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Low Earth Orbiting Photographer (LEOP) Cube Satellite

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Abstract

The exploration and study of space is critical for the future of our society, but the opportunities for educational institutions to get involved in space research have faded dramatically in the last decade with the retirement of the space shuttle program. The USU Get Away Special (GAS) team is designing a new, low cost solution to space research, CubeSat (Cube Satellite). This small satellite, with a volume of approximately one liter, will have a high resolution camera directed at earth, and students will be able to request a picture of their area when the satellite flies overhead. In this way, students will have an eye-in-the-sky to help them be a part of space research. The GAS team expects this project to increase interest in space research and provide an affordable solution for future projects.

Background

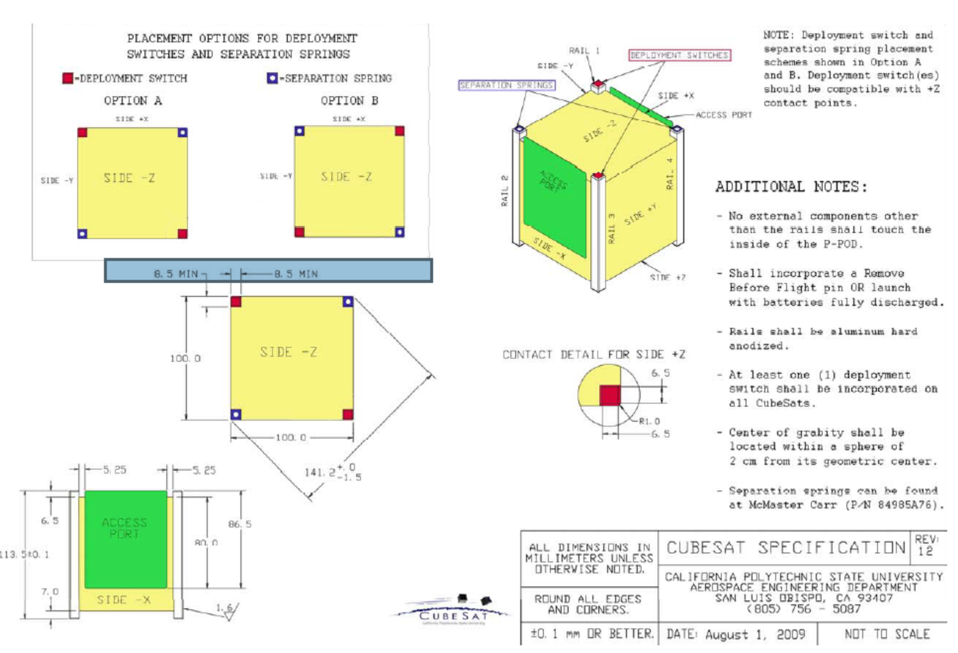
The CubeSat design was initially developed by California Polytechnical State University and Stanford University in order provide a more affordable method of performing space research. In 1999 the universities developed the global specification standards for CubeSats to assist universities worldwide.

Physical Design Specifications:

- Dimensions – 10x10x11cm ~1.0L
- Mass – 1.33Kg
- Side rails must be made of hard anodized aluminum
- At least 75% of rails must be in contact with P-POD rails

Operational Design Specifications:

- No active electronics during launch
- Deployables must wait 30 minutes to deploy after P-POD ejection



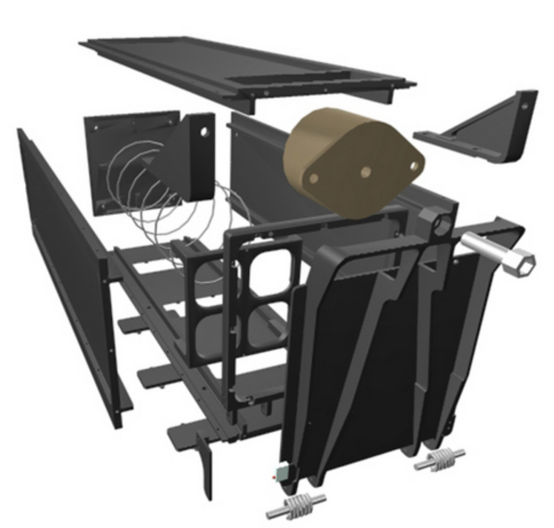
Cubesat Specification diagram

Putting a CubeSat into orbit is made possible through existing rocket launches. It is affordable because the they are able to "piggy back" on these rockets and then be pushed into orbit by P-POD launchers.

