Naval Research Laboratory

Washington, DC 20375-5320

NRL/MR/7634--19-9926

GPS Radio Occultation and Ultraviolet Photometry-Colocated (GROUP-C) Early Orbit Testing Results

Scott A. Budzien
Andrew W. Stephan

Geospace Science and Technology Branch
Space Science Division

Todd E. Humphreys

School of Engineering
Unversity of Texas
Austin, TX

Steven P. Powell
Brady W. O'Hanlon

Cornell University
Ithaca, NY

Rebecca L. Bishop

The Aerospace Corporation
El Segundo, CA

January 29, 2020

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
29-01-2020	NRL Memorandum Report	Feb 2017 – Jun 2019

4. TITLE AND SUBTITLE

GPS Radio Occultation and Ultraviolet Photometry-Colocated (GROUP-C) Early Orbit Testing Results

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
76-6A74-09

6. AUTHOR(S)

Scott A. Budzien, Andrew W. Stephan, Todd E. Humphreys*, Steven P. Powell**, Brady W. O'Hanlon**, and Rebecca L. Bishop***

5d. PROJECT NUMBER

5e. TASK NUMBER
62435N

5f. WORK UNIT NUMBER
6A74

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Naval Research Laboratory
4555 Overlook Avenue, SW
Washington, DC 20375-5320

8. PERFORMING ORGANIZATION REPORT NUMBER

NRL/MR/7634--19-9926

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Naval Research Laboratory
4555 Overlook Avenue, SW
Washington, DC 20375-5320

10. SPONSOR / MONITOR'S ACRONYM(S)

NRL 6.2

11. SPONSOR / MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

*School of Engineering, University of Texas, Austin, 301 E Dean Keeton St, TX 78712-1476; **School of Electrical and Computer Engineering, Cornell University, 418 Phillips Hall, Ithaca, NY 14853-5401;***The Aerospace Corporation, 2310 E. E Segundo Blvd, El Segundo, CA 90245-4609

14. ABSTRACT

The GPS Radio Occultation and Ultraviolet Photometry-Colocated (GROUP-C) experiment was launched to the International Space Station on February 19, 2017. GROUP-C includes both a second-generation high-sensitivity far-ultraviolet photometer measuring horizontal nighttime ionospheric gradients and an advanced software-defined GPS receiver providing ionospheric electron density profiles, scintillation measurements, and lower atmosphere profiles. After routine flight, capture, and installation, GROUP-C underwent Early Orbit Testing to verify its performance prior to science operations. This report reviews the Early Orbit Testing tests; the payload anomalies that delayed completion of on-orbit testing; the successes and failures found, and the work-arounds devised; and recommendations for science operations and future experiments.

15. SUBJECT TERMS

Photometer GPS Remote sensing Airglow
Ionosphere Nightglow Aeronomy

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Scott Budzien
Unclassified Unlimited	Unclassified Unlimited	Unclassified Unlimited	Unclassified Unlimited	42	**19b. TELEPHONE NUMBER** *(include area code)* (202) 767-9372

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

This page intentionally left blank.

CONTENTS

FIGURES

TABLES

EXECUTIVE SUMMARY

The GPS Radio Occultation and Ultraviolet Photometry—Colocated (GROUP-C) experiment was launched to the International Space Station aboard the Space Test Program Houston Pallet #5 (STP-H5) on February 19, 2017. GROUP-C includes both a second-generation high-sensitivity far-ultraviolet photometer measuring horizontal nighttime ionospheric gradients and an advanced software-defined GPS receiver providing ionospheric electron density profiles, scintillation measurements, and lower atmosphere profiles. After routine flight, capture, and installation to the Express Logistics Carrier #1, the GROUP-C experiment underwent Early Orbit Testing to verify its performance prior to science operations. This report reviews the Early Orbit Testing tests; the payload anomalies that delayed completion of on-orbit testing; the successes and failures found, and work-arounds devised; and recommendations for science operations and future experiments.

This page intentionally left blank.

GPS RADIO OCCULTATION AND ULTRAVIOLET PHOTOMETRY—COLOCATED (GROUP-C) EARLY ORBIT TESTING RESULTS

1. INTRODUCTION

1.1 The GROUP-C Experiment Concept

The GPS Radio Occultation and Ultraviolet—Colocated (GROUP-C) experiment was originally conceived in 2010 as a CubeSat mission, combining a compact GPS occultation receiver and high-sensitivity far-ultraviolet (FUV) photometer experiment to be flown as a Space Test Program experiment. The concept was to incorporate a commercial off-the-shelf GPS receiver and a small second-generation FUV photometer to replicate the space weather portion of the *Constellation Observing System for Meteorology, Ionosphere, and Climate* (*COSMIC/FORMOSAT-3*) mission [Anthes et al. 2008] at lower cost. In the same time-frame the Air Force Space and Missile System Center initiated the Space Environment NanoSatellite Experiment (SENSE) to demonstrate several CubeSat technologies for space environment sensing [Sondecker et al. 2013], which included the Compact Tiny Ionospheric Photometer (CTIP) and the Compact Total Electron Content Sensor (CTECS) [Bishop, et al. 2012]. The SENSE effort eased the urgency of demonstrating CubeSat technology using GROUP-C. When the opportunity arose in 2013 for GROUP-C to fly on Space Test Program Houston Pallet #5 aboard the International Space Station (ISS) with the volume, power, and weight constraints removed, the experiment more narrowly focused upon demonstrating second-generation space environment sensors.

1.2 Tiny Ionospheric Photometer (TIP)

Space experiments have relied on 135.6 nm emission to characterize the F-region nighttime ion density for decades, operating on the principle of spectrally isolating the useful 135.6 nm recombination emission from unwanted nightglow. Nearly twenty years ago, NRL introduced the concept for new class of compact, high-sensitivity ionospheric 135.6 nm sensors designed for the COSMIC mission [Dymond et al., 2000; Dymond et al., 2016]. The COSMIC retrievals of ionospheric density and height from occultation data typically assume ionospheric spherical symmetry with no horizontal gradients in the vicinity of the occultation. The presence of horizontal ionospheric gradients can introduce errors into the inversion and lead to inaccurate retrieval results. However, these ionospheric gradients can be characterized using horizontal photometry and supplement GPS occultation results, but the sensor sensitivity should be at least 100 counts s^{-1} R^{-1} to have sufficient signal-to-noise to impact and improve the GPS retrievals [Dymond et al. 2000]. The COSMIC TIP sensors fulfilled their role as pathfinders for nighttime ionospheric photometry; however, these low-cost, first-generation instruments exhibited some shortcomings of the sensor design and its performance on the COSMIC microsatellites [Budzien et al. 2019].

The first problem revealed during preflight tests was red leak, which refers to weak residual sensitivity of the 135.6 nm FUV photometer to detect unwanted longer wavelengths, including visible light ("redder" than ultraviolet). On-orbit, the flaw manifested itself as observations of city lights and moonlit clouds that contaminated nighttime ionospheric signals. The second problem involved scattered light, both external to the TIP sensor assembly and within the TIP optical train. Aboard the crowded, compact satellite bus TIP viewed the nadir through a jagged porthole, and an antenna from another experiment was close to the field-of-view. Inside the instrument several components included stainless steel and iridited aluminum surfaces, which have poor FUV reflectivity, but significant reflectivity in the

Manuscript approved December 13, 2019.

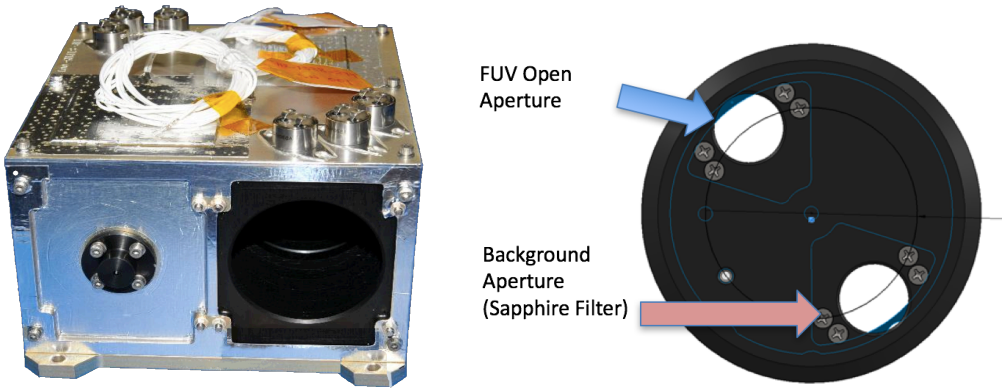


Figure 1. (Left) The refurbished TIP for GROUP-C included optical, electrical, and surface treatment changes for the STP-H5 mission. (Right) The GROUP-C TIP filter wheel is larger in diameter, printed from black Ultem® plastic, and includes both an open aperture and a sapphire filter for red-leak monitoring. The outline of the original, smaller filter wheel is in blue.

visible. The impact of this visible scattered light was that photometer could not operate near the twilight, and the scattered light potentially increased red-leak sensitivity.

The GROUP-C experiment included an upgraded, second-generation TIP module, a refurbished qualification unit from the COSMIC program. Several modifications were made to the TIP optical train to mitigate the scattered light and red-leak problems identified during the COSMIC mission (Fig. 1, left). First, a larger, visibly black filter wheel and black anodizing of the detector housing was implemented to reduce visible scattering and red-leak. A filter overlay was generated using 3-D printing of vacuum-rated black Ultem® polyetherimide plastic with only two filter apertures: one aperture open to collect FUV signal, and the other a sapphire window for monitoring red-leak contamination (Fig. 3, right). Sapphire passes radiation longward of 145 nm, which allows monitoring the contamination alone, without the 135.6 nm ionospheric signal. By differencing the measurements through the open aperture (135.6 nm + red leak) and the sapphire filter (red leak only), the FUV ionospheric signal can be determined. Finally, aboard the STP-H5 pallet TIP did not view through a jagged hole nor have a dipole antenna near the field-of-view.

The mechanical filter wheel testing on the ground in a gravity field was problematic. First the compact direct drive stepper motor does not have the torque to power the filter wheel against gravitational torques, and the detent toques may also be insufficient. Secondly, the black plastic printed overlay added some mass and changed the rotational properties of the filter wheel. Finally, the Hall sensor magnet was affixed manually and may be prone to fiducial errors. These changes and ground testing limitations argue for a robust on-orbit test of the mechanical filter wheel. Much of the planned Early Orbit Testing of the photometer focuses upon optimizing these mechanical issues.

1.3 Fast Orbital TEC, Observables, and Navigation (FOTON) Receiver

GROUP-C includes an advanced software-defined GPS receiver providing ionospheric electron density profiles, scintillation measurements, and lower atmosphere profiles. The GPS occultation sensor is named the Fast Orbital TEC, Observables, and Navigation (FOTON) receiver, developed at Cornell University with heritage to the MICA rocket [Lightsey et al. 2014]. GROUP-C incorporates three space-rated GPS patch antennas designed by The Aerospace Corporation for the SENSE mission [Bishop et al. 2012]. Finally, the FOTON receiver includes customized firmware for this mission to allow limited low-level raw capture of GPS frequencies from the receiver front-end. FOTON routinely collects dual-frequency GPS occultations, makes targeted raw signal captures of GPS signals, and includes multiple antennas to characterize multipath in the ISS environment. Thus, both the receiver and patch antennas are fully Cubesat-compatible, though they were not packaged as such for this ISS mission.

The three antennas are separated by roughly a wavelength and rest on a large ground plane facing aft, so that GPS satellites are acquired at high altitude and appear to set as the ISS orbits. During routine measurements the IQ data are sampled at 100 Hz only for visible GPS satellites. During raw capture operations the sampling is a much higher cadence (6 MHz) over the full receiver passband and lasts only 70 seconds, but the measurements can be downloaded to the ground for detailed analysis. The brief raw capture operation entails significant amounts of ISS telemetry, requiring about 3.5 hours to download. Despite these complexities the GPS payload has fairly few operating modes and can be completely tested within a couple of days of on-orbit operation.

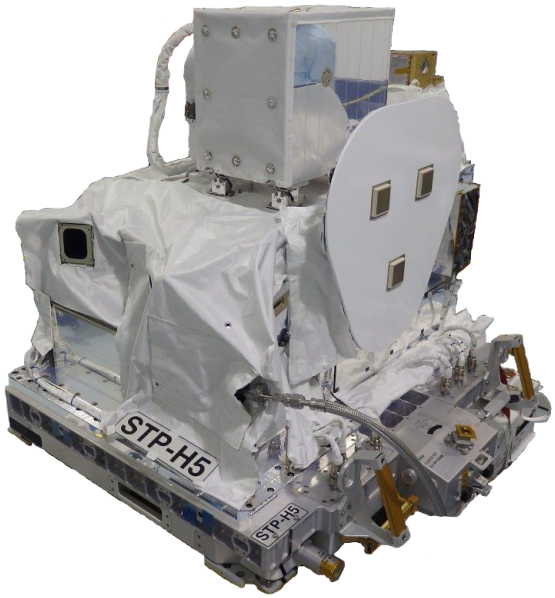


Figure 2. This image of STP-H5 shows the ground plane and three patch antennas, which face the aft direction. The FOTON GPS receiver sits under the thermal blanket toward the viewer.

