

Phoenix CubeSat

Hardware Acceptance Review



Arizona State University
Sarah Rogers, Project Manager
July 19th 2018



Review Objectives & Procedures

Objectives

1. The project is on track to meet a delivery date between August 12 - August 23
2. All outstanding work is identified with an appropriate expected completion date (ECD)

Review Procedures

1. Please ask questions throughout
2. All request for actions (RFAs) shall be called out as they occur (by anyone) and recorded by the Phoenix team
3. Any RFAs not discussed during the review should be emailed to Sarah
 - a. RFA's/comments are due 1 week from the review day (July 26)



Review Agenda

1. CubeSat Readiness Overview
2. Battery Testing Status
3. Vibration Testing Status
4. Functional Test Status
5. Regulatory Status
6. Operational / Ground Station Readiness
7. Technical Compliance
8. Misc. Deliverables & Logistics
9. Unique Requirements
10. Open Work & Schedule
11. Final Assessment

CubeSat Readiness Overview

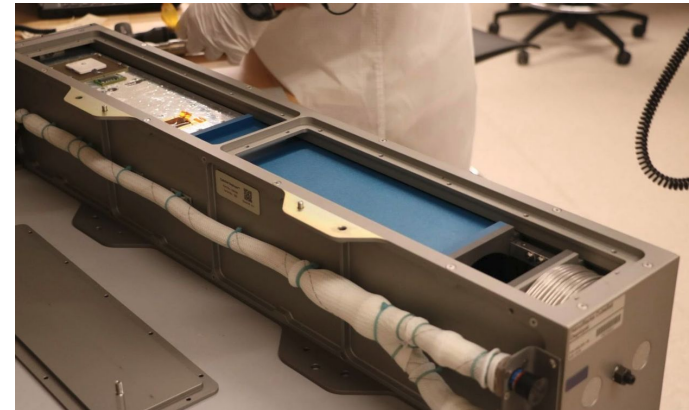
- Assembly / Build Status
 - Payload was vented per Nanoracks requirements - 7/1/2019
 - Two holes drilled, both using #65 bit (0.889 mm hole diameter, yields MEVR of 4652 < 5080)
 - Flight assembly: July 6-8
 - De-mated -Y and UHF antenna: July 12 (still demated)
 - For investigating fault with UHF antenna deployment mechanism
 - Antenna has been sent back to the vendor - expected return date for reassembly by August 2nd
 - De-mated and re-mated +Y panel post-vibe
 - No other integration concerns post-vibe
- Flight Software Status
 - All core FSW functionality is complete, ready for operations
 - Need to add calibration values for the ADCS sun sensors
 - Still performing final systems tests and making minor adjustments where necessary
- Identification of any unresolved technical issues
 - None at this time



Fit Check Status

- Fit-Check Status with NRCSD and Fit-Gauge
 - Completed along with acceptance vbe on July 10, 2019
 - Spacecraft meets fits in deployer
 - Deployment switch on +Y face clicks when CubeSat is moved in deployer
 - Only 1 inhibit needed to keep spacecraft off - no action to fix this

As-built Dimensions [mm]	
+Z end, +X face, Length rail-to-rail, measured from outside of rail	00.13 mm 1
+Z end, +Y face, Length rail-to-rail, measured from outside of rail	100.11 mm
-Z end, +X face, Length rail-to-rail, measured from outside of rail	100.22 mm
-Z end, +Y face, Length rail-to-rail, measured from outside of rail	99.9 m



CubeSat in Nanoracks deployer



Battery Test Results

- Battery Test Status
 - Battery test completed successfully: June 1, 2018
 - Test report currently in Nanoracks portal
- Battery Tests Conducted
 - LOT qualification data used to satisfy the qualification tests per NR-SRD-139 Rev. C. (Cell Over-charge, Cell Over-discharge, and External short tests)
 - Final flight acceptance tests performed at the PACK level
- Battery Tests Waived
 - 14 day test
 - 10 minute rest period between charge and discharge cycles
 - Temperature monitoring

Vibrations Testing

- Vibration Test Results & Status
 - Vibe testing completed July 10, 2019 at ERAU
 - Spacecraft passed successfully - no structural damage, loose screws, or damaged hardware
- Post-Vibration Test Functional Test
 - All inhibits functional post-vibe
 - Functional testing performed after vibe - no change in hardware functionality
 - Issue with UHF antenna was there before vibe, but thought to be a non-issue
- Vibration Test Report Status
 - Still working - ECD: EOD, July 19



Vibe table setup at ERAU



Additional Functional Testing

- Supplementary Environmental Test Status
 - None conducted - only tracked battery testing & vibe
- Integrated system testing
 - Ongoing integrated testing to:
 - Ensure FSW is completely done
 - Gather final metrics on how the OBC behaves
 - Having people foreign to the FSW operate the satellite to provide feedback



