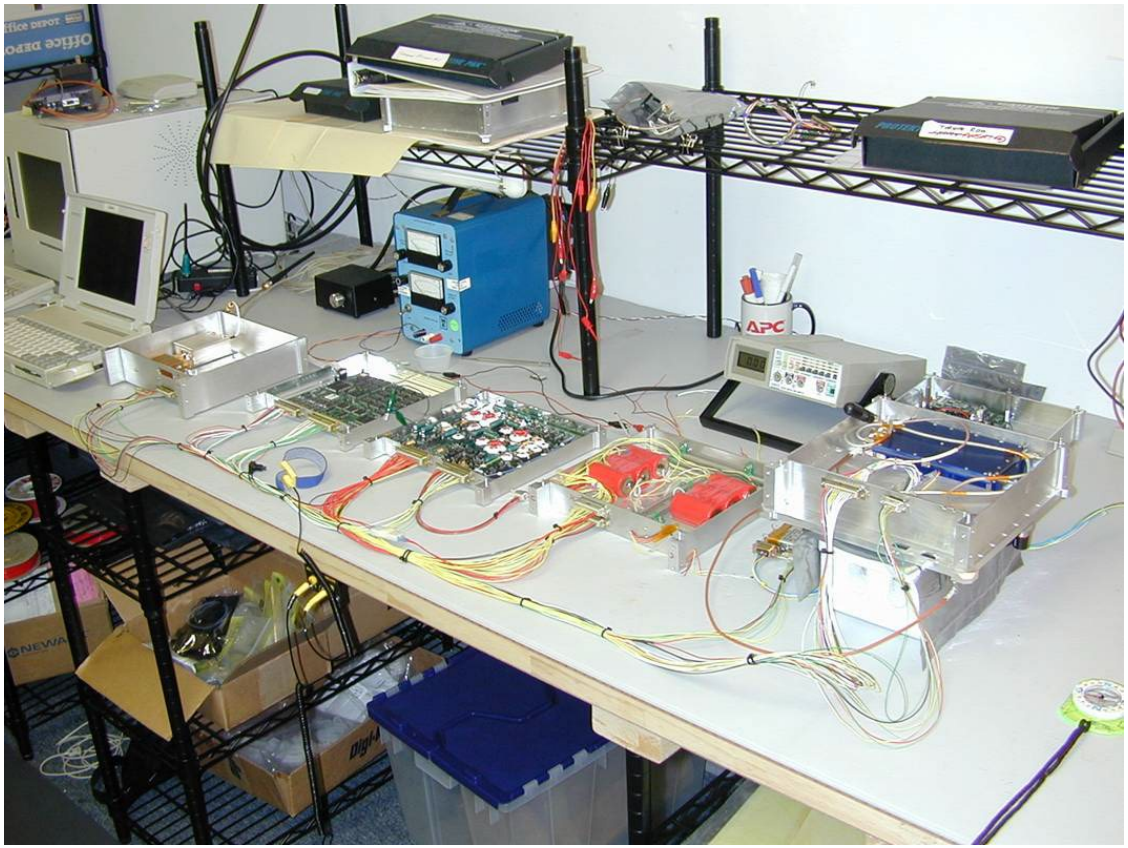
AO-E Recent Events

- 5-Aug-03 Meeting:
  - AMSAT project team of Dick Daniels W4PUJ, Tom Clark W3IWI and Rick Hambly W2GPS
  - SpaceQuest team Dino Lorenzini, KC4YMG, Mark Kanawati N4TPY and Bob Bruhns WA3WDR.
- Spacecraft integration in Dec 2003.
- Launch is scheduled for 31-Mar-04

AMSAT Echo project leader Dick Daniels W4PUJ (right) discussing the project with SpaceQuest's Dino Lorenzini, KC4YMG (middle) and Mark Kanawati N4TPY (left)

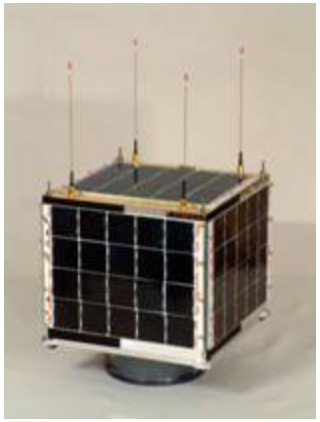
AO-E Recent Events

- 5-Aug-03: Demonstration
  - » data communications
  - » command & control
  - » attitude control subsystem
- “Flat-sat” configuration
  - » special wiring harness designed for this purpose.



