Phoenix - A Study of Heat Islands Through Infrared Remote Sensing

Project Overview

Phoenix is a 3U CubeSat developed by Arizona State University which will measure the effects of Urban Heat Islands in selected US cities through infrared remote sensing. Images will be taken from a Low Earth Orbit of 400 km and a 51.6° inclination of US cities. Phoenix will launch on November 8, 2018 with the ELaNa-21 program on a Cygnus ISS resupply mission. The satellite will deploy from the ISS and remain in orbit for two years before reentering the atmosphere. Phoenix is supported through a cooperative agreement under the NASA USIP Program, and the satellite is owned and will be operated by a student team at Arizona State University.

Communications

Satellite communications will be performed through UHF amateur frequencies (435-438 MHz) and S-Band amateur frequencies (2.4-2.45 GHz). The UHF band will be used for regularly transmitting satellite health data (power consumption, satellite location, and hardware performance) as well as receiving all operation schedules for the satellite which will be uplinked from the ground station. S-Band transmission will be used for downlinking all captured images. Communications will be handled over CCSDS CFDP protocols for both UHF and S-Band frequencies. The IARU has suggested the following frequencies for both bands:

- **UHF:** 437.35 MHz (ITU Emission: 20K0F1D)
- **S-Band:** 2402.5 MHz (ITU Emission: 1M35G1DDN)

Ground Station

The ground station located at Arizona State University will be used for all communication with the satellite. All mission operations will be performed in the ASU mission operations center. Embry Riddle will be used as a backup ground station for communication over UHF frequencies in the event the ASU ground station is under maintenance. There is no backup ground station for S-Band downlinks.

Ciphers & Encryption

Once the mission success criteria has been met, limited information on the spacecraft command system will be released. The amateur community will receive access to a “Housekeeping” parser to allow them to listen to general satellite telemetry so that Phoenix may remain a resource to others in the future. Once minimal mission success criteria have been met, amateurs will also be allowed to downlink images from the satellite to encourage participation in the mission. However, all command codes for spacecraft attitude control, tracking, image capture, and other mission critical operations will require a rotating one-time use cipher key using a simple substitution scheme to maintain operation integrity. The cipher system will be stored in a private GitHub repository. Access to the repository is controlled by the project’s faculty mentor and it will be protected with gpg public/private key pairs. The cipher is the only encryption method on the Satellite.

Positive Transmitter Control

While in orbit, there are methods of controlling the on-board transmitters in the event that the FCC were to request a halt of transmission. The UHF transceiver can set a max transmit time as well as a maximum transmit inhibit time. These are both settings on the hardware and therefore operate independently of the satellite's on-board computer. These will be set to only transmit short heartbeat messages to the ASU ground station, with a buffer of 30 seconds in between, which will cover one downlink opportunity to the ASU Earth Station, but can be changed at any time through a ground station command. There will be up to 4 opportunities per day to communicate with the satellite from the ASU ground station.

The S-Band transmitter will only transmit when its buffer is populated and there is data to send. Data is pulled into the buffer by the satellite computer. In the event of an on-board computer failure, the transmitter would stop receiving data, and therefore, it would be incapable of sending telemetry to the Earth Station. In this state, the transmitter would simply remain on. Updates to the operations schedule can be made at the earliest opportunity to communicate to the satellite from the ground station to override the command to perform an S-Band downlink. In addition, the transmitter is designed to power off automatically after 15 minutes if it is left powered on.