SolarSAT

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June 16, 2009

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

Group – Design, Analysis, Testing.

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

Justin Nelson – Pro/E, Manufacturing, Solar Panel Deployment.

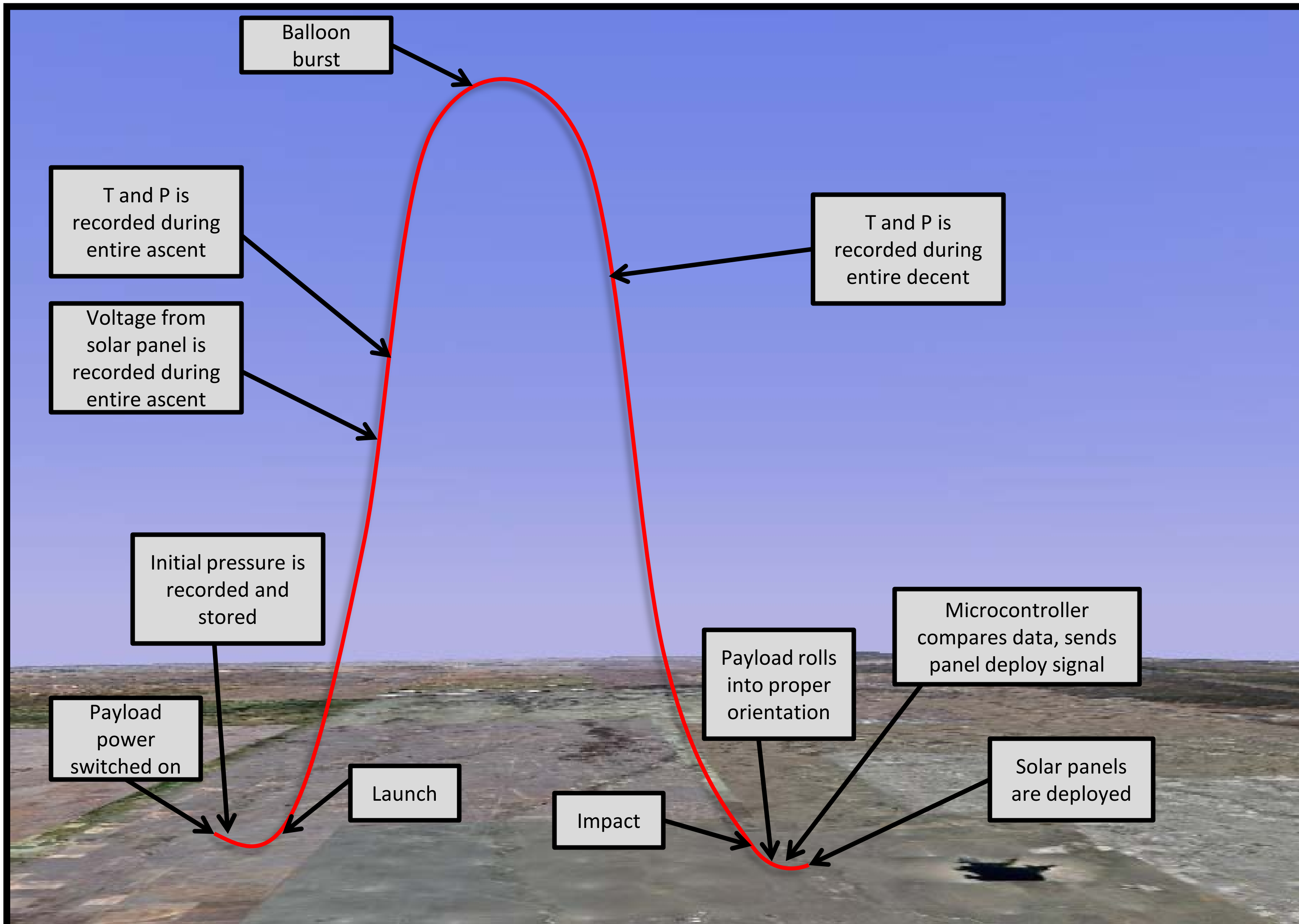
Matt Lyon – Electronics, Programming.

Kenny Vogel – Electronics, Programming.

Mission Requirements

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

Concept of Operations



Subsystems and Specifications

- Power
  - 11.1V LiPoly 3-cell Battery, Power Switch, LM7805 5V Regulator, TLV1117 3.3V Regulator
  - PowerFilm R-14 Solar Panel, load resistor into PIC to measure power output
  - Battery provides 1050 mAh and 10A at max efficiency
  - Battery needs to stay above 7V to remain within voltage regulator specifications
- Data Handling and Control
  - dsPIC30 series Microcontroller
  - DOSonCHIP µSD 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, carbon fiber spring, endcap design

All systems (except for the Solar Panel) are located inside the hollow foam core

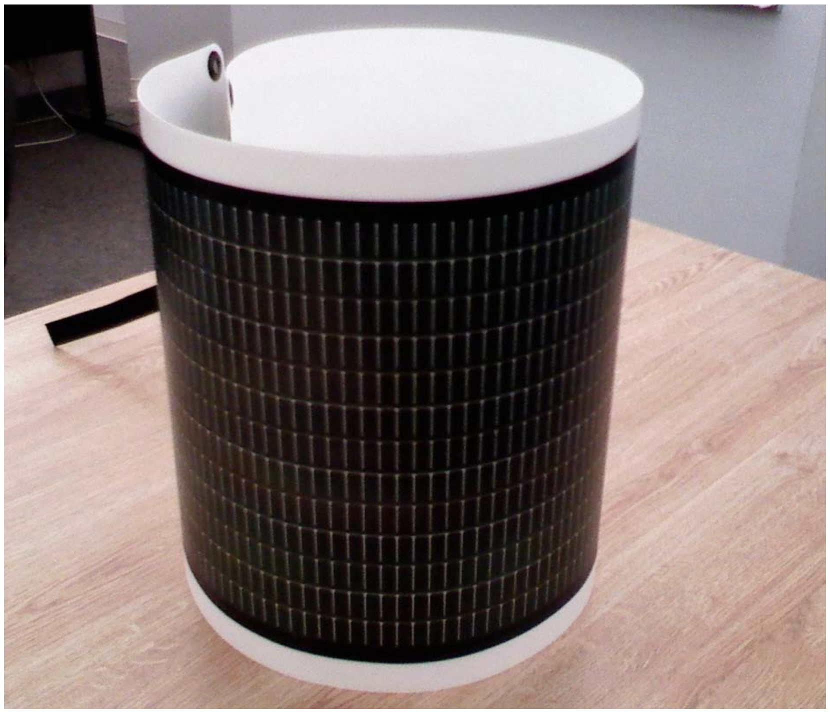
Solar Panel Deployment System

- 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 line holding the springs
- Carbon fiber springs are released and Solar Array is deployed into flat position

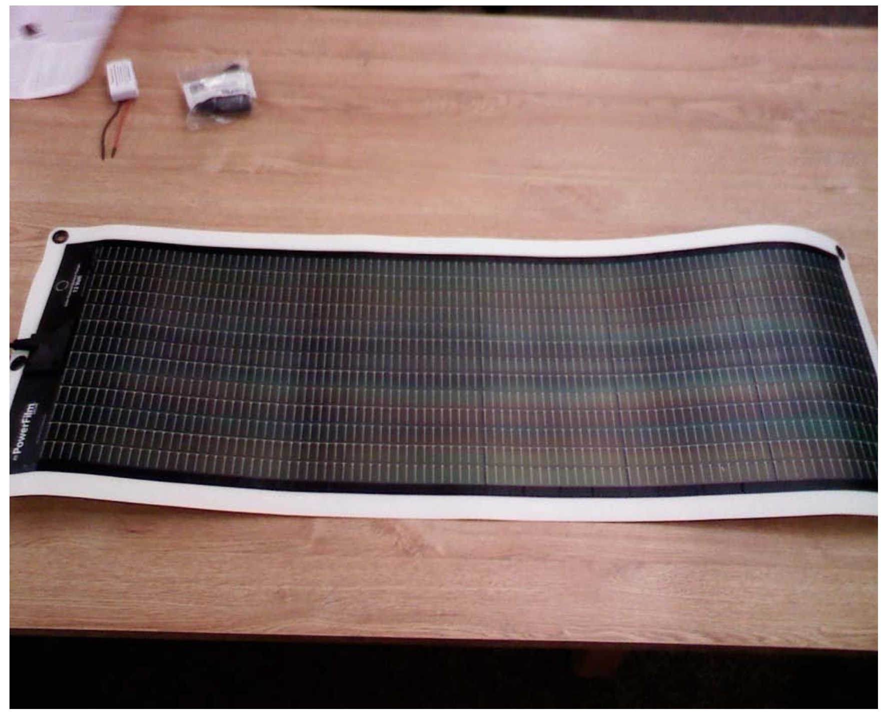
Carbon Fiber Spring

- A flexible carbon fiber sheet is used to “spring” open the solar panels into a flat position when the deploy signal is sent
- The carbon fiber is held down by a length of fishing line
- We chose carbon fiber over other possible alternatives because it is extremely light weight, but still has the necessary characteristics to deploy our solar panel
- The spring will be cut into strips and will be attached to the back of the solar panel
- The carbon fiber shell is located directly under the springs