2. EARLY ORBIT TESTING PLAN

GROUP-C on the STP-H5 payload launched to the ISS aboard the Space-X Dragon Commercial Resupply Services mission 10 (CRS-10) on Sunday, February 19, 2017 at 14:39:00 UT from Cape Canaveral, Florida. After a few days of free flight and an aborted rendezvous with the space station, the Dragon capsule was grappled by the Canadarm2 and finally berthed to the *Harmony* module on February 23 at 13:12 UT. Several days later the STP-H5 payload was removed from the unpressurized trunk of the Dragon, and installed to the ELC #1 location on February 27.

The Early Orbit Test plan was developed largely from the ground and Thermal Vacuum test plans developed before launch and executed during integration. Because TIP had extensive configurable modes, mechanical elements, and scheduled commands, the baseline plan was more extensive and included heritage to the COSMIC/TIP and HREP/RAIDS experiments, so a more extended checkout was planned. In contrast, FOTON included just a handful of operating modes, no mechanical elements, and no scheduled commands, so planned testing was allotted only a few days.

The NRL experiment operations were performed in the Building 209 Payload Operations Control Center (POCC) that has been in use for ISS experiments since 2009. Changes in computer network security necessitated placing a TReK (NASA's Telescience Resource Kit) workstation in the NRL network "DMZ" to receive packets and forward them to POCC machines on the intranet. Outgoing commands are still sent to the Huntsville Operations Support Center (HOSC) from the TReK workstation in the POCC over VPN. This configuration was successfully tested during pre-launch STP-H5 simulations. Both real-time and downloaded near-real-time telemetry is archived onto an NRL file server.

The Early Orbit Testing schedule was made more complicated due to time-sharing the long ISS command window with several other STP-H5 experiments and no commanding during weekend hours. Consequently, the straightforward check-out plan stretched over multiple weeks. Furthermore, due to significant ISS ELC #1 thermal concerns that required a complete payload shutdown of several weeks while the situation was assessed and resolved, the on-orbit check-out period stretched out even further. The GROUP-C sensors did not enter routine science operations until April 28, 2017, fully two months after installation.

The purpose of this report is to document the lessons learned during the on-orbit checkout of the GROUP-C sensors. Since the GPS check-out proceeded nominally, for the most part, this document describes the TIP check-out process in more detail. First we present the quick FOTON testing and results, followed by the more complex TIP testing and results, which took much longer to complete.

2.1 FOTON Early Orbit Testing Plan

Since the FOTON receiver includes only a limited number of modes, the on-orbit configuration can be checked identically to ground testing performed during integration. The portions of the test regimen for on-orbit GPS operations are:

1. FOTON Liveness Test. Power FOTON into IDLE mode. Monitor Health and Status. Duration: 5 minutes.
7. FOTON STREAM Test. Verify that GPS signals are acquired. Set default filters and antenna cycle pattern, enter Mode 1, and monitor. Duration: 15 minutes.
8. FOTON UNRAW Mode Test. Verify that data can be streamed into memory and subsequently transmitted. Duration: 45 minutes.
9. FOTON RAW Mode Test. Verify that raw GPS data can be captured and accurately streamed out in telemetry. Verification cannot be performed using real-time data. Duration: 4.5 hours.

2.2 FOTON Early Orbit Results

The STP Team in Houston performed a successful initial power-up and on-orbit functional check-out of the payload. All our components—GLIB interface box, LITES, TIP (photometer), and FOTON (GPS) turned on, entered safe operating modes, and generated healthy data streams. The FOTON Liveness Test was completed successfully during the STP-H5 power-on sequence.

In the afternoon, NRL had an opportunity to issue commands to the payload. This was the first opportunity to actually test receiving live telemetry and sending commands from the Payload Operation Control Center at NRL to STP-H5. We encountered a couple of configuration problems between our ground station display software and the ISS data streams. The problem was easily resolved when we realized that the flight Health & Status data packet formats differed slightly from the ground-test data formats we previously tested. Ultimately, we successfully displayed both real-time health and status and real-time high-rate science data using the NRL ground stations software.

2.2.1 Day 2017 059: STREAM Mode Test

From NRL we successfully performed simple liveness and commanding checks for FOTON similar to those performed earlier in the day at the payload level. The test configuration was basic streaming mode with 1-minute cycling between each of the four RF switch connections. The receiver successfully acquired satellites, obtained a navigation solution, and streamed science data (Figure 1).

2.2.2 Day 2017 060: UNRAW Test

FOTON operated successfully using UNRAW mode collection and DOWNLOAD mode. This mode means that GRID reports stream as usual from the receiver, but instead of transmitting immediately into the telemetry stream, GLIB stores the data to SD memory, and downloads it later. (This is a similar data handling mechanism to RAW data capture.) During commanding we encountered one command error, but a re-transmission of the command proved successful. The functional test showed nominal UNRAW operation.

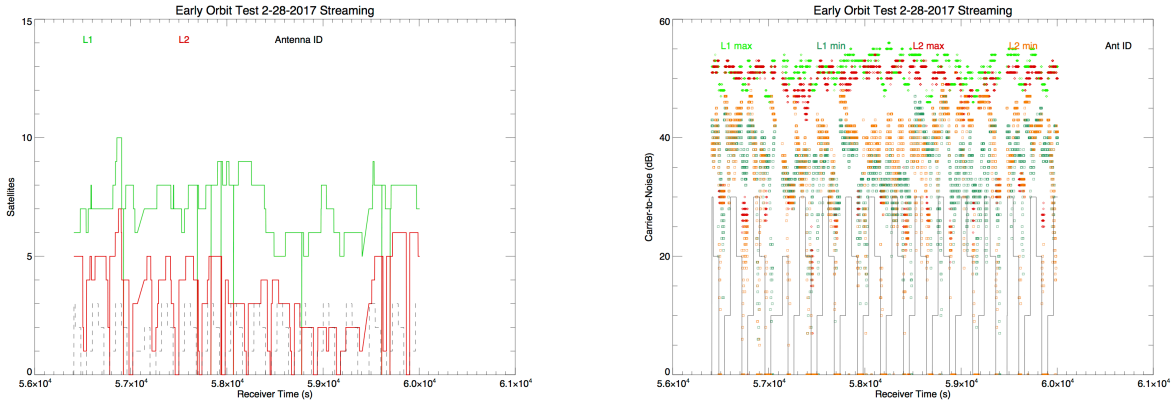


Figure 3. FOTON GPS signals for L1 and L2 in STREAM mode during Feb 28 initialization tests. The left panel shows number of satellites versus antenna switch selection, and the right shows carrier-to-noise ratio C/N_0. On the first power-up of FOTON obtaining a navigation solution took about 3 minutes. The long time is attributed to unlucky cycling into the "NO ANT" RF switch position during the satellite acquisition process. Carrier-to-noise can be seen to drop each the switch is placed in the NO ANT setting, and the number of L2 satellites can be seen to drop in that configuration, too.

2.2.3 Day 2017 061-062: RAW Test

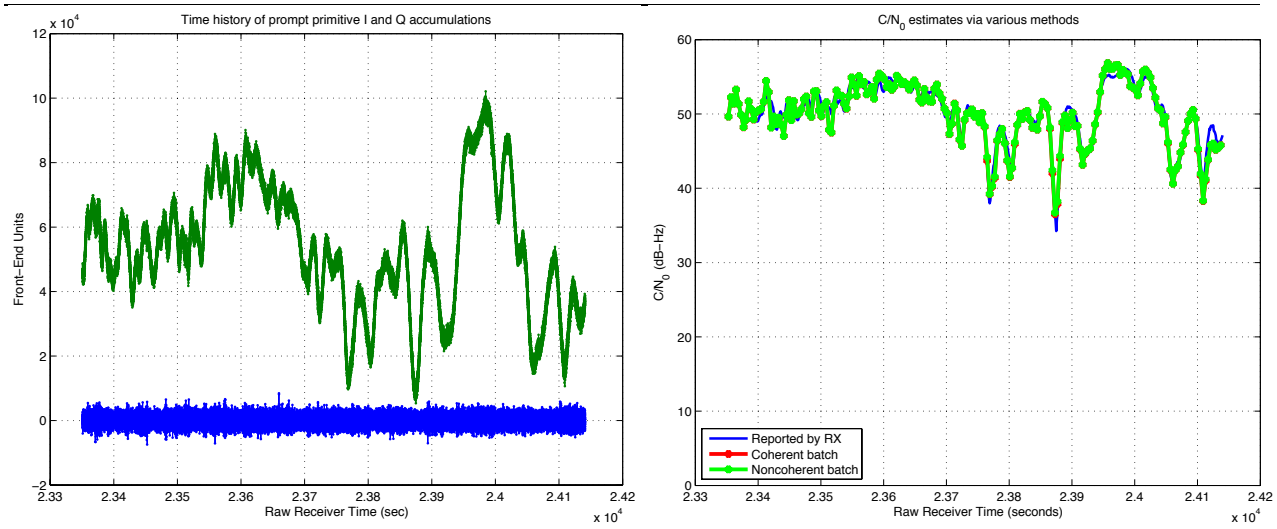
The test of FOTON RAW capture mode extended over two command sessions due to the expected 3.5-hour duration of the DOWNLOAD portion of the test. If the receiver had not been returned to default operating mode, GLIB would have continued to stream hexadecimal 0xFF's through the weekend after the valid capture data had been downloaded. The only commanding performed on Day 062 placed FOTON back into streaming mode using Antenna #1 exclusively.

FOTON Anomaly AF-002, Partial Raw Capture Download. The RAW Mode test proceeded straightforwardly. GPS data were captured from 18:02:49 to 18:04:11, or 82 seconds. The data transfer from FOTON to GLIB started at 18:04 UT and was allowed to run for the nominal 30 minutes. The long data download from GLIB storage started at 18:37. Normally in laboratory testing the data capture filled up 200 MB of memory, was downloaded at a rate of 12 frames/sec (about 15kB/sec), and required 3.5 hours to download. However, analysis of the downloaded Near Real Time (NRT) data from Day 061 showed that the download completed early at 19:55 after an elapsed time of only 78 minutes, when the 0xFF hex codes of empty memory showed up in the telemetry. The volume of data in the NRT file corresponding to these telemetry download times is only about 71 MB. (Only one CCSDS frame is missing this day, and it occurred after the raw data had been completely downloaded, i.e. in the 0xFF-only frames.)

Subsequently, an anomaly was identified in which LITES high voltage commands could trigger a FOTON reset, presumably through the GLIB. However, no LITES high voltage commands were performed during the acquisition and storage of the raw capture. Consequently, the small 71 MB raw dump size is anomalous and the root cause of this problem remains unclear.

2.2.4 Day 2017 061-062: Occultation Analysis

Using streaming mode data collected on Days 061-062 Todd Humphreys at UT performed preliminary analysis of some early FOTON observations, including the first GPS occultation analysis. The data quality is excellent, and the 100-Hz IQ data are capable of tracking down into the troposphere. The true carrier-to-noise ratios, as determined from the statistics of the IQ accumulations, are quite close to the receiver-reported C/N_0 values. The highest ratios register as approximately 54 dB-Hz.



Figures 4. Some signals from PRN05 acquired on Day 61 exhibit strong fluctuations in amplitude (IQ data, left) even while maintaining a fairly healthy C/N_0 overall (right). This may be due to local multipath or blockage by overhead parts of the ISS. The right plot also demonstrates the excellent agreement for carrier-to-noise ratios calculated with different methods and that reported by the receiver.

The clock appears to be extraordinarily stable, indicating an effective temperature control scheme. Although the temperature control scheme is a TCXO (Temperature Controlled Crystal Oscillator), the frequency stability appears much more like an OCXO (Oven Controlled Crystal Oscillator), possibly due to the inherent temperature stability of the receiver box underneath the thermal blankets.

These initial data have very high C/N0 values from space without a multi-element antenna. The JPL Blackjack receiver and its progeny use only 1-bit quantization, whereas FOTON uses 2, which explains part of that, but the Aerospace patch antennas may be providing some extra focusing. The BCP values have exceeded their allotted significant digits in the display just because the Doppler is so high, but there should be no loss of data in the stream. Since the gain of the patch antennas is not optimized for the

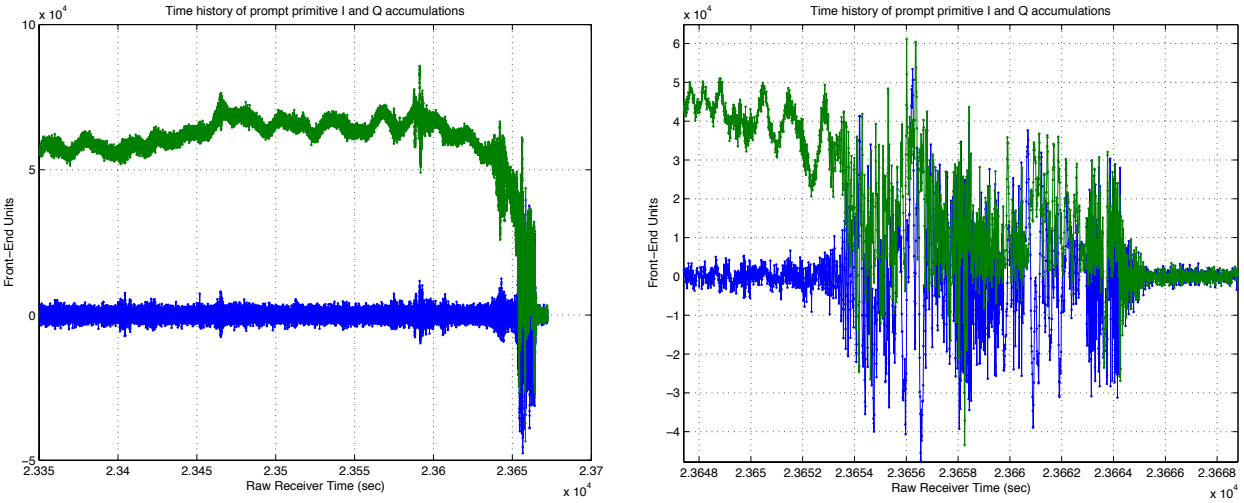


Figure 5. The IQ data for a GPS signal PRN15 undergoing occultation (left) with a zoomed view of the final 21 seconds of the occultation (right). The IQ data show power present in the signal right up until near the end, where it completely collapses. The FOTON phase locked loop is unable to track the rapid phase changes of the signal as it passes through the lowest part of the atmosphere, but detailed data analysis may be able to recover information relevant to the tropospheric portion of the occultation.

troposphere, and the closed loop tracking loses lock deep in the troposphere, the depth of high quality occultations is uncertain.

