Michigan Multipurpose MiniSat
M-Cubed

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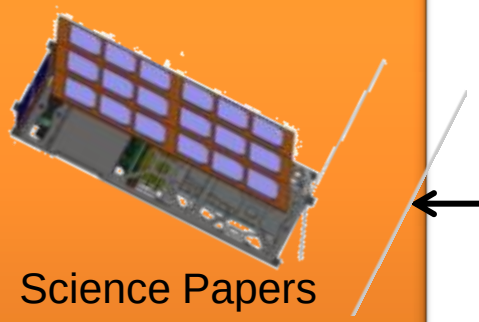
Summer CubeSat Workshop: 8/9/09

Michigan NanoSat Pipeline

Inputs

U of M Ideas
Innovative technology
Entrepreneurial thought

Outputs



Science Papers
Flight Heritage
Entrepreneurial outcomes
Educational experience
U of M Exposure

Fast Feasibility Study

Idea, Technology, & Facility Inventory

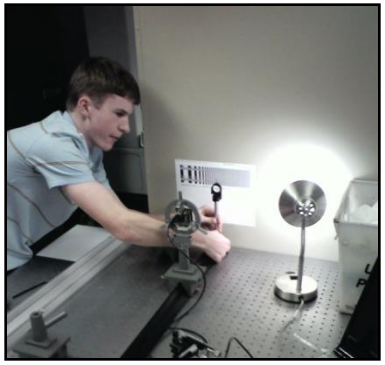
Concept design and Proposal

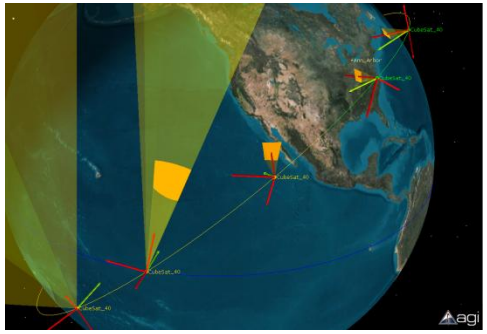
Design, Build, & Test

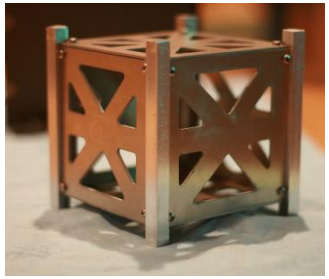
Spacecraft & Mission Ops

M-Cubed Overview

- Develop the first generation S3FL CubeSat to:
  1. Cultivate S3FL capability to develop, build, and operate a CubeSat system.
  2. Promote development of S3FL students through a interdisciplinary design, built, test environment.
  3. “Roll your own” subsystems to image the Earth’s surface in the visual spectrum
- With the success of this first CubeSat system, future missions can encompass more complex payloads while still building upon S3FL heritage designs.