Solar Panel



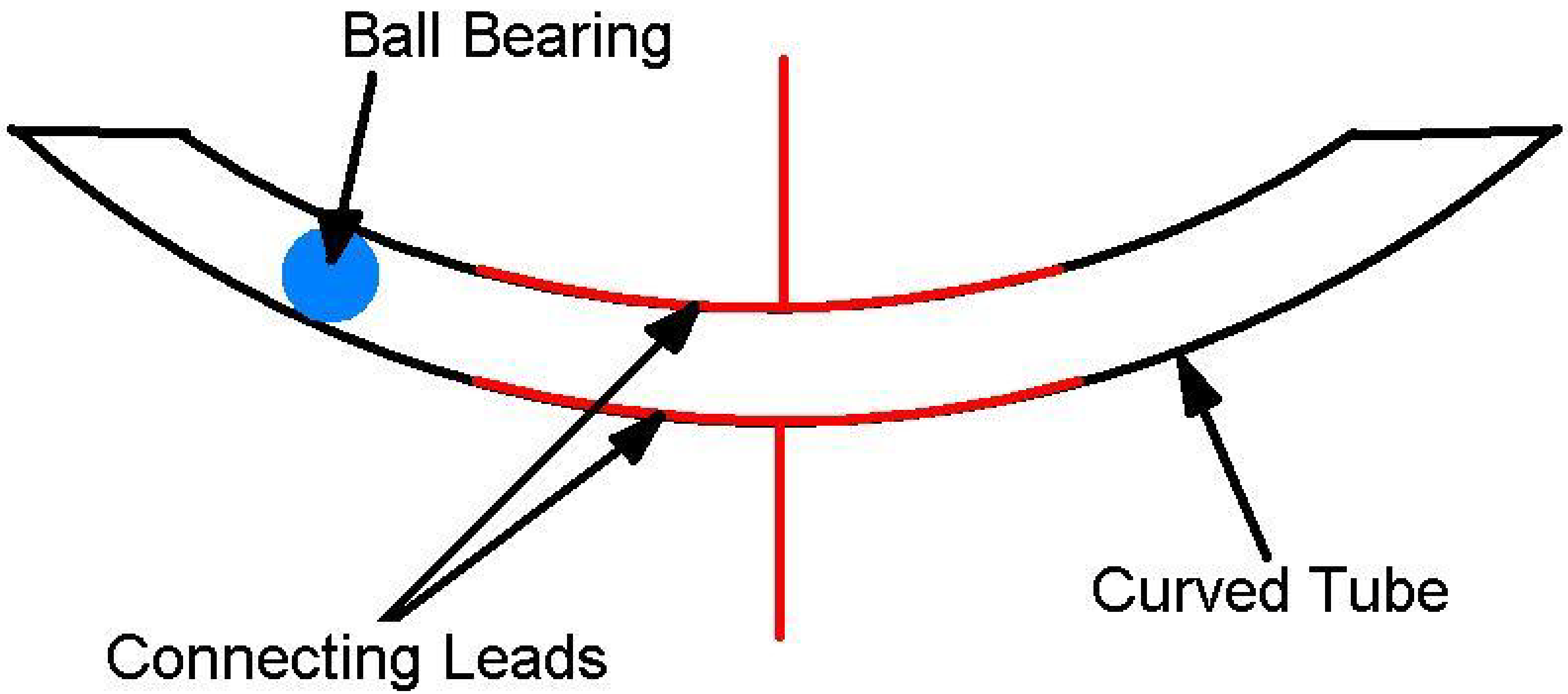
Position During Flight



Deployed Position On Ground

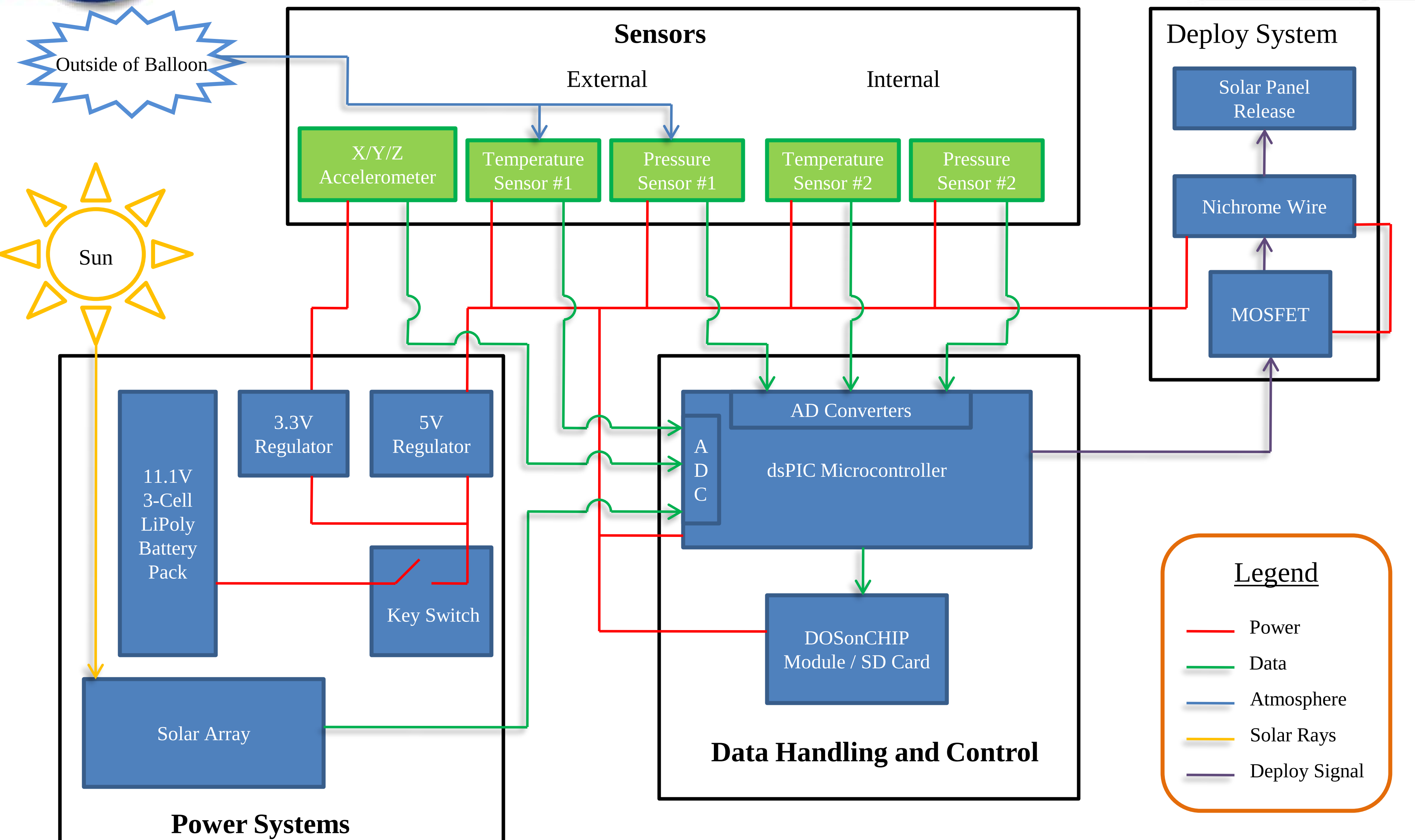
PowerFilm® R-14 Flexible Solar Panel

Drawing of Orientation Sensor

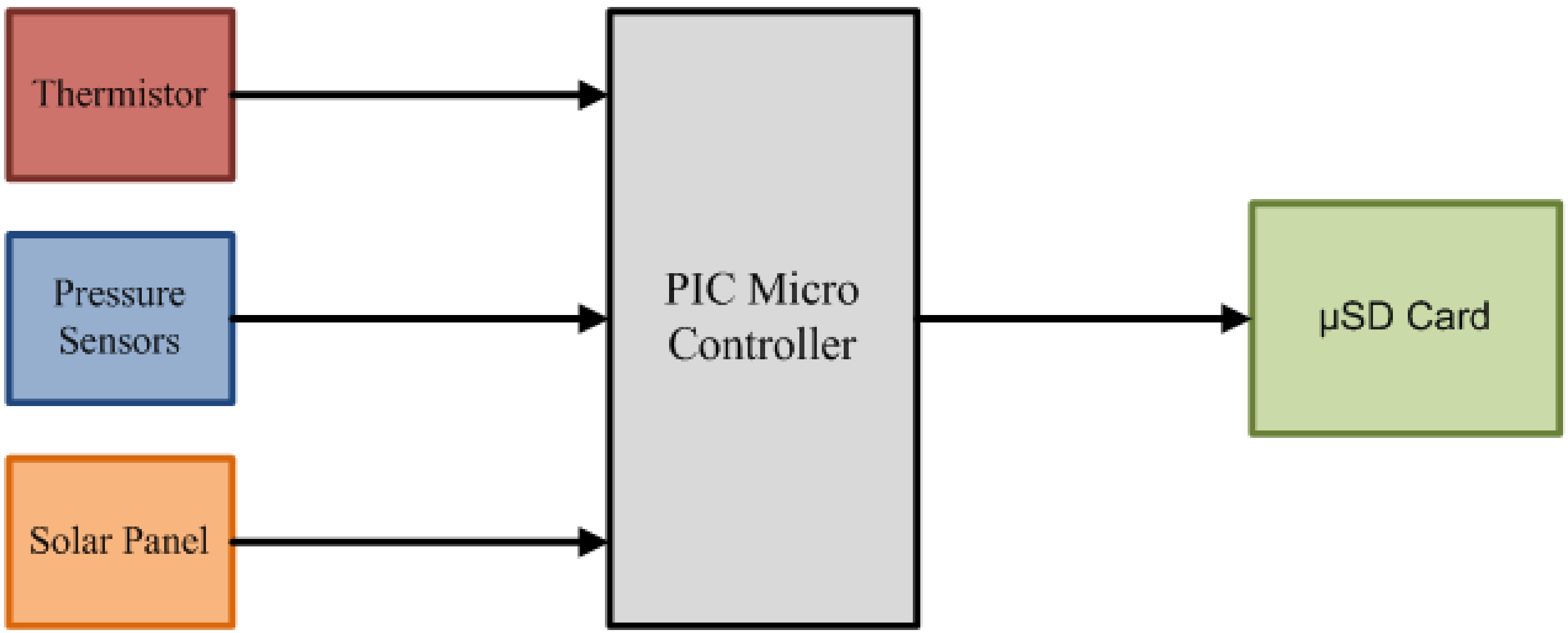


Used only if we cannot get our accelerometer to tell orientation

Functional Block Diagram

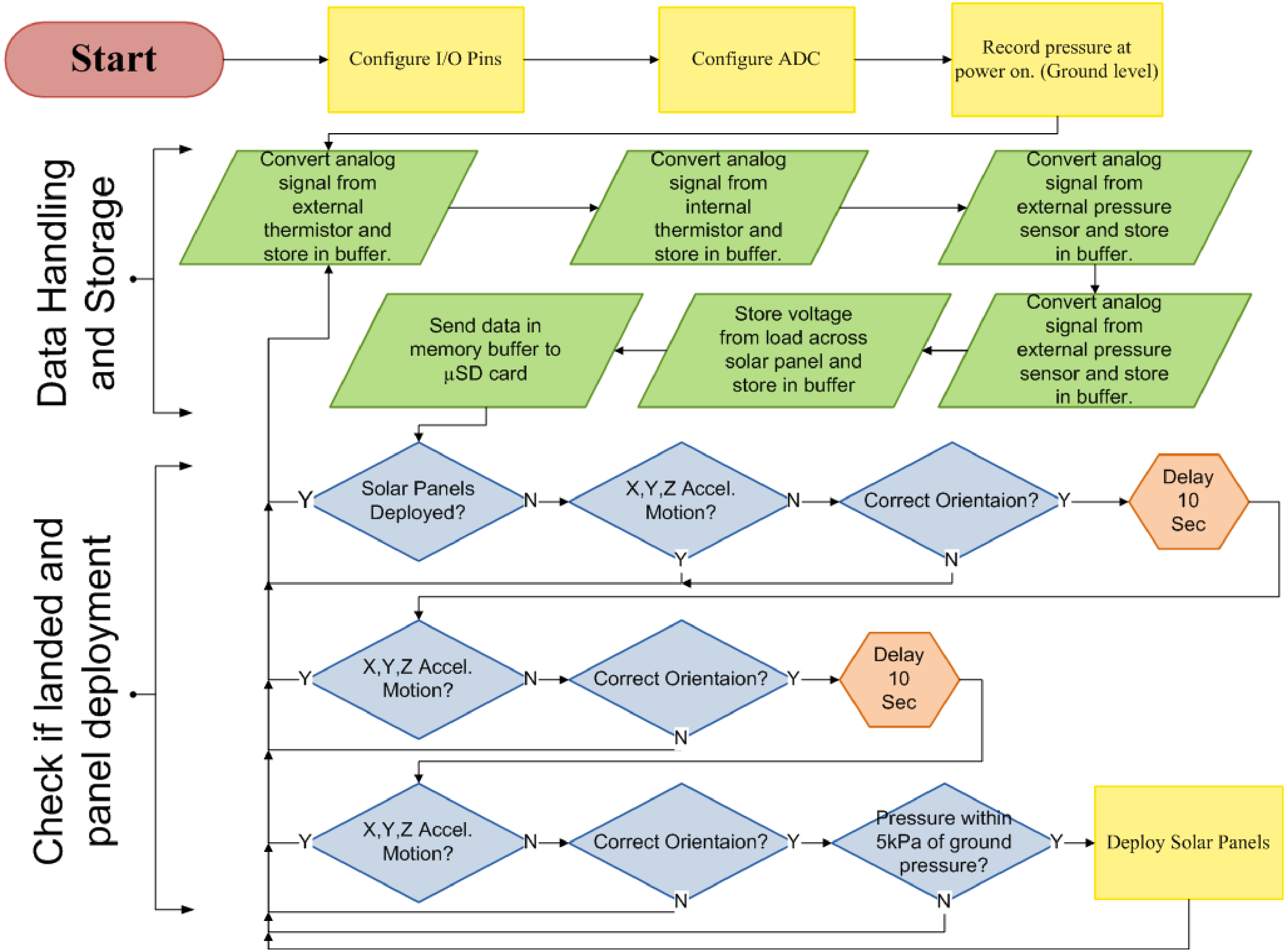