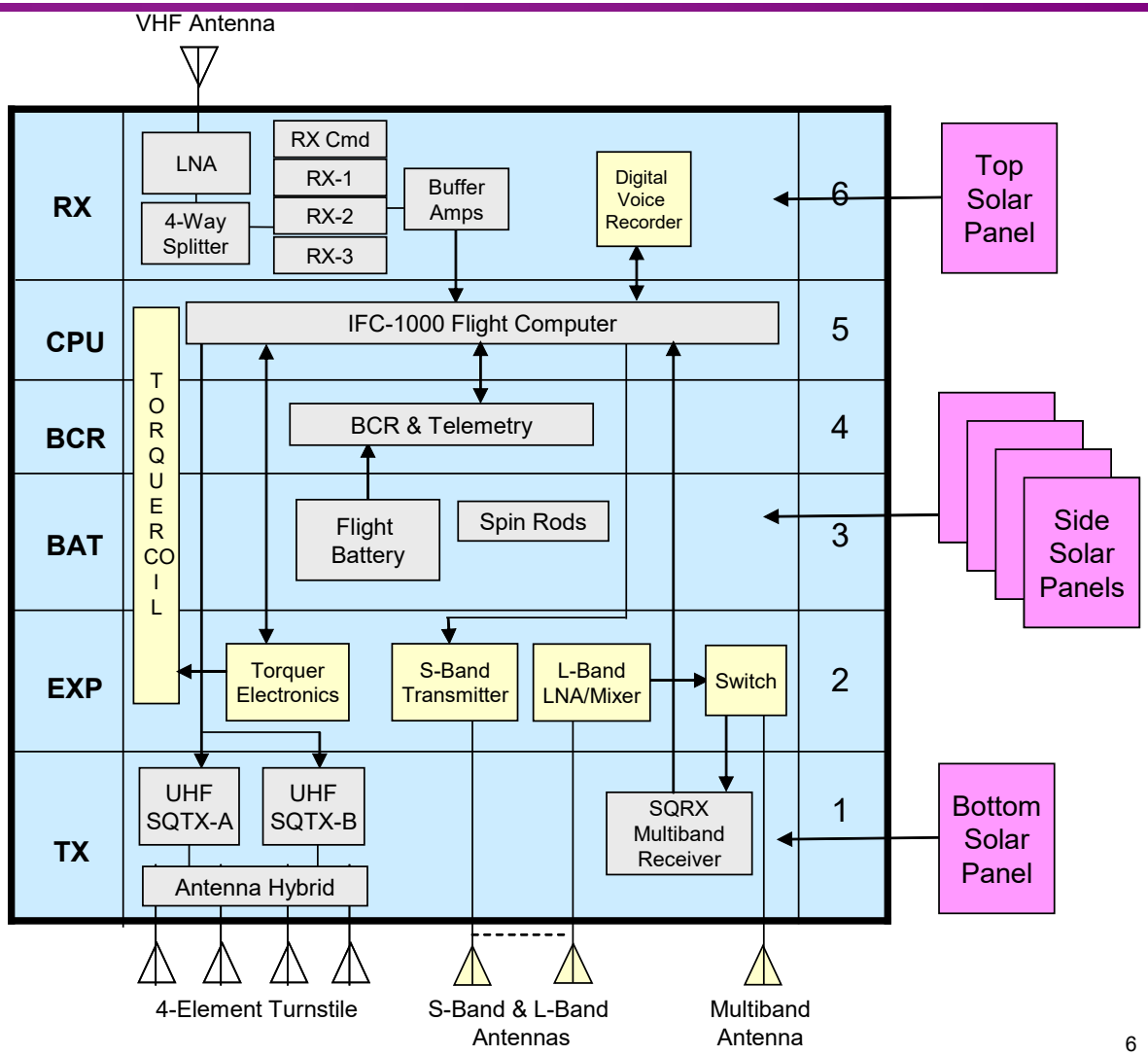
AMSAT OSCAR-E (AO-E) Features Summary

- Mode V/U, L/S and HF/U Operation
  - » V/S, L/U and HF/S are also possible
- Analog operation including FM voice.
- Digital operation
  - » Many speeds possible, 9.6, 38.4 and 57.6Kbps most likely.
  - » Store and forward
- PSK31 repeater mode using 10-meter SSB up and UHF FM down.
- Four VHF Rx and two UHF high power Tx.
- Can be configured for simultaneous voice and data.
- Has a multi-band, multi-mode receiver.
- Can be configured with geographical personalities.
- Advanced power management system.
- Active magnetic attitude control.



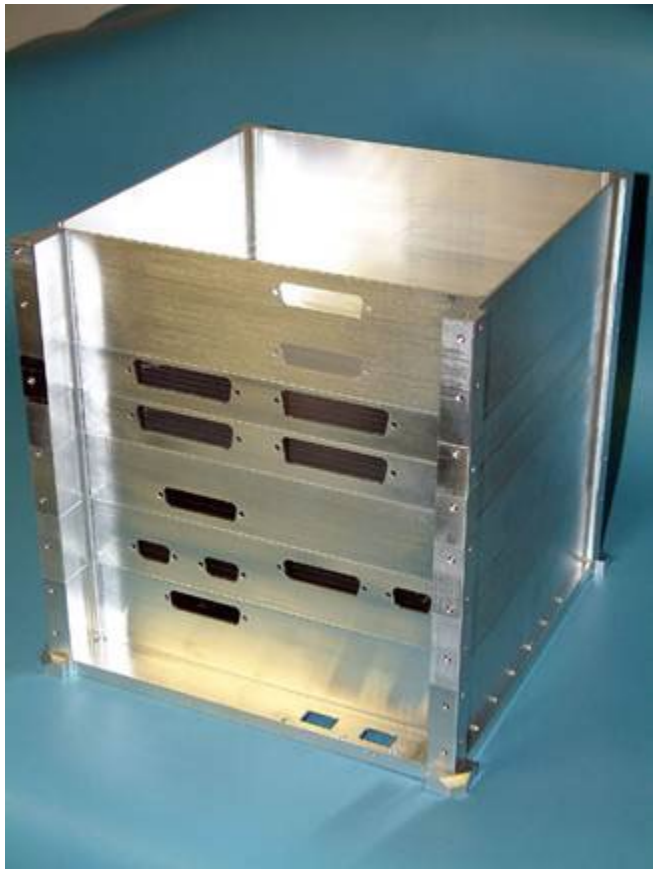
AO-E Technical Overview

- Four VHF receivers.
- A Multi-Band Multi-Mode Receiver.
- Two UHF transmitters.
- Six demodulators and two modulators.
- Integrated Flight computer.
- Batteries, BCR, Regulators
- Wiring harness, RF cabling.
- RF switching and phasing networks.
- 56 channels of telemetry.
- Magnetic attitude control.



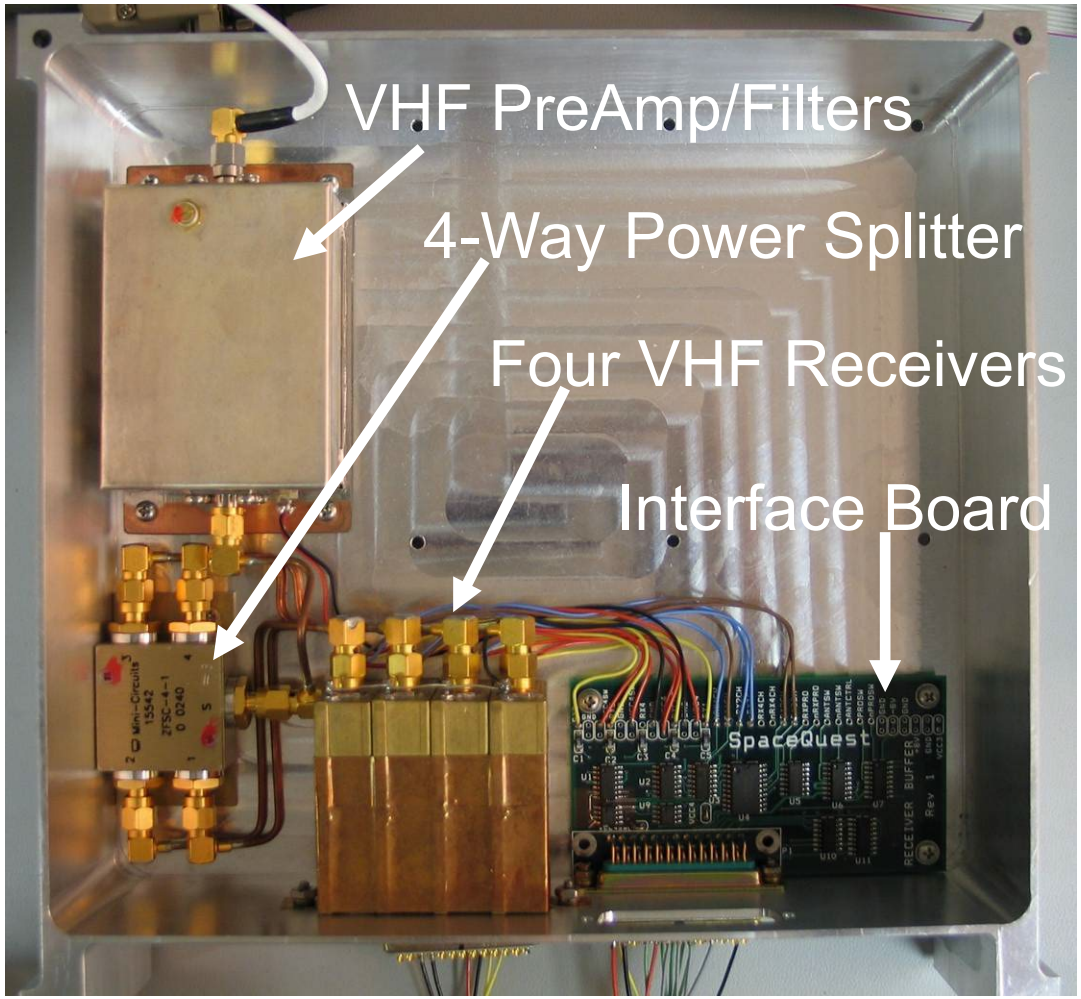
AO-E Structure

- Trays are made from solid blocks of 6061-T6 aluminum, stacked with stainless steel sheer pins and 4 4-40 tie-down rods.
  - Receiver tray: 58mm with 2mm base.
  - CPU tray: 24.8mm with 2mm base.
  - Charger tray: 24.8mm with 2mm base.
  - Battery tray: 38mm with 2mm base.
  - Payload tray: 58mm with 2mm base.
  - Transmitter tray: 39mm with 9mm base.
- Overall 9.5” x 9.5” x 9.5”.