Flight Safety Status

- Safety Data Template Status
 - Working on updates - ECD: July 19
 - Have minor questions on content
- Bill of Materials Status
 - Updated to reflect the as-built state of the spacecraft
 - Submitted to NASA and cleared as of 7/16
- As-Built Mass
 - Final mass: 4.161 kg
 - Final mass reflected in both the ODAR components document and the SDT



Regulatory Status

- IARU & FCC Status
 - FCC experimental license grant obtained - Letter uploaded to Nanoracks portal
 - **File Number:** 0139-EX-CN-2018
 - **Satellite callsign:** WJ2XOY **Operator callsign (Sarah's):** KI007Y
 - **Operating frequencies:** 437.35 MHz
 - **License Start Date:** 11/1/2018 **License End Date:** 11/1/2020
 - Updated spacecap file to reflect omitted S-Band, submitted to FCC
- NOAA Remote Sensing License
 - NOAA license obtained - 12/13/2017
 - Data protection plan approved
 - Rotating cipher to be used for schedule uplinks only, no encryption on downlink
 - Waiver for non-earth imaging - approved, can use for space calibration
 - Needs to be updated to reflect omitted S-Band



Operational Readiness

- Ground station status
 - Primary GS: ASU, backup: ERAU (Prescott, AZ)
 - Licensing status: only an operator ham radio license required
 - Operational readiness: components are there, but requires further work
 - Need independent UHF rotor system
 - Develop ground software for scheduling & visualizing data
 - Additional testing required to verify RF characteristics
 - Goal: operational readiness achieved by end of Sept 2019
- Operational Team Readiness
 - Procedures for operating CubeSat are well understood
 - Focus now ground software readiness
- 18th Space Control Squadron Coordination (space-track.org)
 - ASU has registered account on space-track, and so do all current operators
 - Satellite is not officially registered (requires more specific launch information) - need to submit registration form



Nanoracks Requirement Compliance

- Verification matrix completed based on NR-NRCSD-S0003
- Deviations from Nanoracks Requirements
 - None
- Waived Requirements:

Paragraph Title	Requirement Text	Verification Method	Status	Notes
Rail Continuity	The CubeSat rails shall be continuous. No gaps, holes, fasteners, or any other features may be present along the length of the rails (Z-axis) in regions that contact the NRCSD rails.	I	Waived (2018)	Fasteners to the ADCS are on rails - flatheads are used
Rail Envelope	The minimum extension of the +/-Z CubeSat rails from the +/-Z CubeSat faces shall be 2mm.	I	Waived (2018)	Extension from -Z end: Extension from +Z end: Using tuna can space for +Z end



Requirements Compliance (Cont.)

- Highlighted Requirements

Paragraph Title	Requirement Text	Verification Method	Status	Notes
Switch Contact Surface Area	Roller/slider switches shall maintain a minimum of 75% surface area contact with the NRCS rails (ratio of switch contact to NRCS guide rail width) along the entire Z axis	I	Partial Compliance	One inhibit switch clicks when CubeSat is jostled in the deployer
Post-Deployment Timer	CubeSat shall not operate any system (including RF transmitters, deployment mechanisms or otherwise energize the main power system) for a minimum of 30 minutes where hazard potential exists. Satellites shall have a timer (set to a minimum of 30 minutes and require appropriate fault tolerance) before satellite operation or deployment of appendages where hazard potential exists.	I, T	Compliant	See startup sequence on next slide
Outgassing / External Contamination	Satellites shall comply with NASA guidelines for selecting all non-metallic materials based on available outgassing data. Satellites shall not utilize any non-metallic materials with a Total Mass Loss (TML) greater than 1.0 percent or a Collected Volatile Condensable Material (CVCM) value of greater than 0.1 percent	I	Compliant	