Data Flow Diagram

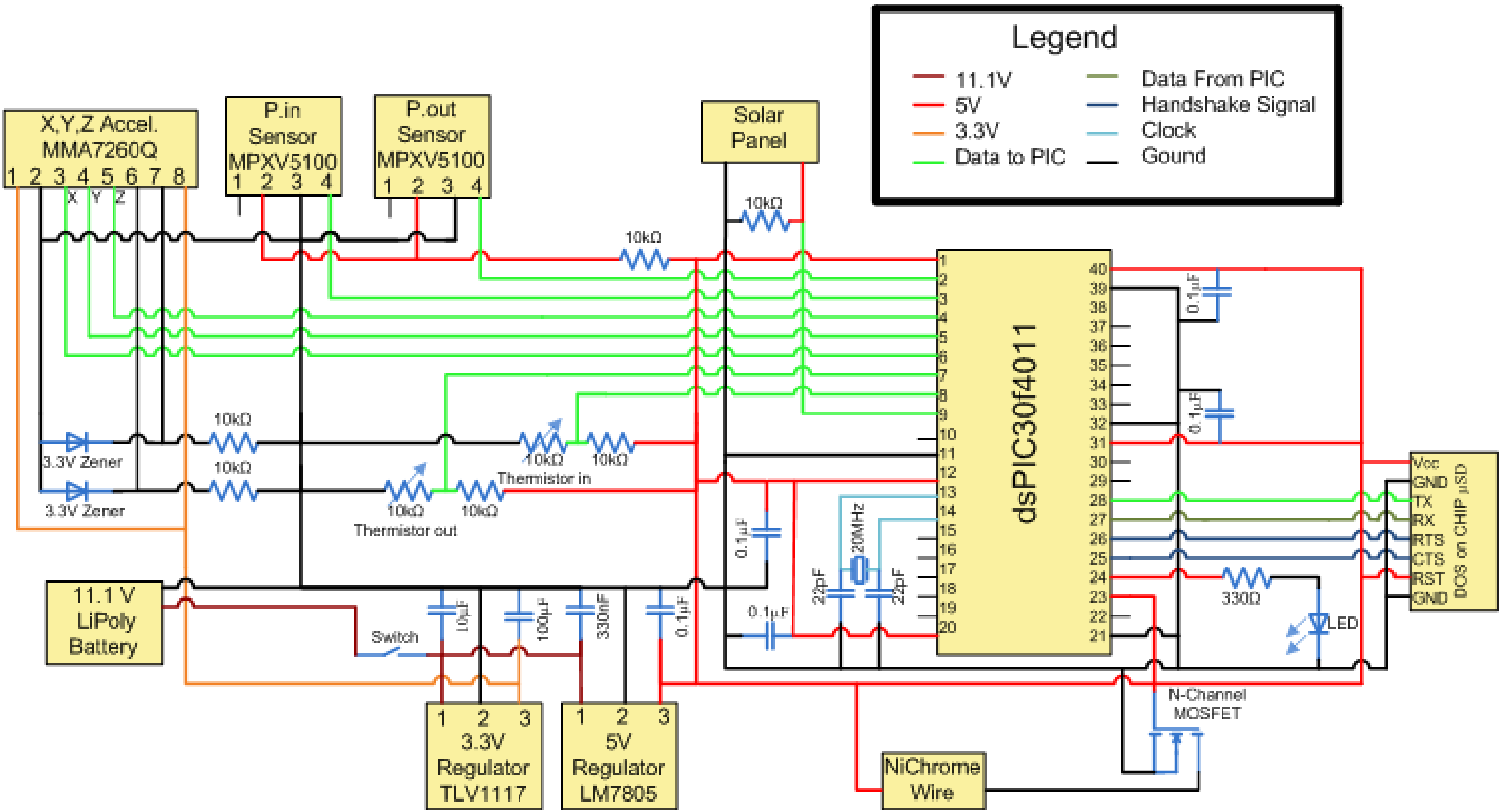


- Payload can be in active or inactive states.
- Analog signals from sensors will be sent to PIC.
- Data will be converted via A/D converters onboard the PIC.
- Digital data will be sent to and stored on μSD card.
- 2GB micro SD card will ensure enough memory to store all data.
- All sensors and chips rated to operate at temperatures of at least -40°C.