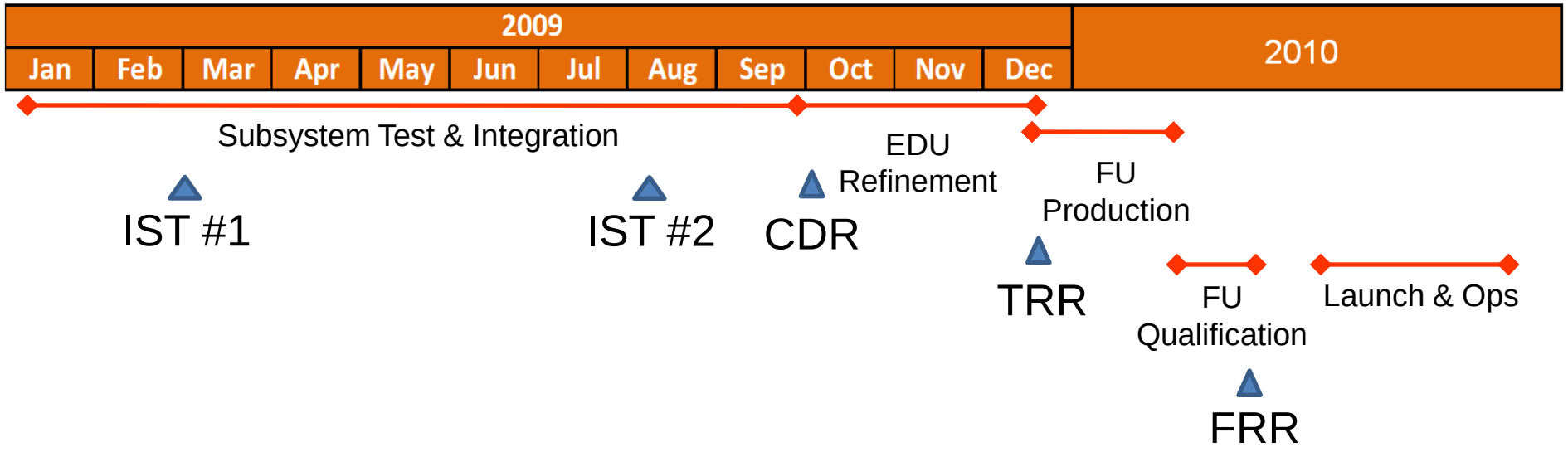




Baseline Design

- Payload
  - uEye CMOS 1.3 MP Camera Payload
  - Toradex Colibri PXA270 Processor
- C&DH
  - Atmega 164P Microcontroller
- Telemetry
  - Analog Devices 7020-1 Tx/Rx
  - 13.5 & 65 cm Antennas
- ADCS
  - Passive control with permanent magnets & hysteresis material
- Power
  - Emcore ATJ solar cells
  - Li-Ion 3.7 V 2.2 A-hr
- Structures
  - Custom design compliant with CubeSat specifications
- Harness Interface
  - Custom Header

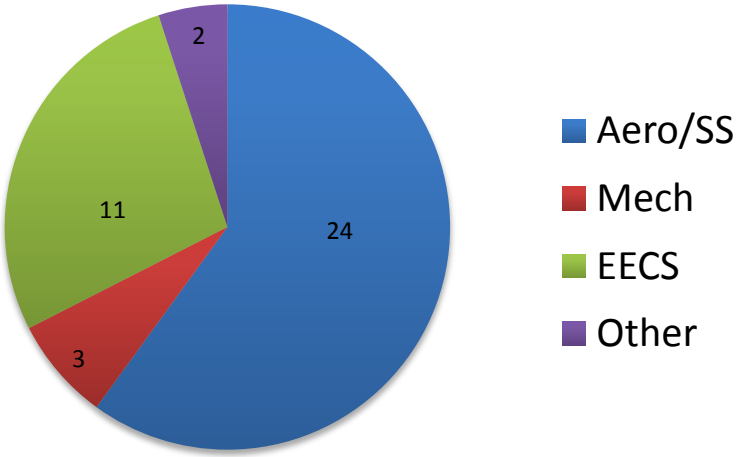
Schedule



- Goal of having subsystem integration complete by end of Summer
- Awaiting NASA BAA for a educational CubeSat launch opportunity in summer 2010

Personnel

- Expanded team to include new students to carry on knowledge following graduation of leads
- 36 undergrads + 4 graduate students involved



Payload Overview

- Design, validation, integration and testing of a system to:
  - Properly focus incident light
  - Trigger CMOS camera
  - Autonomously save image
  - Integrate with the Command and Data Handling subsystem
- IDS-UI-1646LE-C Color CMOS Camera
  - Resolution: 1280x1024 pixels
  - Pixel Size: 3.6x3.6 µm
- Plano Convex Glass Lens (12 mm Focal Length)
- Colibri Toradex PXA270

