SolarSAT

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Mission Overview

- **Mission Objectives:**
  - **Primary:**
    - Quantify the effects of change in altitude on solar cell efficiency.
    - Measure T, P, and V output from solar cells and test their independent effects on solar cell efficiency
  - **Secondary:**
    - Post-flight, roll into a specific orientation, and deploy solar panels for increased solar panel exposure to the sun
    - Reasons for post-flight deployment include the possibility that our device could be air-dropped into hostile environments on earth (or other planets) and continue to take environmental data on the ground
    - Leave ample space inside for possible future experiments
    - Design landing protection to have less than 10% damage to solar cells
Mission Overview

• **Expectations:**
  • The efficiency of solar panels will change as the environment around it changes.
  • Lower temperatures should improve solar cell efficiency
  • Pressure should have minimal effects on solar cell performance
  • There should be a higher photon absorption rate at higher altitudes due to less light being scattered by the atmosphere
Team Member Responsibilities


Khongor Jamiyanaa – Pro/E, Manufacturing, Carbon Fiber.


Matt Lyon – Electronics, Programming.

Kenny Vogel – Electronics, Programming.
## Mission Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Method</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payload must not exceed weight of 1.5 kg</td>
<td>Design</td>
<td>Not Compliant</td>
</tr>
<tr>
<td>Payload must survive the environment at 100,000ft in elevation.</td>
<td>Design, Test, Analysis</td>
<td>Needs Testing</td>
</tr>
<tr>
<td>Payload must be able endure up to 15 G’s</td>
<td>Design, Test, Analysis</td>
<td>Needs Testing</td>
</tr>
<tr>
<td>The center of gravity for the payload must be within one inch of flight string.</td>
<td>Design</td>
<td>Compliant</td>
</tr>
<tr>
<td>Payload must not interfere with communication frequencies of the balloon.</td>
<td>Design</td>
<td>Compliant</td>
</tr>
<tr>
<td>Shall not exceed budget of $1000</td>
<td></td>
<td>Partially Compliant</td>
</tr>
<tr>
<td>The SolarSat must meet all mission objectives.</td>
<td>Design, Test</td>
<td>Partially Compliant</td>
</tr>
</tbody>
</table>
Subsystems and Specifications

- Power
  - 11.1V LiPoly 3-cell Battery, Power Switch, 7805 5V Regulator
  - PowerFilm R-14 Solar Panel
  - Battery provides 1050 mAh and 10A at max efficiency
  - Battery needs to stay above 7V to remain within voltage regulator specifications

- Data Control and Handling
  - dsPIC30 series Microcontroller
  - DOSonCHIP uSD module for data recording
  - Needs to remain above -40°C to remain within operating specifications

- Sensors
  - Temperature (inside and outside)
  - Pressure (inside and outside)
  - Accelerometer / Orientation

- Panel Deployment
  - MOSFET, Nichrome wire, spring, endcap design
Solar Panel Deployment System

- Start a timer at power-on (so that conditions for deployment are not met during launch)
- Sat should roll into the proper orientation for deployment at touchdown due to offset end cap design
- Check accelerometer for no motion / correct orientation
- Check pressure sensor and compare to launch pressure
- We are considering a ball-in-track orientation sensor as a backup or supplement for the X-Y-Z accelerometer
- If all sensors are at specified values, then the signal is sent from the microcontroller
- Signal is sent through a MOSFET, allowing circuit to close through Nichrome wire, and causes it to heat up, burning a fishing wire holding the springs
- Springs are released and Solar Array is deployed into flat position
Solar Panel

Position During Flight

Deployed Position On Ground

PowerFilm® R-14 Flexible Solar Panel
Drawing of Orientation Sensor

- Ball Bearing
- Connecting Leads
- Curved Tube
- Payload can be in active or inactive states.
- Analog signals from sensors will be sent to PIC.
- Data will be converted via A/D converters onboard the PIC.
- Digital data will be sent to and stored on µSD card.
- 2GB micro SD card will ensure enough memory to store all data.
- All sensors and chips rated to operate at temperatures of at least -40°C.
Preliminary Model
Clear Polycarbonate
End Ring Design Analysis
## End Ring Analysis Comparison

<table>
<thead>
<tr>
<th>Style</th>
<th>Max von Mises Stress (kPa)</th>
<th>Weight of two panels (kg)</th>
<th>Other Weights (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rectangular</strong></td>
<td>77634.97</td>
<td>0.65</td>
<td>Solar Panel 0.41</td>
</tr>
<tr>
<td><strong>Oval</strong></td>
<td>67499.67</td>
<td>0.59</td>
<td>Foam 0.38</td>
</tr>
<tr>
<td><strong>Triangular</strong></td>
<td>68258.10</td>
<td>0.66</td>
<td>Battery 0.09</td>
</tr>
<tr>
<td><strong>Circular</strong></td>
<td>54840.90</td>
<td>0.63</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ultimate Stress of Polycarbonate (kPa)</th>
<th>Weight left (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>86184.47</td>
<td>0.62</td>
</tr>
</tbody>
</table>