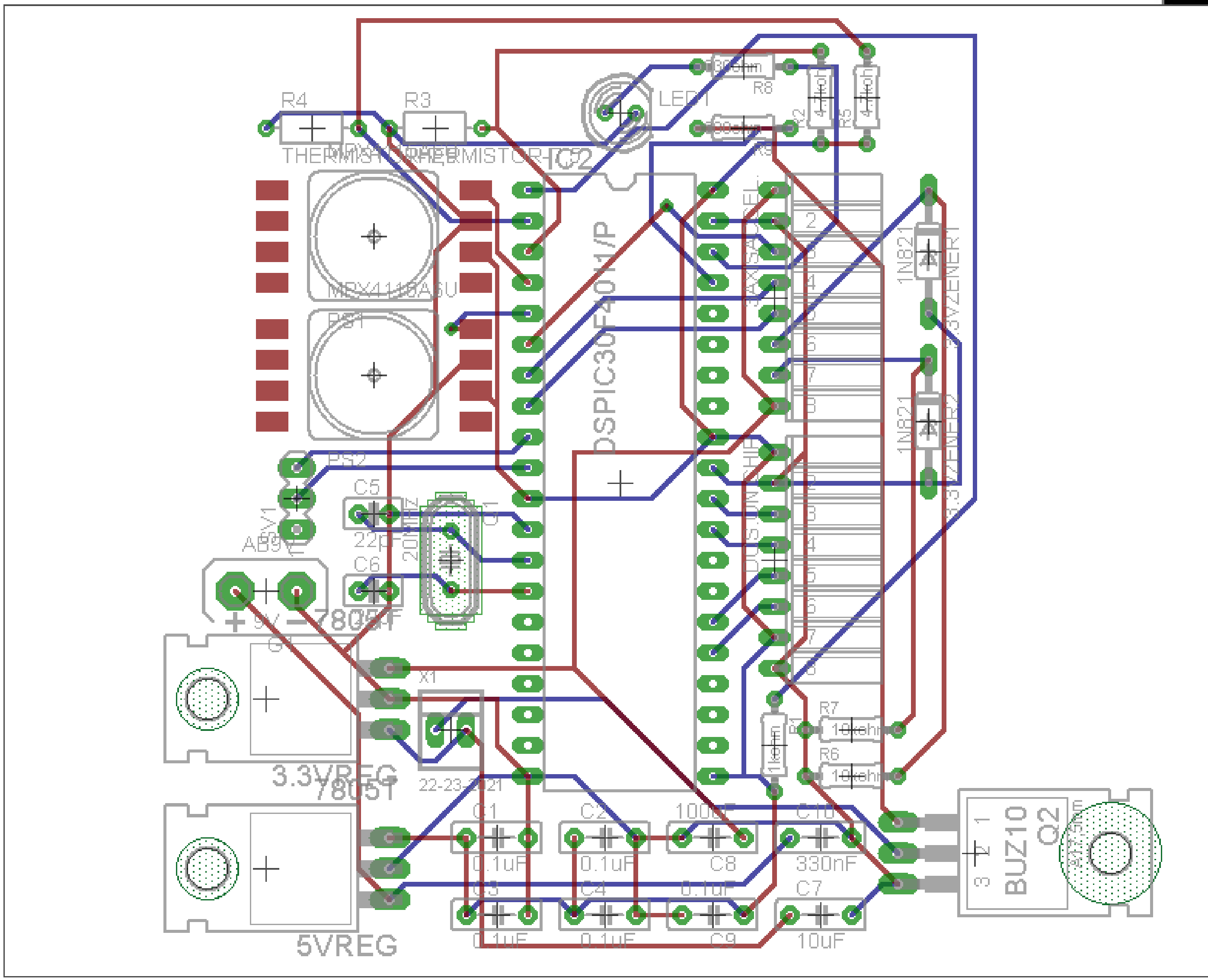
Software Flow Chart



Wiring Diagram

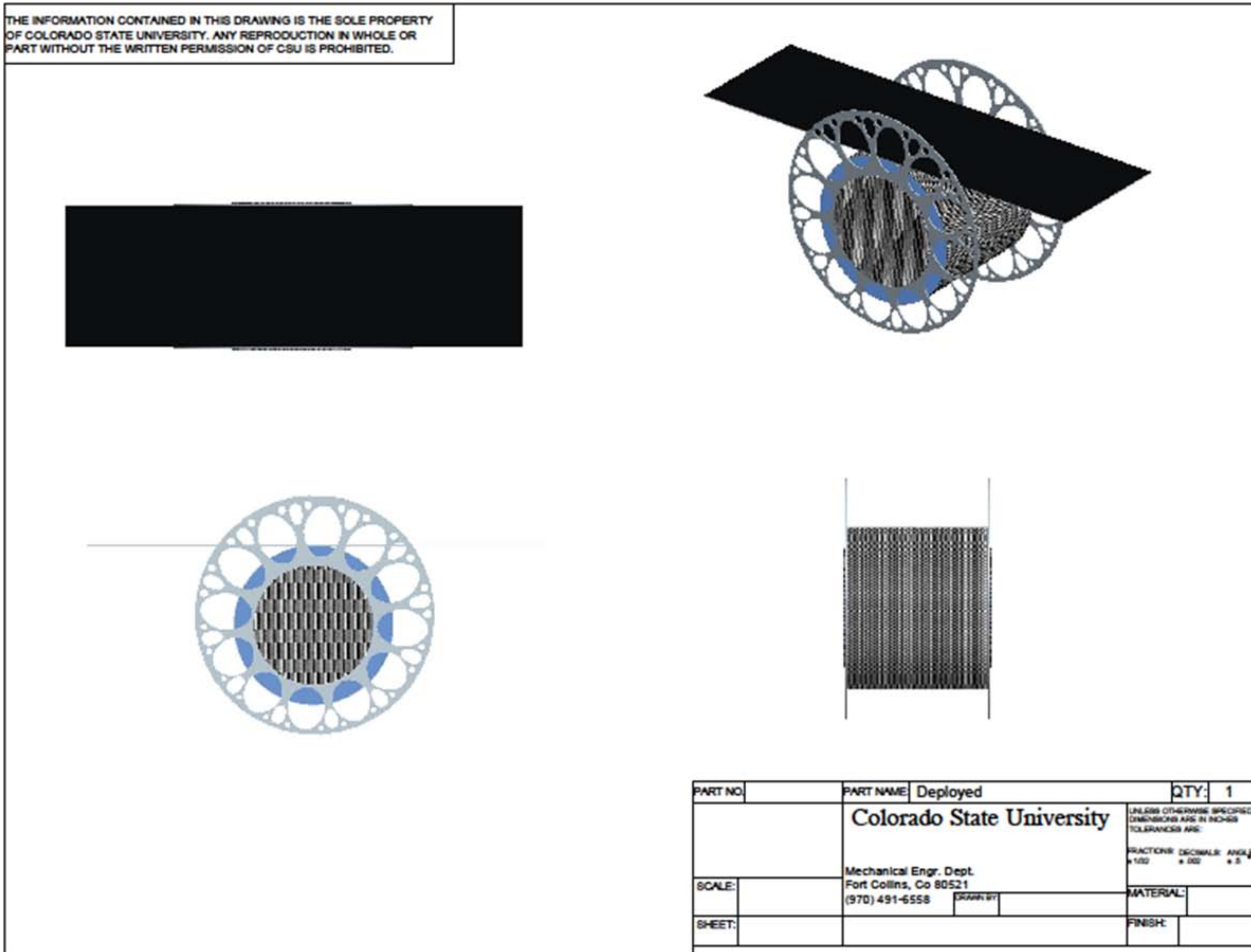


Circuit Board Diagram

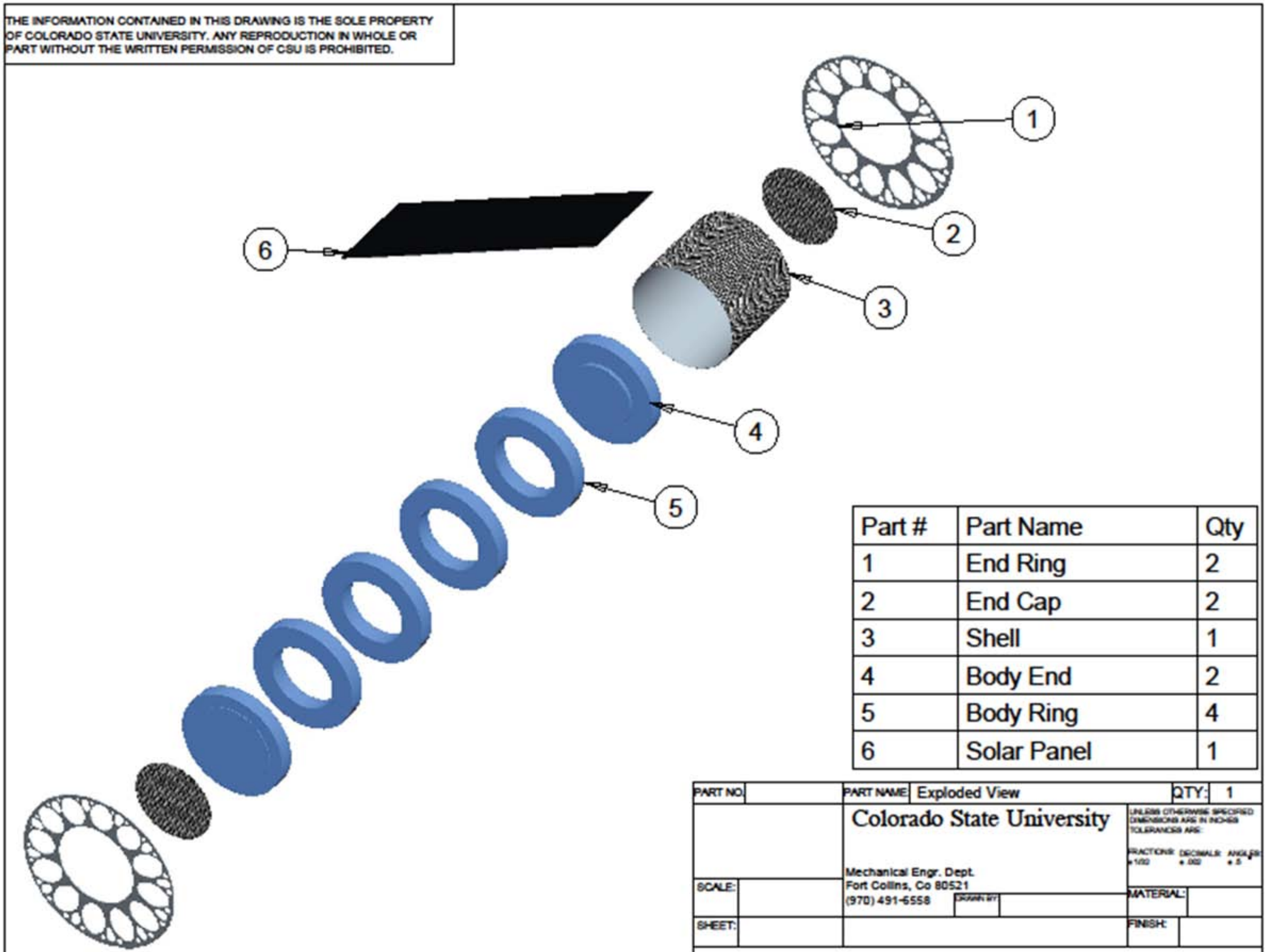


- Circuit board is custom made by etching process

Model (deployed position)