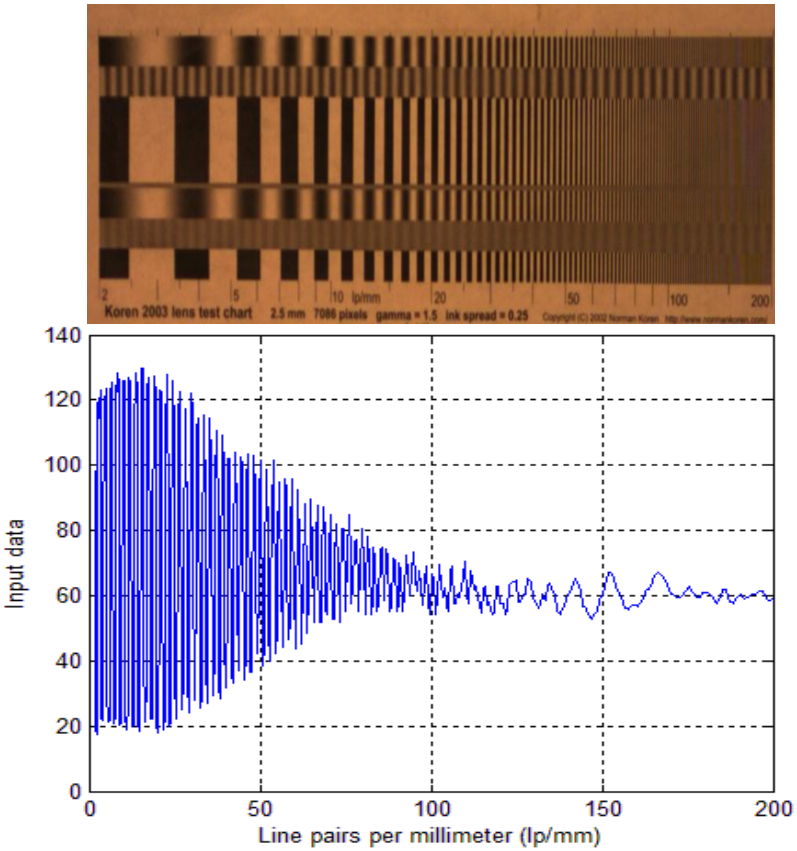
IDS-UI-1646LE-C CMOS Camera (left)

Colibri PXA270 Microprocessor (right)

Image taken at Michigan using selected IDS Camera and Lens

Completed Payload Testing

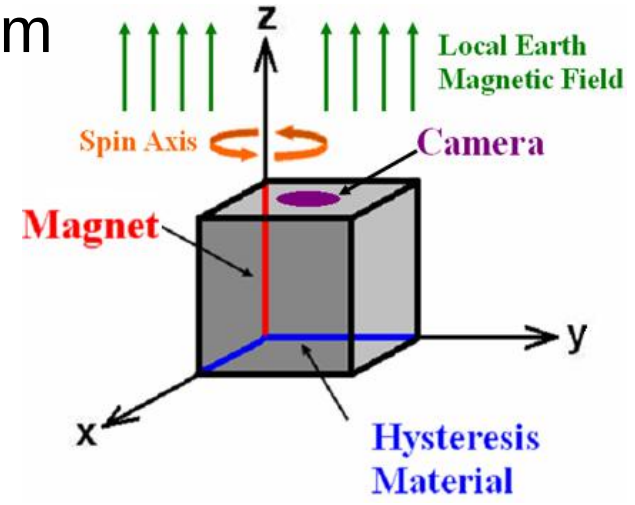
- Modulation Transfer Function (MTF) Quality
  - Method to quantify image resolution
  - Defines a 'good' picture
  - 50% MTF ~60 line pair/mm
- Rotation Effects
  - Used rate table to quantify blurring
  - Negligible blurring effects for spin rate of 7° /sec
- Vacuum Survivability
  - Making sure camera survives thermal vacuum environment

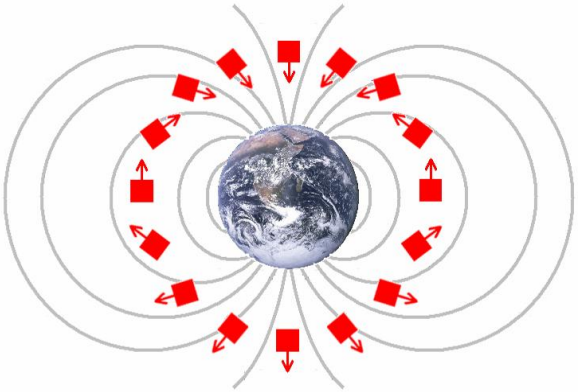


Resolution test image (top) and corresponding MTF plot (bottom)

