CUBESAT SOLAR PANELS

May15-12

Client: John Carr, NASA

Advisor: Gary Tuttle

MEMBER CONTRIBUTIONS

Luke Dahlman -Team Leader

Organizes/conducts meetings, emails, & group documents

Antjuan Buffett-Team Intermediary

Acts as a link between members in order to try to bring about an agreement or reconciliation

Tom Henry – Webmaster

Designed and updates group website

Gathers group work for public posting

Anh Ho, Dustin Pierce - Key Concept Holders

Helps group to understand their common objectives and assists in planning how to achieve these objectives

Ryan Bissett, Isaac Johns -Team Communicators

Writes group reports based on group's previous week's work

Gathers individual contributions

PRELIMINARY PROBLEM STATEMENT

Our group is tasked with designing and implementing a deployable and retractable boom that fits inside a 1 cubic foot satellite used to deploy and retract a solar cell array with a minimum area of $9ft^2$.

PRELIMINARY DESIGNS-SCISSOR JACK

- Size Constraint
  - $1 ft^3$ cube
  - $4\text{-}9 ft^2$ solar panels
- Scissor Design
  - Motor
    - 3 ft-lb
    - 2 phase motor deploy and retract
    - Stepper motor
  - Power Transmission
    - Screw drive

PROBLEM STATEMENT

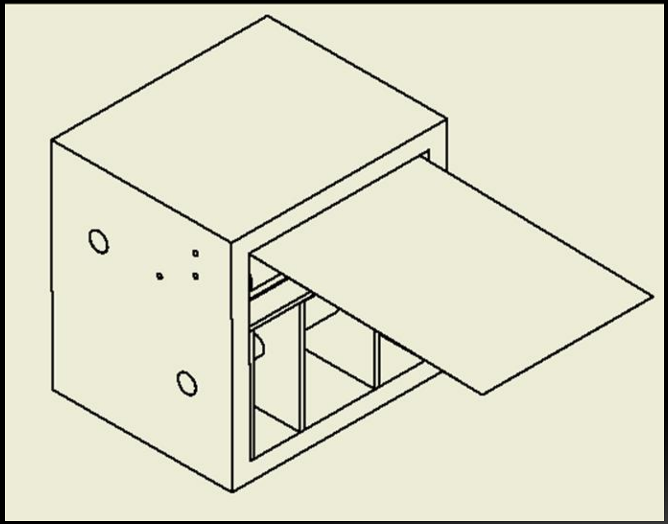
Our group is tasked with designing and implementing a deployable and retractable boom that fits inside a CubeSat (10cm x 10cm x 10cm) used to deploy and retract a solar cell array with a minimum area of $4ft^2$ using bendable solar arrays.

PRELIMINARY DESIGNS-FAN

- One dual phase motor
- One servo motor
- Difficult to reach 9 ft^2 solar panels
- Gear Drive
  - At pivot point - 360° rotation
  - One to unfold – achieve more than 1 foot radius
- The Area of this method will never achieve 100% full of solar cells
  - 25mm bending radius
  - $A_{cell,min}$ = 1cm x 1cm $A = \pi R^2$
- Solar Panel Calculation. $R = \frac{4ft^2}{\pi}$

PRELIMINARY DESIGN-TAPE MEASURE

- Size Constraint
  - 1000cm^3 cube-sat
  - 4-9ft^2 solar panels



- Measure tape technique
  - Motor
    - <100 oz-inch
    - Brushed motor
    - Single phase motor deploy
    - Continuous
  - Power Transmission
    - Spur Gears deploy
    - Retract – spiral coil

FINAL DESIGN DECISION

Grading	Importance
1	Low
3	Medium
5	High

Size Chart	
1	Only 1 design
2	Multiple design

Decision Making Pugh Matrix

#	Design	# of Components	Size	Solar Area	Require Motor Torque	Prototype Cost	Final Grade
1	Fan	Low	1	Limited	Medium - High	Medium	15
2	Scissor	Medium	1	Neutral	Medium - High	Low	17
3	Tape	High	1 & 2	Neutral	Low	High	17