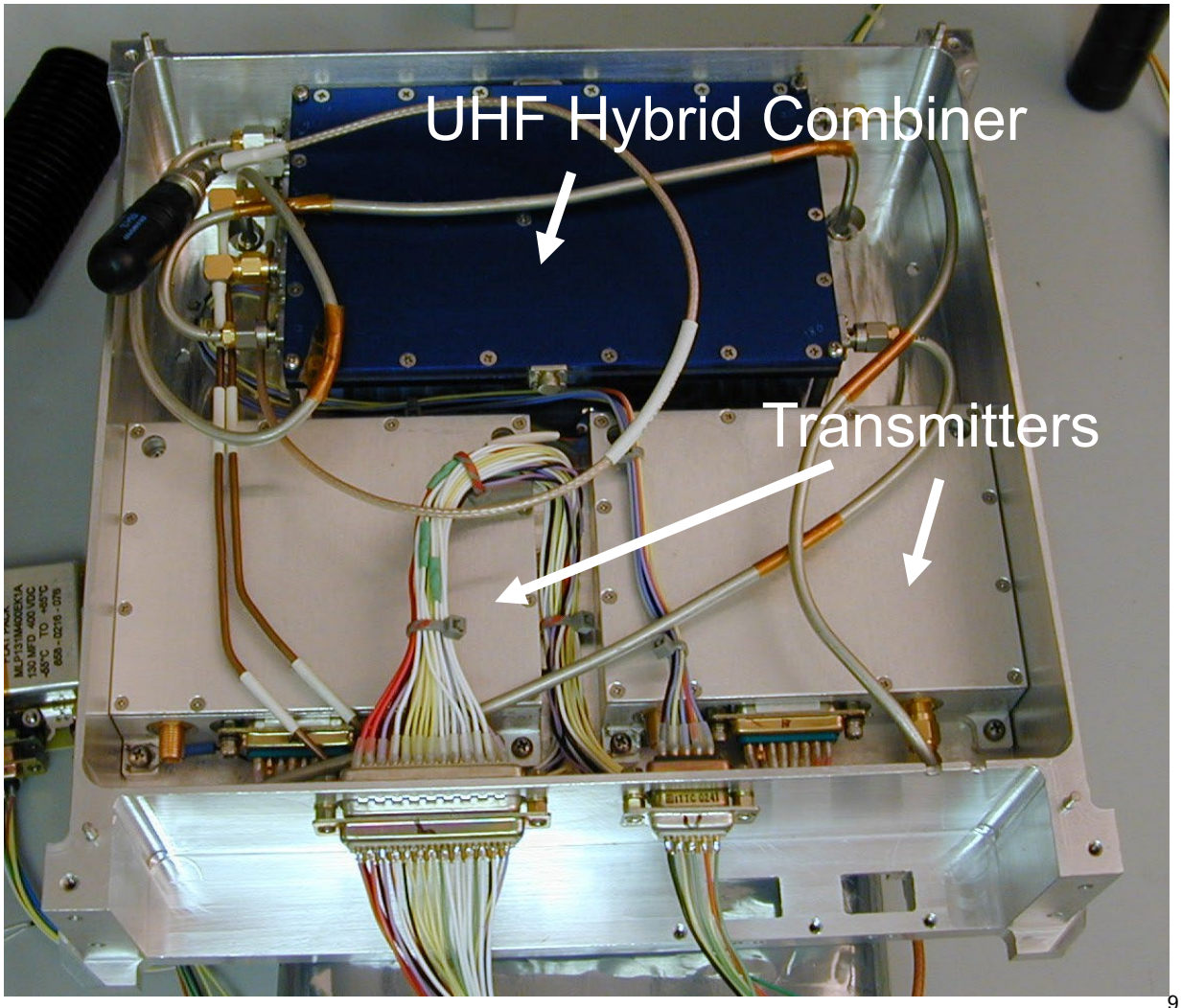
AO-E RF Subsystems Receivers

- 4 miniature VHF FM receivers
  - » <40 mW each
  - » <40 gm each
- Each receiver has 2-channel capability
- Sensitivity is -121dbm for 12db SINAD