Passive Attitude Control

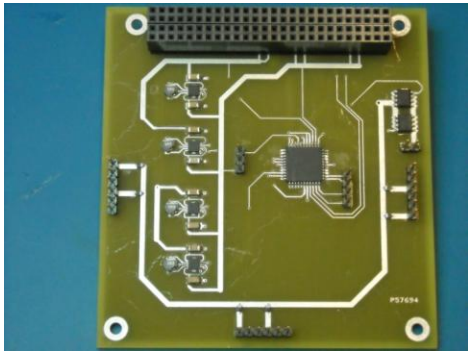
- Passive magnetic attitude control system
  - Permanent magnet
    - Aligns camera axis with local magnetic field
  - Hysteresis materials
    - Dampens angular velocities
- Justification over active control system
  - No power consumption
  - Less mass
  - Mission requirements can be fulfilled without full attitude determination
- Heritage on Earth-imaging missions
  - University of Tokyo: XI-IV ~ 4 years
  - University of Tokyo: XI-V ~ 2 years
  - University of Louisiana: CAPE-1 ~ 6 months
- Materials
  - Magnet – Alnico 5
  - Hysteresis – HyMu 80



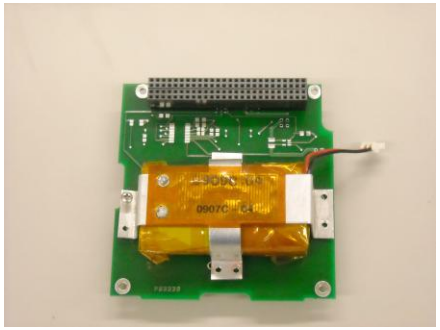


Electrical Power System

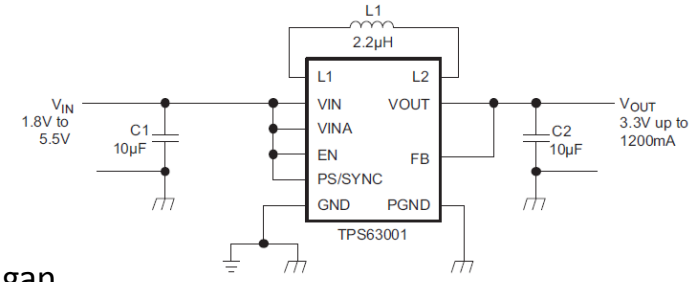
- Emcore ATJ solar cells
- Lithium ion battery
  - 3.7 V, 2.2 A-hr Panasonic 18650 cell
- Direct energy transfer topology
- Buck-boost DC-DC converters for regulation
  - TI TPS63000 series chips
- LTC2309 ADC for health telemetry data



