Equipment

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RFM22B Transceiver

Baojie BJ-450 UHF 420-430Mhz Radio Amplifier

MSP136VDG-160 Preamp 136-138 (preferred frequency range)

M2 436CP42UG

MSP136VDG-160 Preamp 136-138 (preferred fre

EdgeCube Satellite

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Jernigan can send ground commands to turn off all RF either temporarily or permanently

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The Applicant, Sonoma State University, is a unit of the California State University system. It is a comprehensive state university.

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EMC Analysis of EdgeCube

Summary of EdgeCube

EdgeCube is a 3U cubesat being launched into orbit at 545-km altitude, and 97.4-degree Sun synchronous orbit. EdgeCube is operated from a single ground station location at Sonoma State University in California. The frequency used for space to earth communication and earth to space communication is 437.465 MHz (typical desired frequency). This report reviews the situation as regards other authorized operators in this frequency range and operating range. No significant interference is reasonably expected to occur with the local amateur radio club due to the low power (0.5 watt) of the omni-directional RF radiation.

Compliance with Local Amateur Radio Operators

Because the operating frequency is in the amateur frequency range, we coordinated with the local amateur radio club. For a previous cubesat the operator of the S/C has discussed the situation with the local amateur radio club in Santa Rosa the largest nearby city. Previously we operated a CubeSat in this band called T-LogoQube. All communication with the CubeSat occurred at elevations with high gain antennas at angles greater than 30 degrees. Longer duration downlink communications have a maximum RF power of 0.5 watt. We can examine any situation for a downlink and see the RF path is clear and halt any overlapping transmissions if necessary. Past experience with cubesats has shown that significant interference is unlikely at RF powers less than 0.5 watt. All EdgeCube transmission will be under 0.5 watts of RF power.

Interference would only occur for a physically nearby satellite using the same frequency. FCC frequency coordinated assignment should avoid this possibility. Even if this type of interference were to occur we can cease transmission for a modest period until differential drag physically separates the two spacecraft.

Rare short duration uplinks, typically less than ~1 sec, at higher power are implemented with high gain pointed Yagi antennas on the ground for which the RF power is directed away from any ground RF sources to avoid any nearby receivers. The likelihood of any interference is cause the loss of data reception by the CubeSat with no comparable interference of with the HAM communications.

Compatibility within Operating Range

ITU radio regulations provide power flux density (PFD) limits, above which coordination with terrestrial and aeronautical mobile systems is required.

* Terrestrial Services: -125 dBW/m2/4KHz

* Aeronautical Mobile (R): -125 dBW/m2/4KHz

* Aeronautical Mobile (OR): -140 dBW/m2/4KHz

These specified power levels typically would adversely effect the RF environment are much higher than the omni-directional emission expected from a <0.5 watt transmitter used by the EdgeCube cubesat. Clearly this fact would not be the case for higher levels of power which transmit data at higher baud rates.

EdgeCube Satellite Technical Description

Mission Overview: EdgeCube will make a global measurement of the red edge that monitors a sharp change in leaf reflectance in the range 600 to 800 nm from changes in vegetation chlorophyll absorption and mesophyll scattering due to seasonal leaf phenology or stress. EdgeCube has been specifically designed to monitor the red edge characteristics of ~200 km areas of the earth using 9 narrow spectral bands in the wavelength range 600-800 nm. Two additional sensors will be flown: one will measure the optical and Infrared broadband signal in order to measure the incoming solar radiance. The incoming solar radiance is needed in order to calculate the top-of-atmosphere reflectance (at-sensor radiance/incoming solar radiance), thus normalizing the data through the seasons and by latitude. Although EdgeCube's ground spatial resolution is substantially less than conventional multispectral satellites, its design will monitor changes in the red-edge on a global scale within the telemetry limitations of a cubesat.

The satellite will be launched as a secondary payload on a Falcon 9 scheduled for launch during October 2018. EdgeCube will be inserted into a Sun synchronous circular orbit at 545 km. Transmission will begin ~3 hours after launch. Atmospheric friction will slow the satellite and reduce the altitude of the orbit, until de-orbiting occurs 3-5 years after launch. See the Orbital Debris Assessment Report for details.