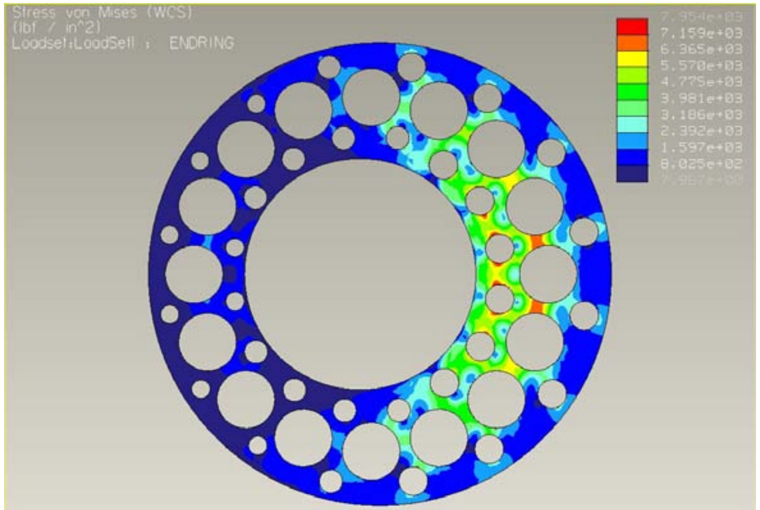


Exploded View

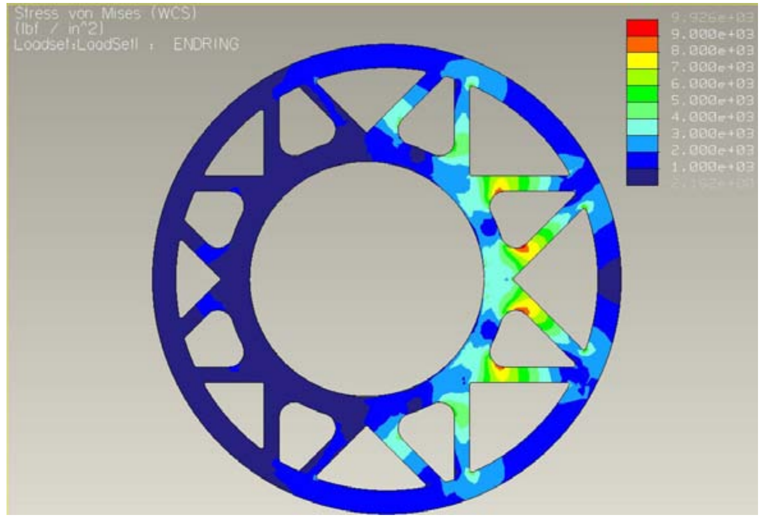


Part #	Part Name	Qty
1	End Ring	2
2	End Cap	2
3	Shell	1
4	Body End	2
5	Body Ring	4
6	Solar Panel	1

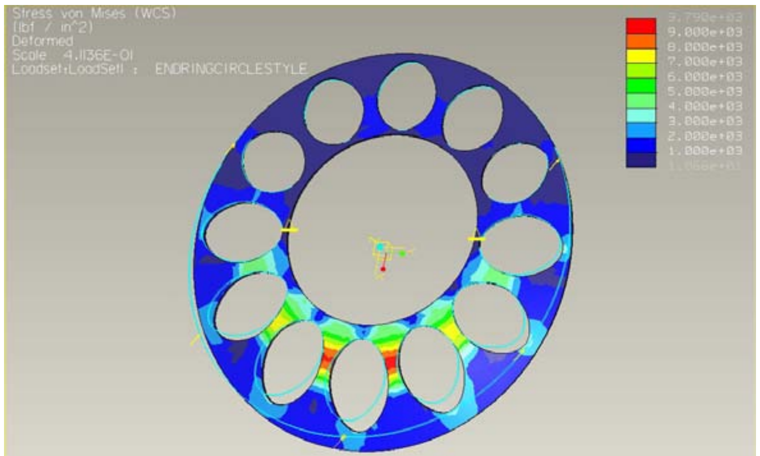
Clear Polycarbonate End Ring Design Analysis



