

Chandra Flight Note

FLIGHT NOTE NO.	#553
SUBJECT	Day 2014/185-187 Mission Load Segment Uplink Error
DATE	09/07/2014
AUTHOR	Frank Schackart, Paul Viens

This flight note describes the Mission Load Segment Uplink Error of day 2014:185 and recommends closure.

Summary:

During the realtime support starting on 187:2120¹, the FOT operations crew detected the spacecraft ObsID and quaternions seen in realtime telemetry did not match those expected, but instead indicated the spacecraft had not performed the maneuver scheduled to begin at 2122 GMT. The spacecraft was not in Safe Mode, no other safing actions had been executed, and no errors were present in the OBC error log. A response team was assembled to investigate the problem, which showed on day 2014:185, the first command load set of the JUL0714B schedule (CL187:2111.cld) was uplinked approximately 11 minutes before the specified Load After Time. The early uplink caused SCS 128, containing the vehicle commanding, to shift its execution sequence from the JUN3014B loads to Step 360 of the JUL0714B loads, while SCS 131, containing the science commanding, executed as planned. Once the problem was detected, all on-board loads were stopped. New load products were built and uplinked on DOY 188, with return to science at 188:20:47.

1. Problem

- a. During the support on 2014:187:21:20-23:35, the FOT operations crew discovered discrepancies with the expected spacecraft attitude while performing the Backstop portion of the State of Health checks.
 - i. The spacecraft quaternions seen in realtime telemetry did not match those expected, but instead matched the ObsID and quaternions of the prior observation, indicating the spacecraft had not performed the maneuver scheduled from 2014:187:21:22 to 2014:187:22:07.
 - ii. All other SOH checks nominal
 1. Spacecraft not in Safe Mode
 2. No other onboard safing actions executed
 3. No errors present in OBC error log

¹ All times are GMT (EDT +4 hours)

2. Response
 - a. On-duty OC contacted LSE
 - b. Response team assembled
 - c. CAP 593A executed to activate SCS 107 via ground command to fully safe ACIS instrument and terminate the Observing command loads
 - d. SCS 128 and 129 terminated using post-approved CAP 1321
 - e. Contents of SCS128 dumped and examined via CAP 750AJ
 - f. After confirming the cause was understood, new load products were built and uplinked on DOY 188
3. Sequence of Events
 - a. As part of normal Chandra operations, the JUL0714B load package was approved on 2014:183
 - b. Real time DSS-65 contact moved from 185:02:45-04:45 to 185:02:30-04:30
 - c. The first load segment in the series, CL187:2111.cld was available for uplink after 2014:185:03:48, as shown in the table below. A realtime support spanned the "Load After" time from 2014:185:02:30 to 2014:185:04:45

*****LOAD GENERATED*****		
Load name:	CL187:2111	Load type: ATS - A
	COMBINED	VEHICLE
SCS Number:	128 / 131	128
Number of critical Cmds:	68	63
Load Maximum Error Severity:	1	0
Number of Cmds in load:	638	391 (executable cmds)
Load By Time:	2014:187:21:17:52.154	
Load After Time:	2014:185:03:48:01.285	
First Command Time:	2014:187:21:18:52.154	
Last Command Time:	2014:189:07:37:11.266	
Number of Cmds to uplink:	2430 (uplinkable cmds)	
Uplink Duration (seconds):	58.32	
Load break was set to 2014:189:09:21:52.154		
(Planning Period Start Time + Fixed Load Duration Time)		
Load name: CL187:2111		
Load uplink opportunity #1; DSN station is: DSS-24; PASS number is: 2118.		
LOAD uplink time: 2014:187:11:00:00.000		
Load uplink opportunity #2; DSN station is: DSS-24; PASS number is: 2119.		
LOAD uplink time: 2014:187:18:55:00.000		
** There are only 2 uplink opportunities for this load, but 3 were desired.		

- d. 2014:185:03:30 on-duty operators commanded on the downlink.
- e. Instead of uplinking the above load segment after the specified Load After Time, the on-duty operators uplinked and activated load segment CL187:2111 approximately 11 minutes early, as shown in the image below:

Load Uplink (Delete this Event Edit this Event)			
Event Times: 2014:185:02:23:26.000 - 2014:185:02:23:26.000 (edit)			

Uplink Time: 2014:185:03:37:04	Load Segment: CL187:2111	SCS #: 128	Load Name: JUL0714B
2014:185:03:40:06	ACTIVATE SCS	...	
Number of Commands: 2430	Commands Rejected No	Memload Reject Count 0	

Load Uplink (Delete this Event Edit this Event)			
Event Times: 2014:185:02:23:43.000 - 2014:185:02:23:43.000 (edit)			