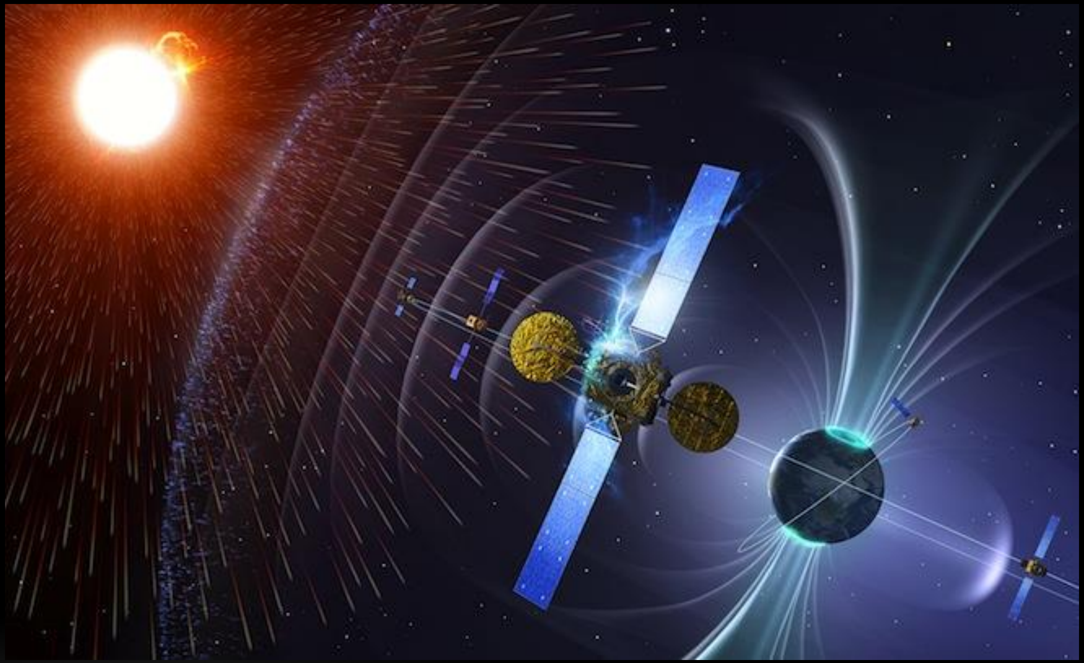
Our Final design were based on # of components at the beginning when the constraint of cube-sat is 1 ft^3, but when the constraint were reduce by 1/9 of the regular size.

FUNCTIONAL REQUIREMENTS

- Repeatable operation.
- Low power consumption.
- Structural rigidity when extended.
- Physical Limitations of Materials
- Receive and interpret the signal.
- Execute the command while monitoring boom tension.
- Latch at full extension.

