SupportSat

Critical Design Review
University of Colorado Boulder
2 April, 2004

Project Managers:
John Chouinard
Brian Taylor
Mission Description

- Gather magnetometer interference data
- Test intelligent pixel matching operations
Mission Goals and NASA Benefits

- Show effect of flight equipment on magnetometer readings
- Demonstrate intelligent pixel matching algorithm
  - Scale and make images linear
  - Find ground features
  - Match pixels between subsequent pictures
- Steps for stereoscopic imaging
System Requirements

• Testing equipment to be used on DINO spacecraft
  – Mission: determine cloud heights from space

• All sub-systems using DINO equipment except for power and thermal

• Power and thermal
  – Must remain powered throughout flight and above 0° C
  – Components should be light weight
Project Organization
Colorado Space Grant Consortium
SupportSat

John Chouinard
and
Brian Taylor
Co-Project Managers
and
Systems Team

ADCS
Lisa Hewitt
Pham, Steven
Poteraj, Jaclyn

Science
William Willcockson
Espisito, Ariel
Rubin, Casey

Power/Thermal
Paul Roberts
Brewley, Justin
Nervais, Fabien

C&DH/Software
Joe Wang
Kirby, James
Lindberg, Derek

Structure/
Mechanisms
Andrew Young
Handley, Ward

Rivera, Juan
Attitude and Determination
Control Systems

Team Lead: Lisa Hewitt
Mission

• To use gyroscopes to determine attitude of SupportSat aiding intelligent imaging operations
• To test DINO’s magnetometers, gyroscopes, and their respective interfaces
Honeywell HMC 2003 Magnetic Hybrid

• The magnetometers were selected in order to test the equipment that DINO will be flying
• The magnetometers will test interface data to be analyzed for use by DINO
• Interface Requirements: Three channel analog to digital converter per magnetometer
Analog Devices ADXRS150

- The gyroscopes were chosen because DINO will be using them.
- The gyroscopes will take frequent samples of the positioning of the satellite to maintain and monitor camera position.
- Interface Requirements: One channel analog to digital converter per gyroscope.
Analog to Digital Converters

Multiplexer:
ADG426
- 16 channels
- Low power
- Low resistance
Will sample data from each device then relay data through one output to converter

A/D Converter
Max164
- 12 bit
- CMOS
Will take analog input data from multiplexer and convert to digital data to be sent to the flight computer
Flight Readiness

• Order parts
• Test interfaces once parts are received
• Test equipment under wind simulations comparable to flight conditions
Test Plan

• Run equipment under similar flight circumstances to ensure proper operation and interface
Issues and Concerns

• Possible software incompatibility of the converters with the flight computer
# Budget

<table>
<thead>
<tr>
<th>Name</th>
<th>Cost</th>
<th>Weight</th>
<th>Power</th>
<th>Thermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetometers</td>
<td>$398</td>
<td>&lt;200g</td>
<td>12V @ 20mA</td>
<td>-40C to 85C</td>
</tr>
<tr>
<td>Gyroscopes</td>
<td>$99</td>
<td>&lt; 1.5g</td>
<td>5V @ 6mA</td>
<td>-40C to 85C</td>
</tr>
<tr>
<td>A/D converter</td>
<td>Free (Samples)</td>
<td>~ 2g</td>
<td>5V @ 6mA</td>
<td>-40C to 85C</td>
</tr>
<tr>
<td>Multiplexer</td>
<td>Free (Samples)</td>
<td>~5g</td>
<td>12V @ 20 mA</td>
<td>-40C to 85C</td>
</tr>
</tbody>
</table>
Science Team

Team Lead: William Willcockson
Mission

• Prepare Canon Digital Rebel camera for flight
• Develop image analysis algorithm to be used in-flight
Canon Digital Rebel

- Identical to the cameras to be flown on DINO
- Terrain features in preview shots will trigger hi-res shots
- USB for picture downloads, digital I/O for camera configuration
Sub-System Interfaces

- Digital I/O inputs from the flight controller to receive configuration commands
- USB for image capture commands and image uploading
Flight Readiness

- Camera must be hooked up to its digital I/O lines
- Camera must be integrated into the balloon-sat
Test Plan

- Image analysis algorithm will undergo ground testing
- Camera will be tested to confirm its operational readiness within the balloon-sat
Issues and Concerns