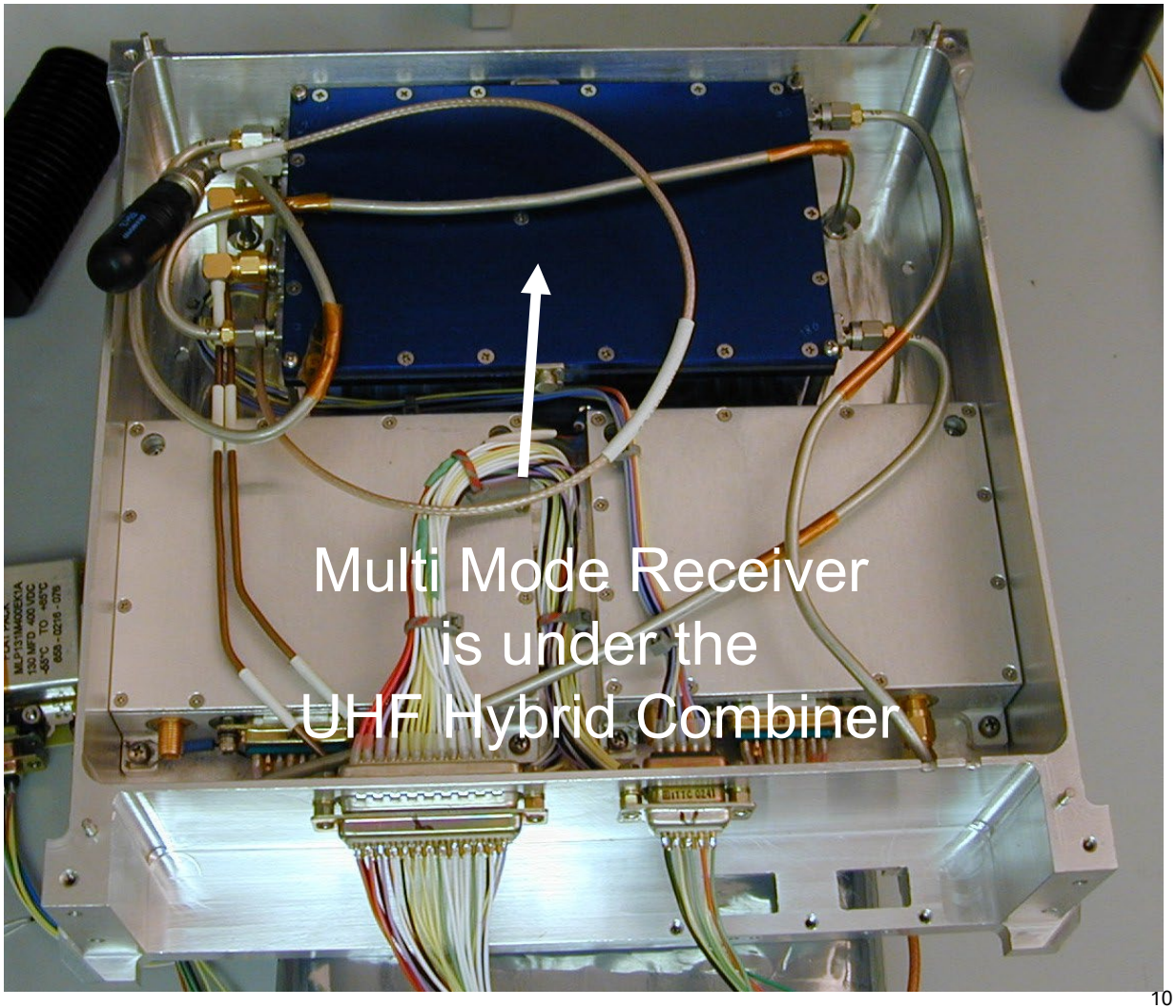
AO-E RF Subsystems Transmitters

- Two UHF FM transmitters that can be operated simultaneously.
- 0-8 watts output each.
- Frequency agile in 2.5KHz steps, tunable over about 20 MHz.



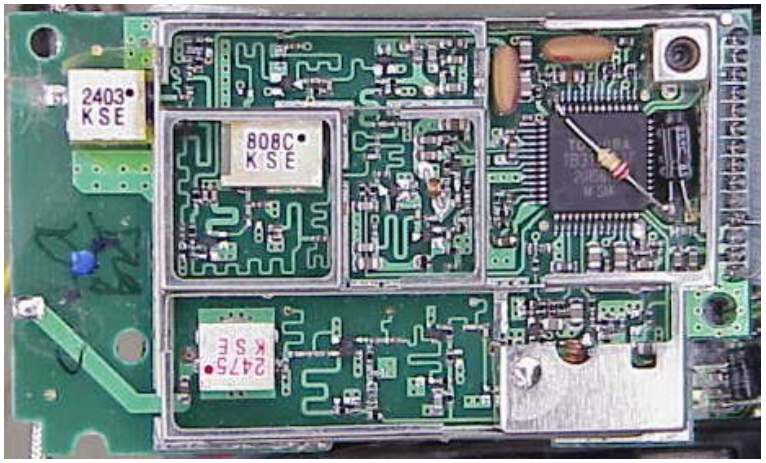
AO-E RF Subsystems
Multi-band Receiver

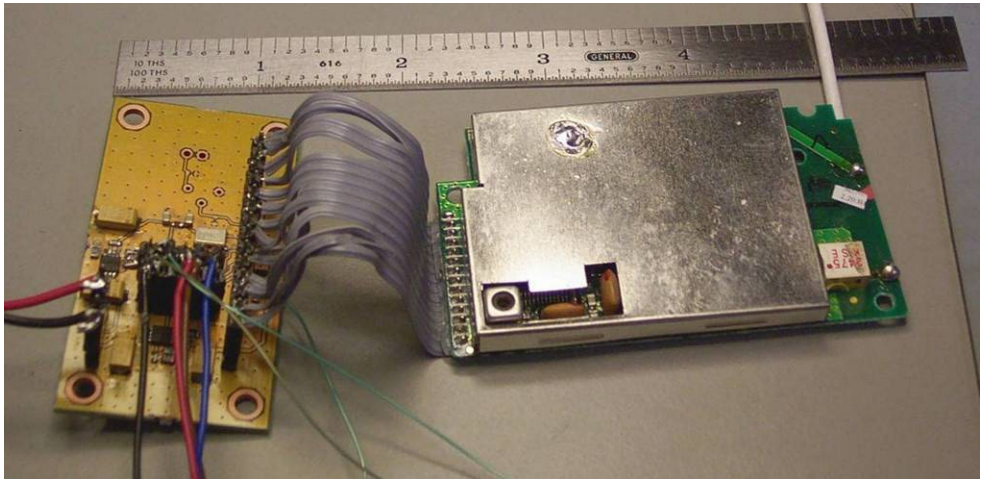
- All-mode, 10m, 2m, 70cm and 23cm.
- Performance limited by broadband antenna.



AO-E RF Subsystems
2.4 GHz S-Band Transmitter

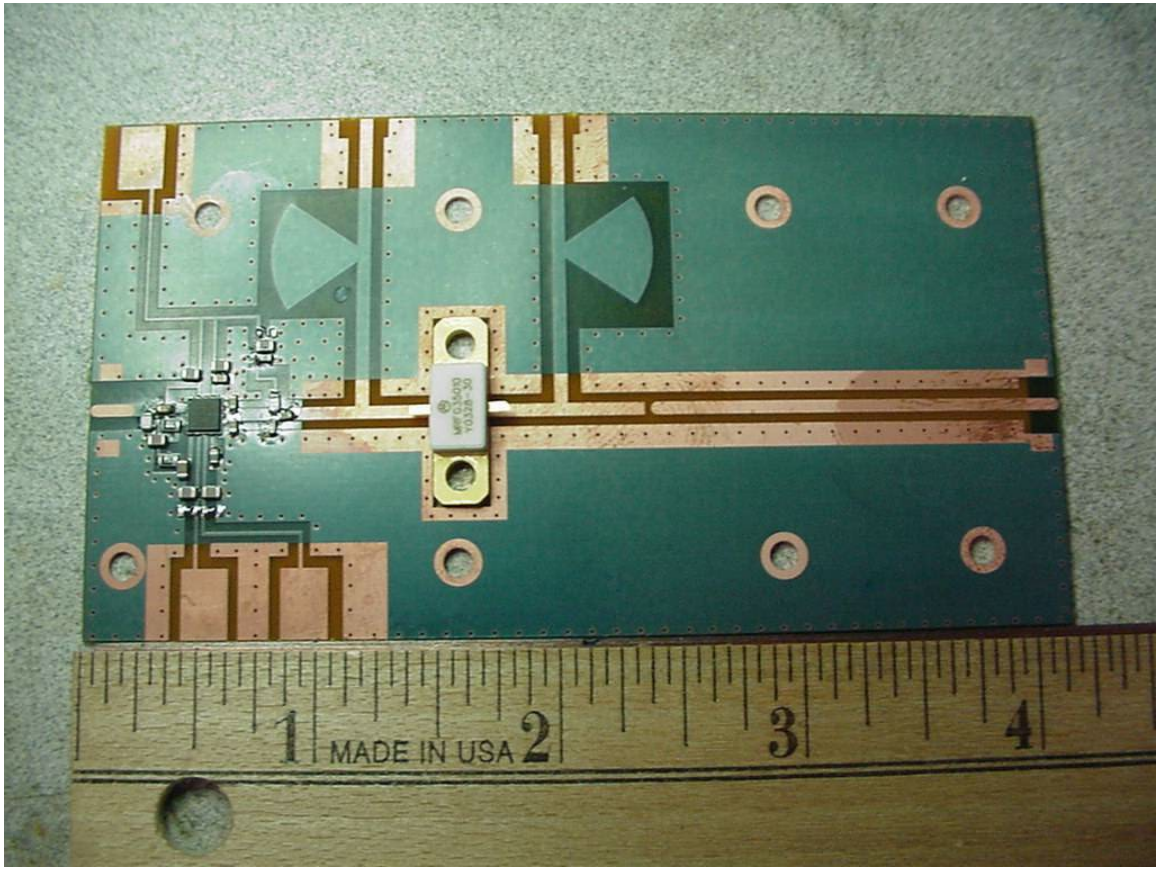
- Chuck Schultz KE4NNF – Exciter & interface board.
- Exciter draws 38.3 mA
- +5.0 dBm output(will be +6dbm).
- Will remove header/socket.
- Verifying programming & switch control sequences.
- Will adjust PLL loop filter bandwidth to reduce residual FM deviation by a factor of ten.