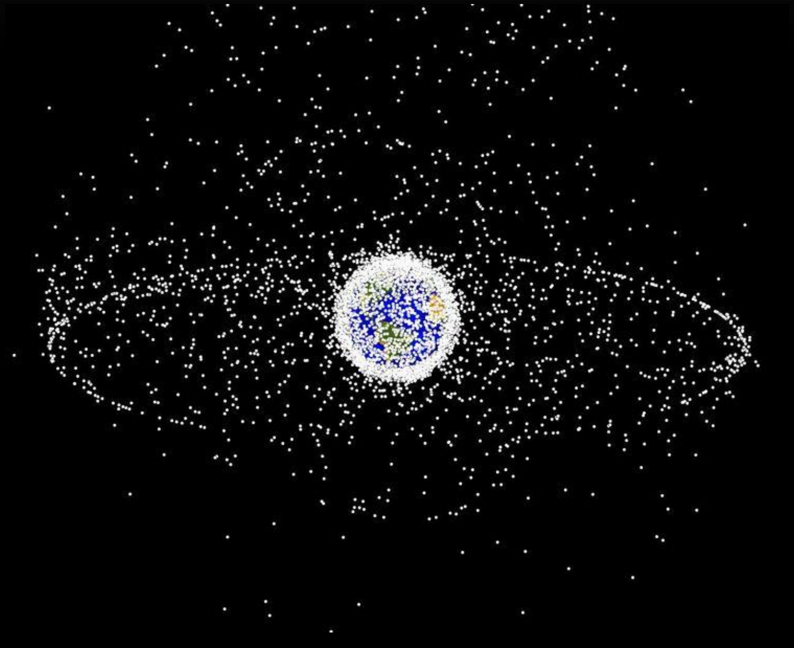
NON-FUNCTIONAL REQUIREMENTS

- Temperature
- Radiation
- Elasticity
- Reliability/Lifetime
- Fixed components
- Weight
- Size



POTENTIAL RISKS

- In Low Earth Orbit (LEO), the primary risks are:
  - Temperature swings (-250F to +250F)
  - Radiation exposure
  - UV exposure
  - Extremely low pressure (Vacuum)
  - Near zero ease of access
  - High-velocity impacts from space debris



MARKET FOR CUBESATS

- Comparable Cost: $10,000
- Purpose: Space Research
- Users
  - NASA, Client
  - Universities
  - Private Corporations

MATERIAL COSTS

Materials	Manufacture/Vendor	Part Number	Shipping Delays	Price
Bearing	Fastenal	474467	<week	1.75
Silicone Wheels	Ebay	Ebay	<week	21
Motor Driver	Pololu	VNH5019	<week	22
Gear Motor	Pololu	1577	<week	25
Solenoid	Bicron Electronics	SC0424L0625	Obtained	Free Sample
Spring	Small Parts	CF021-0025	<week	37.95

Total Cost without PLC: $368.46

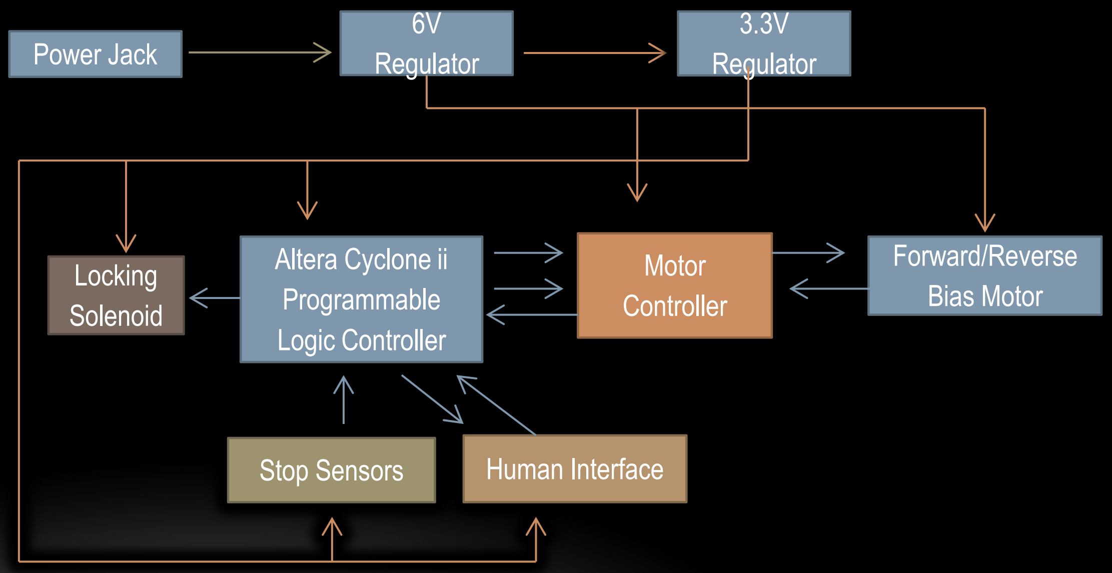
TECHNOLOGY PLATFORM

Hardware

- Atmel Rad-Hard PLC
- Motor
- Motor controller
- Relays
- Sensors
- Solar array

Software

- VHDL
- A2D conversion



IMPLEMENTING PROTOTYPE

Each individual member researched & selected at least one component of the final design

