Development of a Self-Orienting Solar Array for CubeSats

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Objective: Develop a solar array design for the CubeSat family of space craft. The design adheres to the following requirements: **1)** Must have the ability to orient Solar Panels towards the Sun to maximize solar power generation; **2)** Must within the space of a 3U CubeSat for launch; **3)** The movement must use no power or computation internal to the CubeSat

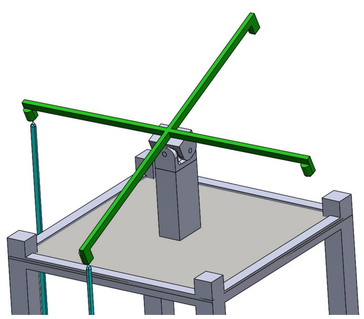
CubeSat Background

- Design originated in late 1990's
- Small satellites built up from individual units
- 1 unit = 10cm x 10cm x 10cm cube
- CubeSats make space more accessible to small institutions
- Causing a revolution in Space, Defense, and Conservation Research

Photograph of San Francisco, CA taken from a CubeSat and 3 Unit CubeSat (Courtesy of Planet Labs Inc., San Francisco, CA)

Design Philosophy

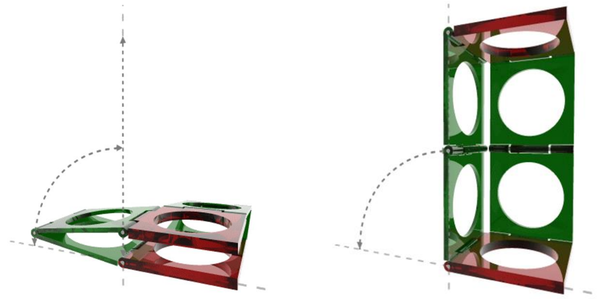
- Use a Universal Joint to allow for full range spatial pointing
- Use smart materials as prismatic actuators to control position



Universal Joint for Solar Array Orientation

Creating Clearance

- Universal Joint movement requires separation from the CubeSat Chassis
- Solution: Sarrus Linkage
- Straight-line Mechanism developed in the 1850's
- Spatial 6-Revolute Joint Mechanism

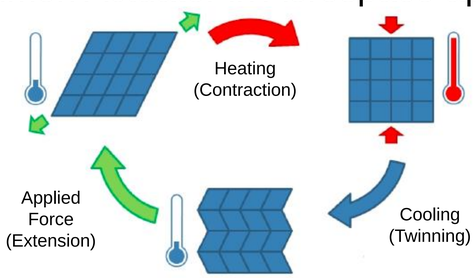


Sarrus Linkage Collapsed (Left) and Deployed (Right)

Image Source: "Sarrus linkage," *Wikipedia*, 28-Feb-2018. [Online]. Available: https://en.wikipedia.org/wiki/Sarrus_linkage. [Accessed: 09-Apr-2018].

Nitinol Material

- Shape Memory Alloy, phase dependent on temperature
- Temperature can be reached by passing an electric current through the nitinol
- Common Actuator in Aerospace applications



Nitinol Phase Transformation

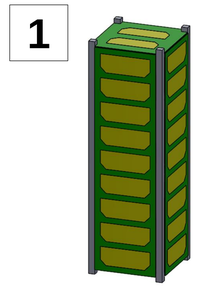
Image Source: J. P. Swensen and A. M. Dollar, "Optimization of Parallel Spring Antagonists for Nitinol Shape Memory Alloy Actuators," in *IEEE International Conference on Robotics & Automation (ICRA)*, Hong Kong, China, 2014.

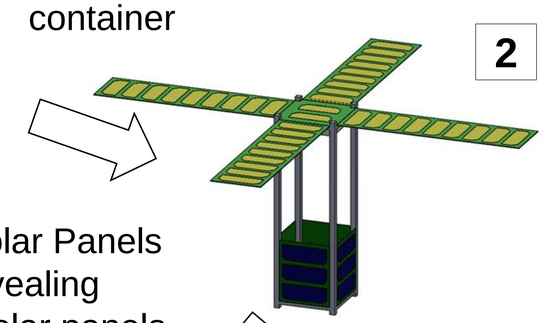
Actuation Design

- Pass electric current through Nitinol Springs
- Electric current from auxiliary solar panels
- 4 Nitinol Springs, acting as antagonistic pair

Deployment Procedure

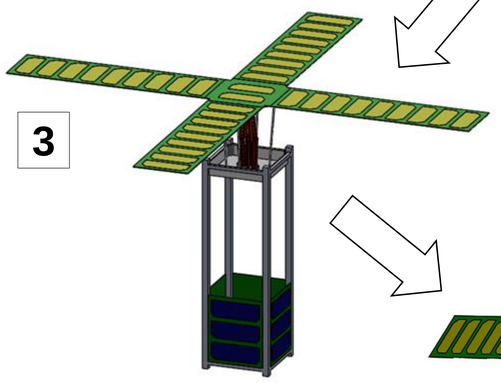
1. CubeSat is Stowed in its deployment container

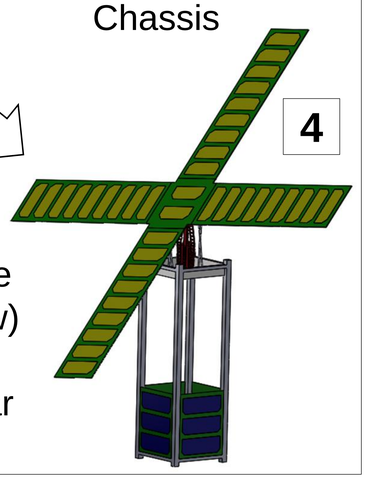




2. Main Solar Panels deploy, revealing auxiliary solar panels

3. Sarrus Linkage creates separation from Chassis





4. Nitinol springs pull the Main Solar Array (yellow) in the direction the sun strikes the auxiliary solar panels (blue)