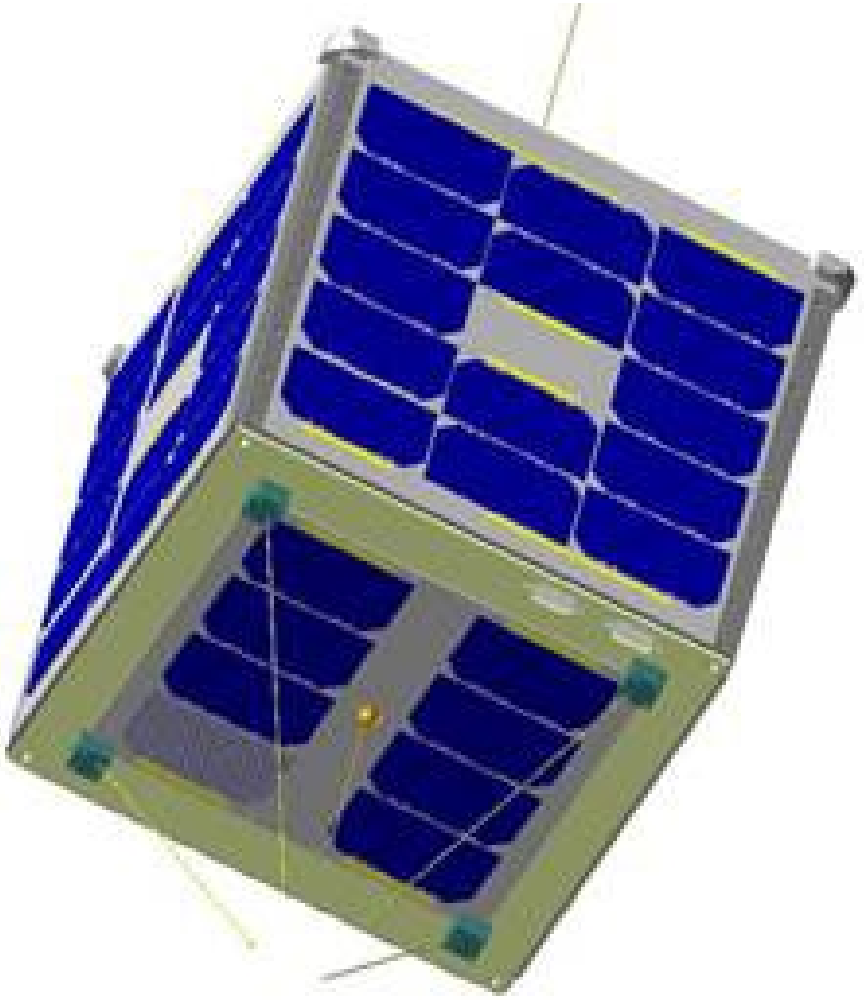
AO-E RF Subsystems
2.4 GHz S-Band Transmitter

- Harold Sanderson KT4XK - PA
- Working on interstage matching into a new Motorola GAS device.



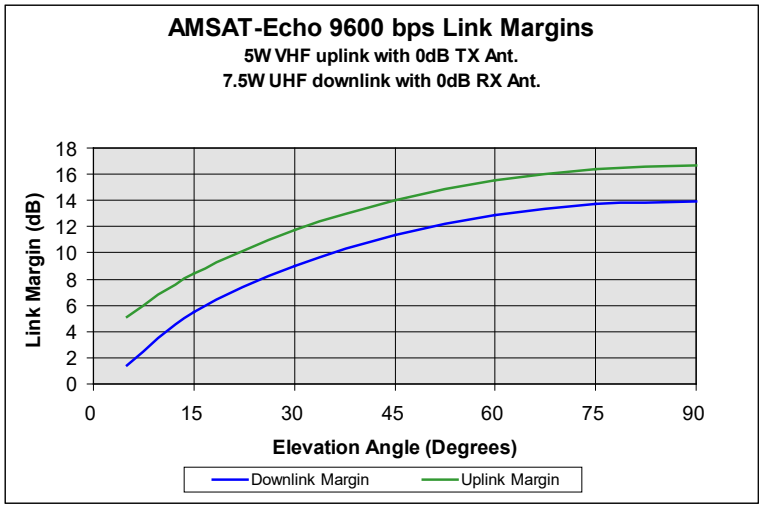
AO-E RF Subsystems Antennas

- VHF 18” whip on top.
- UHF “Mary” Turnstile on bottom.
  - One Tx RHCP
  - One Tx LHCP
- L+S band “open sleeve” antenna on the bottom.
- Multi-band Multi-Mode Rx shares VHF whip.



AO-E Link Budget

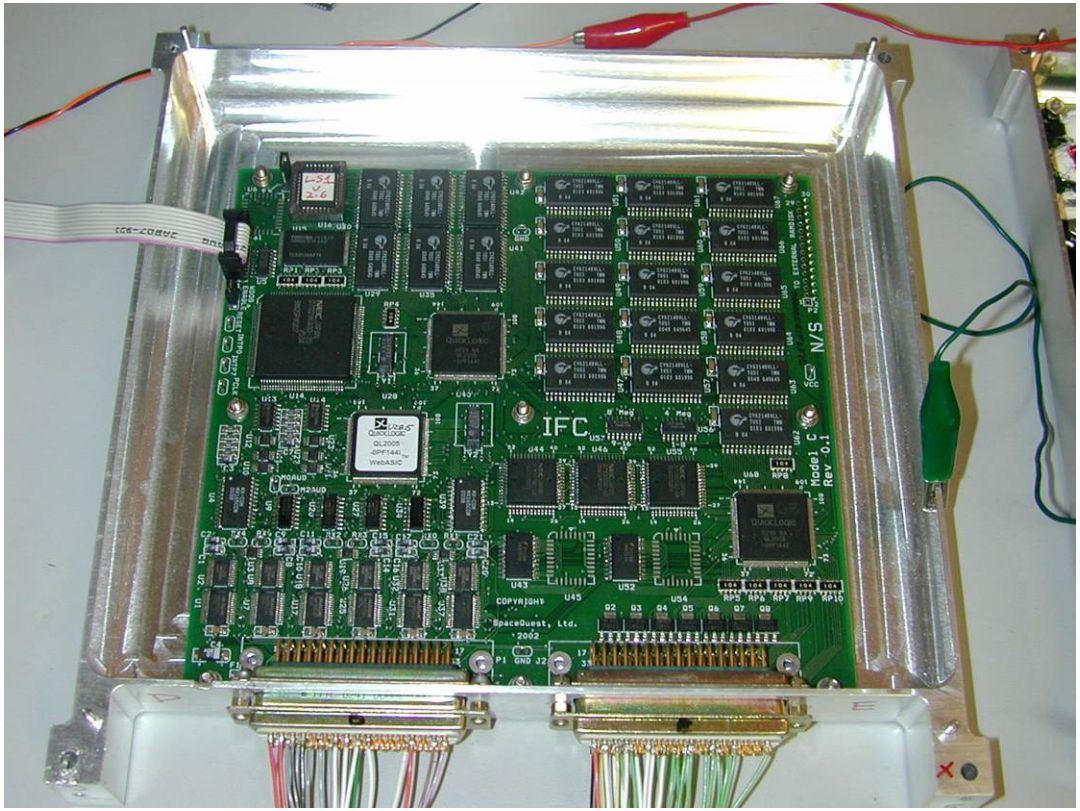
- Tx's adjustable from 1 to 8 Watts; max efficiency at 8 Watts.
- Modulation is baseband shaped raised-cosine-in-time FSK. Many speeds possible, 9.6, 38.4 and 57.6Kbps most likely.