For each component members were asked to create a test for functionality

Individual Components to be Tested	
Programmable Logic Controller	Microcontroller
Solenoids	Wheels
Motor	Springs
Bearings	Tape

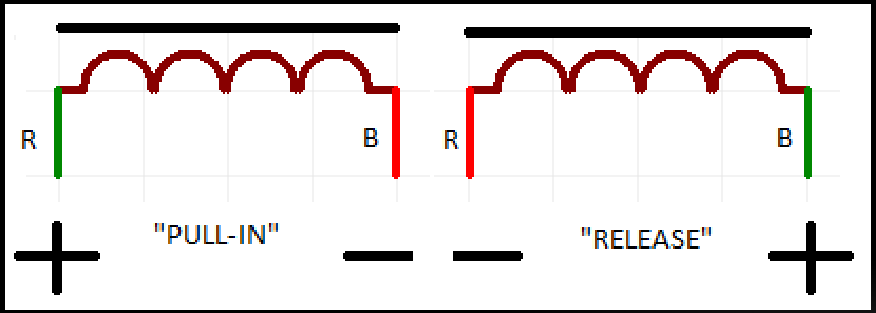
BEARINGS

- Prototype
  - Fastenal
  - 30-35% Greased
- Space Implementation
  - Timken
- Design, Structure and Testing
- Lubrication
  - Prototype
  - NASA test and usage

SOLENOIDS

General

- Used to latch boom
- Reduce power consumption
- Testing

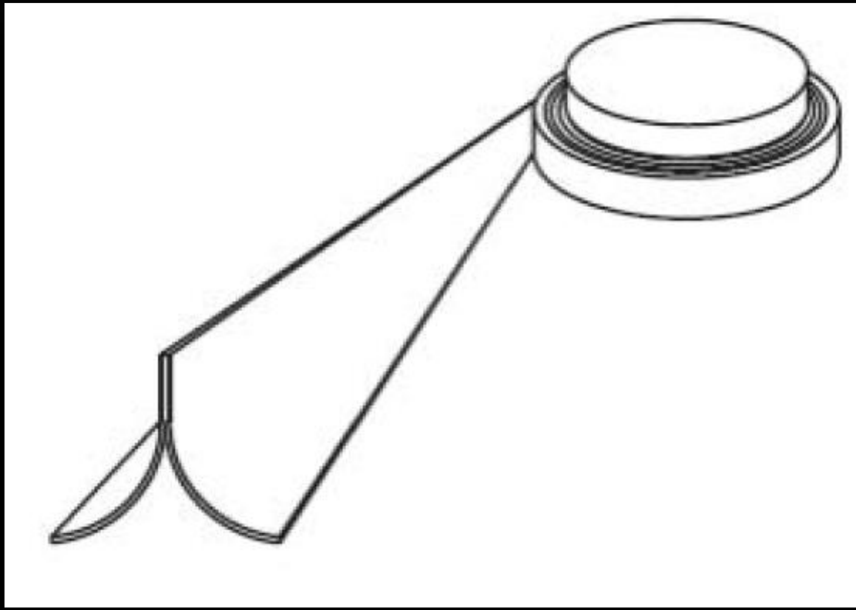


Magnetic Latching System

- Stays in position when voltage is removed.
    - Held out by spring.
    - Held in by magnet.
- Reverse voltage to move core in other direction.
- “Zero-Power-to-Hold”

TAPE MEASURE BOOM

- TRAC Boom
  - AFRL
  - Nanosail-D
- Elgoloy Stainless Steel
- Tape Measure Design
- Guide Plate
- Test