Startup Sequence

- Upon each OBC restart:
 1. Check for number of antennas deployed
 2. If no antennas deployed, start 30 min timer, turn on power rails when done and start flight software
 3. If antennas already deployed, start flight software immediately

```
File Edit View Search Terminal Help
[2019-07-05 11:57:29]
[2019-07-05 11:57:52] ==> Loading startup procedure
[2019-07-05 11:57:52] ==> Turning on UHF Antenna power rail...
[2019-07-05 11:57:52]   -> Sending command...
[2019-07-05 11:57:53] ==> Checking for deployed antennas...
[2019-07-05 11:57:53] twim_pdc_transfer failed with code: -4
[2019-07-05 11:57:53]   -> No antennas deployed.
[2019-07-05 11:57:53]   -> Delaying 30 minutes before starting CFE...
[2019-07-05 11:57:53] 07 dc (i=29)
[2019-07-05 11:58:53] 07 dc (i=28)
[2019-07-05 11:59:53] 07 dc (i=27)
[2019-07-05 12:00:53] 07 dc (i=26)
[2019-07-05 12:01:53] 07 dc (i=25)
[2019-07-05 12:02:53] 07 dc (i=24)
[2019-07-05 12:03:53] 07 dc (i=23)
[2019-07-05 12:04:53] 07 dc (i=22)
[2019-07-05 12:05:53] 07 dc (i=21)
[2019-07-05 12:06:53] 07 dc (i=20)
[2019-07-05 12:07:53] 07 dc (i=19)
[2019-07-05 12:08:53] 07 dc (i=18)
[2019-07-05 12:09:53] 07 dc (i=17)
[2019-07-05 12:10:53] 07 dc (i=16)
[2019-07-05 12:11:53] 07 dc (i=15)
[2019-07-05 12:12:53] 07 dc (i=14)
[2019-07-05 12:13:53] 07 dc (i=13)
[2019-07-05 12:14:53] 07 dc (i=12)
[2019-07-05 12:15:53] 07 dc (i=11)
[2019-07-05 12:16:53] 07 dc (i=10)
[2019-07-05 12:17:53] 07 dc (i=9)
[2019-07-05 12:18:53] 07 dc (i=8)
[2019-07-05 12:19:53] 07 dc (i=7)
[2019-07-05 12:20:53] 07 dc (i=6)
[2019-07-05 12:21:53] 07 dc (i=5)
[2019-07-05 12:22:53] 07 dc (i=4)
[2019-07-05 12:23:53] 07 dc (i=3)
[2019-07-05 12:24:53] 07 dc (i=2)
[2019-07-05 12:25:53] 07 dc (i=1)
[2019-07-05 12:26:53] 07 dc (i=0)
[2019-07-05 12:27:53] 07 dc (i=-1)
[2019-07-05 12:28:54] Startup delay over - Turning on ADCS and GPS power rails before starting CFE.
[2019-07-05 12:28:54] ==> Turning on ADCS power rail...
[2019-07-05 12:28:54]   -> Sending command...
[2019-07-05 12:28:55] ==> Turning on GPS Main power rail...
[2019-07-05 12:28:55]   -> Sending command...
[2019-07-05 12:28:56] ==> Turning on GPS LNA power rail...
[2019-07-05 12:28:56]   -> Sending command...
[2019-07-05 12:28:57] ==> Starting CFE now
[2019-07-05 12:28:57] ==> Startup procedure completed successfully
[2019-07-05 12:28:57] Auto booting to CFE in 5 Secs
[2019-07-05 12:28:57] 'm' for maintenance ..... m
[2019-07-05 12:29:01]
```



Deliverables & Logistics

- Investigation Summary Form completion status
 - ISF provided to Nanoracks - uploaded to portal 5/23/2018
- Export Classification Status
 - ECL signed on 1/23/2018 - uploaded to Nanoracks portal
- Shipping Logistics Status
 - Flying with satellite to Houston for delivery between 8/12 - 8/23
- Hardware Transfer Paperwork
 - Need hardware transfer paperwork from Nanoracks (draft of DD1149)
 - No additional outstanding non-technical / non-safety related deliverables exist



Unique Integration Requirements

- CubeSat must be integrated with +Z end in tuna can space
 - Approved to use tuna can space
- Remove all protective kapton tape
 - Over ADCS earth horizon sensors
 - Over camera lens
- Please mind sun sensors on satellite panels
 - Don't lay cubesat down on a hard surface on any of its sides
 - Prop up rails on -Z end
- If the RBF pin must be inserted again, please insert the pin fully, and in one motion



Open Work & Schedule

- Open Work Prior to Delivery
 - Finish updates to SDT, vibe report - ECD July 19
 - Calibrate ADCS sun sensors - ECD July 19
 - UHF antenna is repaired by EnduroSat - ECD Aug 2
 - All de-mated parts must be re-integrated with loctite - ECD Aug 3
 - Upload deployment branch software to OBC - ECD: Aug 12
- Open Work Prior to Operations
 - Ground station software is complete - ECD Sept 30
 - Rotor system can successfully track CubeSats in LEO - Sept 30
 - ICOM-9100 is integrated with yagis and to hear from CubeSats in LEO - Sept 30



Hardware Readiness Assessment

- On track to deliver spacecraft to Houston by August 12
 - Damaged antenna expected back by Aug 2nd
 - FSW is in a stable, comfortable position for operations
 - Satellite can be delivered to Houston any time in the range of Aug 12 - Aug 23
- Any additional questions / concerns / issues leading up to final integration and launch
 - When do we deploy from the ISS?
 - Is any charging done after delivery



Phoenix has been an incredible and valuable learning experience for students of all different backgrounds. Thank you all for this opportunity and thank you for your support throughout the many phases of this project. Getting here would not have been possible without you.