- Antenna gain on the UHF is +2 dBic at +/- 45 degrees to -6 dBic at the backside of the spacecraft.
- VHF ant feeds LNA with 0.7db NF and 20db gain, then BPF with 1.5db loss. Overall Rx perf. -125 dbm for 12db SINAD.

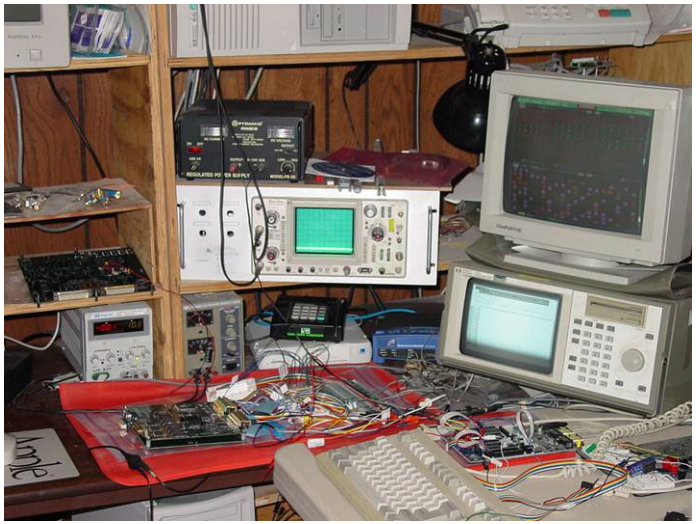
AO-E Integrated Flight Computer (IFC)

- Developed by Lyle Johnson KK7P.
- Flight proven, low-power < 300 mW,
- 6 Rx and 6 Tx SCC channels
- 1 MB EDAC, 16 MB RAM,16MB flash
- 6 agile demodulators
- 2 agile modulators



AO-E Spacecraft Flight Software

- Spacecraft Operating System (SCOS)
  - » Used on all Microsats
  - » Thanks to Harold Price NK6K for its use.
  - » Kernel port started. Enhancements planned for drivers and supporting S/W.
- Boot Loader
  - » Bob Diersing N5AHD
- Command And Telemetry Program
  - » Ground station
  - » Windows based - about 75% complete
- Boot Loader Prototype
  - » Ground station
  - » Windows based - done.



Jim White WD0E's Integration Lab

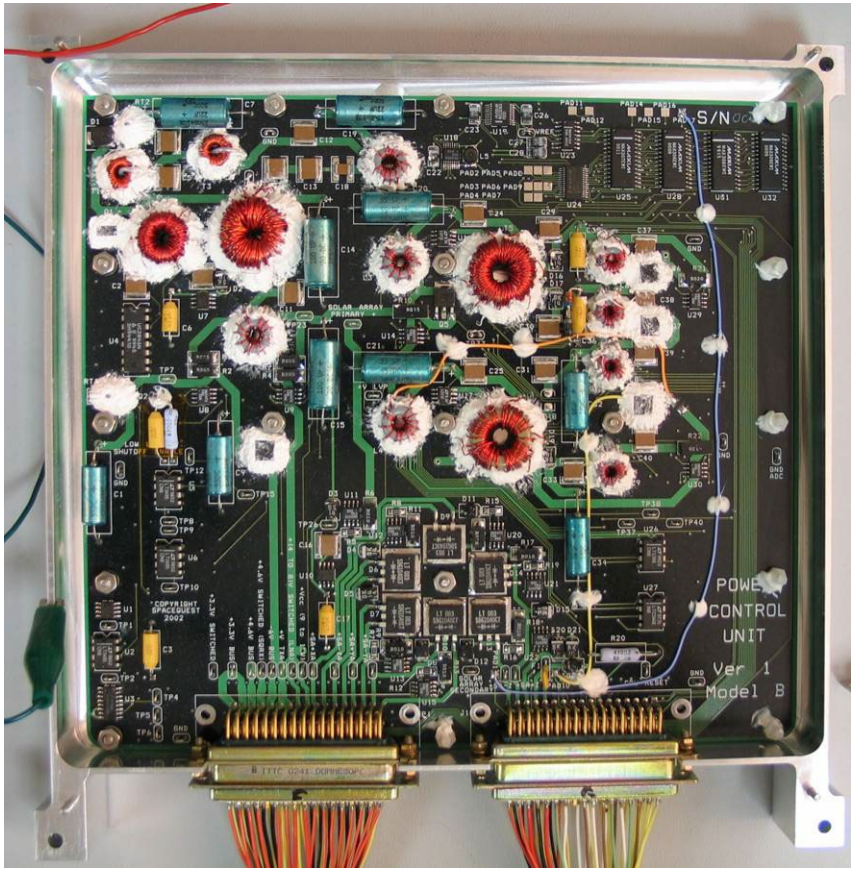
- Housekeeping task
  - » Has been created and will soon be tested.
- Communication protocol for the Digital Voice Recorder
  - » interface is documented.

AO-E Power Generation

- Six high efficiency Solar Panels
  - » Triple junction MCORE GaAs cells (~27%).
  - » ~20 Watts when not in eclipse (12-14 Watts per side).

