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

Processes:
- 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 an 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

**2009**

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**2010**

- **Subsystem Test & Integration**
- **EDU Refinement**
- **FU Production**
- **FU Qualification**
- **Launch & Ops**

**Key Points:**

- **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
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
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
Operations SW Beta Images

Start of a pass

Time synchronized, health updated
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