Uplink Time: 2014:185:03:37:08	Load Segment: CL187:2111	SCS #: 131	Load Name: JUL0714B
2014:185:03:40:11	ACTIVATE SCS	...	
Number of Commands: 2430	Commands Rejected No	Memload Reject Count 0	

- f. The last segment of the JUN3014B schedule was still running in SCS 128 (the only remaining commands were to turn on the downlink at 185:03:45). When the new command load set was uplinked, SCS 128 was active at step 360 waiting until 185:03:45 to continue. The uplink overwrote the SCS (the SCS contents dumped on day 187 matched the JUL0714B expected contents), but the SCS was still active and holding on step 360.
- g. The subsequent commanding to activate SCS 128 was rejected and resulted in an entry in the OBC error log due to the attempt to activate an active SCS. SCS 131 activation was nominal.
- h. At 185:03:45, SCS 128 step 360 of the JUL0714B schedule executed, which was another absolute time delay command. At that point SCS 128 was waiting (at step 361) until 2014:188:15:51:22.528 to execute the next command.
- i. The crew dumped the OBC error log, but failed to realize SCS 128 was not on step 2 as it should have been.

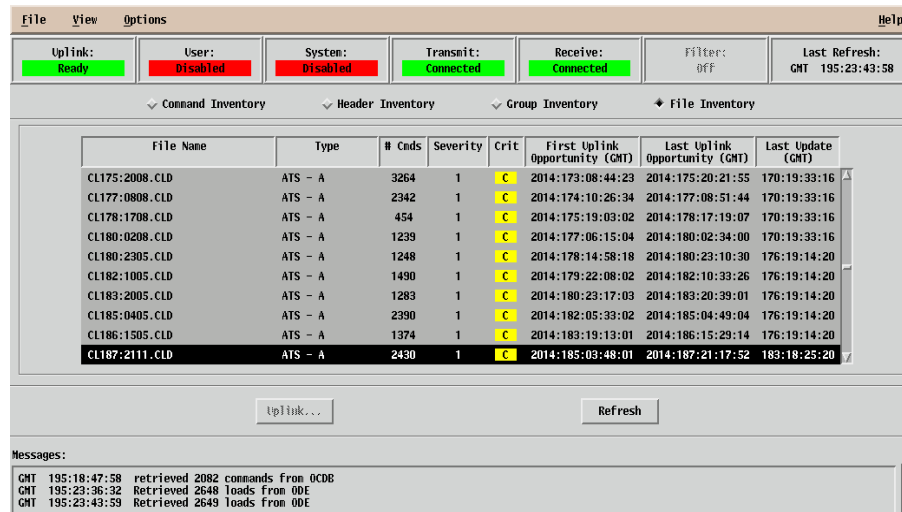
When the Observing Loads were running without the Spacecraft Loads on day 187, both the SIM (~187:21:22) and HETG (~187:21:25) were moved in NPM with the momentum monitor enabled. In addition the ObsID was also updated (~187:21:24). The spacecraft maneuver did not occur due to the misconfiguration of SCS 128. The Vehicle loads did not execute as planned. The following table shows the planned commands and those that were executed and not executed :

TIME (UTC)	JUN3014 (SCS 128)	JUL0714 (SCS 128)	JUL0714 (131)	Command Executed?
2014:185:02:02:56	AOEPHUPS, STEP= 342			✓
2014:185:03:45:00.000	CIMODESL, STEP= 360			
2014:185:03:45:00.257	CTXBOF, STEP= 362			
2014:185:03:45:00.514	CPABOF, STEP= 364			
2014:185:03:45:00.771	CTXAOF, STEP= 366			
2014:185:03:45:01.028	CPAAON, STEP= 368			
2014:185:03:45:01.285	CTXAON, STEP= 370			
2014:185:03:45:01.285	COSSEND, STEP= 371			
2014:187:21:18:52.154		AOACRSTD, STEP= 2		
2014:187:21:19:52.154		AOFUNCDS, AOPCADSD=21, STEP= 4		
2014:187:21:20:52.154		AOFUNCDS, AOPCADSD=32, STEP= 6		
2014:187:21:21:52.154		AONMMODE, STEP= 8		
2014:187:21:21:52.154			SIMTRANS, POS= 75624, STEP= 2	✓
2014:187:21:21:52.411		AONM2NPE, STEP= 10		
2014:187:21:21:56.511		AOUPTARQ, STEP= 12		
2014:187:21:21:58.154		AOSTRCAT, STEP= 21		
2014:187:21:22:02.405		CNOOP, STEP= 71		
2014:187:21:22:02.405		AOMANUVR, STEP= 72		
2014:187:21:24:52.154			COAOSQID, ID= 14528, STEP= 7	✓
2014:187:21:25:26.493			4OHETGRE, STEP= 17	✓
2014:187:22:20:00.000		CIMODESL, STEP= 103		
2014:188:15:51:21.503		CNOOP, STEP= 359		
2014:188:15:51:22.528		COSATDLY, STEP= 360		command executed at 185:03:45
2014:188:15:51:22.528		CNOOP, STEP= 361		
2014:188:15:57:38.177		COSATDLY, STEP= 362		
2014:188:15:57:38.177		AOFUNCEN, AOPCADSE=32, STEP= 363		
2014:188:15:58:38.177		AOFUNCEN, AOPCADSE=21, STEP= 365		
2014:188:18:47:15.444		AOACRSTD, STEP= 367		