Mark Kanawati N4TPY carrying $20,000 worth of solar cells and sooo casually spreading glue all over

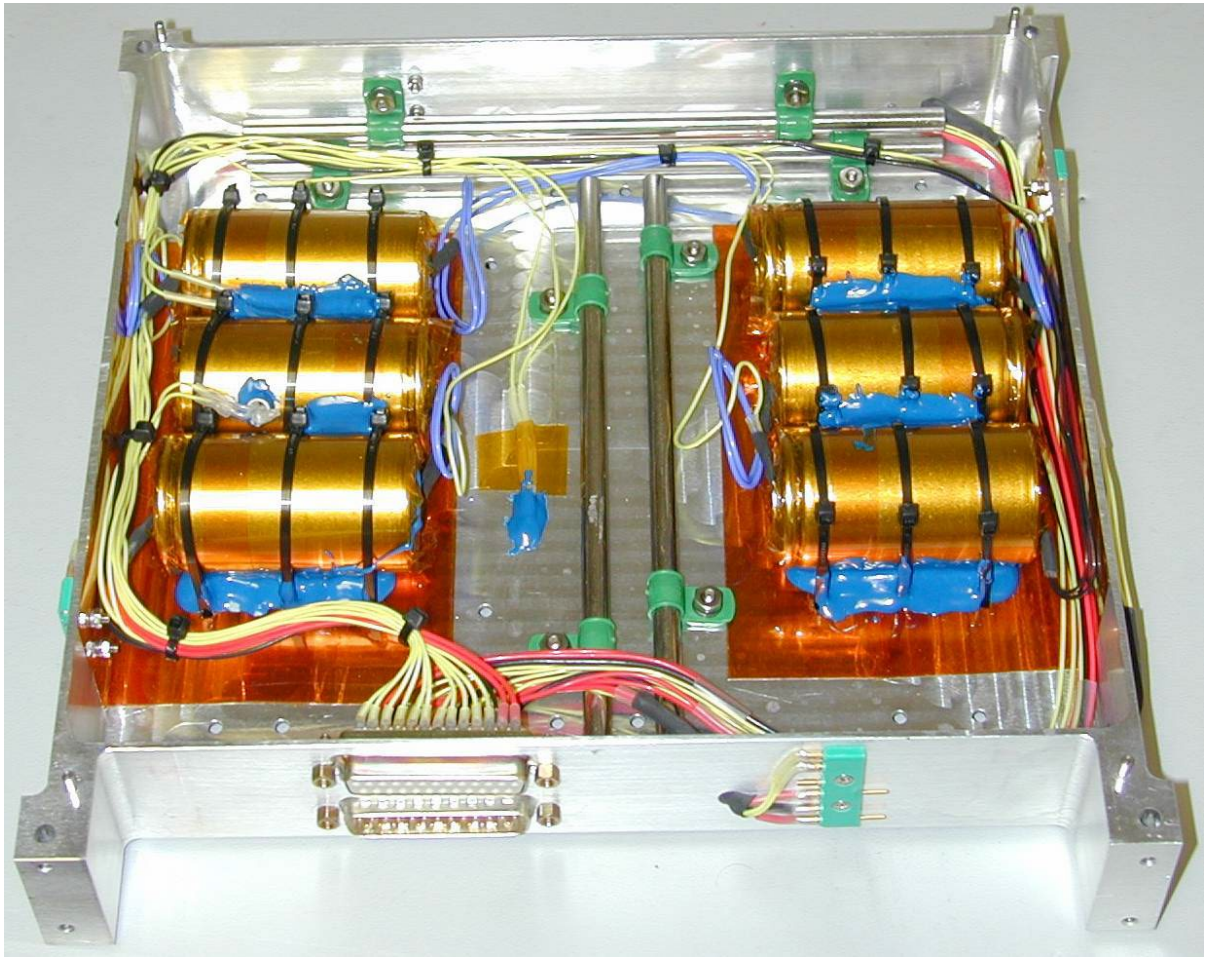
AO-E Power Distribution
Battery Control Regulator (BCR)



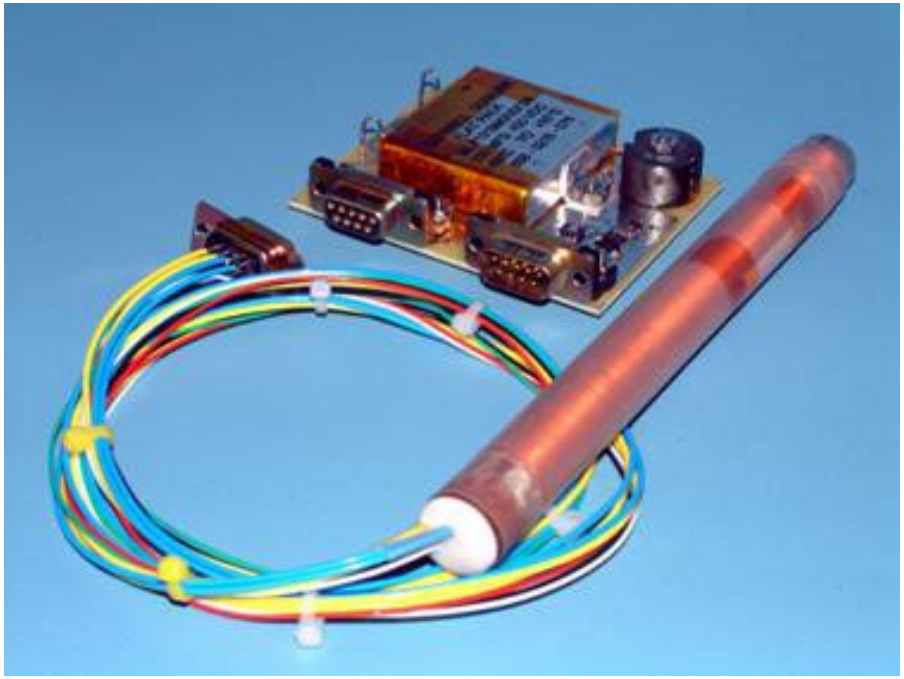
- Autonomous, fail-safe.
- Operates at 50KHz with 89% efficiency.
- Keeps the spacecraft alive at all costs.
- Charges the battery using only solar panel power, so will charge a dead battery.
- Prevents the battery from overcharging or depleting completely at any temperature
- Provides the necessary voltages and telemetry.

AO-E Power Distribution Batteries

- Matched set of six NiCd cells
- 4.4 Ah each, nominal 8 VDC.



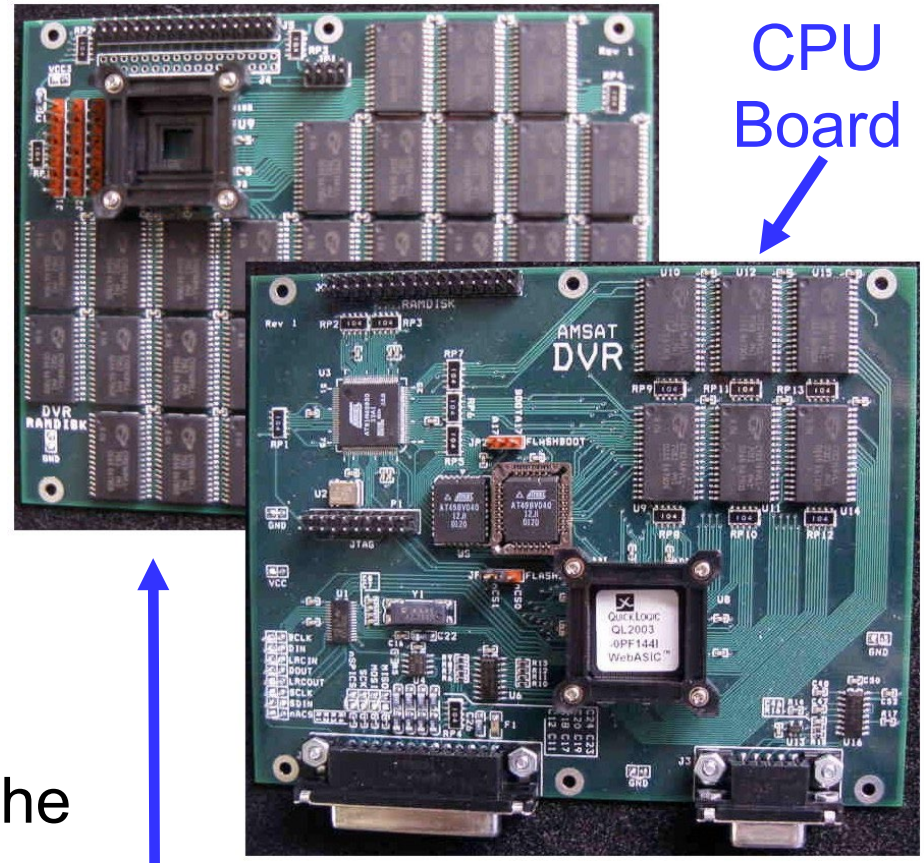
AO-E Attitude Control (Experimental)