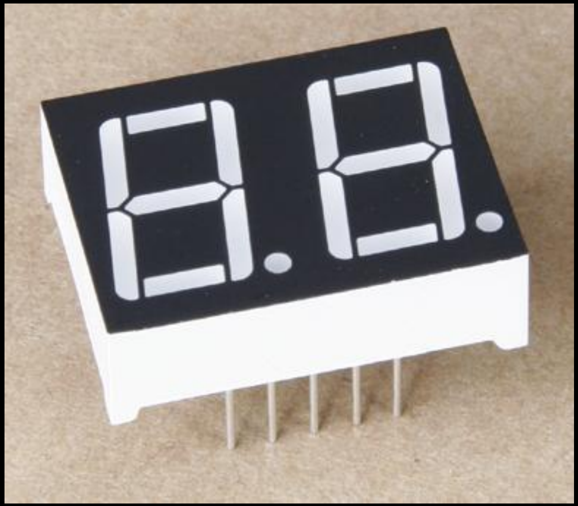


CONSTANT FORCE SPRING

- The spring we will use can be found here.
- This spring is:
  - Compact
  - Correctly tensioned
  - Low cost.
  - Spaceworthy
- For NASA's actual use
  - Vulcan Spring's products recommended

HUMAN TO MACHINE INTERFACE

- Test Requirement
- Simplified Design
- Three Switches, Two Pole
  - Stop
  - Send Out
  - Send In
- Seven Segment Display



PROGRAMMABLE LOGIC CONTROLLER

- ALTERA Cyclone II Test
  - Reprogrammable
  - Quartus II VHDL
- AT40KEL040
  - Rad Hard
  - 233 I/O Pins
  - ATMEL FPGA Designer®
- 3.3V Supply
- MIL STD 883 Method 1019

MOTOR

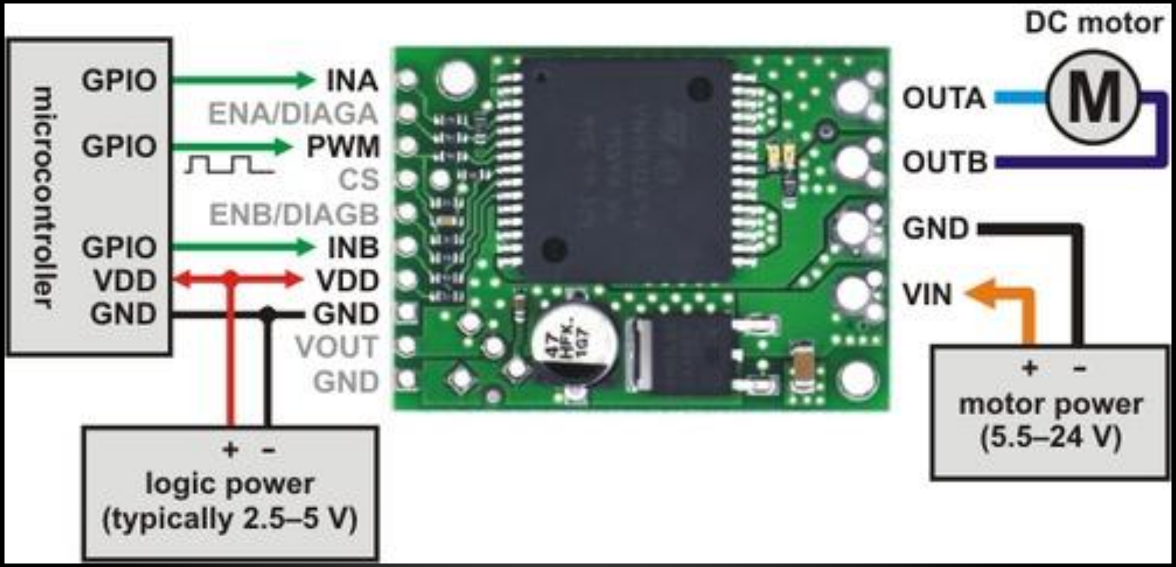
- Brushed DC motor with gearbox
- 57 rpm
- Small size
- 260 oz·in stall torque
- Terminal resistance and torque testing