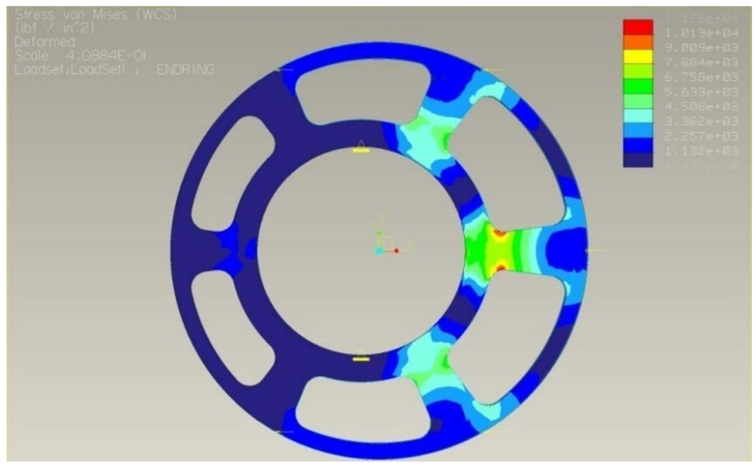
Circular



Triangular

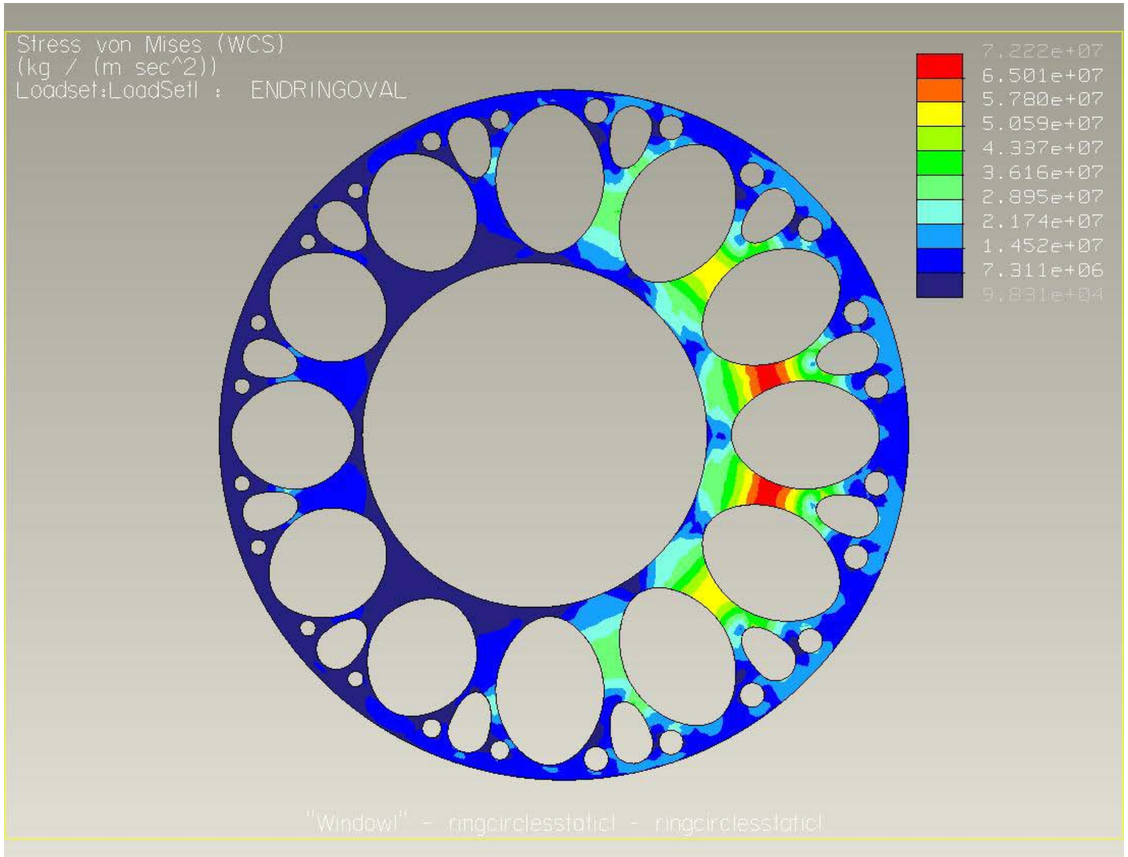


Oval



Rectangular

Clear Polycarbonate End Ring Design Analysis



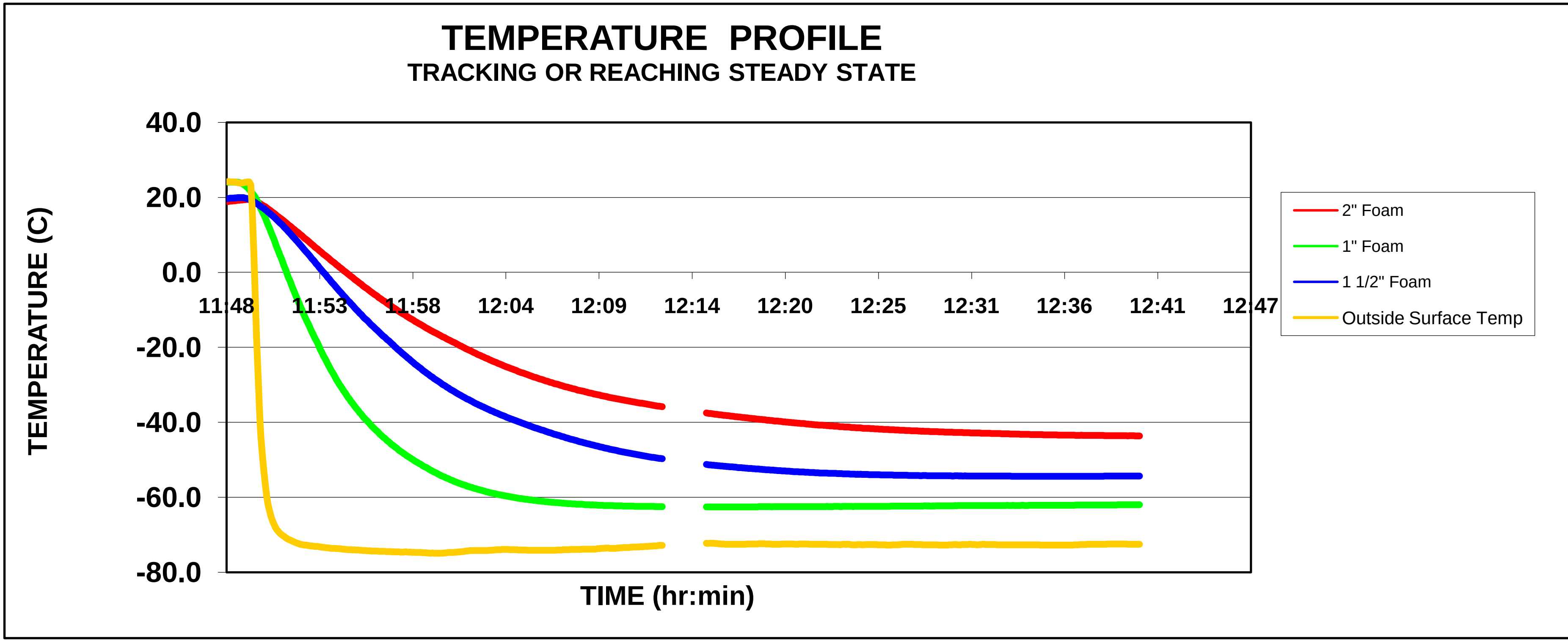
Double Oval (chosen design)

End Ring Analysis Comparison

Style	Max von Mises Stress (kPa)	Weight of two panels (kg)		Other Weights (kg)
Rectangular	***77634.97***	***0.65***	**Solar Panel**	0.41
Oval	***67499.67***	***0.59***	**Foam**	0.38
Triangular	***68258.10***	***0.66***	**Battery**	0.09
Circular	***54840.90***	***0.63***	**Carbon fiber spring**	0.25
Double Oval	***72220.00***	***0.46***		
				Weight left (kg)
Ultimate Stress of Polycarbonate (kPa)	**86184.47**			0.37

- 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, spring, and battery, we only have 0.37 kg left for everything else
- We have chosen the Double Oval design because it is the lightest weight and still has the necessary strength

Thermal Testing