2.2.5 Day 2017 065: FOTON Anomaly and Recovery.

During ground testing of TIP, LITES, and FOTON no anomalies were observed that could not be attributed to operating with acceleration due to gravity. However, these tests on the ground were performed in a specific order and from a cold start, with FOTON OFF or IDLE when LITES was tested, and no LITES activity when FOTON was tested. Day 065 was a Monday command window during which FOTON was in its default STREAM mode when LITES was adjusted.

FOTON Anomaly AF-003, FOTON Data Rate Drop. At the start of the command window at 19:00 UT, the Health & Status data showed FOTON in STREAM mode, yet very few real-time HRT frames were being received at the NRL ground station from FOTON. Normally, one would expect between 10-25 frames/second. Since the FOTON counter of H&S frames received by CIB continued to increment once per second, GLIB was responding to H&S requests normally. FOTON seems to have stopped transmitting GPS data to GLIB while in the streaming state (Figure 6). The data rate from FOTON was typical of what is received during IDLE mode. After a FOTON reset was performed, the instrument was placed back into STREAM mode, and HRT packets flowed at the normal rate by 19:10 UT. We subsequently discovered an interaction between issued LITES HV commands (any) and FOTON, which triggered this this peculiar operational state of the GPS receiver.

This was the only significant hardware anomaly observed with the FOTON receiver as integrated into the GROUP-C experiment.

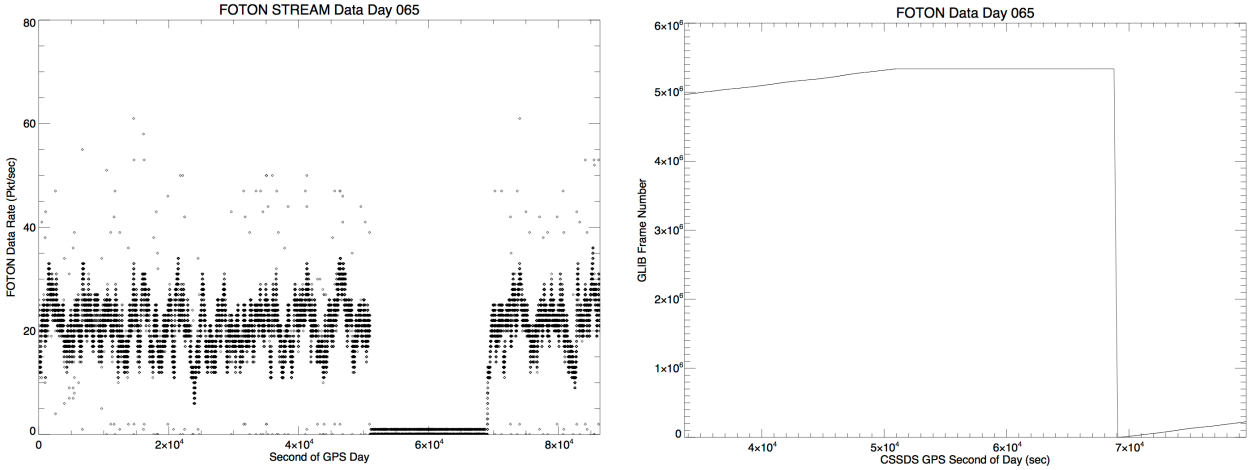


Figure 6: (Left) The output rate of FOTON frames suddenly dropped at 14:09:35 from 20/sec to zero. No FOTON data packets are missing, according to both the CCSDS and GLIB frame counters, but the counter values nearly flat-lined (right) for nearly 5 hours, until FOTON was reset end re-entered STREAM mode.

2.3 TIP Early Orbit Testing Plan

In contrast to FOTON, the TIP photometer has a wide variety of operational modes, includes mechanisms, and was unable to be fully tested in a gravity field on the ground pre-flight in its GROUP-C configuration. While the ground testing focused on ensuring COSMIC mission subsystems were operational, Early Orbit Testing evaluated both the functionality and performance of the various

subsystems. The filter wheel mechanism, in particular, required both tuning and troubleshooting to perform science operations and achieve scientific measurement objectives.

The objectives for Earlt Orbit Testing of TIP were:

1. TIP Liveness Test. The objective of this test is to verify that the TIP experiment powers up and the TICE boots and can receive commands and send data packets. Duration: 2 minutes
2. TIP Standby-Mode Test. The objectives of this test are to verify that the TIP filter heater operates and to monitor the visible light in the viewing direction using the sun sensor in preparation for later tests. Duration: 1 orbit
3. TIP Motor Test. The objectives of this test are to evaluate the TIP stepper motor operation in orbit using the built-in operational mode. Duration: 1 orbit
4. TIP Detector Dark Test. The objectives of this test are to evaluate the TIP detector dark counts and High Voltage operation in orbit. Must have daytime command capability to turn off HV, if required. Duration: 1 orbit
5. TIP UV, Background, and Dark Test. This test evaluates the UV and red-leak performance. This should only be performed under nighttime conditions at ISS altitude when real-time commanding is available. Duration: 1 nighttime pass.
6. TIP automated Command Test. Test command loads, updates, and executes automated time-tagged commands from the ISEM (without HV operation using benign commands). Duration: 1 orbit.
7. TIP automated HV Command Test. Verify automated commanding including HV operations on the nightside. Duration: 1 nightside pass.
8. TIP Terminator Probe. Characterize the count rate in the twilight region between nighttime at the ISS and nightime on the disk. Command capability required. Duration: 1 orbit
9. TIP operational configuration. Upload anticipated operational parameters. Duration: Monitor for 3 orbits.

On account of live commanding once per day, some of the planned tests were combined so that multiple objectives could be achieved in one commanding session.

2.4 TIP Early Orbit Testing Results

The STP Team in Houston performed a successful initial power-up and on-orbit functional check-out of the payload after installation. First ISEM has to be powered to obtain the NRL data streams, then TIP was powered, entered safe a safe operating modes, and generated a healthy data stream. Thus, the TIP Liveness Test was completed successfully during the STP-H5 power-on sequence. Later that afternoon, NRL issued commands to the GROUP-C TIP sensor.

2.4.1 Day 2017 059: Standby Mode Tests

Neither the TIP detector high voltage nor the filter wheel was powered during performance tests associated with initialization activities. However, the SrF_2 filter heater was turned on during STP-H5 initialization, and it remained powered continuously all day. The filter required about 64 minutes to heat up from 7 C to 101 C (Figure 7), which is significantly longer than 45-min specification for mirror warm-up time requirement of the original COSMIC mission. (GROUP-C has no warm-up time requirement.)

Since the filter wheel is positioned behind the heated filter, the filter wheel has no impact upon radiative loss rates from TIP's heated filter. Consequently, this slower heating rate must reflect the differences in the thermal environment on STP-H5 compared to COSMIC. Notably, radiator tape was applied to the external, nadir face of TIP, whereas the COSMIC photometers were black anodized and were encapsulated entirely within the satellite bus.

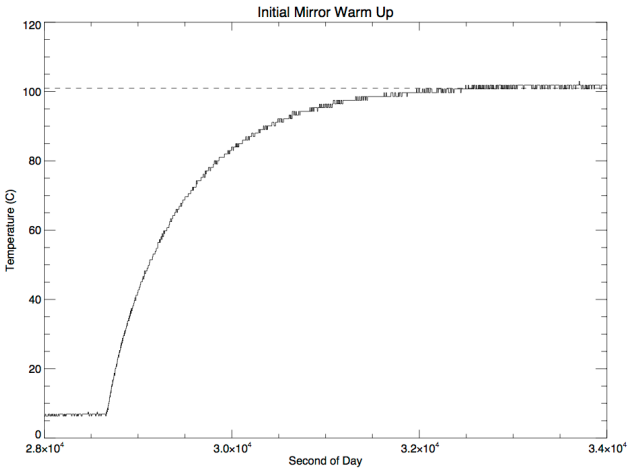


Figure 7: Warming up the TIP from filter from 7C to 101 C took slightly more than 1 hour.

After completing its liveness test, TIP was left in a high data rate standby mode (STANDBY_LAB). Low voltage was left on, HV was off, and the filter was operating at 100C. The filter wheel was not moved during testing. The visible light below the ISS was monitored by the Sun sensor as it viewed the nadir direction. Dayside passes could be observed, but the count rates remained less than 7 units of 255, as expected.

2.4.2 Day 2017 060: TIP First Light

The second day of GROUP-C on-orbit testing included operating the TIP HV and filter wheel, then collecting first light for TIP. The opportunity for live commands during a nightside pass provided the opportunity to test the built-in nighttime operational mode, which tests wheel operation, UV, and dark measurements, but not the red-leak, because the sapphire aperture was not preprogrammed into the original COSMIC-era flight software.

The TIP photometer High Voltage was commanded on during a nightside pass, and the filter wheel was powered to alternate between the UV aperture and occasional shuttering for dark counts. TIP collected first light data (Figure 8). The ascending node nightside pass was not particularly good for ionospheric signals: the data were collected in the local time just before dawn. Most points reflect signal with the open aperture, about 1000 counts. Regular samples were taken as the filter wheel was closing the aperture: these have lower intensity due to partial shuttering. Dark counts were very low, 10 or fewer per second. A few spikes likely correspond to city lights. A large ramp up to 100,000 counts was observed near the dawn terminator. There are no recognizable equatorial arcs, though we would not expect strong arcs just before dawn, particularly at low altitudes beneath the ISS. With a sensitivity of roughly 1000 counts/sec/Rayleigh, if all the counts are attributed to 135.6 nm, TIP was observing very weak signals on the order of 1 Rayleigh. The TIP was placed back in STANDBY mode at the end of the night pass.

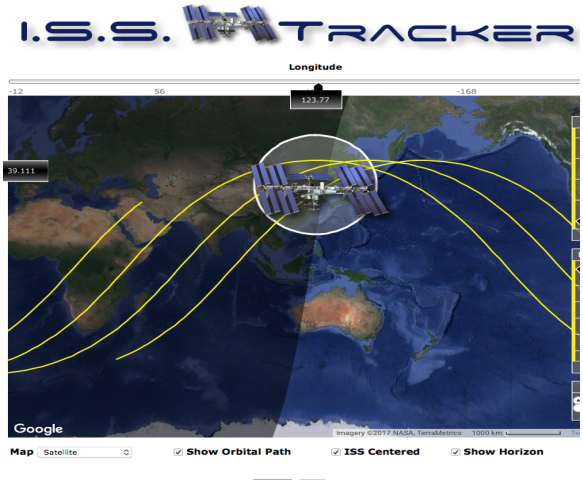


Figure 8. The position of the ISS end the end of the nightside pass data collection for TIP.

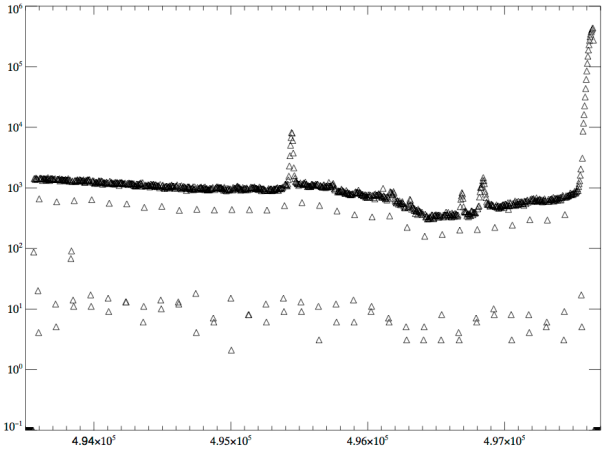


Figure 9. A log plot shows counts for 1.14-sec samples with weak nightglow, low dark counts, city lights, and the morning terminator near the end.

2.4.3 Day 2017 061: TIP UV, Background, and Dark Test

The photometer tests consisted of uploading a custom wheel pattern and testing motor performance executing the pattern. The physical layout of apertures on the 40-position GROUP-C/TIP photometer filter wheel differs from the layout of the heritage COSMIC/TIP filter wheel. (The UV aperture and main dark-count locations are the same, but the background filter is a new wheel position; the COSMIC/TIP pinhole apertures have been eliminated.) Consequently, three of four pre-programmed wheel position patterns stored in the flight computer's ROM are incorrect for this ISS mission. Fortunately, on boot-up these tables are copied into RAM and can be customized using built-in commands.