MOTOR DRIVER

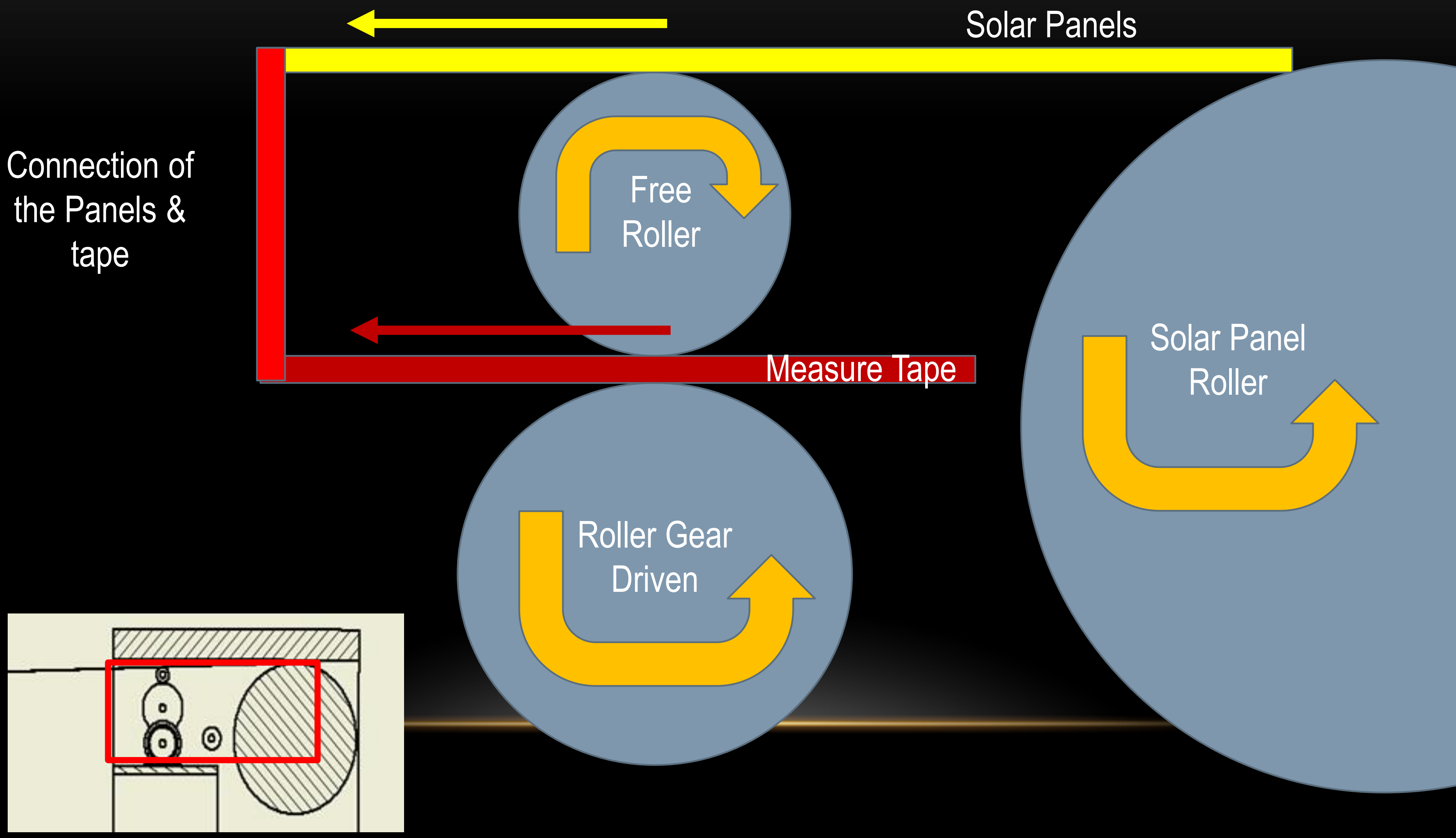
- Operates at 6V delivering continuous 12 A
- Various built in shutdowns and protections
- Compact Size
- Test current sense ability and motor indicator LEDs