- We tested three different foam core thicknesses, each with a thermocouple inside and a slab of dry ice in contact with the outside
- The results show that on average at steady state, every ½ inch thicker the insulation, the inside will be about 10 °C warmer

Manufacturing Progress

Template for foam core cut on CNC

Cutting of foam core section with hot wire cutter

Sanding of foam core sections

Stack of foam core sections (pre-hollowed)

Manufacturing Progress

Polycarbonate endcap

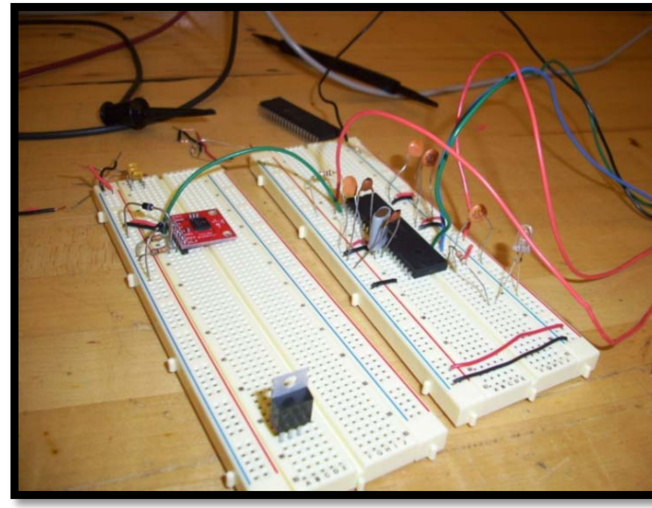
Ascent position test fit

Deployed position test fit

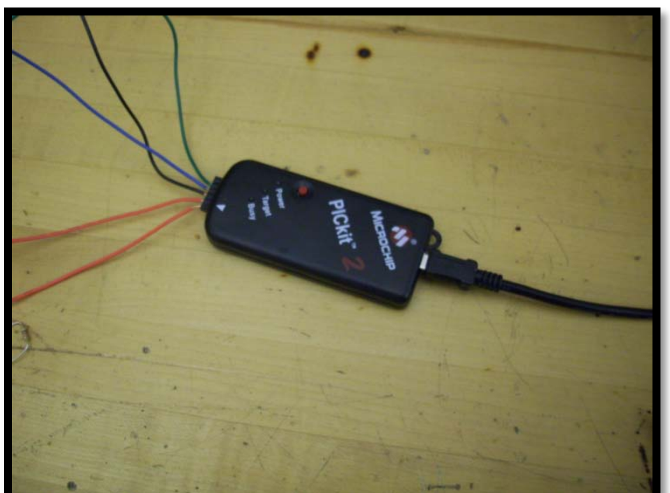
Cutting of carbon fiber

Manufacturing Progress

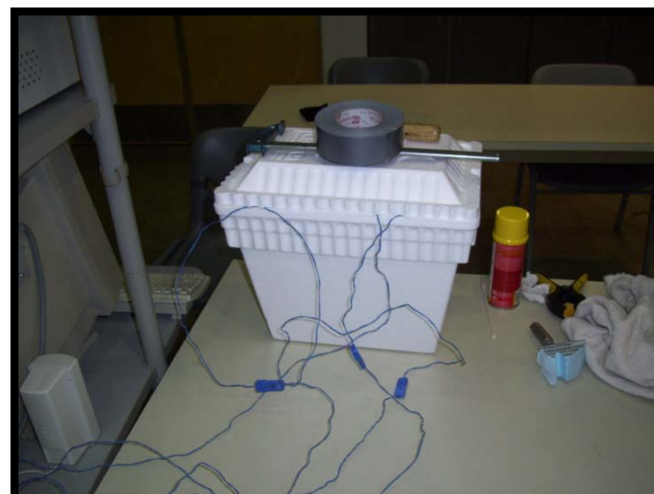
Carbon fiber manufacturing



Accelerometer test circuit



PicKit 2 Programmer



Thermal testing with dry ice

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 tried 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