Images courtesy of CubeSat.org

P-POD Launcher

The P-Pod has space for three 1U CubeSats. The CubeSats rest along rails with a spring mechanism in the back. When the spring is released it pushes the CubeSats out of the P-POD and into space. When the spring releases, it triggers each CubeSat to begin their individual startup sequences.

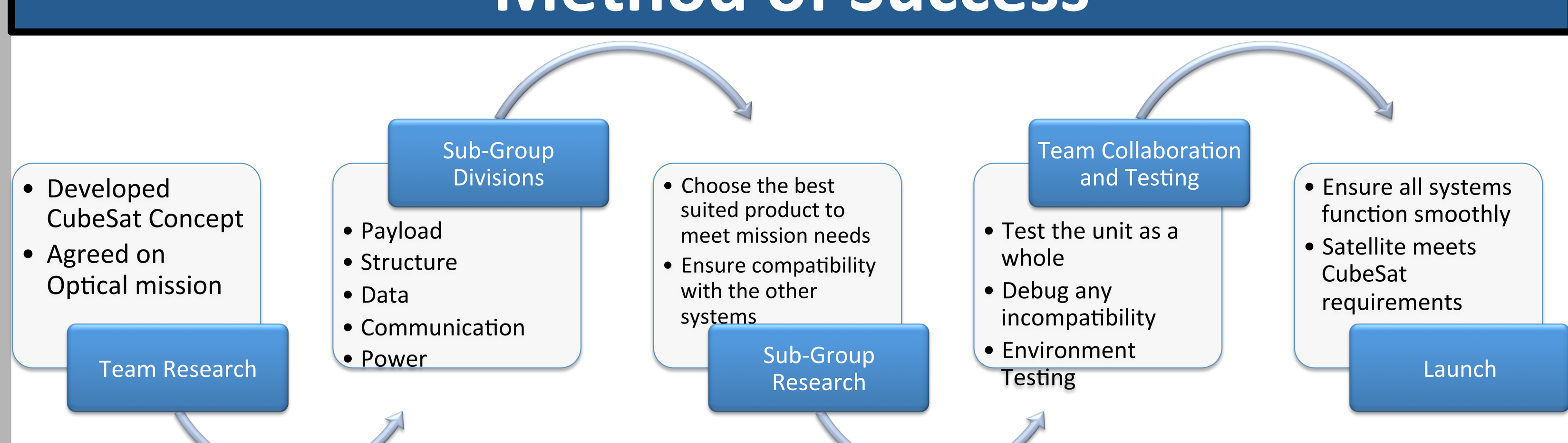


P-POD part schematic

Objectives

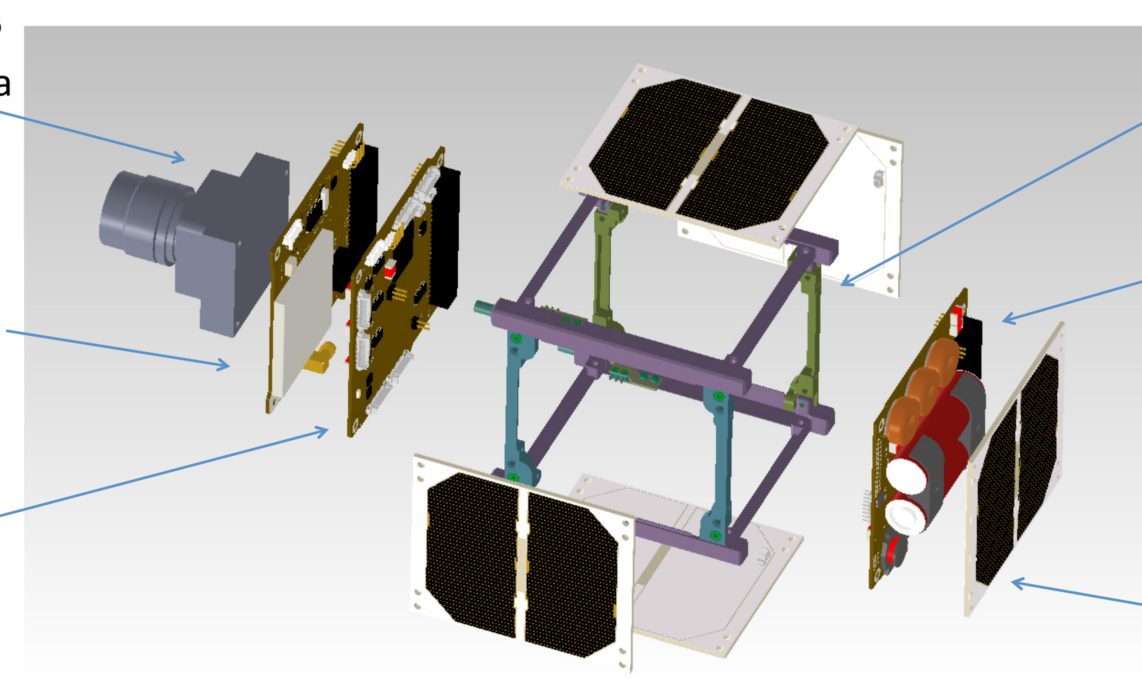
1) Design, build, test, and launch a functioning CubeSat
2) Capture high definition images of earth features
3) Promote and increase awareness of CubeSats globally

Method of Success



Features and Configuration

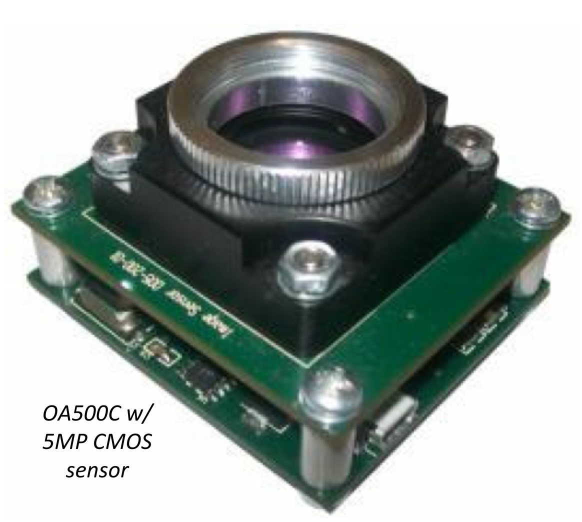
Assembly



Payload

The objective for the LEOP team is to capture higher resolution images than any CubeSat before. Our selection for this component was the OA500C 5MP CMOS