Prototype EPS Board

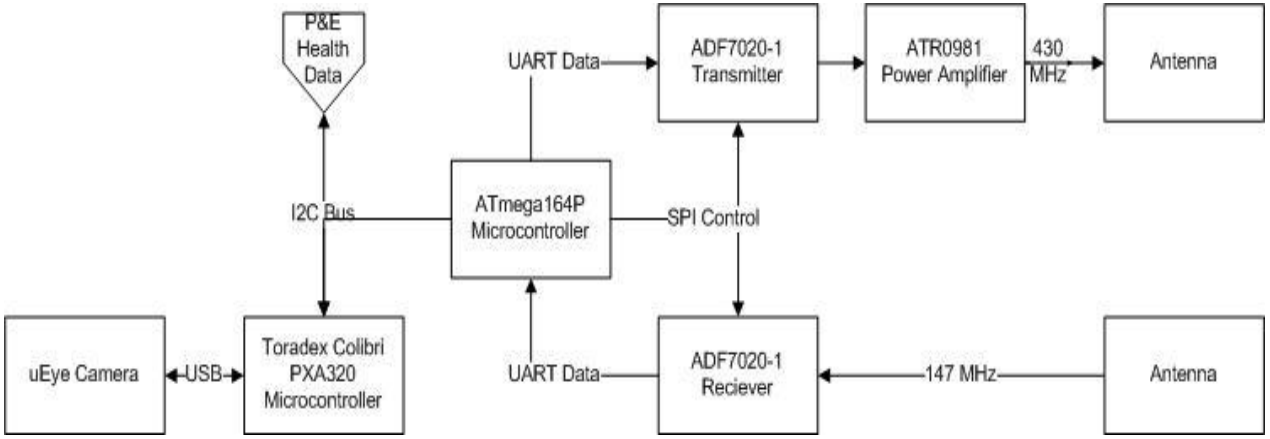


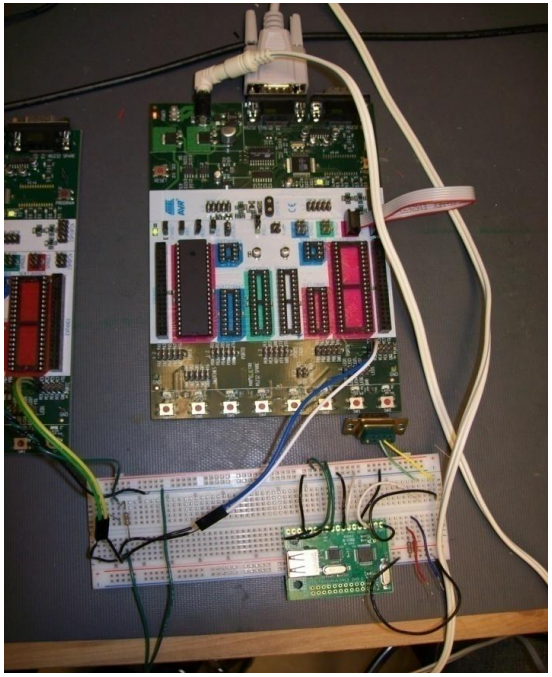
Prototype Battery Board



Command and Data Handling

- Flight Computer: Atmel 164P Microcontroller
- Prototype Board Operational
  - Real Time Clock, Watchdog Timer, SPI Communication, EEPROM Storage, Radio Transmission, USART Communication



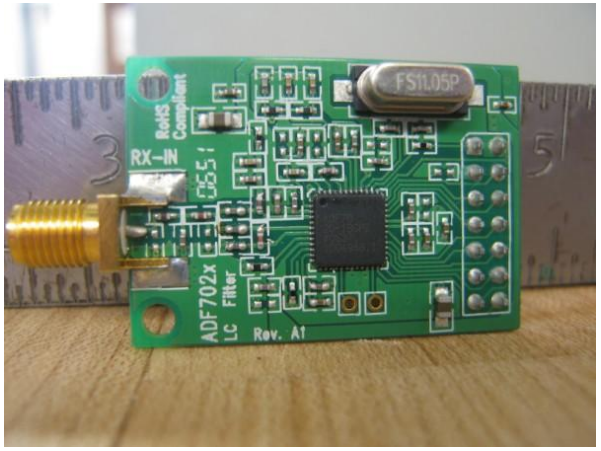


STK500 Demoing I2C

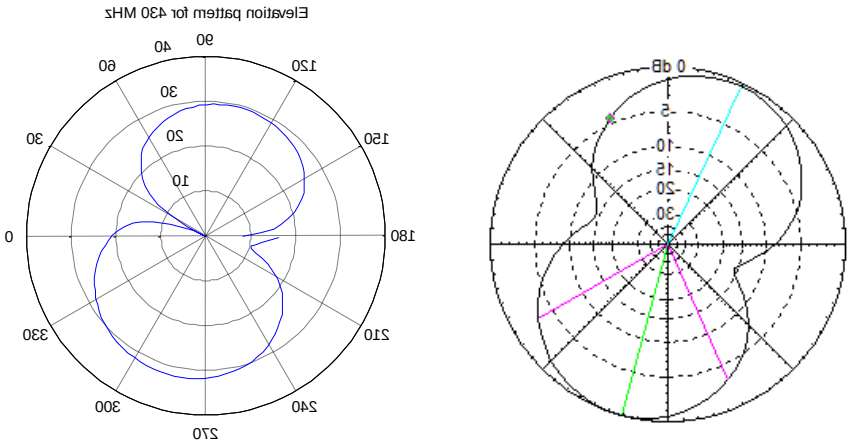
Atmel 32AP7000. Same line as 32AP7002. Actual dimensions: 12 x 12 mm

Telemetry

- AD7020-1 Tx/Rx Radios
  - Transmit@430 MHz
  - Receive@ 140 MHz
- Spring Steel Antennas
  - Length 1 16.5 cm(430 MHz)
  - Length 2 65 cm(140 MHz)
- Sharing Umich Ground Station resources with RAX
- AX.25 Transmission Protocol