The built-in legacy CHOP pattern (Pattern #3) moves the filter wheel among the positions 0, 2, and 4; a new CHOP pattern was devised to alternate among the positions 10 (UV), 20 (DARK), and 30 (BKGD). The pattern in RAM was successfully updated by sending commands to modify the table of 64 position entries using WRx commands.

TIP Anomaly AT-001, Filter Wheel Stopped. After successfully loading the new filter wheel pattern, TIP entered CHOP_LAB mode. The filter wheel performed the wheel positioning correctly, but stopped moving after about 30 seconds when the pattern sent the filter wheel past the Hall sensor fiducial location. The filter wheel was later reset, but again stopped moving as it went past the fiducial. This behavior suggests stepper motor positioning errors (jitter) or errors reliably detecting the fiducial location, and indicates that the default stepper motor parameters require troubleshooting and adjustment for this flight.

2.4.4 Troubleshooting the Filter Wheel

Due to ISS Express Logistics Carrier (ELC) #1 power supply temperature anomalies, the subsequent 20 days of Early Orbit Testing stretched out over 54 days. The effort during that time was split between troubleshooting the filter wheel performance and troubleshooting automated time commands through ISEM. Rather than a blow-by-blow account, this report will account for the important anomalies and ultimate solutions. Some of the filter wheel anomalies originated due to user error implementing seldom-used TIP commands, but the TIP flight software operated as designed. First we focus on the filter wheel.

2017 065: TIP Anomaly AT-004, Filter Wheel Fiducial Error.

2017 072: TIP Anomaly AT-005, Filter Wheel Immediate Error.

Both of these anomalies ultimately originated in user error, associated with the order of filter wheel commands. However, the first tests did successfully establish that filter wheel motor performance during built-in NIGHT mode appeared steady and reliable, because the wheel did not pass the fiducial location. The filter wheel encountered an error when it passed the fiducial. During these tests, new wheel patterns were uploaded successfully through commands. A slow manually-stepped scan revealed that the fiducial signal may be briefly seen, but the wheel did not always encounter the fiducial on Step 36 as expected as the wheel passed the fiducial location. Finally, slow stepping near the fiducial seemed to work during tests, and the motor movement by step count also appeared to work reliably.

2.4.5 ELC #1 Temperature Exceedance

During the two-week period 2017 073 through 2017 087 the STP-H5 payload was shut down for an ELC #1 power supply temperature exceedance. This anomaly was eventually resolved, but no TIP data besides episodic heath and status were received. During this period when the flight experiment was shut down, both software and wheel performance tests were completed on the TIP Engineering Unit available on the ground at NRL that assisted in the troubleshooting process.

2.4.6 Optimizing Filter Wheel

After the temperature exceedance anomaly was resolved, STP-H5 and TIP resumed operations. Since the fiducial signal seemed unreliable (indicating jitter or a weak Hall sensor fiducial signal) and step counting appeared robust, a series of tests were performed to minimize mechanical jitter and optimize step-counting operations. This was a built-in work-around in the TIP flight software. Importantly, unlike during preflight ground testing of the TIP photometer, the fiducial signal does not appear to reliably remain on once the fiducial is detected and motion stops at position 36. The fiducial signal is clearly working, because the wheel stops and displays the proper step count. Perhaps the magnetic signal for the Hall effect sensor is weaker, or the wheel is jittering or moving off of the stepper motor detents in the weightless environment. Another possibility is that the angular placement of the magnet on the wheel differs from the built-in microstep phases hardwired into the flight software.

TIP was powered but in IDLE mode. Once the SrF_2 filter heater was powered, and the time required to warm up the filter from 7 to 100C was 59 minutes, consistent with the results from the February 28 initialization. The bulk of the commands focused upon performing repeated fiducial searches to assess the statistical performance for locating the fiducial, remaining on the fiducial when stopped, and going directly to the fiducial after exactly 1 rotation. Many tests were performed using different time constants for the stepper motor. The test results for the both filter wheel optimization tests are:

- Fiducial, 1 Rev. This is the expected behavior for the command sequence.
- Fiducial, >1 Rev. Occasionally, the filter wheel may miss a fiducial signal near the end of the first rotation, but detect the fiducial on a subsequent revolution
- Fiducial, <1 Rev. This is usually manifested with the wheel moving only 0 or 1 steps before detecting the fiducial, and likely results from the wheel jittering backward off of the fiducial, so that a small forward motion reasserts the fiducial.
- Lost. The filter wheel does not stop on the fiducial after 3 or more rotations is considered lost, and the motion times out.

The results from the Fiducial Detection Tests on Days 088 and 094 (Tables 1 and 2) have been combined into a bar chart (Figure 10). The outcome of the fiducial searches is expressed as a percentage of the total number of trials for each of the motor speeds. The reliability for detecting fiducial signals is not a simple function of speed: certain speeds are noticeably worse than speeds on either side, which likely results from resonances and motor jitter.

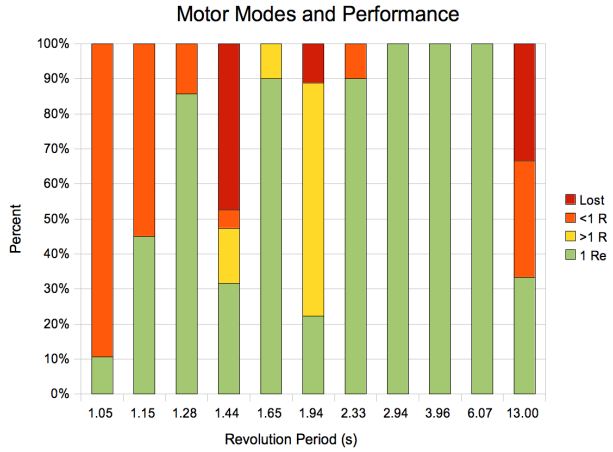


Figure 10. Plot of the percentage of successful fiducial searches for different stepper motor pulse lengths.

The most reliable filter wheel speeds are 2.94-6.07 seconds. A speed 2.94 seconds means that the cadence of chopped UV/background will be about 5.3 seconds, corresponding to a horizontal resolution of 39 km. (The goal for the GROUP-C experiment is 20 km.) By switching to the 1.65-sec rotation period, we can obtain 30 km resolution. TIP will likely only achieve the 10-20 km horizontal resolution when operating during moonless passes, because the filter wheel remains fixed on the UV aperture continuously. The default rotation speed ultimately chosen for CHOP mode in August 2017 was the faster 1.65 sec rotation speed.

Table 1. Repeated Fiducial Search Results, Day 088

Mode Index	Pulse Width (ms)	Rotation Time (s)	Trials	Fiducial 1 Rev	Fiducial >1 Rev	Fiducial <1 Rev	Lost
21	26	1.05	9	2	0	7	0
22	29	1.15	10	2	0	8	0
23	32	1.28	10	9	0	1	0
24	36	1.44	7	0	0	1	6
25	42	1.65	10	9	1	0	0
26	48	1.94	9	2	6	0	1
27	58	2.33	10	9	0	1	0
28	73	2.94	10	10	0	0	0
29	99	3.96	10	10	0	0	0

Table 2. Repeated Fiducial Search Results, Day 094

Mode Index	Pulse Width (ms)	Rotation Time (s)	Trials	Fiducial 1 Rev	Fiducial >1 Rev	Fiducial <1 Rev	Lost
21	26	1.05	10	0	0	10	0
22	29	1.15	10	7	0	3	0
23	32	1.28	11	9	0	2	0
24	36	1.44	12	6	3	0	3
29	99	3.96	4	4	0	0	0

30	152	6.07	3	3	0	0	0
31	325	13	3	1	0	1	1

2017 094:, TIP Anomaly AT-009, Sunsafe Motion to Position 0.

After the completion of fiducial tests, the TIP sensor was placed into safe mode using an appropriate command sequence to avoid motor errors (e.g. AT-004 and AT-005). However, rather than moving to position 20 and maintaining that position, the filter wheel unexpectedly moved to position 0 periodically. This behavior was traced to a TIP flight code error: instead 16 rows of 16-bytes to specify filter wheel patterns 4-7, the flight source code has 16 rows of 15 pattern data bytes. This caused byte misalignments throughout these four unmodifiable filter wheel patterns and means that the entire 16th row of pattern data is zeroes, so the final pattern (#7, SAFE) spends ¼ of its time at zero. Amazingly, this bug was not detected until the TIP software was pushed to its limits during GROUP-C on-orbit testing. The mitigation is to use only modifiable, uploadable wheel pattern operations.

2.4.7 Terminator Probe

The filter wheel was sent into sun-safe position, and the filter wheel motor was disabled at position 20. Then HV was turned on to monitor count background and dark count rate across the nightside pass, from terminator to terminator. The FOTON GPS navigation information was used to calculated the ISS location.

As ISS crossed the evening terminator, before the Sun set below the hard limb, TIP data show significant leakage signal (20k counts/sec). This occurred when the ISS was lit, even though the nadir direction was already in night. The leakage signal is much weaker (300 counts/sec) crossing the morning terminator. If the leakage signal depends upon scattered light in the local ISS environment, we may expect the leakage signal to vary with beta angle.

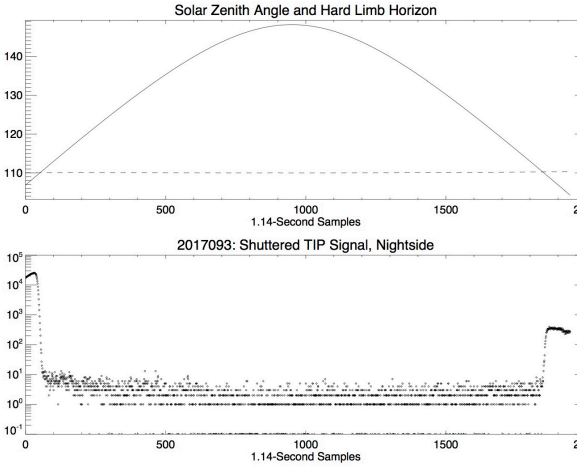


Figure 11: Scattered light signal and dark counts observed during a nightside pass with the TIP detector shuttered. ISS position was interpolated from the FOTON navigation messages to calculate solar zenith angle.

2.4.8 Automated Time-tagged Commands Through ISEM

ISEM is the interface computer for the GROUP-C and LITES experiments aboard STP-H5 and a GSFC experiment. The ISEM has responsibility for real-time commands to the GROUP-C sensors, Health and Status telemetry from the sensors, high rate science telemetry from the sensors, and sending scripted, timed commands to the TIP sensor. Scheduled commands from ISEM to TIP were successfully tested during PRCU tests pre-flight. Receiving telemetry and sending real-time commands was largely uneventful. During ground testing weeks-long communication to and from ISEM was not performed, though, and the ground environment is a more benign particle radiation environment than the ISS orbit. Periodic reboots of COTS computer hardware in space is typical, as we found aboard the STP HICO-RAIDS Experiment Payload in 2009. Due largely to communications problems that arose and the need for periodic reboots of the ISEM computer, the scheduled commands proved more difficult to test.

ISEM Anomaly A-011, SCA Error. This SCA error is one of the more common errors encountered when performing schedule uploads to ISEM, occurring when the ISEM computer is unable to append a newly uploaded schedule. This generally occurs when ISEM requires a reboot, and it can prevent execution of scheduled commands until it gets resolved. This occurs throughout the mission with sufficient frequency that a work-around procedure was devised when a reboot could not be performed quickly.

ISEM Anomaly A-012, Unexpected Upload Request. Once the communication errors begin, the upload process can become corrupted, with ISEM getting out of sync so that uploads are unexpected or uploads are incomplete. A very short file upload may break this cycle and has been used several times successfully. This condition may be associated with either spotty communications to ISEM from an error condition or occasionally with a file upload being interrupted from a communications loss-of-signal to the ISS.

ISEM Anomaly A-013, Intermittent Health and Status Packets

Anomaly A-014, ISEM Unresponsive to Commands

As the communications between ISEM and CIB becomes more intermittent, ISEM can stop responding to Health and Status telemetry requests in a timely manner. This appears as intermittent H&S data from both FOTON and TIP. Over time if communications worsen, ISEM will also stop responding to commands from the CIB. The most effective workaround is a reboot of ISEM, which has the effect of restoring nominal communications.

2.4.9 Successful Automated Command Tests

In parallel with troubleshooting automated scheduled commands, two tests were successfully performed. The first on 2016107 successfully uploaded a realistic schedule that corresponds to actual ISS terminator crossings. The command buffers for day and night were loaded with realistic commands with the exception of turning on high voltage. The schedule executed as expected. The table comparing the times of the scheduled commands, the CCSDS time when the ISEM LRT reported a timed command, and the CCSDS time when TIP echoed the command indicate that the commands appear to be sent within a second of the expected time, as the differences above expected TIP output latency are quite small. The CCSDS times for the ISEM LRT vary significantly, up to 10's of seconds from the expected command times, which may reflect the communication anomaly taking place at the time.

Later a second test on 2017114 successfully demonstrated TIP high voltage cycling as expected on the dayside and nightside. This was the first test to successfully upload a schedule that corresponds to actual ISS terminator crossings, use HV across the nightside, implement the newly-defined CHOP pattern for the UV and background apertures, and operate the wheel at an optimized speed (2.33 sec/rev) ignoring the fiducial signal. One pass was collected at a wheel speed of 1.65 sec/rev, but the ISEM HV On command buffer was updated to use the more conservative 2.33 sec/rev speed.