camera with a 35mm C-mount lens. Most conventional cameras use a CCD (charge-coupled device) sensor to capture images. The CMOS (complementary metal-oxide semiconductor) sensor proved to be a better option because it uses 1/100 of the power of a CCD sensor. The trade off though is in the sensor's sensitivity. CCD sensors are traditionally more sensitive than a CMOS sensor. Being that we are looking at the earth, which is relatively still, this will ultimately not pose as an issue.

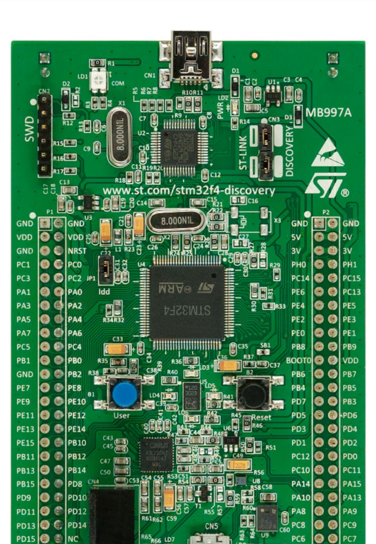
Satellite image resolution is measured in meters/pixel meaning that every pixel represents a certain length on the ground. CubeSats previously have been able to get resolution as high as 30-40m/P. We plan to double or triple this quality. Meeting this mark will depend on LEOPS orbit altitude. We could see quality as high as 5m/P at 100km or 25m/P at 300km.