- All calculated stress values are for a 10G point load on a 1.5kg object.
- The load is at a 45° angle to the plane of the end cap.
- Although we only expect a 5G load on landing, we would like at least a safety factor of two or higher to ensure the end caps do not break.
- Minus the solar panel, foam core, and battery, we only have 0.62 kg left for everything else.
Preliminary Solar Cell Testing

- **Control Test:** Measure the amount of voltage absorbed by the solar panel at ground level to compare with data collected during the flight.
- **Plexiglass Test:** Measure the effects of shadowing and blocking of electromagnetic spectrum by plexiglass End Rings.
- **Temperature Test:** Measure the effects of varying temperatures on solar cell efficiency in a controlled environment.
- **Pressure Test:** Record the effects of extremely low pressure on the Solar Array.
Required Testing

• **Pitch Test**: The SolarSAT will be dropped down a flight of stairs. This is to simulate the SolarSAT being dragged after landing.

• **Drop Test**: To see if the SolarSAT will survive the impact, the SolarSAT will be dropped from two stories.

• **Whip Test**: To simulate balloon burst, a string will be tied to the SolarSAT and the swung over head.

• **Functional Test**: The SolarSAT must be able to function during the entire flight.

• **Cold Test**: The SolarSAT will be placed in a container with dry ice. Thermocouples will be placed inside and outside of the SolarSAT to measure the temperature difference.
Potential Points of Failure

1. Battery failure / voltage drop due to low temperature
   - Use a LiPoly 3 cell battery, which has a lower voltage drop due to temperature than most other batteries and has enough voltage and current to run all circuits

2. Break on landing
   - Use end caps made of carbon-fiber and plexi-glass to withstand force from landing

3. Solar panel doesn’t deploy when landed, and ball-in-track for orientation doesn’t work properly
   - End caps will be offset so center of gravity will make it roll to correct orientation
   - Test ball in track system to make sure ball doesn’t get stuck and make it so it can easily press down button when in proper orientation
4. Strong G forces when balloon ruptures
   - Make sure that soldering of circuits and mounting brackets are strong enough to withstand high G forces

5. Electronics failure due to low temperature environment
   - Buy parts that can operate at low temperatures
   - Cylinder foam core will insulate circuits as well as a heater to help prevent components from getting too cold

6. Programming/wiring failure
   - Thorough testing of Solar-Sat operation before launch

7. Bad solar reading due to orientation of panel, and shadowing
   - Design SolarSAT so that it will have relatively consistent sunlight no matter what the orientation is
   - Use plexi-glass end caps so that they do not block out the sun from the solar panels
## Parts List

<table>
<thead>
<tr>
<th>Part</th>
<th>Company</th>
<th>Model</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcontroller</td>
<td>MicroChip</td>
<td>dsPIC30F4011/4012</td>
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<tr>
<td>Temperature Sensor</td>
<td>Maxim Electronics</td>
<td>DS18B20+</td>
<td>0 (Sampled)</td>
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<tr>
<td>Pressure Sensor</td>
<td>FreeScale</td>
<td>MPXV5100GC6U</td>
<td>0 (Sampled)</td>
</tr>
<tr>
<td>Digital Accelerometer</td>
<td>FreeScale</td>
<td>MMA7456LT</td>
<td>0 (Sampled)</td>
</tr>
<tr>
<td>Analog Accelerometer</td>
<td>FreeScale</td>
<td>MMA7331LT</td>
<td>0 (Sampled)</td>
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<tr>
<td>Voltage Regulator</td>
<td>Mouser Electronics</td>
<td>LM7805</td>
<td>7.41</td>
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<tr>
<td>DOSonChip μSD Module</td>
<td>SparkFun</td>
<td>BOB-08215</td>
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<tr>
<td>Smart Charger</td>
<td>BatterySpace.com</td>
<td>CH-UN1550DC-3</td>
<td>19.95</td>
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<tr>
<td>3 Cell Li-Poly Battery</td>
<td>BatterySpace.com</td>
<td>PL-553562D-3S-WR-10-12C</td>
<td>42.66</td>
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<tr>
<td>Solar Panel</td>
<td>Solar World</td>
<td>PowerFilm R-14</td>
<td>244.48</td>
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<tr>
<td>Polystyrene</td>
<td>Southerlands</td>
<td>Dow Styrofoam Scoreboard</td>
<td>31.99</td>
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<tr>
<td>Polycarbonate</td>
<td>Fort Collins Plastics</td>
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<td>N/A</td>
</tr>
<tr>
<td>Carbon Fiber Fabric</td>
<td>Composite Envisions</td>
<td>2x2 Twill 50&quot; 3k 5.7oz</td>
<td>73.98</td>
</tr>
<tr>
<td>Epoxy Resin and Hardener</td>
<td>Composite Envisions</td>
<td>US Composites</td>
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<tr>
<td></td>
<td></td>
<td>TOTAL (to date)</td>
<td>$578.79</td>
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