- Digital I/O lines will need to be routed through the camera body
## Budget

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<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>Canon Digital Rebel</td>
<td>&lt;$800 with lens</td>
<td>690 g</td>
<td>TBD</td>
<td>0° - 40°C</td>
</tr>
<tr>
<td>Micro controller</td>
<td>&lt;$20</td>
<td>&lt;20 g</td>
<td>&lt;1 mW</td>
<td>-20° - 40°C</td>
</tr>
</tbody>
</table>
Command and Data Handling / Software

Team Lead: Joe Wang
Mission

• To coordinate data handling and satellite operations

• Requirements:
  – Collect data from magnetometer, gyros and camera
  – Create software for subsystems
  – Create pixel matching software
  – Interface flight computer (Arcom VIPER) with peripheral devices
Flight Computer: VIPER
Flight Computer: VIPER

• Reasons this component was initially chosen:
  – Low power consumption of 1.6 W
  – Has most number of serial ports (5) as compared with other boards plus 2 USB
  – Has 8 general purpose I/O pins with expansion possibilities
  – Meets all interface and design requirements
  – Good processing speed of 400MHz
  – Allows for Compact Flash

• The flight computer will function as a central control unit, compiling data and running algorithms
Compact Flash Card (1 GB)
Compact Flash Card (1 GB)

- Compact flash memory format is compatible with both the VIPER board and digital camera
- Provides inexpensive storage for large amounts of data, which will be necessary to hold the digital pictures taken in-flight
Sub-System Interfaces

• The following devices are inputs to the flight computer:
  – Magnetometer
  – Gyros
  – Digital Camera
  – 5 volt power supply
Flight Readiness

- Complete software for data transfers from peripheral devices
- Debug Software
- Obtain components and wire to the peripheral devices
- Test hardware and software once successfully implementation
Test Plan

• Hardware Testing
  – Automated scripts will test all functions of all subsystems in a logical and safe manner

• Low-level Code Testing
  – Language Unit Test Framework
  – Automatically tests code to make sure it performs as expected

• Document all code thoroughly as it is written
Issues and Concerns

• The proficient completion of all necessary software
## Budget

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<th>Power</th>
<th>Thermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIPER</td>
<td>$475.00</td>
<td>96 g</td>
<td>1.6 W (320 mA @ 5 V)</td>
<td>-20° C to +70° C</td>
</tr>
<tr>
<td>1.0 GB CF Card (2)</td>
<td>$244.99</td>
<td>10 g</td>
<td>Included with VIPER’s power supply</td>
<td>0° C to +70° C</td>
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</table>
Power / Thermal

Team Lead: Paul Roberts
Mission

• To ensure that all subsystems retain power and temperature requirements throughout the duration of the flight.
Kokam 3.7V Lithium Polymer and Charger

Why battery was chosen:
- Extremely light weight
- Small dimensions
- Acceptable cost

• Provides power to the satellite
Space Blanket

• Why this was chosen:
  – Extremely light weight
  – Inexpensive
  – 80% heat retention

• Provides insulation for satellite
Ceramic Resistors

• Why this was chosen:
  – Extremely light weight
  – Inexpensive
  – Ceramic resistors used in the past

• Provides heat and correct power requirements
Timer Circuit

- Why this was chosen:
  - Small
  - Relatively Inexpensive
  - Multiple timing periods
  - Adjusts from one minute to two hours

- Ensures hinge deployment time
DemoSat II Power and Thermal Supply Circuit

V1DC = 3.7Vdc
V2DC = 3.7Vdc
V3DC = 3.7Vdc
V4DC = 3.7Vdc
V5DC = 3.7Vdc
V6DC = 3.7Vdc
V7DC = 3.7Vdc
V8DC = 3.7Vdc
R1Value = 25
R2Value = 60
R3Value = 25
R4Value = 30
R5Value = 7
R6Value = 1
Flight Readiness

- Obtain parts
- Cold tests
- Interface, wire and solder
Test Plan

• Cold Tests
  – Resistors
  – Insulation

• Power
  – Timer circuit
  – Energy dissipated by resistors
  – Correct voltage requirements
Issues and Concerns

- Heat from resistors
- Battery life due to resistors
- Voltage regulator for hinge deployment
## Budget