2.5 TIP Early Orbit Test Summary

By 2017 Day 117 all of the on-orbit test objective had been completed, major anomalies were identified, and successful work-arounds had been implemented. The flexibility of the TIP flight software is excessive for a simple photometer with 40 potential commands. However, we learned that for a demonstration project, the configurability of the TIP sensor was extremely useful for implementing the required hardware and software work-arounds. Early Orbit Testing had stretched over weeks rather than days due to a combination of encountering ISS-related thermal anomalies, troubleshooting both ISEM

communications and automated TIP commands, optimizing filter wheel operations in the face of unanticipated hardware performance, and using about an hour per day of real-time commanding.

Table 3. TIP Early Orbit Test Completion and Anomalies

Test	Date		Comments
Liveness Test	2017 059	✔	STP-H5 Power-up Sequence
Standby-mode Test	2017 059	✔	STP-H5 Power-up Sequence
Motor Test	2017 060	✔	Built-in mode tested during night pass. Obtained first UV light, dark counts, and dawn terminator
Dark Test		✔	
UV/Background/Dark Test	2017 061	HW	Anomaly AT-001. Filter wheel stopped.
	2017 065	UE	Anomaly AT-004. Filter wheel fiducial error.
	2017 072	UE	Anomaly AT-005. Filter wheel immediate error.
	2017 094	FSW	Anomaly AT-009. Sunsafe motion to position 0.
	2017 110	✔	Completed custom CHOP pattern at optimized speeds using uploaded scheduled commands.
Automated Command Test	2017 090	UE	Anomaly AT-008. Commands did not execute on TIP
	2017 093	UE	Anomaly AT-008. Commands did not execute on TIP
	2017 103	FSW	Anomaly AT-011. ISEM SCA Error.
	2017 107	FSW	Anomaly AT-012. Unexpected upload packet ISEM.
	2017 107	FSW	Anomaly AT-011. ISEM SCA Error.
	2017 107	FSW	Anomaly A-013. Intermittent communication CIB.
	2017 107	FSW	Anomaly A-014. No ISEM command ACKS at CIB.
	2017 107	✔	Executed benign commands using uploaded scheduled commands.
Autom. HV Command Test	2017 111	FSW	Anomaly AT-011. ISEM SCA Error.
	2017 114	✔	Completed custom CHOP pattern at optimized speeds using uploaded scheduled commands.
Terminator Probe	2017 093	✔	Performed probe of twilight terminator

UE = User Error, HW=Hardware Anomaly, FSW=Flight Software Anomaly

3. LESSONS LEARNED

A significant objective of the GROUP-C experiment entailed technology demonstration of both the TIP and FOTON sensors themselves, the sensing methods used, and the ISS as a platform for space weather sensing. Early Orbit Testing revealed much concerning the hardware involved; the methods will prove themselves over time as the data are collected. A summary of lessons learned from this Early Orbit Test Periods is provided.

Table 4. Lessons Learned from GROUP-C

System	Lesson Learned	Outcome
FOTON	"Raw capture" operating mode has proven useful for advanced and novel GPS observations	CONOPS has been developed for GPS ground interference data capture. Occultations deep into troposphere may be also be useful.
FOTON	Test as you fly	Serial ground testing by sensor teams did not detect the HV interaction between LITES and FOTON.

System	Lesson Learned	Outcome
TIP	Filter wheel mechanism positioning accuracy was worse than expected.	The next-generation Tri-TIP photometer design eliminates the filter mechanism.
TIP	Flexible TIP flight software provided work-around for filter wheel and offered added on-orbit test capability.	Longer EOT period. Removing the filter mechanism and commands streamlines Tri-TIP software and FPGA design and testing. Some overrides from TIP retained for Tri-TIP
TIP	Sapphire filter performed as expected to monitor red-leak signal	Sapphire beamsplitter incorporated into Tri-TIP design, but VUV filter version.
STP-H5	The ISEM experiment computer works well as a C&DH interface for the GROUP-C experiment.	Good communication between NRL and ISEM teams during test, integration, and operations was coordinated by STP. Support from GSFC and STP teams is excellent.
STP-H5	"DoD Payload" loop is a valuable tool managing STP-H5 operations	Coordination among experiment teams for optimal use of ISS command time.
STP-H5	Time sharing the ISS command window and restriction to work-week impacted troubleshooting activity.	Longer EOT test period.
ISS	Thermal anomaly in ISS	Longer EOT test period than expected.
ISS	Scattered light in the ISS environment restricts TIP data to night at ISS altitude (not the ground terminator)	Shorter nightside passes, reducing some low-latitude ionosphere coverage. Better light baffles are needed to minimize this.
ISS	ISS precession closely matches lunar cycle. Many months, the best night passes coincided with full moon. TIP is our first moonlight-sensitive ISS sensor.	Launch delay had some observational impact. Less of the very best quality science data early in the mission than originally expected.
STP-H5	Individual sensors should include a soft reboot command: shared power busses complicate hard power-cycles of sensors.	TIP, FOTON, and Tri-TIP all include software reset capability.

4. SUMMARY

The GPS Radio Occultation and Ultraviolet Photometry—Colocated (GROUP-C) experiment was launched to the International Space Station aboard the Space Test Program Houston Pallet #5 (STP-H5) on February 19, 2017. GROUP-C includes both a second-generation high-sensitivity far-ultraviolet photometer measuring horizontal nighttime ionospheric gradients and an advanced software-defined GPS receiver providing ionospheric electron density profiles, scintillation measurements, and lower atmosphere profiles. After routine flight, capture, and installation to the Express Logistics Carrier #1, the GROUP-C experiment underwent Early Orbit Testing to verify its performance prior to science operations.

All Early Orbit Tests were successfully completed by both sensors. The FOTON unit completed tests quickly and was ready for science operations after four days. The TIP sensor took significantly longer to complete check-out. Some ISS and payload anomalies delayed completion of on-orbit testing.

Other anomalies were inherent to the TIP sensor, and required and extra degree of troubleshooting to devise successful work-arounds. The Early Orbit Testing achieved its purpose, proving that the sensors survived launch and would collected appropriate space environment measurements on-orbit. The GROUP-C experiment as a whole entered science operations on April 28, 2017.

ACKNOWLEDGEMENTS

The STP-H5/GROUP-C experiment was integrated and flown under the direction of the Department of Defense Space Test Program. Work at the University of Texas was supported by the National Research Foundation under Grant No. 1454474 (CAREER).

REFERENCES

R. A. Anthes, P. A. Bernhardt, Y. Chen, L. Cucurull, K. F. Dymond, D. Ector, S. B. Healy, Ho S.-P., D. C Hunt, Kuo Y.-H., H. Liu, K. Manning, C. McCormick, T. K. Meehan, W J. Randel, C. Rocken, W S. Schreiner, S. V. Sokolovskiy, S. Syndergaard, D. C. Thompson, K. E. Trenberth, Wee T.-K., N. L. Yen, and Z. Zeng (2008), "The COSMIC/FORMOSAT-3 Mission: Early Results", *Bull. Am. Met. Soc*., **89,** 313-333, doi://10.1175/BAMS-89-3-313.

R. L. Bishop, D. A. Hinkley, D. R. Stoffel, D. E. Ping, P. R. Straus, T. R. Brubaker 2012, "First Results From the GPS Compact Total Electron Content Sensor (CTECS) on the PSSCT-2 Nanosat," Proceedings of the 26th Annual AIAA/USU Conference on Small Satellites, Logan, Utah, USA, August 13-16, 2012, paper: SSC12-XI-2.

S. Budzien, B. Fritz, A. Stephan, P. Marquis, S. Powell, B. O'Hanlon, A. Nicholas, K. Dymond, and C. Brown 2019, "Comparison of second and third generation 135.6 nm ionospheric photometers using on-orbit and laboratory results," *Proc. SPIE, 11131, CubeSats and SmallSats for Remote Sensing III*, 1113102, doi: 10.1117/12.2528791.

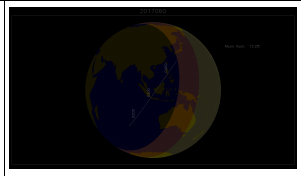
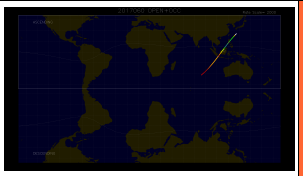
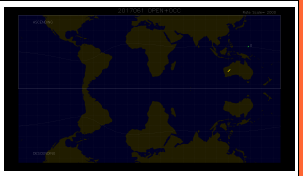
K.F. Dymond, J. B. Nee, and R. J. Thomas (2000), "9. The Tiny Ionospheric Photometer: An Instrument for Measuring Ionospheric Gradients for the COSMIC Constellation", *Applications of Constellation Observing System for Meteorology, Ionosphere, and Climate*, pp 273-290 (Springer, New York, NY).

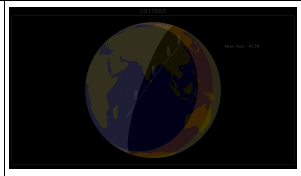
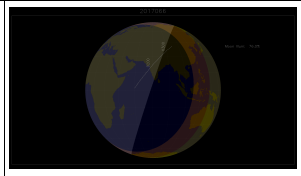
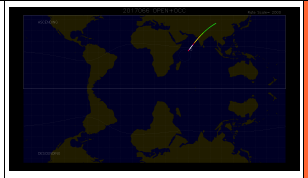
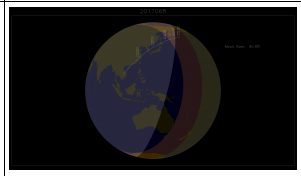
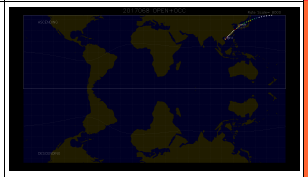
K. F. Dymond, S. A. Budzien, C. Coker, and D. H. Chua (2016), "The Tiny Ionospheric Photometer (TIP) on the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC/FORMOSAT-3)", J. Geophys. Res. Space Physics, 121, 10,614-10,622, doi:10.1002/2016JA022900.

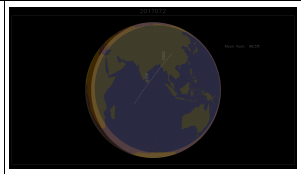
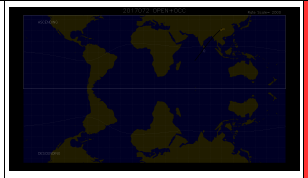
E. G. Lightsey, T. E. Humphreys, J. A. Bhatti, A. J. Joplin, B. W. O'Hanlon, and S. P. Powell, "Demonstration of a Space Capable Miniature Dual Frequency GNSS Receiver", *NAVIGATION, Journal of The Institute of Navigation*, Vol. 61, No. 1, Spring 2014, pp. 53-64. doi://10.1002/navi.52

G. Sondecker, IV, P. La Tour, and L. Abramowitz, 2013, "SENSE: The USAF SMC/XR NanoSatellite Program for Space Environmental Sensing", Proceedings of the 27th Annual AIAA/USU Conference on Small Satellites, Logan, Utah, USA, August 12-15, 2013, paper: SSC13-XI-7.

Table 5. GROUP-C Early Orbit Testing Observation Summary

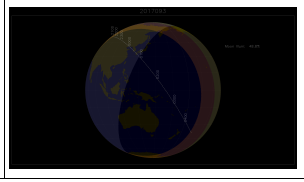
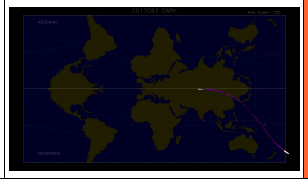
Day	Date	Orbit Geometry	TIP Count Rate Map	TIP Mode	GPS Mode	LITES Mode	Comments
059	Feb 28			NIGHTSECS=28237 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=10	IDLE= 36% DATA= 64% DNLD= 0% OCC_N3= 8 OCC_N2= 16 OCC_D3= 5 OCC_D2= 23 CMDS=6	MODE = RAW HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 35.9C CMDS = 6	STP-H5 Initialization GROUP-C Initial Power-on FOTON STREAM mode test TIP tested and left in STANDBY-LAB mode at fiducial
060	Mar 01			NIGHTSECS=29156 UVSECS = 1088 BGDSECS= 0 DRKSECS= 72 OTHSECS= 73 HVCOVERAGE= 4.0% MODE=STBY CMDS=5	IDLE= 4% DATA= 94% DNLD= 2% OCC_N3= 6 OCC_N2= 22 OCC_D3= 9 OCC_D2= 21 CMDS=18	MODE = RAW HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 24.1C CMDS = 5	TIP First Light: Real-time nightside collection FOTON UNRAW/DOWNLOAD mode test FOTON returned to STREAM mode
061	Mar 02			NIGHTSECS=30763 UVSECS = 35 BGDSECS= 39 DRKSECS= 3 OTHSECS= 750 HVCOVERAGE= 2.7% MODE=STBY CMDS=8	IDLE= 1% DATA= 67% DNLD= 22% OCC_N3= 5 OCC_N2= 16 OCC_D3= 2 OCC_D2= 14 CMDS=11	MODE = RAW HV-NIT= 0% HV-DAY= 3% HVVMAX= 2049V HVI = 4.8uA HVCMDS= 8 TEMP3 = 26.9C CMDS = 14	TIP Filter Wheel Test New CHOP pattern: ver 2, 2017/03/02 Anomaly AT-001 (non-persistent fiducial signal) FOTON RAW capture test Anomaly AF-002 (truncated raw dump)
062	Mar 03			NIGHTSECS=30472 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=0	IDLE= 1% DATA= 28% DNLD= 71% OCC_N3= 0 OCC_N2= 0 OCC_D3= 0 OCC_D2= 0 CMDS=5	MODE = RAW HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 27.7C CMDS = 1	FOTON returned to STREAM mode
063	Mar 04			NIGHTSECS=32638 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=0	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 3 OCC_N2= 17 OCC_D3= 3 OCC_D2= 13 CMDS=0	MODE = RAW HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 29.9C CMDS = 0	(Saturday)