OA500C w/ 5MP CMOS sensor

Data Processing

The heart of LEOP is in its processing capabilities. All functions of the satellite will be managed with the STM32F4DISCOVERY board. It is fully equipped with all the features that LEOP needs to integrate all of its components and to have them function in sync.



STM32F4DISCOVERY

Features

-Micro-USB port for camera
-Outstanding power efficiency
-1 Mbyte Flash memory
-192 Kbytes SRAM
-ART Accelerator
-7 layer AHB bus matrix
-Customizable pins

Communication

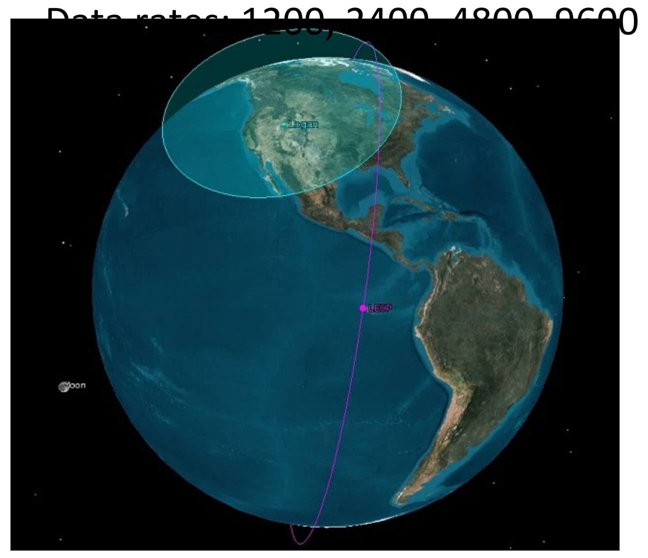
A huge challenge of the LEOP team is data management. Image transmission will prove to be difficult because of the amount of data that is required to transmit. The simplest and most effective method is to use radio frequencies. This is an easy task and requires limited licensing to operate. This process will require a VHF transmitter and a UHF receiver with the following capabilities.

VHF Transmitter

Frequency range: 130-160MHz
Transmit Power: 300mW PEP, 150mW average
Data rates: 1200, 2400, 4800, 9600 bit/sec

UHF Receiver

Frequency range: 400-450MHz
Data rate: 300-1200 bit/s
-100dBm Sensitivity for BER 10E-5



Theoretical orbit of LEOP @450km w/ UHF receiver range

As LEOP orbits the earth it will only come into contact with our team when it comes into range of the UHF Receiver. The receiver is able to capture data within a region that extends 10º from the surface of the earth making a region in the shape of a cone. Depending on the altitude and speed of LEOP we will be able to expect data rates of ~1.2kb/s. This would take roughly a day to transmit a full color image or about 6 hours for a grey scale image. Other universities may become involved that could allow us to use their UHF receivers to stream even more data.

Control and Power

When LEOP is pushed into orbit it will be spinning in all manner of directions, and it is essential to find a way to stabilize it so that the camera is oriented to the earth. This is done by magnetorquers, small coils that pulse electric current to create a countering magnetic fields that stabilizes the satellite's spin. They are related to the power supply because the coils are actually integrated into the solar panels of the satellite. The coils are strategically positioned along three faces of the CubeSat in order to orient the satellite on its three axis. Although this orientation process takes a couple of days after deployment it is worth it because of its reliability and cost effectiveness.

The power itself will be provided by five solar panels purchased from Clyde Space, an aerospace company specialized in CubeSats. Five sides of LEOP will have solar panels which are connected to rechargeable lithium batteries. The power supplied to LEOP is essential and has to be managed effectively among each component. Each panel is rated to create 2.1W of power at 28ºC. With five panels this will serve well to provide for the needed power of LEOP.

What is Next?

- Integrate all components and ensure system compatibility
- Conduct environmental testing to study the effects of space on the components
- Continue to promote LEOP with Community Outreach Programs and a public website

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