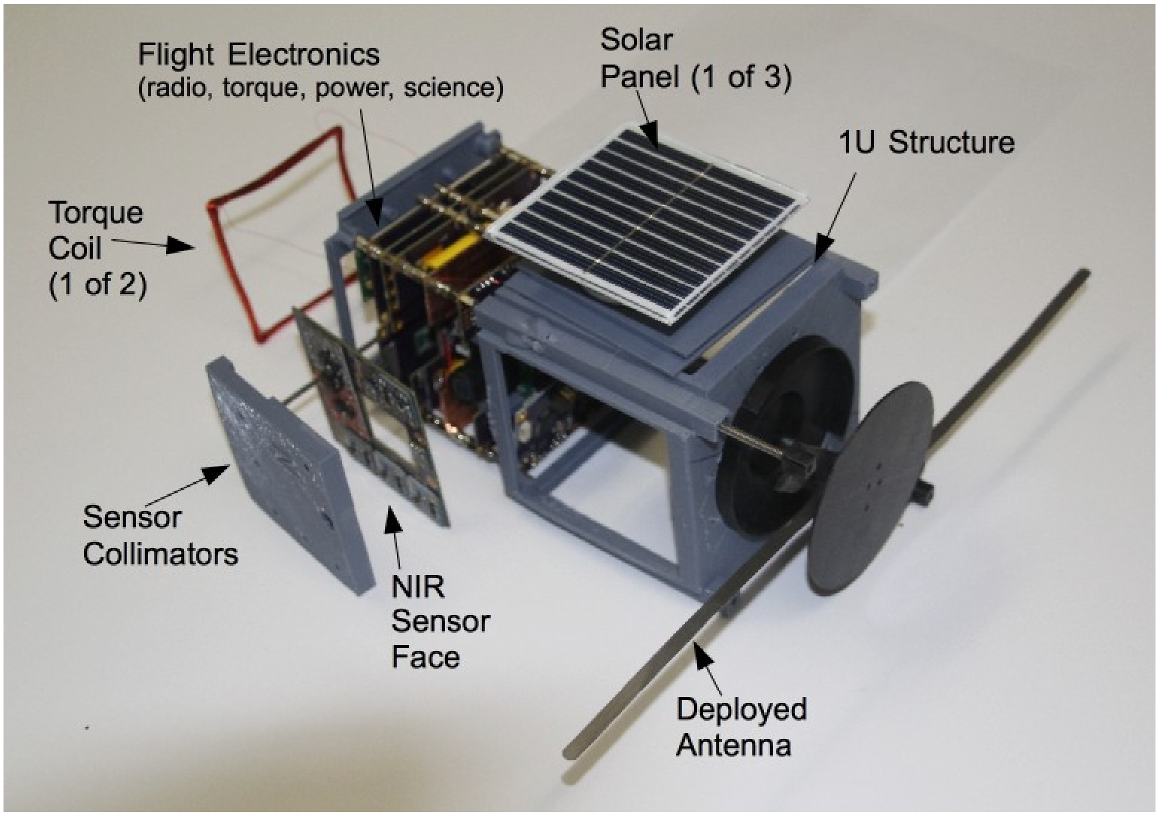

Figure: This figures shows an image of the EdgeCube flight electronics. The 1U board stack is arranged in the 1U flight configuration and is mounted with actual hardware. The 1U outer structure is shown translated to towards the antenna to reveal the details of the internal structure. The stack of flight includes the science electronics for operating the NIR sensors, the S/C power monitor, the torque board for controlling the spin rate and pointing of the S/C. The stack also includes a ~300 g copper block (total S/C mass ~1.4 kg) to define the principle momentum axis. The NIR collimator and the sensor face that carries hold the sciences sensors are displaced separated from the 1U box for clarity. Similarly one solar panel and one torque coil are shown separated from the compact electronics box for visual clarity. The pop up dipole antenna is shown in the deployed configuration.

The satellite contains the following systems: **Attitude Determination and Control (ADC), Command and Data Handling (CDH), Communications (COM), and Electrical Power System (EPS).**

Attitude Determination and Control (ADC) Subsystem: The ADC is a purely electromagnetic system to keep EdgeCube's spin axis pointing within ~30 degrees of the north pole. The system consists of 2 torque coils, triaxis magnetometer, triaxis rate gyros, and a sun sensor. The spin rate is controller

Command and Data Handling (CDH) and Communications (COM) Subsystem is integrated into a single COM concept.
EdgeCube's CDH system is a distributed network which integrates the data gathering process across many nodes on a network. There is a special network node that monitors the power system. A special node called the uStar gathers all the telemetry data from all the nodes on the network. This function is integrate into the tiny simple OS. This tiny OS also sends all telemetry packets to the ground using an RFM22B packet transceiver.

Electrical Power Subsystem (EPS): The Electrical Power Subsystem will is based on three fixed identical solar module arrays. A fourth face houses the sciences sensors. The system uses 3 five watt solar panels and one 1 amp-hour NiCd battery pack. The system has a power point tracker.

Thermal Control Subsystem (TCS): The TCS moderates temperature changes passively using a large 300 g copper heat sink. The heat sink resides near the CG of the S/C also serves as a momentum reservoir.

Structure Subsystem: The structure is fabricated with Aluminum that is 3D printed.

Propulsion Subsystem: No propulsion subsystem is included.

Payload Subsystem: The payload consists of a set of single element NIR sensors with narrow band filters.

The Goal of the EdgeCube Missions

The overall goal of the EdgeCube mission map the surface of the Earth (~200 km resolution) in chlorophyll using ~10 narrow band NIR filters.
The radio communications links are necessary to support control of the experiment, and to transmit the telemetry data to the University.