Day	Date	Orbit Geometry	TIP Count Rate Map	TIP Mode	GPS Mode	LITES Mode	Comments
064	Mar 05			NIGHTSECS=31192 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=0	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 7 OCC_N2= 9 OCC_D3= 4 OCC_D2= 19 CMDS=0	MODE = RAW HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 28.5C CMDS = 0	(Sunday)
065	Mar 06			NIGHTSECS=33635 UVSECS = 1269 BGDSECS= 0 DRKSECS= 86 OTHSECS= 86 HVCOVERAGE= 4.0% MODE=STBY CMDS=6	IDLE= 0% DATA= 79% DNLD= 0% OCC_N3= 6 OCC_N2= 15 OCC_D3= 4 OCC_D2= 10 CMDS=4	MODE = MIXD HV-NIT= 8% HV-DAY= 13% HVVMAX= 2689V HVI = 7.5uA HVCMDS= 10 TEMP3 = 27.7C CMDS = 19	FOTON STREAM mode recovery Anomaly AF-003 (FOTON HRT rate drop 14:09:40 LITES HV1->Lev 0) TIP & LITES joint nightside pass Anomaly AT-004 (SAFE mode motor error)
066	Mar 07			NIGHTSECS=31829 UVSECS = 769 BGDSECS= 0 DRKSECS= 50 OTHSECS= 50 HVCOVERAGE= 2.6% MODE=STBY CMDS=64	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 4 OCC_N2= 13 OCC_D3= 3 OCC_D2= 15 CMDS=0	MODE = NORM HV-NIT= 0% HV-DAY= 1% HVVMAX= 2689V HVI = 6.2uA HVCMDS= 2 TEMP3 = 26.3C CMDS = 4	TIP filter wheel test #2: Fiducial Detection
067	Mar 08			NIGHTSECS=34174 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=0	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 8 OCC_N2= 15 OCC_D3= 4 OCC_D2= 17 CMDS=0	MODE = NORM HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 24.7C CMDS = 0	
068	Mar 09			NIGHTSECS=32609 UVSECS = 61 BGDSECS= 59 DRKSECS= 60 OTHSECS= 885 HVCOVERAGE= 3.1% MODE=STBY CMDS=18	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 6 OCC_N2= 19 OCC_D3= 5 OCC_D2= 21 CMDS=0	MODE = MIXD HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 22.7C CMDS = 1	TIP filter wheel test #3: Custom BaF2 pattern
069	Mar 10			NIGHTSECS=33936 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=7	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 6 OCC_N2= 36 OCC_D3= 5 OCC_D2= 38 CMDS=0	MODE = RAW HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 20.3C CMDS = 2	TIP filter wheel test #4: New Chop pattern TIP filter wheel test #5: New Chop pattern, no fiducial Anomaly AT-005 (command order user error)

Day	Date	Orbit Geometry	TIP Count Rate Map	TIP Mode	GPS Mode	LITES Mode	Comments
070	Mar 11			NIGHTSECS=33136 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=0	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 18 OCC_N2= 28 OCC_D3= 18 OCC_D2= 33 CMDS=0	MODE = RAW HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 20.3C CMDS = 2	(Saturday)
071	Mar 12			NIGHTSECS=33367 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=0	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 15 OCC_N2= 35 OCC_D3= 14 OCC_D2= 42 CMDS=0	MODE = RAW HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 20.0C CMDS = 0	(Sunday)
072	Mar 13			NIGHTSECS=33369 UVSECS = 422 BGDSECS= 419 DRKSECS= 56 OTHSECS= 56 HVCOVERAGE= 2.7% MODE=STBY CMDS=21	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 8 OCC_N2= 32 OCC_D3= 9 OCC_D2= 34 CMDS=0	MODE = RAW HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 20.4C CMDS = 0	TIP data exhibits no UV counts during observation Occultation of PRN20
073	Mar 14			NIGHTSECS=32507 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=0	IDLE= 0% DATA= 79% DNLD= 0% OCC_N3= 2 OCC_N2= 20 OCC_D3= 5 OCC_D2= 15 CMDS=0	MODE = RAW HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 18.3C CMDS = 0	Anomaly A-006 ELC #1 LVPS Temperature Exceedance
074	Mar 15			NIGHTSECS=33291 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=OFF CMDS=0	IDLE= 0% DATA= 0% DNLD= 0% OCC_N3= 0 OCC_N2= 0 OCC_D3= 0 OCC_D2= 0 CMDS=0	MODE = OFF HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 14.2C CMDS = 0	No data
075	Mar 16			NIGHTSECS=31341 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=OFF CMDS=0	IDLE= 0% DATA= 0% DNLD= 0% OCC_N3= 0 OCC_N2= 0 OCC_D3= 0 OCC_D2= 0 CMDS=0	MODE = OFF HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 14.2C CMDS = 0	No data

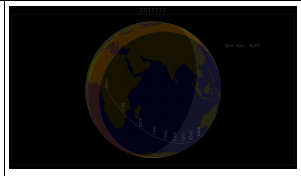
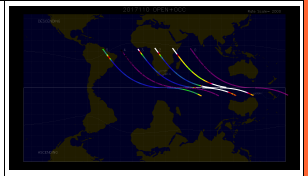
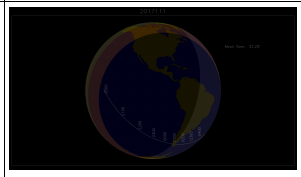
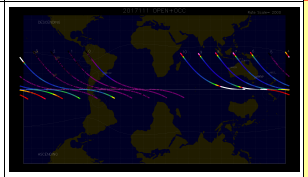
Day	Date	Orbit Geometry	TIP Count Rate Map	TIP Mode	GPS Mode	LITES Mode	Comments
076	Mar 17			NIGHTSECS=32644 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=OFF CMDS=0	IDLE= 0% DATA= 0% DNLD= 0% OCC_N3= 0 OCC_N2= 0 OCC_D3= 0 OCC_D2= 0 CMDS=0	MODE = OFF HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 14.1C CMDS = 0	No data
077	Mar 18			NIGHTSECS=30045 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=OFF CMDS=0	IDLE= 0% DATA= 0% DNLD= 0% OCC_N3= 0 OCC_N2= 0 OCC_D3= 0 OCC_D2= 0 CMDS=0	MODE = OFF HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 14.6C CMDS = 0	No data
078	Mar 19			NIGHTSECS=31346 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=IDLE CMDS=0	IDLE= 69% DATA= 18% DNLD= 0% OCC_N3= 0 OCC_N2= 5 OCC_D3= 1 OCC_D2= 2 CMDS=3	MODE = RAW HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 15.6C CMDS = 1	Anomaly A-006 ELC #1 LVPS Temperature Exceedance About 4 hours of status data
079	Mar 20			NIGHTSECS=28648 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=OFF CMDS=0	IDLE= 0% DATA= 0% DNLD= 0% OCC_N3= 0 OCC_N2= 0 OCC_D3= 0 OCC_D2= 0 CMDS=0	MODE = OFF HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 14.8C CMDS = 0	No data
080	Mar 21			NIGHTSECS=29692 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=OFF CMDS=0	IDLE= 0% DATA= 0% DNLD= 0% OCC_N3= 0 OCC_N2= 0 OCC_D3= 0 OCC_D2= 0 CMDS=0	MODE = OFF HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 14.9C CMDS = 0	No data
081	Mar 22			NIGHTSECS=27281 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=OFF CMDS=0	IDLE= 0% DATA= 0% DNLD= 0% OCC_N3= 0 OCC_N2= 0 OCC_D3= 0 OCC_D2= 0 CMDS=0	MODE = OFF HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 14.8C CMDS = 0	No data

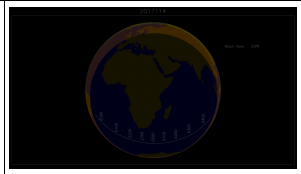
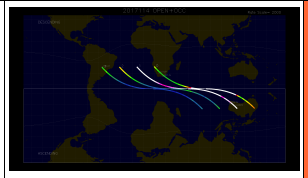
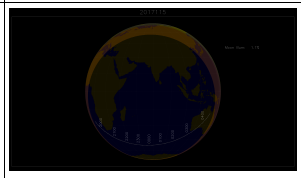
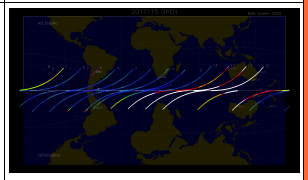
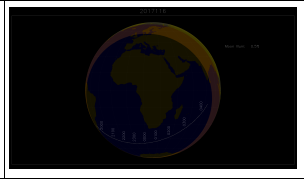
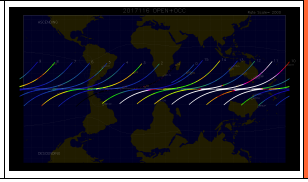
Day	Date	Orbit Geometry	TIP Count Rate Map	TIP Mode	GPS Mode	LITES Mode	Comments
082	Mar 23			NIGHTSECS=27681 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=OFF CMDS=0	IDLE= 0% DATA= 0% DNLD= 0% OCC_N3= 0 OCC_N2= 0 OCC_D3= 0 OCC_D2= 0 CMDS=0	MODE = OFF HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 15.0C CMDS = 0	No data
083	Mar 24			NIGHTSECS=26116 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=OFF CMDS=0	IDLE= 0% DATA= 0% DNLD= 0% OCC_N3= 0 OCC_N2= 0 OCC_D3= 0 OCC_D2= 0 CMDS=0	MODE = OFF HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 15.1C CMDS = 0	No data Expedition 50 EVA 3
084	Mar 25			NIGHTSECS=26326 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=OFF CMDS=0	IDLE= 0% DATA= 0% DNLD= 0% OCC_N3= 0 OCC_N2= 0 OCC_D3= 0 OCC_D2= 0 CMDS=0	MODE = OFF HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 15.1C CMDS = 0	No data
085	Mar 26			NIGHTSECS=25964 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=OFF CMDS=0	IDLE= 0% DATA= 0% DNLD= 0% OCC_N3= 0 OCC_N2= 0 OCC_D3= 0 OCC_D2= 0 CMDS=0	MODE = OFF HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 15.2C CMDS = 0	No data
086	Mar 27			NIGHTSECS=26326 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=OFF CMDS=0	IDLE= 0% DATA= 0% DNLD= 0% OCC_N3= 0 OCC_N2= 0 OCC_D3= 0 OCC_D2= 0 CMDS=0	MODE = OFF HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 15.1C CMDS = 0	No data
087	Mar 28			NIGHTSECS=27184 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=IDLE CMDS=0	IDLE= 0% DATA= 0% DNLD= 0% OCC_N3= 0 OCC_N2= 0 OCC_D3= 0 OCC_D2= 0 CMDS=0	MODE = RAW HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 15.7C CMDS = 0	Approval to operate at ELC #1 LVPS under relaxed temperature constraints TIP and FOTON powered Status data

Day	Date	Orbit Geometry	TIP Count Rate Map	TIP Mode	GPS Mode	LITES Mode	Comments
088	Mar 29			NIGHTSECS=27412 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=67	IDLE= 68% DATA= 27% DNLD= 0% OCC_N3= 1 OCC_N2= 5 OCC_D3= 1 OCC_D2= 4 CMDS=7	MODE = MIXD HV-NIT= 7% HV-DAY= 11% HVVMAX= 2689V HVI = 4.8uA HVCMDS= 3 TEMP3 = 16.1C CMDS = 20	TIP filter wheel test #6: Fiducial search performance FOTON Default STREAM ops Anomaly AF-003 (FOTON HRT rate drop 16:24:41 LITES HV1->Lev0)
089	Mar 30			NIGHTSECS=29162 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=0	IDLE= 18% DATA= 28% DNLD= 0% OCC_N3= 3 OCC_N2= 4 OCC_D3= 0 OCC_D2= 6 CMDS=0	MODE = RAW HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 16.1C CMDS = 0	Power-down due to EVA. Expedition 50 EVA 4 for MDM replacement and more
090	Mar 31			NIGHTSECS=28744 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=12	IDLE= 0% DATA= 0% DNLD= 0% OCC_N3= 0 OCC_N2= 0 OCC_D3= 0 OCC_D2= 0 CMDS=0	MODE = MIXD HV-NIT= 10% HV-DAY= 15% HVVMAX= 2689V HVI = 4.8uA HVCMDS= 3 TEMP3 = 16.9C CMDS = 14	D3 power cycle to sync GLIB clock TIP Scheduled Command Test #1 Anomaly AT-008 (Scheduled commands not executed)
091	Apr 01			NIGHTSECS=31130 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=0	IDLE= 0% DATA= 0% DNLD= 0% OCC_N3= 0 OCC_N2= 0 OCC_D3= 0 OCC_D2= 0 CMDS=0	MODE = NORM HV-NIT= 37% HV-DAY= 63% HVVMAX= 2561V HVI = 4.8uA HVCMDS= 0 TEMP3 = 18.9C CMDS = 0	(Saturday)
092	Apr 02			NIGHTSECS=29852 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=0	IDLE= 0% DATA= 0% DNLD= 0% OCC_N3= 0 OCC_N2= 0 OCC_D3= 0 OCC_D2= 0 CMDS=0	MODE = NORM HV-NIT= 38% HV-DAY= 62% HVVMAX= 2561V HVI = 4.8uA HVCMDS= 0 TEMP3 = 19.9C CMDS = 0	(Sunday)
093	Apr 03			NIGHTSECS=32454 UVSECS = 0 BGDSECS= 0 DRKSECS= 2214 OTHSECS= 2214 HVCOVERAGE= 6.8% MODE=STBY CMDS=35	IDLE= 61% DATA= 39% DNLD= 0% OCC_N3= 3 OCC_N2= 14 OCC_D3= 4 OCC_D2= 13 CMDS=4	MODE = NORM HV-NIT= 37% HV-DAY= 62% HVVMAX= 2689V HVI = 6.2uA HVCMDS= 3 TEMP3 = 20.8C CMDS = 4	TIP & FOTON initialized after power cycle TIP Dark Count and Scattered Light Check TIP Scheduled Command Test #2 FOTON default STREAM ops