<table>
<thead>
<tr>
<th>Name</th>
<th>Cost</th>
<th>Weight</th>
<th>Power</th>
<th>Thermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery (8)</td>
<td>$ 18.20</td>
<td>34.02 g</td>
<td>3.7V (out)</td>
<td>-40°C to 85°C</td>
</tr>
<tr>
<td>Charger (2)</td>
<td>$ 99.90</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Blanket</td>
<td>$ 3.95</td>
<td>85 g (max)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Timer Circuit</td>
<td>$ 16.95</td>
<td>8 g</td>
<td>12VDC 200mA</td>
<td>-40°C to 85°C</td>
</tr>
<tr>
<td>Wiring</td>
<td>≈ $ 1/ft</td>
<td>≈ .1 g</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Resistors (6)</td>
<td>$ .50</td>
<td>≈ 1 g</td>
<td>N/A</td>
<td>-40°C min</td>
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</table>
Structure and Mechanisms

Team Lead: Andrew Young
Mission

• To supply a sturdy structure that will aid in the success of the mission
• To keep components safe from the elements for reuse
• To deploy a magnetometer attached to a CTD hinge
CTD Hinge

- Chosen for ability to deploy components
- Mission will be complete upon deployment of the magnetometer
- Requires 10W at 28V for 3 minutes
Satellite Structure

- Cube was selected for its stability and efficient use of space.
- The mission will be accomplished if all of the parts can be reused on later missions.
- The structure must be capable of holding all of the components.
Satellite Structure
Sub-System Interfaces

• The CTD hinge requires 28V of power from the batteries.

• The satellite is required to hold all of the Sub-Systems inside the structure.
  – ADCS, Science, Power/Thermal

• The CTD hinge must be mounted on the outside
Flight Readiness

- The CTD hinge will be bent to the appropriate angle
- The structure will be closed up and sealed
- All of the components will be turned on
- The structure will be attached to the balloon
Test Plan

- Impact testing - terminal velocity
- Thermal testing - temperature difference
- Stair pitched test - dropped down the stairs
- Whip test - circular motion with an abrupt change
- The CTD hinge will be deployed and bent multiple times
Issues and Concerns

• Having the most efficient use of space
• The mounting of the camera
• The attachment of the satellite to the balloon
• The mount for the CTD hinge
  – Gives too much or not enough
# CTD Hinge Budget

<table>
<thead>
<tr>
<th>Name</th>
<th>Cost</th>
<th>Weight</th>
<th>Power</th>
<th>Thermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTD Hinge</td>
<td>FREE</td>
<td>21 grams</td>
<td>10W at 28V for 3 minutes</td>
<td>Space Blanket</td>
</tr>
</tbody>
</table>
## Budget

<table>
<thead>
<tr>
<th>Name</th>
<th>Cost</th>
<th>Weight</th>
<th>Power</th>
<th>Thermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>$50</td>
<td>85g</td>
<td>n/a</td>
<td>n/a</td>
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<tr>
<td>Foam Core</td>
<td>$10</td>
<td>125g</td>
<td>n/a</td>
<td>n/a</td>
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</table>
## Total Mass/Cost Budget

<table>
<thead>
<tr>
<th>Team</th>
<th>Mass (grams)</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADCS</td>
<td>208.5</td>
<td>497</td>
</tr>
<tr>
<td>Science</td>
<td>710</td>
<td>820</td>
</tr>
<tr>
<td>C&amp;DH/Software</td>
<td>116</td>
<td>965</td>
</tr>
<tr>
<td>Power/Thermal</td>
<td>373</td>
<td>370</td>
</tr>
<tr>
<td>Structure</td>
<td>210</td>
<td>60</td>
</tr>
<tr>
<td>Mechanism</td>
<td>21</td>
<td>None</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1638.5</strong></td>
<td><strong>2712</strong></td>
</tr>
</tbody>
</table>
Project Schedule

- 4/2/2004: SupportSat CDR
- 5/1/2004: End of Assembly
- 6/2/2004: End of Testing
- 6/5/2004: SHOT Workshop, Launch #1
- 6/5/2004: Redesign and Test
- 7/1/2004: DemoSat II, Launch #2
- 8/1/2004: Post Launch Review
- 8/30/2004: SupportSat Final Report
Questions?