Phoenix CubeSat Data Protection Plan

Arizona State University

Revision 3 - 7/29/2018

Record of Revisions

Revision No.	Description of Revision	Pages Affected	Date Revised	Issued By
0	Initial Release	All	-	Sarah Rogers
1	Updated to describe the regulations behind collecting non-earth images, as well as clarify earlier questions regarding data collection, amateur involvement, and data storage. Contact information for the ERAU ground station was also added. Finally, the launch date was adjusted, as the spacecraft will no longer be launching on ELaNa-21.	2, 3, 8, & 9	7/31/2018	Sarah Rogers
2	Updated to reflect the new Data Protection Plan format, released on 10/03/2018	All	12/13/2018	Sarah Rogers
3	Updated the data protection description and ground station diagram to reflect that images will be downlinked over UHF frequencies, rather than S-Band.	2,3,4	7/29/2019	Sarah Rogers

1. Introduction

1. Data Protection Strategy

1.1.1 Data Protection Summary

Phoenix is a 3U CubeSat developed at Arizona State University to study the Urban Heat Island Effect over several US cities through thermal infrared remote sensing. Phoenix will operate in the amateur frequency bands under an open, but limited communication link. UHF amateur bands (435-438 MHz) will be used for uplinking mission operations schedules and for downlinking all housekeeping telemetry and images to support the science objective. The ground station at ASU is a protected facility which will serve as the primary command center for uplinking all commands and downlinking all data from the spacecraft. A backup ground station is located at Embry Riddle Aeronautical University (ERAU) in Prescott, Arizona. All commands will be encrypted through a rotating cipher. Downlinked data is not encrypted. The Phoenix CubeSat is meant to serve as an educational platform for the greater community, and therefore, all thermal images and their associated metadata captured by the Phoenix CubeSat will be made publicly available through the project website (phxcubesat.asu.edu) and through the ASU Data Archives Library.

1.1.2 Data Protection Diagram

Command uplink over UHF frequencies will only be scheduled when the satellite is over the ASU Ground Station (or backup station at ERAU). 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 integrity during operations. During command uplink, the satellite will listen for next valid passcode in a secret list to accept commands. If the passcode matches the passcode on the satellite, the command will be received and stored on the OBC. From there, commands will be passed to the other onboard components to execute operations. 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 ASU Ground Station is located on the rooftop of the ISTB4 building. Access to the rooftop is restricted by badge control and granted to those authorized by building management. The UHF radio and TNC, along with the primary operating computer are located in a rooftop mezzanine also behind restricted badge access. The radios are operated remotely from the missions operation center in the main building, where all command uplink will be sent and all downlinks received. The missions operations center is a multi-use facility used by several space missions. Access to it is restricted by badge control and granted to students and staff working on the missions and related projects.

The ground station is a radio connected to a modem which outputs to a computer. Telemetry will be converted from a custom file format into standard image and data files. These files will be stored on the local ground station machine as well as in an ASU google drive accessible to the larger team who will perform steps such as image calibration and alignment. Raw and reduced products will put on the team website as well as archived for long term storage in the ASU Data Archive.