Day	Date	Orbit Geometry	TIP Count Rate Map	TIP Mode	GPS Mode	LITES Mode	Comments
094	Apr 04			NIGHTSECS=30908 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=94	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 11 OCC_N2= 32 OCC_D3= 11 OCC_D2= 37 CMDS=0	MODE = NORM HV-NIT= 39% HV-DAY= 61% HVVMAX= 2689V HVI = 6.2uA HVCMDS= 0 TEMP3 = 21.4C CMDS = 3	TIP filter wheel test #7: Fiducial search performance Anomaly AT-009 (Safe mode unexpected motion)
095	Apr 05			NIGHTSECS=33397 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=0	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 14 OCC_N2= 34 OCC_D3= 8 OCC_D2= 30 CMDS=0	MODE = NORM HV-NIT= 39% HV-DAY= 61% HVVMAX= 2689V HVI = 6.2uA HVCMDS= 0 TEMP3 = 22.0C CMDS = 0	
096	Apr 06			NIGHTSECS=32001 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=14	IDLE= 1% DATA= 71% DNLD= 26% OCC_N3= 3 OCC_N2= 19 OCC_D3= 5 OCC_D2= 20 CMDS=10	MODE = NORM HV-NIT= 37% HV-DAY= 58% HVVMAX= 2689V HVI = 6.2uA HVCMDS= 12 TEMP3 = 21.8C CMDS = 12	FOTON RAW/DOWNLOAD Test #2 TIP Initialization and New Safing Procedure Test
097	Apr 07			NIGHTSECS=33643 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=38	IDLE= 1% DATA= 33% DNLD= 67% OCC_N3= 0 OCC_N2= 0 OCC_D3= 0 OCC_D2= 0 CMDS=5	MODE = NORM HV-NIT= 36% HV-DAY= 51% HVVMAX= 2689V HVI = 6.2uA HVCMDS= 30 TEMP3 = 20.2C CMDS = 30	FOTON default STREAM ops TIP STANDBY
098	Apr 08			NIGHTSECS=32886 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=0	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 5 OCC_N2= 16 OCC_D3= 5 OCC_D2= 16 CMDS=0	MODE = MIXD HV-NIT= 6% HV-DAY= 14% HVVMAX= 2689V HVI = 6.2uA HVCMDS= 21 TEMP3 = 20.8C CMDS = 32	
099	Apr 09			NIGHTSECS=33517 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=0	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 3 OCC_N2= 17 OCC_D3= 0 OCC_D2= 18 CMDS=0	MODE = RAW HV-NIT= 0% HV-DAY= 0% HVVMAX= 2689V HVI = 6.2uA HVCMDS= 14 TEMP3 = 20.8C CMDS = 30	

Day	Date	Orbit Geometry	TIP Count Rate Map	TIP Mode	GPS Mode	LITES Mode	Comments
100	Apr 10			NIGHTSECS=33519 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=0	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 6 OCC_N2= 11 OCC_D3= 4 OCC_D2= 16 CMDS=0	MODE = RAW HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 20.3C CMDS = 0	8-deg yaw bias (-4 to +4deg) for SAGE calibration
101	Apr 11			NIGHTSECS=33141 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=0	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 4 OCC_N2= 15 OCC_D3= 2 OCC_D2= 21 CMDS=0	MODE = RAW HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 20.9C CMDS = 0	
102	Apr 12			NIGHTSECS=33916 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=0	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 4 OCC_N2= 18 OCC_D3= 2 OCC_D2= 15 CMDS=0	MODE = RAW HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 22.1C CMDS = 0	
103	Apr 13			NIGHTSECS=32543 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=44	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 6 OCC_N2= 18 OCC_D3= 7 OCC_D2= 20 CMDS=0	MODE = MIXD HV-NIT= 12% HV-DAY= 15% HVVMAX= 2689V HVI = 6.2uA HVCMDS= 9 TEMP3 = 23.4C CMDS = 13	Scheduled Command Test #3 Anomaly AT-011 (SCA Error on Append)
104	Apr 14			NIGHTSECS=34084 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=0	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 6 OCC_N2= 21 OCC_D3= 4 OCC_D2= 24 CMDS=0	MODE = NORM HV-NIT= 34% HV-DAY= 51% HVVMAX= 2689V HVI = 7.0uA HVCMDS= 32 TEMP3 = 24.6C CMDS = 32	
105	Apr 15			NIGHTSECS=31765 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=0	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 9 OCC_N2= 35 OCC_D3= 5 OCC_D2= 39 CMDS=0	MODE = NORM HV-NIT= 36% HV-DAY= 52% HVVMAX= 2689V HVI = 7.4uA HVCMDS= 31 TEMP3 = 24.9C CMDS = 31	(Saturday)

Day	Date	Orbit Geometry	TIP Count Rate Map	TIP Mode	GPS Mode	LITES Mode	Comments
106	Apr 16			NIGHTSECS=33624 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=0	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 15 OCC_N2= 38 OCC_D3= 12 OCC_D2= 38 CMDS=0	MODE = NORM HV-NIT= 36% HV-DAY= 53% HVVMAX= 2689V HVI = 7.6uA HVCMDS= 31 TEMP3 = 25.9C CMDS = 31	(Sunday) Return to previous yaw bias
107	Apr 17			NIGHTSECS=31244 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=77	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 17 OCC_N2= 32 OCC_D3= 14 OCC_D2= 40 CMDS=0	MODE = NORM HV-NIT= 34% HV-DAY= 57% HVVMAX= 2689V HVI = 7.7uA HVCMDS= 22 TEMP3 = 27.8C CMDS = 23	Scheduled Command Test #4 Anomaly A-012 (Schedule Upload Error) Anomaly AT-011 (SCA Error on Append) Anomaly A-013 (Intermittent H&S packets) --Communication issues with CIB and ISEM
108	Apr 18			NIGHTSECS=33004 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=CHOP CMDS=6	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 6 OCC_N2= 21 OCC_D3= 6 OCC_D2= 29 CMDS=0	MODE = NORM HV-NIT= 39% HV-DAY= 61% HVVMAX= 2689V HVI = 7.7uA HVCMDS= 0 TEMP3 = 28.1C CMDS = 0	TIP STANDBY Anomaly A-014 (No command ACKs) Anomaly A-015 (LITES does not receive passthru cmds) --Communication issues with CIB and ISEM
109	Apr 19			NIGHTSECS=30947 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=SBYC CMDS=2	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 4 OCC_N2= 18 OCC_D3= 5 OCC_D2= 17 CMDS=0	MODE = NORM HV-NIT= 31% HV-DAY= 52% HVVMAX= 2689V HVI = 8.9uA HVCMDS= 1 TEMP3 = 29.7C CMDS = 2	ISS -XVV Maneuver
110	Apr 20			NIGHTSECS=32018 UVSECS = 2904 BGDSECS= 1518 DRKSECS= 0 OTHSECS= 6755 HVCOVERAGE= 34.9% MODE=MIXED SBYC/CHOP CMDS=44	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 0 OCC_N2= 1 OCC_D3= 0 OCC_D2= 1 CMDS=0	MODE = NORM HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 25.3C CMDS = 0	Scheduled Command Test #5 TIP CHOP Mode -One pass at 1.65 sec/rev wheel speed -Stored commands at 2.33 sec/rev wheel speed
111	Apr 21			NIGHTSECS=30708 UVSECS = 5354 BGDSECS= 2721 DRKSECS= 0 OTHSECS=13035 HVCOVERAGE= 68.7% MODE=CHOP CMDS=97	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 5 OCC_N2= 14 OCC_D3= 2 OCC_D2= 16 CMDS=0	MODE = NORM HV-NIT= 16% HV-DAY= 23% HVVMAX= 2817V HVI = 9.1uA HVCMDS= 2 TEMP3 = 26.5C CMDS = 9	+XVV Maneuver Scheduled Command Test #5, continued Anomaly AT-011 (SCA Error on Append) FOTON Default STREAM ops (5 decent UV passes after test; weak ionosphere)

Day	Date	Orbit Geometry	TIP Count Rate Map	TIP Mode	GPS Mode	LITES Mode	Comments
112	Apr 22			NIGHTSECS=31125 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=0	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 4 OCC_N2= 16 OCC_D3= 5 OCC_D2= 10 CMDS=0	MODE = NORM HV-NIT= 39% HV-DAY= 61% HVVMAX= 2817V HVI = 9.1uA HVCMDS= 0 TEMP3 = 29.7C CMDS = 0	(Saturday)
113	Apr 23			NIGHTSECS=30673 UVSECS = 0 BGDSECS= 0 DRKSECS= 0 OTHSECS= 0 HVCOVERAGE= 0.0% MODE=STBY CMDS=0	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 3 OCC_N2= 16 OCC_D3= 5 OCC_D2= 15 CMDS=0	MODE = NORM HV-NIT= 38% HV-DAY= 62% HVVMAX= 2817V HVI = 9.1uA HVCMDS= 0 TEMP3 = 29.3C CMDS = 0	(Sunday)
114	Apr 24			NIGHTSECS=30563 UVSECS = 2357 BGDSECS= 1412 DRKSECS= 0 OTHSECS= 3780 HVCOVERAGE= 24.7% MODE=CHOP CMDS=100	IDLE= 0% DATA= 68% DNLD= 0% OCC_N3= 1 OCC_N2= 10 OCC_D3= 1 OCC_D2= 8 CMDS=0	MODE = NORM HV-NIT= 39% HV-DAY= 58% HVVMAX= 2817V HVI = 9.2uA HVCMDS= 11 TEMP3 = 29.3C CMDS = 15	Scheduled Command Test #6 TIP CHOP Mode -One pass at 1.65 s/rev, schedule at 2.33 s/rev speed FOTON Default STREAM ops Anomaly AF-003 (FOTON HRT rate drop 16:12:24 LITES HV2->Lev0)
115	Apr 25			NIGHTSECS=31020 UVSECS = 8337 BGDSECS= 4988 DRKSECS= 0 OTHSECS=13366 HVCOVERAGE= 86.0% MODE=CHOP CMDS=4	IDLE= 2% DATA= 32% DNLD= 0% OCC_N3= 0 OCC_N2= 0 OCC_D3= 0 OCC_D2= 0 CMDS=3	MODE = MIXD HV-NIT= 26% HV-DAY= 44% HVVMAX= 3073V HVI = 10.5uA HVCMDS= 8 TEMP3 = 29.1C CMDS = 25	ISEM Reboot and D3 Power Cycle for GLIB time sync FOTON Default STREAM ops Scheduled Command Test #7 TIP CHOP Mode (2.33 sec/rev)
116	Apr 26			NIGHTSECS=30416 UVSECS = 9085 BGDSECS= 5437 DRKSECS= 0 OTHSECS=14560 HVCOVERAGE= 95.6% MODE=CHOP CMDS=0	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 3 OCC_N2= 20 OCC_D3= 4 OCC_D2= 19 CMDS=0	MODE = NORM HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 29.1C CMDS = 0	Good occultations along track

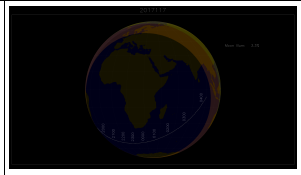
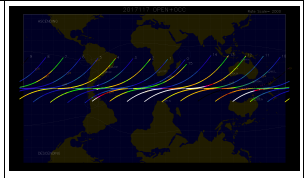
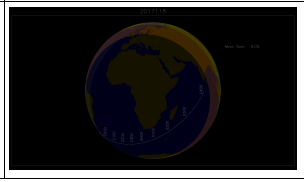
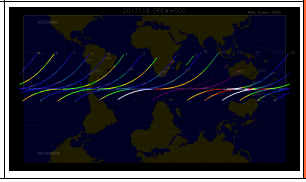
Day	Date	Orbit Geometry	TIP Count Rate Map	TIP Mode	GPS Mode	LITES Mode	Comments
117	Apr 27			NIGHTSECS=31753 UVSECS = 9539 BGDSECS= 5730 DRKSECS= 0 OTHSECS=15342 HVCOVERAGE= 96.4% MODE=CHOP CMDS=128	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 6 OCC_N2= 27 OCC_D3= 5 OCC_D2= 22 CMDS=0	MODE = NORM HV-NIT= 0% HV-DAY= 0% HVVMAX= 0V HVI = 0uA HVCMDS= 0 TEMP3 = 29.0C CMDS = 0	Scheduled Command Test #8 Multi-day Operations TIP CHOP Mode (2.33 sec/rev) - TIP passes sometimes bright, sometimes dim - Ephemeris from STK and TLE
118	Apr 28			NIGHTSECS=30584 UVSECS = 9345 BGDSECS= 5597 DRKSECS= 0 OTHSECS=14985 HVCOVERAGE= 97.9% MODE=CHOP CMDS=0	IDLE= 0% DATA=100% DNLD= 0% OCC_N3= 18 OCC_N2= 17 OCC_D3= 16 OCC_D2= 28 CMDS=0	**MODE = NORM** **HV-NIT= 0%** **HV-DAY= 0%** **HVVMAX= 0V** **HVI = 0uA** **HVCMDS= 0** **TEMP3 = 29.5C** **CMDS = 0**	**End of Early Orbit Testing** **Transition to Operations** Good ground site coverage CHOP performance still seems irregular: some TIP passes bright, some dim.