ELECTRICAL INTERFACE

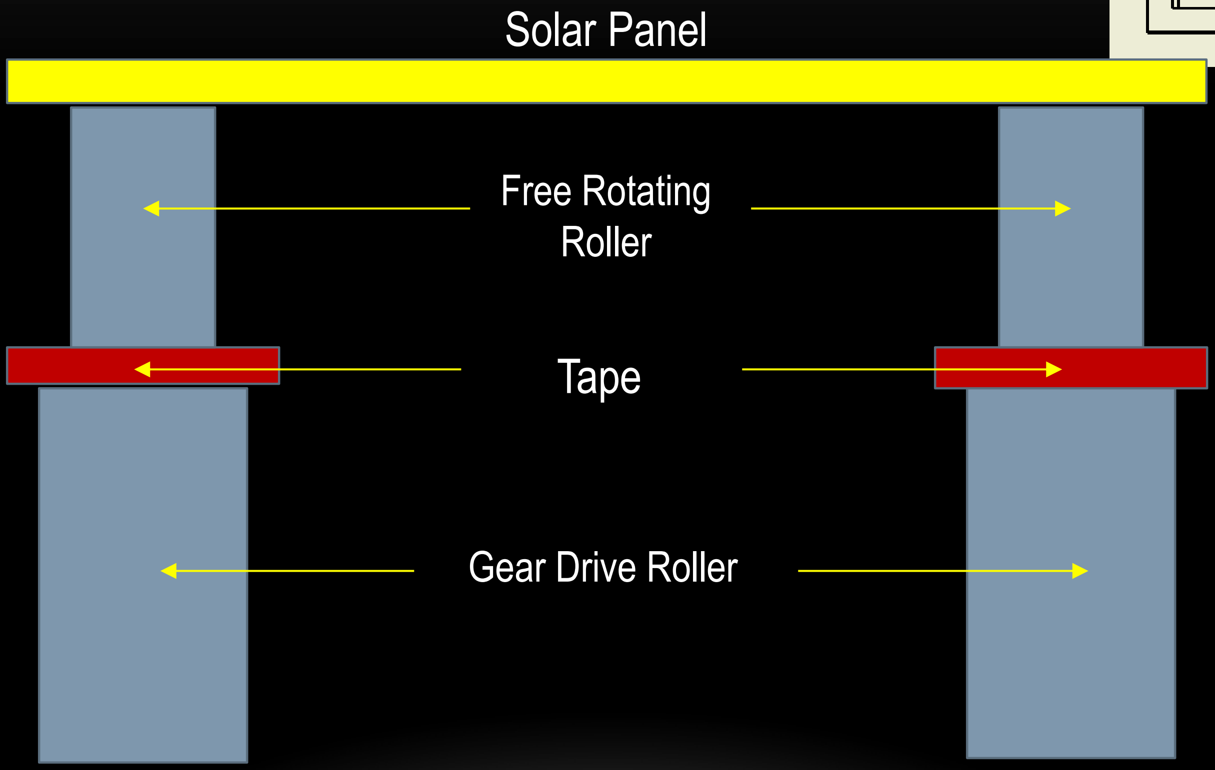
- 172:1 Gearmotor with 260 oz-in stall torque
- Motor Driver
- Atmel Microcontroller

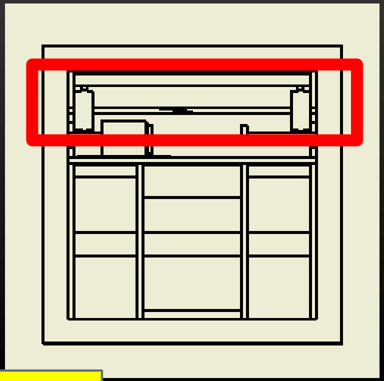


ZOOM-IN SIDE VIEW



ZOOM-IN FRONT VIEW





PROJECT MILESTONES AND SCHEDULE

• Analog or Digital	10/05/2014
• Circuit Outlines and Improvements	10/31/2014
• Our Design Constraints were changed	11/01/2014
• Redesigned our 1U CubeSat	11/12/2014
• Final Circuit Completion	11/26/2014
• Material Selections	12/05/2014
• Draft Design Sent to NASA	12/06/2015
• Bill Of Materials	12/07/2014

PLAN FOR NEXT SEMESTER

• Material Ordering	12/19/2014
• Circuit Assembled	02/02/2015
• Complete Local testing	02/06/2015
• Complete all Testing	02/20/2015
• Ship prototype to NASA	02/20/2015