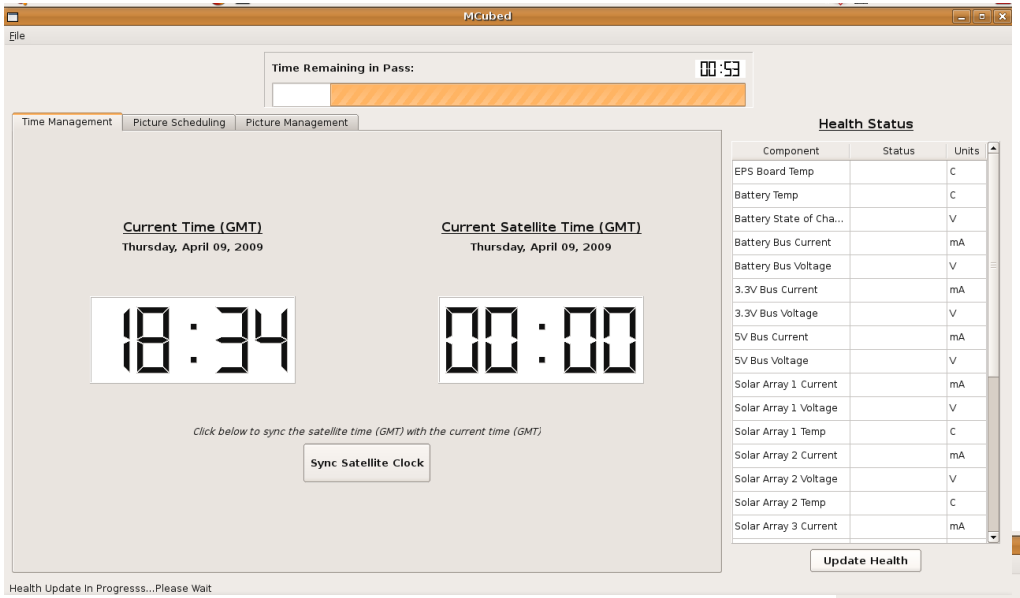


AD7020-1 Radio

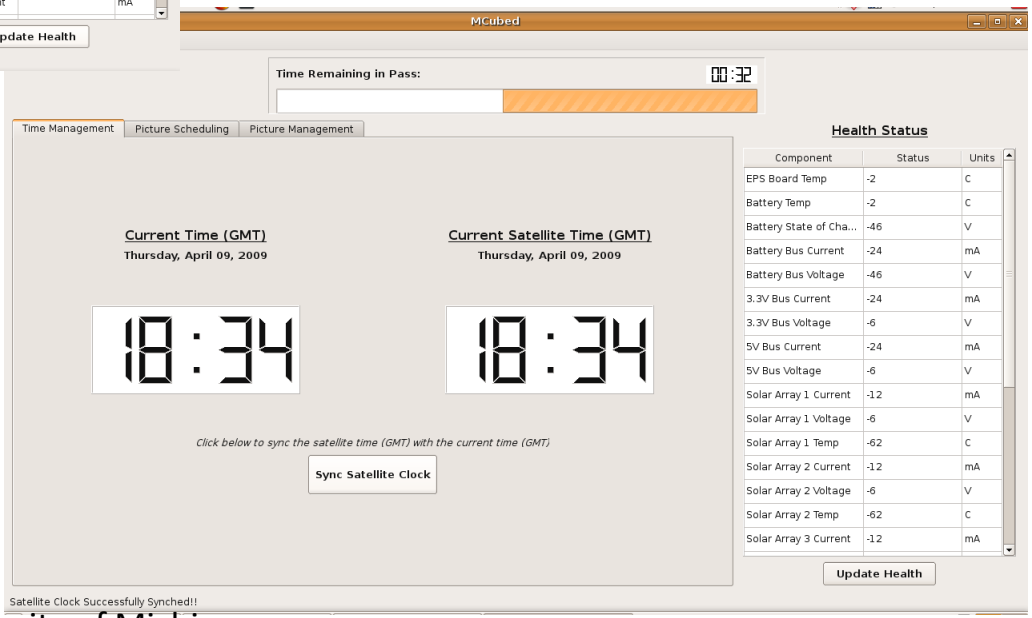


Antenna Skewing Tests
Simulation (right), Actual (left)