Table 6. GROUP-C Anomalies and Related Events During Early Orbit Testing

Code	Device	Julian Date	UT	GPS cumulative	Status	Description	Impact	Resolution	Notes
AT-001	TIP	2017061	2017-Mar-2 17:37:28	1172511466	Closed, work around required	TIP filter wheel patterned motion in CHOP mode stopped after less than one minute.	Cannot perform UV/background differencing during nightside passes. No background samples significantly degrade science data quality.	**Fiducial signal does not persist when the wheel is at position 36, causing the motor to report being lost.** Work-around: Use fiducial override during patterned motion and tune motor operation parameters.	The reason the fiducial signal does not persist compared to pre-flight testing is unknown. This fiducial anomaly will continue to impact CONOPS.
AF-002	Unknown	2017061	2017-Mar-2 19:55:49	1172519767	Open	The download of the RAW dump stopped after only 71 MB of an expected 195 MB.	Truncated RAW dumps are not usable for occultation analysis.		Did FOTON stop sending, or did GLIB stop listening? GLIB still sent occasional packets. Looks like FOTON entered IDLE mode.
AF-003	Unknown	2017061	2017-Mar-2 15:58:27	1172505525	Closed	FOTON STREAM mode high rate data packets suddenly dropped from 20/sec to 0-1/sec.	No GPS radio occultation science data.	LITES HV commanding causes FOTON to enter low data rate mode	Did GLIB stop reading out its buffer or did FOTON not fill it?
AF-003	Unknown	2017065	2017-Mar-6 14:09:35		Closed	FOTON STREAM mode high rate data packets suddenly dropped from 20/sec to 0-1/sec.	No GPS radio occultation science data.	LITES HV commanding causes FOTON to enter low data rate mode	2nd recurrence. This was when AF-003 was detected. Data review found an event on Day 061.
AT-004	TIP	2017065	2017-Mar-6 20:47:42	1172868447	Closed	Command to SAFE mode from NITE_LAB mode failed to move the wheel to position 20 (closed).	PMT active area remained exposed to light from the telescope, which risks detector damage if a Sun incursion occurred.	**User error.** Change from one mode to another is likely to induce rapid changes from one motor position/phase to another, leading to a filter wheel error. Perform fiducial search between modes changes, as recommended in the Command & Telemetry Manual. TIP is working as designed.	

AT-005	TIP	2017072	2017-Mar-13 18:18:33	1173464261	Closed	TIP filter wheel patterned motion in CHOP mode never properly started, because wheel became lost immediately.	Cannot perform UV/background differencing during nightside passes. No background samples significantly degrade science data quality.	**Command order**. Wheel was not enabled before patterned motion was enable. Once patterned motion is enabled, wheel destination cycles through the pattern values, whether or not the wheel is enabled. Wheel enable introduced sudden change in position. TIP is working as designed.	Always enable the wheel before starting patterned motion. Use WSM to start patterned motion. Built-in mode change commands affecting the filter wheel should be performed only when the wheel is at the pattern's start position or at the fiducial.
A-006	Other	2017073	2017-Mar-14 18:58		Open	ELC#1 LVPS Exceedance Shutdown	The STP Team disabled 28V power on Discrete 1, Discrete 3, and 28V operational power, affecting TIP, FOTON, GLIB, and LITES.		STPH-5 had to reduce power when temperature in LVPS exceeded 25C. Mar 19: Temp limit raised to 28C. This will continue to impact operations.
E		2017078	2017-Mar-19 00:08:52			Power-up for CRS-10 Undocking			D1 on at 00:08:52 D3 on at 00:14:17
AF-003	Unknown	2017078	2017-Mar-19 ~04:40		Closed	FOTON STREAM mode high rate data packets suddenly dropped from 20/sec to 0-1/sec.	No GPS radio occultation science data.	LITES HV commanding causes FOTON to enter low data rate mode	3nd recurrence? Other activity on P/L?
A-006	Other	2017078	2017-Mar-19 10:52:00		Open	ELC#1 LVPS Exceedance Shutdown	The STP Team disabled 28V power on Discrete 1, Discrete 3, and 28V operational power, affecting TIP, FOTON, GLIB, and LITES.		STPH-5 had to reduce power when temperature in LVPS exceeded 25C. Mar 19: Temp limit raised to 28C. Mar 28: Temp limit raised to 35C . This will continue to impact operations.
E		2017087	2017-Mar-28 17:52:00			Power-up under relaxed ELC #1 LVPS temperature restrictions			D1 on at 17:52:00 D3 on at 17:52:16
E		2017089	2017-Mar-30 06:36:37			Power-down before EVA			D1 off at 06:36:37 D3 off at 06:39:12
E		2017089	2017-Mar-30 19:37:45			Power-up after EVA			D1 on at 19:39:30 D3 on at 19:37:45

AL-007	GLIB	2017089	2017-Mar-30 19:39:30		Closed	GLIB GPS clock did not sync with ISEM GPS time	GLIB GPS clock started counting from a value of 100 (in H&S)	**User error.** The STP-H5 power-up requires waiting 5 minutes between powering ISEM and powering D3 (GLIB). Inadequate time was allotted in this instance.	Correct using D3 power cycle after ISEM has been up and running more than 5 min.
E		2017090	2017-Mar-31 16:19:48			Power Cycle D3 to sync GLIB clock			D3 off at 16:19:48 D3 on at 16:20:38
O		2017090	2017-Mar-31			LITES HV=0xB7			
AT-008	TIP	2017090	2017-Mar-31 19:50:42	1175025000	Closed	TIP did not execute timed commands from ISEM.	TIP received timed commands from ISEM on a 5-minute cadence to change the science sampling rates, but the rates never changed.	**User error.** The ISEM GROUP-C command interface holds 96 bytes, zero-filled and includes a command length parameter. The command length must be set to the length of the TIP hex bytes in the buffer. TIP and the ISEM Control Center are working as designed.	This issue is specific to TIP; LITES is insensitive to excess zero bytes.
O		2017093	2017-Apr-3 15:00			LITES HV=0xBB			
AT-009	TIP	2017094	2017-Apr-4 16:50:50	1175359868	Closed, work around required	TIP safe mode did not maintain a fixed wheel position of 20, but went to position 0 for 1/4 of the samples.	PMT active area will be periodically exposed to light from the telescope during wheel motion, which risks detector damage if a Sun incursion happens.	**Flight Code Error**. The TIP flight code aboard GROUP-C included a typo in the hard-coded unmodifiable wheel patterns. This caused cumulative byte misalignment so that the last 16 bytes of the SAFE mode are zero. Use other commands to safe the sensor.	Do not use MSF command any more. A corrected SAFE wheel pattern will be stored at the PINH pattern location during initialization. Use WSM or wheel destination commands to move filter wheel to closed position using pattern #2 PINH.
O		2017096	2017-Apr-6 16:00			LITES Begin scheduled commanding beta=+21 deg			
AL-010	GLIB	2017098	2017-Apr-08 05:42	1175665362	Open	H&S information froze 5 seconds and LITES reinitializes to Mode 0 and HV off.	Sudden loss of all science data.		What is the impact to automated commanding? FOTON operation unaffected.
O		2017099	2017-Apr-9 23:00			(Incomplete) End of scheduled commanding. beta< +5deg			

E		2017100	2017-Apr-10 7:57:45			Undock Soyuz			Solar arrays parked about 6 hours. Some attitude changes.
E		2017100	2017-Apr-10 15:00:00 2017-Apr-10 15:00:00			8-deg yaw bias (-4 to +4 deg) for SAGE calibration (2 hrs 15m to complete maneuver)			Lasts until GMT Day 106
O		2017103	2017-Apr-6 16:35:45			LITES Begin scheduled commanding beta=-9 deg			
AT-011	Other	2017103	2017-Apr-13 16:34:11	1176136469	Open	Append schedule table returned SCA CMD error. Timed commands did not execute.	Inability to schedule routine nighttime operations. Loss of TIP science data.		The ISEM GUI was used to generate schedule files. "Append" command status remained 00 (success), schedule update time changed. Reason for SCA error is unknown.
E		2017106	2017-Apr-16 15:00:00 2017-Apr-16 15:00:00			8-deg yaw bias end (+4 to -4 deg) beta=20 deg			
O		2017107	2017-Apr-17 15:20			LITES Begin scheduled commanding HV=0xBB			
A-012	Other	2017107	2017-Apr-17 15:31:44	1176478322	Open	Failed upload of TIP schedule table to ISEM with upload packet start/end errors.	Inability to schedule routine nighttime operations. Loss of TIP science data.		The ISEM GUI was used to generate schedule files. No SCA error occurred in this case. Later learned that ISEM was experiencing anomalous communications with CIB.
O		2017107	2017-Apr-17 17:01:27	1176483700		TIP begin scheduled commanding. No HV.			Scheduled commanding executed completely and finished 4/18 7:30 UT
A-013	Other	2017107	2017-Apr-17 22:15:29	1176502548	Open	LITES and FOTON H&S packets became intermittent.	Inability to monitor experiment status and operating mode.		Packets arrived in spurts. Assumed to be an issue with either ISEM or CIB.
A-014	Other	2017108	2017-Apr-18 15:31:44	1176478322	Open	Failed upload of TIP schedule table to ISEM, many commands not acknowledged, no error messages returned in TIP stream.	Inability to schedule routine nighttime operations. Loss of TIP science data.		Probably part of a worsening communication issue with ISEM.

A-015	Other	2017108	2017-Apr-18 17:00		Open	Passthrough commands failed to reach LITES.	Inability to perform critical experiment configuration changes in real-time.		Probably part of a worsening communication issue with ISEM. TIP passthrough commands worked.
O		2017109	2017-Apr-19 17:01:27	1176667216		LITES schedule HV off for maneuver			Scheduled command executed nominally. Second HV off a 23:00 worked, too.
E		2017110	2017-Apr-20 00:50:20			Maneuver to -XVV start beta=20 deg			For 50S Suyuz docking
O		2017110	2017-Apr-20 15:22	1176736922		TIP begins scheduled commanding. HV on nightside.			
E		2017111	2017-Apr-21 03:30:00			Maneuver back to +XVV complete			Docking complete, return to normal attitude
O		2017111	2017-Apr-21 14:40			Manual HV power up, always on, HV = 0xBB			
AT-011	Other	2017103	2017-Apr-13 16:34:11	1176136469	Open	Append schedule table returned SCA CMD error. Timed commands did not execute.	Inability to schedule routine nighttime operations. Loss of TIP science data.		"Append" command status remained 00 (success), schedule update time changed. Reason for SCA error is unknown.
O		2017111	2017-Apr-21 16:55			LITES HV=0xC3			
E		2017112	2017-Apr-22 08:05:00 2017-Apr-22 11:55:00			Cygnus 7 capture			
AL-016	LITES	2017114	2017-Apr-24 15:00		Open	First observation of Pulse Height spikes in bins 0 and 255 HVoff at 15:42	TBD. Potential for reduced sensitivity and dead time effects.		
O	LITES	2017114	2017-Apr-24 16:12			LITES HV2=0xC3			
AF-003	Unknown	2017114	2017-Apr-24 16:12:05		Closed	FOTON STREAM mode high rate data packets suddenly dropped from 20/sec to 0-1/sec.	No GPS radio occultation science data.	LITES HV commanding causes FOTON to enter low data rate mode	3nd recurrence? Other activity on P/L? Resumed on day 115
O	LITES	2017114	2017-Apr-24			LITES HV2=0xC5			

			16:27						
O	LITES	2017114	2017-Apr-24 17:16			LITES HV1=0xC3			
E		2017114	2017-Apr-24			ISEM UART adjust 100 to 300 ms			
O	LITES	2017115	2017-Apr-25 15:09			LITES Raw Mode			
E		2017115	2017-Apr-25 15:24			Reset of ISEM software			LITES HV off sent by ISEM during boot sequence
E		2017115	2017-Apr-25 15:45			Power Cycle D3 to sync GLIB clock			
O	LITES	2017115	2017-Apr-25 17:00			LITES HV1=0xC3			
O	LITES	2017115	2017-Apr-25 17:30			LITES cycled bias voltage to test ion rejection			
O	LITES	2017115	2017-Apr-25 17:55			LITES HV ramp-up to test for count rate recovery. Reached 0xD3 (3072V)			
O	LITES	2017115	2017-Apr-24 18:28			LITES HV off			
E		2017117	2017-Apr-27 04:21:00 2017-Apr-27 05:45:00			SM Reboost			Quaternions are updated within this window
E		2017118	2017-Apr-28	Enter Science Operations					