

Phoenix CubeSat Non-Earth Imaging Waiver Request

April 4, 2018

Dear NOAA Commercial Remote Sensing Regulatory Affairs,

Arizona State University requests that the requirement that non-earth imaging be prohibited be waived for the Phoenix CubeSat to support the science objective.

Background:

The Phoenix CubeSat developed by Arizona State University aims to study the Urban Heat Island Effect over several US cities through thermal infrared remote sensing. In addition, Phoenix will prepare the student team for their future careers as well as promote the engagement of the public community during the operations phase. The payload is the Tau 2 640 Infrared camera developed by FLIR technologies, which provides a resolution of 640 x 512 pixels with a pixel size of 17 μ m. 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 spacecraft is expected to be launched on the ELaNa-21 mission on November 8, 2018, where it will be deployed from the ISS and assume a Low Earth Orbit of 400 km and 51.6° inclination. Phoenix will then orbit the earth for two years before undergoing atmospheric reentry.

Request:

Clause e of Section 10 of our NOAA Contract of Agreement states that “non-earth imaging is prohibited.” We are requesting that this clause be waived from our contract of agreement, so that images of planetary calibrators (the moon, mars, Jupiter) can be captured for instrument calibration purposes. The resolution of the instrument is such that most planetary calibrators will occupy 20 or fewer pixels.

We request this waiver for the following reasons:

1. Astronomical calibrators are needed to calibrate the camera without atmospheric error.
2. Calibration to space is performed by many Earth imaging satellites, including Landsat, GOES, and MODIS.
3. More accurate thermal images allow our data to be used widely within the scientific community to benefit the research of others and improve the understanding of our earth.

If space calibration is allowed, we would slew the satellite to take an image of astronomical calibrators like the Moon, Mars, or the black of space, before and after each imaging pass.

These data will be managed according to the project data protection plan. Images will be processed at the ASU data center and, after being examined and calibrated by the team, released publicly on the web.

Sincerely,

Judd Bowman, Associate Professor

Daniel Jacobs, Assistant Professor

Sarah Rogers, Student Team Lead

NOAA NEI Waiver Q&A - ASU Phoenix CubeSat
5/16/2018

The following questions arose after submitting a waiver request to NOAA to collect images of Non Earth objects. These questions intend to further clarify that the Phoenix CubeSat is incapable of resolving Artificial Resident Space Objects (**ARSOs**), which should not be imaged.

1. Given that ASU intends to “slew the satellite to take an image of astronomical calibrators like the Moon, Mars, or the black of space before and after each imaging pass” (source: Phoenix CubeSat NEI Waiver Request, 2nd to last paragraph), How many sequential images of a celestial body will be required to calibrate the system?
 - a. Only one image is required to calibrate the system
2. What is the slew rate of the Phoenix CubeSat?
 - a. The slew rate is 1.5 deg/sec
3. Will Phoenix CubeSat’s metadata information (at time of calibration imagery collection) be included in the downlink with the calibration imagery data (e.g. “pointing angles, time and position at capture, time of download, calibration parameters, effective aperture,” etc.)?
 - a. No. Images and metadata will be downlinked separately and combined during post-processing.
4. Will the Phoenix CubeSat imagery consist of single-frame (still imagery) or multi-frame (video). If video, what is the frame rate?
 - a. The satellite will only capture single images. No video will be recorded.
5. How will ASU comply with Section 3 of the NEI appendix, specifically the ban on incidental ARSO collection? i. Section 3.d.vi explicitly requires that non-consenting, non-resolved ARSO imagery be correlated with space-tracking.org catalog
 - a. In the event that an ARSO is captured in a non-Earth calibration image, we would use the metadata collected at the time of imaging to reference past TLE data on space-track.org and interpret which satellite may have been imaged.
6. Will this correlation can be done before calibration events to avoid incidental ARSO collection?
 - a. The correlation will not be done before imaging passes.
7. Can the slew rate allow track of ARSOs?
 - a. The ADCS slew rate cannot track ARSO’s. The satellite 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. To perform space calibration, the satellite will slew to a fixed orientation and take an image.
8. What is the process to identify and to request permission of ARSO owner if resolved imagery is planned? Including 90 days advance notice of ARSO collection with NOAA?

- a. We do not plan to collect any ARSO imagery during the mission lifetime.
9. What is the schedule for calibration events? Before every imaging session?
 - a. Calibration events will occur before and after every imaging session, which will occur once per orbit.
10. How will the DPP be modified to reflect the requirements of NEI, namely to ensure that NEI collection is properly archived and not inappropriately released?
 - a. The Phoenix CubeSat has applied for an Experimental License with the FCC. There is no longer a requirement to make all data publicly available, which the DPP must be updated to describe. Therefore, all NEI targets will be carefully examined during post processing to verify that no ARSOs are resolved in calibration images prior to releasing them on the project website.
11. What is the Data protection plan regarding access, review, control, and dissemination/disposal of NEI imagery data?
 - a. all images will be made publicly accessible on the project's website (www.phxcubesat.asu.edu), as part of the regulations of being an operator on the amateur frequency bands. There will be a section of the website specific to calibration data.
12. Can the NEI imagery be encrypted on the SD card, i.e. the onboard storage, so that would still be encrypted even if the downlink was not encrypted?
 - a. The spacecraft will not have the capability to encrypt images on the SD card.
13. Can ASU separate and segregate the calibration events and downlinking from the main mission imaging and downlinking
 - a. Yes, calibration images will be flagged and downlinked separately from images.
14. Would ground control know if commands were issued to change the satellite attitude or issue imaging commands outside of calibration or main mission events?
 - a. Yes, all commands, including imaging commands, will be logged with time, target coordinates if applicable, and spacecraft orientation. Logs will be maintained on the spacecraft and ground side.