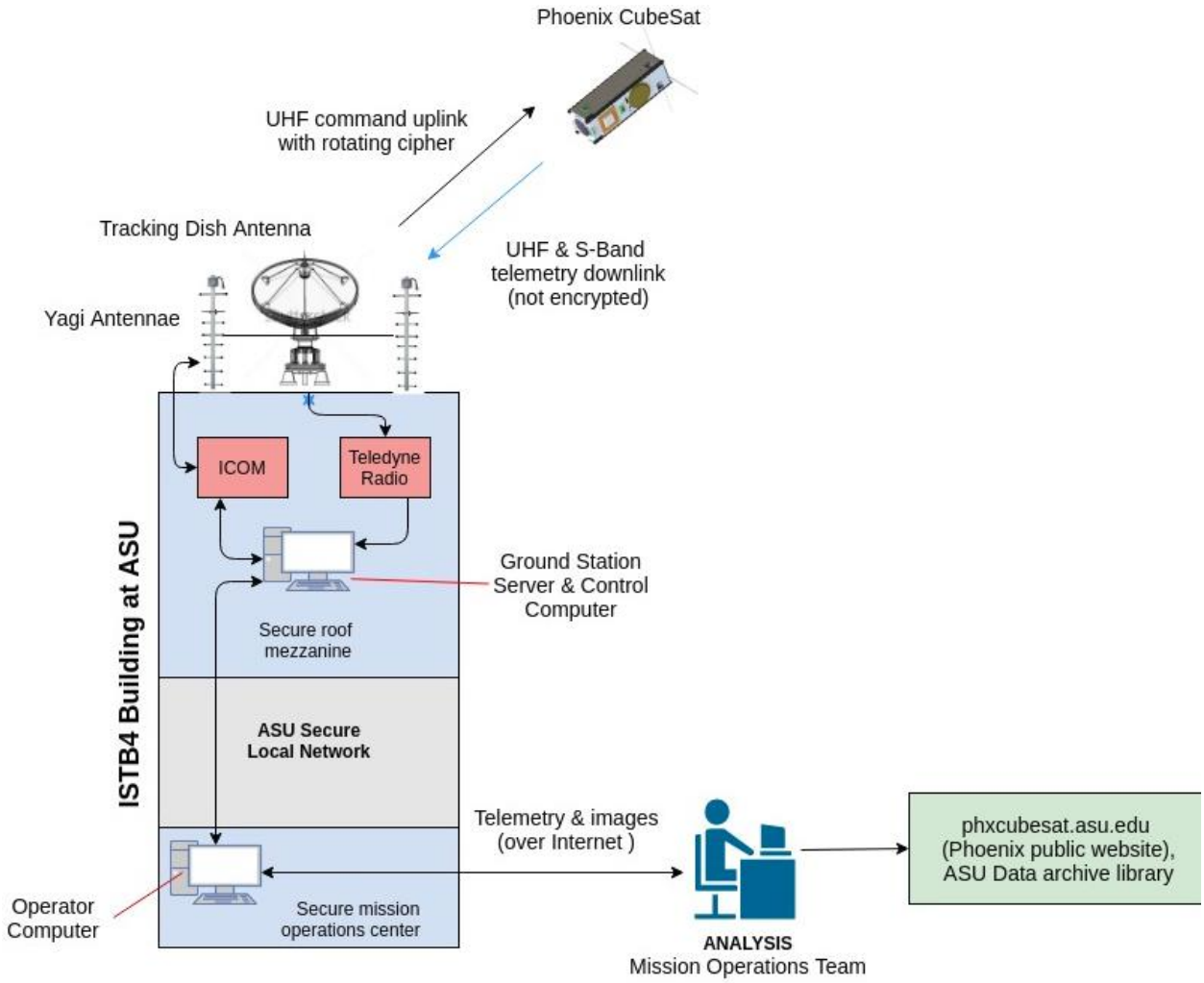

Figure 1:Data Protection Diagram

In addition to science downlinks, to facilitate the primary mission objective of educating others, the amateur community will receive access to a "Housekeeping" parser to allow them to listen to the satellite's health beacon telemetry. Instructions on how to ping the satellite for a housekeeping packet will be released through the Phoenix website. An additional mission goal is to allow the amateur community to command image downlinks of files which have been tagged by the team for this purpose. Only publicly released images will be downloadable. Images released on the website will be tagged on the spacecraft for public download. Amateurs will not command when and where images are taken.

2. PROGRAM SPACE SEGMENT

2.1 Space Segment Description

2.1.1 Orbital Information

The CubeSat will operate in LEO and deployed from the ISS.

Orbital Parameters:

Altitude: 400 km
Apogee: 401 km
Perigee: 409 km
Inclination: 51.6°
Orbital Period: 90 minutes
Expected Orbital Lifetime: 2 years
Expected Operational Lifetime: 1 year

2.1.2 On Board Propulsion

The spacecraft has no on board propulsion system.

2.1.3 Sensor(s)

The Tau2 640 is an infrared camera developed by FLIR Technologies. It is the only imaging sensor that the satellite will contain. The payload provides a resolution of 640 x 512 pixels with a pixel size of 17μm. The camera will be fitted with a 100mm lens yielding a 6.2° x 5° field of view and a typical ground footprint of 43 by 35 km. The anticipated best theoretical resolution is 68 m/pixel, and the worst anticipated resolution is 110 m/pixel.

2.2 Communications

2.2.1 Communications Links

UHF Communications Link - Uplink

Emission ID: 20K0F1D
Direction: Uplink
Frequency: 437.35 MHz
Data: Command uplink
Encryption: rotating, one time, cipher

UHF Communications Link - Downlink

Emission ID: 20K0F1D
Direction: Downlink
Frequency: 437.35 MHz
Data: Used for downlinking all housekeeping and image telemetry.
Encryption: none

2.2.2 Link Characteristics

Phoenix is a Class 1 Mission. Therefore, this section is omitted.