Operations SW Beta Images

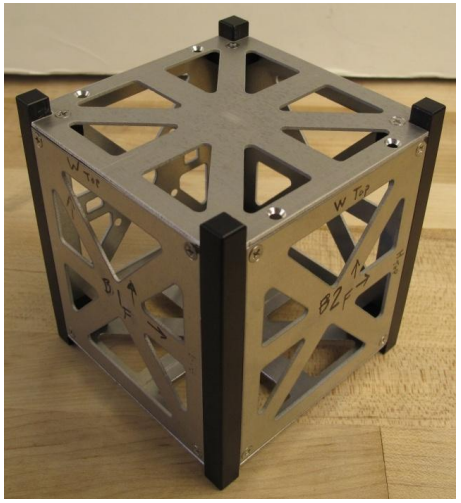


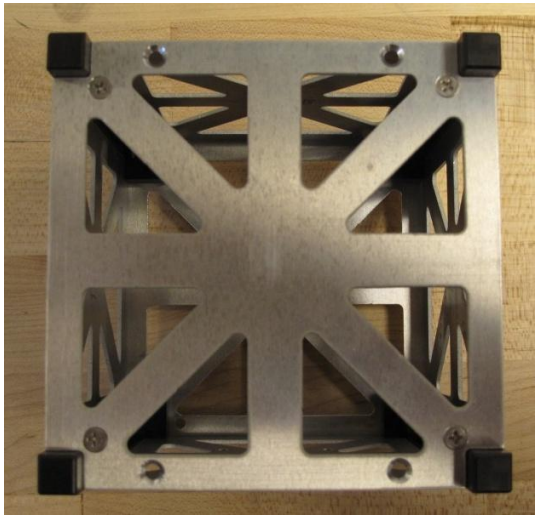
Start of a pass

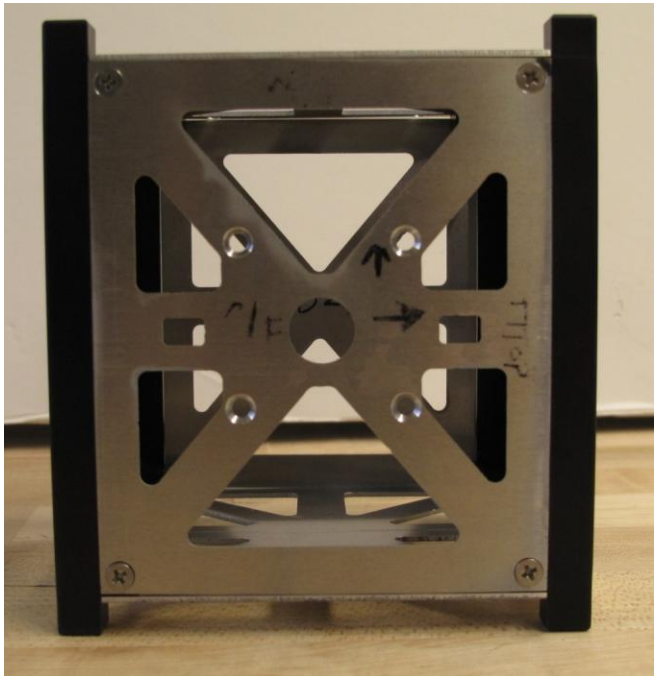


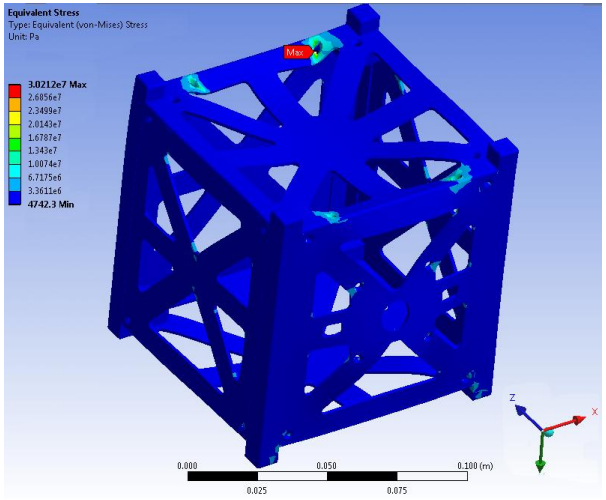
Time synchronized, health updated

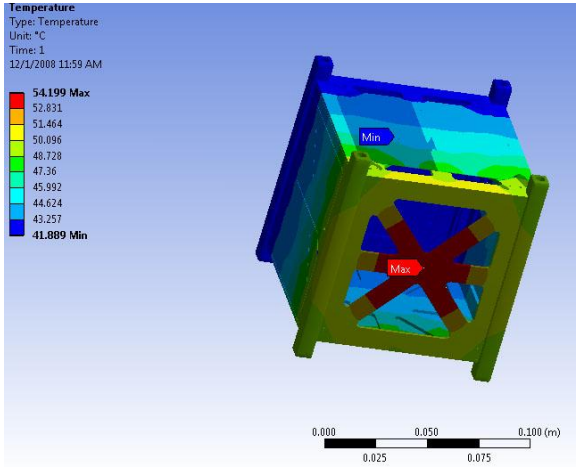
Structures





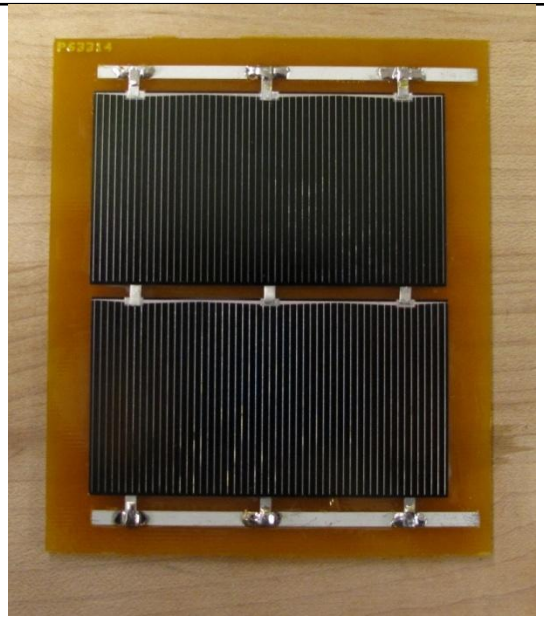


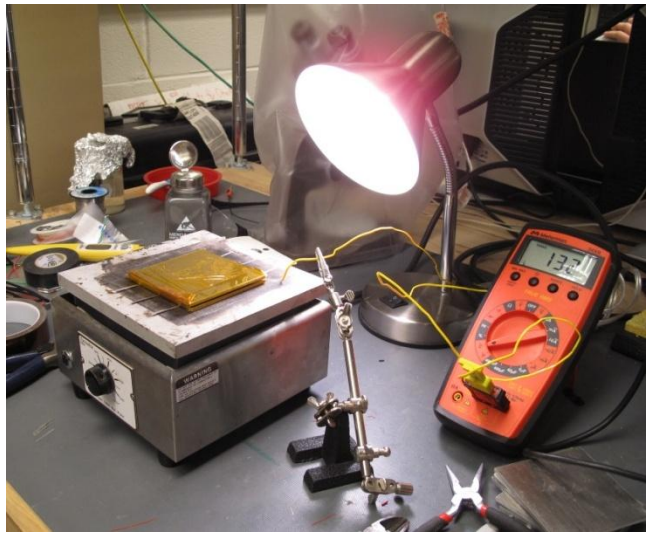

Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: Pa
3.0212e7 Max
2.6856e7
2.3499e7
2.0143e7
1.6787e7
1.343e7
1.0074e7
6.7175e6
3.3611e6
4742.3 Min
Max
0.000
0.050
0.100 (m)
0.025
0.075


Temperature
Type: Temperature
Unit: °C
Time: 1
12/1/2008 11:59 AM
54.199 Max
52.831
51.464
50.096
48.728
47.36
45.992
44.624
43.257
41.889 Min
Min
Max
0.000
0.050
0.100 (m)
0.025
0.075

Solar Panel Development

- Develop in-house solar panel manufacturing capabilities
- Manufacturing process tested using expendable cells
- Final panels to include
  - Emcore ATJ cells
  - 0.031” PCB backing
  - NuSil space-grade silicone adhesive





HAS Update

- Conducted 4 successful Balloon flights during summer
- Developed reliable, redundant tracking
  - AeroComm (900 MHz)
  - TNC-X / Radio (Amateur Radio)
  - MicroTrak (APRS)
  - Cellphone tracker (Cell Network)
- Successfully demonstrated 2-way communication and In-flight Cut Down
- Flew Radio Interference Survey Instrument