- Active magnetic attitude control has replaced passive system.
- Doug Sinclair VA3DNS has implemented the torquer rod with electronics.
- Semi-permanent magnetic rods who's strength and polarity can be adjustable over a period of 15 seconds. (15 seconds give us maximum charge).
- It's possible to turn the satellite upside down.

Digital Voice Recorder (DVR)

- Multi-channel digital recorder.
- Samples audio from a selected receiver output at 16 bits/48 kHz.
- Playback on either downlink.
- Up to 64MB of RAMdisk storage, providing almost 12 minutes recording time.
- Based on the same ARM7 processor planned for use in the IHU3 for upcoming high-orbit missions.



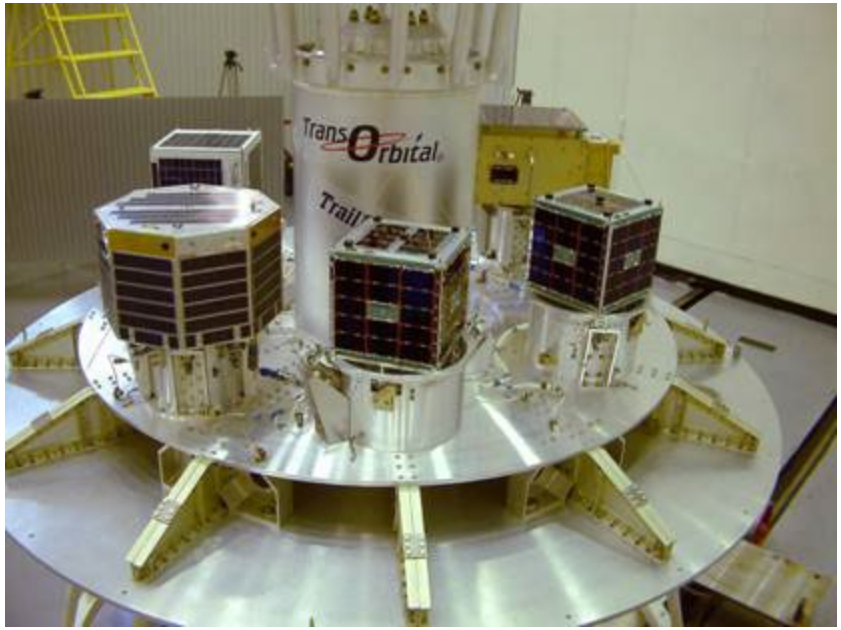
AO-E Status Update Integration

NASA Goddard Space Flight Center has returned the AMSAT Integration Lab to us!

- Thanks to Ron Parise WA4SIR and the GARC.
- Needs roof and floor repair.
- Furniture and test equipment will be provided.

AO-E Status Update
Launch

Launch planned for
March 2004



Two AprizeStar satellites by SpaceQuest ready for launch. These are very similar to AO-E.

Dnepr LV (SS-18) launch from Baikonur Cosmodrome in Kazakhstan, Dec 2002

Integration of MicroSats to Space Head

Space Head Loading into Silo

Dnepr Launch from Silo

AO-E Space for Optional Payloads

- Advanced Data Communications for the Amateur Radio Service (ADCARS)
- ☑ L-Band/S-Band Communications System
- Robust Telemetry Link
- GPS Receiver
- ☑ Active Magnetic Attitude Control
- ☑ Digital Voice Recorder (DVR)
- Low Frequency Receiver
- APRS
- ☑ PSK-31
- ☑ Multi-band Receiver/Antenna
- ☑ High Efficiency Solar Arrays

Advanced Data Communications for the Amateur Radio Service (ADCARS)

Apply digital encoding techniques to improve communication links and bandwidth utilization.

- Multi-band TDMA single frequency data link for multiple simultaneous users and modes.
  - » voice, data, video, telemetry, etc.
- S-band downlink, due to bandwidth requirements.
- L-band uplink.
- Optional signal regeneration.
- Optional integration with on-board systems.
  - » File transfer
  - » Telemetry
  - » Data communication
  - » MPEG recordings

Channel capacity:

$$C = B\log_2\left(1+\frac{S}{N}\right)$$

where:

C = channel capacity, bits/sec

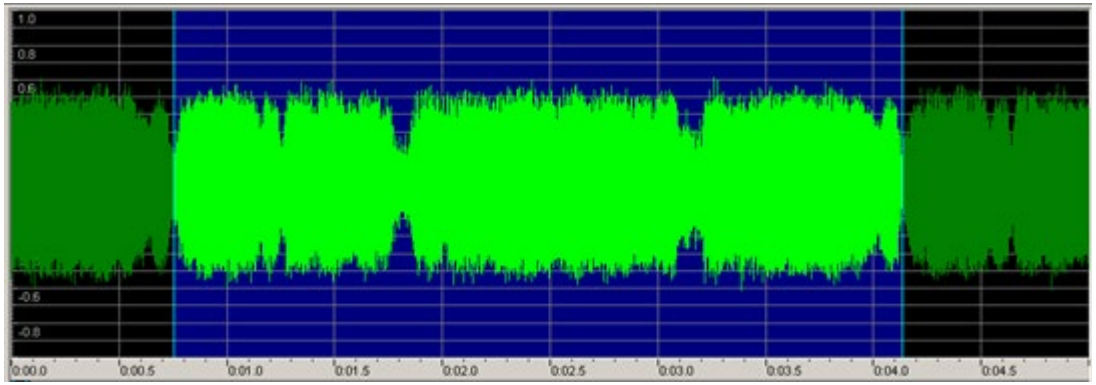
B = channel bandwidth, Hz

S = signal power, W

N = noise power, W

Robust Telemetry Link
Proposal for a FEC-Coded Telemetry Link

With FEC the bits corrupted in a fade can be regenerated from the others that are received. It doesn't matter how deep the fades are, as long as most of the frame gets through



AO-40 S-band telemetry as received by W2GPS and WB4APR using the 12-meter dish at the US Naval Academy on January 18, 2001. The time span is 3.38 seconds, the spin period at that time.

A short, deep fade that causes a single bit error is enough to destroy an entire frame even if the average Eb/No is high. AO-40's 11-second frame has multiple deep fades when the antennas are not earth-pointing so every frame is almost guaranteed to have at least one bit error.