3. GROUND SEGMENT

3.1 Ground Segment Locations

3.1.1 Ground Segment Locations

The ASU Ground Station will serve as the primary mode of communications with the Phoenix CubeSat. The Embry Riddle Ground Station will be a backup ground station for communications over UHF in the case where the ASU Ground Station is not operational. Satellite command schedules and telemetry would be collected in their database and sent to the mission operations team through private email in this situation. For both universities, the ground station operation center may only be accessed by members of the university who have card access to the facility and are trained on the ground station.

Facility ID: ASU Ground Station
Physical Address:
Arizona State University
781 E Terrace Mall,
Tempe, AZ 85287
GPS Coordinates
33° 25' 28.4304" N
111° 55' 40.8036" W
Functions
The ASU Ground Station has the capabilities for UHF communications, as well as for uplink encryption and data archival.
Ownership
James Bell - ASU Ground Station Project Investigator
Daniel Jacobs - ASU Ground Station Faculty Lead
Scott Smas - Program Manager
Point of Contact (for onsite inspections):
Daniel Jacobs

Facility ID: ERAU Ground Station
Physical Address:
Embry Riddle Aeronautical University
3700 Willow Creek Rd,
Prescott, AZ 86301
GPS Coordinates
34° 36' 52.1712" N
112° 27' 0.6624" W
Function
The ERAU Ground Station has the capabilities for UHF communication only, and it can provide for uplink encryption as well as data archival.
Ownership
Dr. John Post - ERAU Ground Station Faculty Lead

Point of Contact (for onsite inspections):

Dr. John Post

4. SECURITY PLAN

4.1 Physical Security

4.1.1 General Security Measures

Phoenix is a Class 1 system. Therefore, this section does not apply.

4.1.2 Cryptographic Hardware

Phoenix is a Class 1 system. Therefore, this section does not apply.

4.1.3 Remote Sensing Data

Phoenix is a Class 1 system. Therefore, this section does not apply.

4.1.4 Personnel

Phoenix is a Class 1 system. Therefore, this section does not apply.

4.2 Network Security

4.2.1 Command & Control

Phoenix is a Class 1 system. Therefore, this section does not apply.

4.2.2 Distribution

Phoenix is a Class 1 system. Therefore, this section does not apply.

4.2.3 Storage

Phoenix is a Class 1 system. Therefore, this section does not apply.

4.3 Cryptographic Security

4.3.1 Encryption

Phoenix is a Class 1 system. Therefore, this section does not apply.

4.3.2 Key Management

Phoenix is a Class 1 system. Therefore, this section does not apply.

4.4 Preventative Measures & Immediate Actions

4.4.1 Preventative Security Measures

Phoenix is a Class 1 system. Therefore, this section does not apply.

4.4.2 Immediate Access

A breach of security measures outlined within this Data Protection Plan (DPP) would involve the private cipher codes used to permit command uplink becoming available to an unauthorized party. Such an event would give anyone with the codes the authority of sending a command schedule to the spacecraft. In the event of a breach in security, the Phoenix team will notify NOAA (the licensing authority) within 24 hours of discovery.

5. RESTRICTED OPERATIONS

5.0.1 Geographic Exclusion Areas

Phoenix is a Class 1 system. There are no geographic exclusion areas for Phoenix.

5.0.2 Night Time Imaging

Phoenix is a Class 1 system. There are no restrictions on nighttime imaging for Phoenix.

5.0.3 Non-Earth Imaging

Phoenix is a Class 1 system. Under previous guidance, approval for non-Earth imaging of celestial bodies was sought and granted on July 12, 2018. Lunar calibrations will be performed before and after an image pass to assist with post-processing all thermal images on the ground, and for calibrating the payload in the absence of atmospheric errors. The team does not intend to collect ARSO imagery during the mission lifetime, and the satellite does not have the capability to do so. The satellite has a slew rate of 1.5 deg/sec, and will only be able to track objects with a latitude and longitude coordinate on the Earth. It does not have the capability to track an object in orbit, and therefore cannot track ARSOs. To perform space calibration, the satellite will slew to a fixed orientation and take an image.

All NEI will be flagged onboard the spacecraft as separate from Earth images. All metadata associated with NEI, including pointing information and timestamps, will be downlinked separately from the images themselves, and then paired with the images through ground-processing. All NEI will be be made publicly available on the project website and in the archive library.

All NEI will be examined closely to ensure that no ARSOs are captured in the images before they are released to the public or used in any form of data analysis. In the event that an ARSO is accidentally captured, NOAA will be immediately notified, and mission operators would use the image metadata to interpret which satellite may have been imaged based on TLE data from Space-track.org.

5.0.4 State of Israel

Phoenix is a Class 1 system. Therefore, this section does not apply.