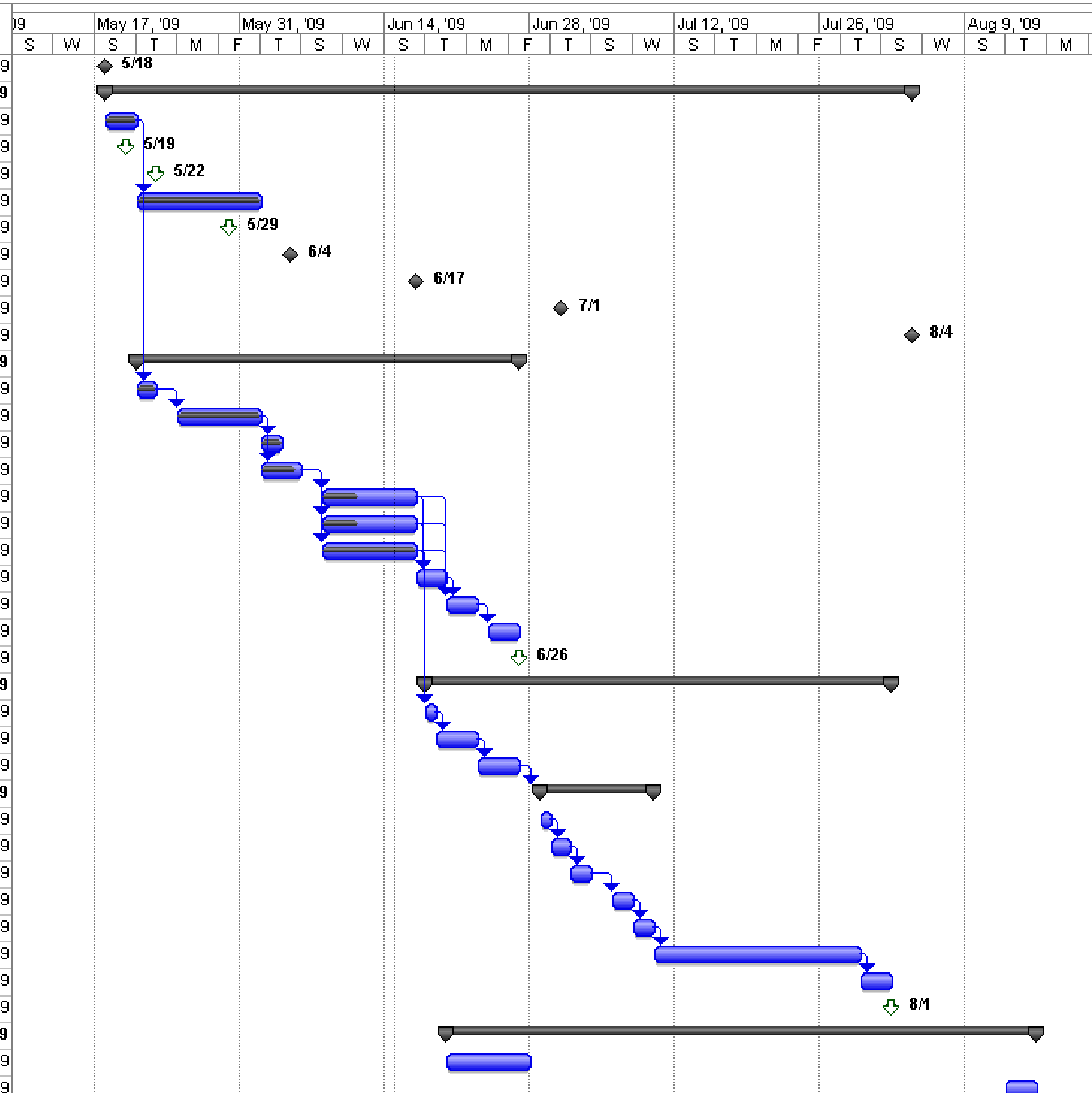
1. Battery failure / voltage drop due to low temperature
   - Use a LiPoly 3 cell battery, which has a lower voltage drop due to temperature than most other batteries and has enough voltage and current to run all circuits
2. Break on landing
   - Use end caps made of carbon-fiber and plexi-glass to withstand 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

Potential Points of Failure

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

Tentative Schedule

ID		Task Name	Duration	Start	Finish
1		Project Start	0 days	Mon 5/18/09	Mon 5/18/09
2		**Design and Planning**	**59 days**	**Mon 5/18/09**	**Tue 8/4/09**
3	✓	Concept Generation and Brainstorming	3 days	Mon 5/18/09	Wed 5/20/09
4	✓	Objectives and Constraints Due	0 days	Tue 5/19/09	Tue 5/19/09
5	✓	Project Plan Due	0 days	Fri 5/22/09	Fri 5/22/09
6	✓	Detailed Design	8 days	Thu 5/21/09	Mon 6/1/09
7	✓	Modes of Failure Report Due	0 days	Fri 5/29/09	Fri 5/29/09
8		Payload Report Due	0 days	Thu 6/4/09	Thu 6/4/09
9		Critical Design Review	0 days	Wed 6/17/09	Wed 6/17/09
10		Progress Report Due	0 days	Wed 7/1/09	Wed 7/1/09
11		Final Report Due	0 days	Tue 8/4/09	Tue 8/4/09
12		**Manufacturing**	**28 days**	**Thu 5/21/09**	**Fri 6/26/09**
13	✓	Initial Concept Prototype	2 days	Thu 5/21/09	Fri 5/22/09
14	✓	Ordering of Parts	6 days	Mon 5/25/09	Mon 6/1/09
15	✓	Foam Core	2 days	Tue 6/2/09	Wed 6/3/09
16		Protective Ends	4 days	Tue 6/2/09	Fri 6/5/09
17		Electronics	7 days	Mon 6/8/09	Tue 6/16/09
18		Sensors	7 days	Mon 6/8/09	Tue 6/16/09
19	✓	Solar Cells	7 days	Mon 6/8/09	Tue 6/16/09
20		Other Mechanisms / Parts	3 days	Wed 6/17/09	Fri 6/19/09
21		Assembly	2 days	Sat 6/20/09	Mon 6/22/09
22		Additional Integration, Finishing Touches	3 days	Wed 6/24/09	Fri 6/26/09
23		Manufacturing Complete Deadline	0 days	Fri 6/26/09	Fri 6/26/09
24		**Testing**	**35 days**	**Thu 6/18/09**	**Sat 8/1/09**
25		Plexiglass effects on Solarcell	1 day	Thu 6/18/09	Thu 6/18/09
26		Temperature Effects	3 days	Fri 6/19/09	Mon 6/22/09
27		Pressure Chamber	4 days	Tue 6/23/09	Fri 6/26/09
28		**Required Tests**	**10 days**	**Mon 6/29/09**	**Thu 7/9/09**
29		Stair Pitch Test	1 day	Mon 6/29/09	Mon 6/29/09
30		Drop Test	2 days	Tue 6/30/09	Wed 7/1/09
31		Whip Test	2 days	Thu 7/2/09	Fri 7/3/09
32		Functional Test	2 days	Mon 7/6/09	Tue 7/7/09
33		Cooler Test	2 days	Wed 7/8/09	Thu 7/9/09
34		Revisions, additional testing	14 days	Fri 7/10/09	Wed 7/29/09
35		Final System Checks	3 days	Thu 7/30/09	Sat 8/1/09
36		Launch Date	0 days	Sat 8/1/09	Sat 8/1/09
37		**Optional**	**44 days**	**Sat 6/20/09**	**Sat 8/15/09**
38		RockOn Workshop	6 days	Sat 6/20/09	Sat 6/27/09
39		JPL Trip	3 days	Thu 8/13/09	Sat 8/15/09



Parts List

Part	Company	Model	Cost ($)
Microcontroller	MicroChip	dsPIC30F4011/4012	7.50
Temperature Sensor	Maxim Electronics	DS18B20+	0 (Sampled)
Pressure Sensor	FreeScale	MPXV5100GC6U	0 (Sampled)
Digital Accelerometer	FreeScale	MMA7456LT	0 (Sampled)
Analog Accelerometer	FreeScale	MMA7331LT	0 (Sampled)
Voltage Regulator	Mouser Electronics	LM7805	7.41
DOSonChip µSD Module	SparkFun	BOB-08215	49.64
Smart Charger	BatterySpace.com	CH-UN1550DC-3	19.95
3 Cell Li-Poly Battery	BatterySpace.com	PL-553562D-3S-WR-10-12C	42.66
Solar Panel	Solar World	PowerFilm R-14	244.48
Polystyrene	Sutherlands	Dow Styrofoam Scoreboard	31.99
Polycarbonate	Fort Collins Plastics	9034 Lexan	77.70
Carbon Fiber Fabric	Composite Envisions	2x2 Twill 50" 3k 5.7oz	73.98
Epoxy Resin and Harderner	Composite Envisions	US Composites	84.59

Parts List

Part	Company	Model	Cost ($)
Carbon Fiber Tube	CarbonFiberTubeShop	SM3236F	47.30
3 Axis Accelerometer	SparkFun	MMA7260Q	23.92
3.3V Regulator	Texas Instruments	TLV1117	0 (Sampled)
Microchip	PicKit 2 Programmer	PG164120	34.82
Foam Board Adhesive	Sutherlands	PL300	4.59
Cooler	Safeway	N/A	4.27
Dry Ice	Safeway	N/A	17.24
		TOTAL	783.64

Budget remaining: $216.36