- j. For the realtime DSS-54 contact, on-duty operators commanded on the downlink at 187:22:34. OC and CC detected spacecraft misconfiguration, completed SOH, and notified LSE.
 - k. CAP 593A executed to safe ACIS instrument.
 - l. Since the commands from the JUL0714B load did not properly execute, on-board command load continuity was no longer correct. Therefore, SCSs 128 and 129 were terminated; stopping the science mission. Replan products were developed and uplinked on DOY 188. A total of 20.75 hours of science time was lost.
4. Root Causes
- a. Failure to execute uplink checks

Although the OC/CC did compare the First Uplink Opportunity Time (seen on the Command Operations window) with the Load After time found in the hardcopy version of the JUL0714B load package, (which matched), neither checked the actual GMT time to ensure it was after the time specified on both the EHS Command Operations windows and the hardcopy information contained in the load package prior to uplinking CL187:2111 to SCS 128.

The screenshot images below show the First Uplink Opportunity Time as seen from the Command Operations window.



- b. Desire by OC/CC to uplink loads prior to embedded downlink turn-on commands

The realtime contact was originally scheduled for 185:02:45:00 to 185:04:45:00, but was changed to 185:02:30:00 to 185:04:30:00, 15 minutes earlier than the time the spacecraft was programmed to autonomously turn on the downlink. The OC/CC proactively desired to uplink the load segment

prior to the momentary glitch that they knew would occur at 185:03:45:00 (BOT) when the scheduled commands to turn on the downlink would execute.

- c. Failure by OC/CC to react in accordance with SOP_FSW_SOFTWARE_DUMP (Step 9.0) with an OBC Error related to SCS128, and to notify the LSE in a timely manner

The on-duty controllers are required to report any errors detected in the OBC Error Log, unless the errors are specifically exempted by FN 405 (The OBC Error Log). When the crew attempted to activate SCS 128 (which was already active), the OBC reported an Invalid SCS Transition error for SCS 128. An error for SCS 128 is not a non-reportable or expected error in the OBC Error Log, and thusly, should have been reported immediately to the LSE. The LSE was not notified of the error in the OBC error log until close to 24 hours had passed since the SCS 128 error was detected.

5. Mitigation Actions

- a. This incident was reviewed with all certified OCs and CCs. The review stressed the importance of following approved procedures and practices and of reporting all errors, limits and other off-nominal events immediately.
- b. FOT Operations reviewed SOP_OPS_ON_LINE_OPERATIONS, which directs load uplinks, for clarity and completeness. The SOP as written includes steps to prevent an error such as this from occurring. A new SOP that specifically addresses load uplinks was in development at the time of this incident and is expected to be complete by 01 Oct 2014.
- c. All controllers were given simulation training designed to demonstrate and reinforce proper command load uplink techniques.
- d. A new training document that provides additional detailed information regarding SCS functionality, with specific attention to the daily loads is expected to be completed NLT 01 Oct 2014.
 - i. Training will be issued to every currently certified controller.
 - ii. Training will be added to the initial training and certification requirements for new controllers.
- e. An enhancement request for the ONLS to “check load before/after times before load uplinks” was submitted. The planned implementation will alert the controllers if they attempt to uplink an ATS load prior to its First Uplink Opportunity Time. The controller will have the option to override the warning if necessary, but the default response will be to cancel the load uplink. There will be no change for RTS loads, PRT loads or FSW patch loads. The enhancement is slated to be included in ONLS 4.1.

6. Further potential problem avoidance and impact mitigation strategies or follow-on actions:
 - a. Modify the FSW to check that an SCS is inactive before allowing it to be loaded. This concept was declined for two reasons. First, in some contingency scenarios it may become desirable to be able to load an active SCS. Second, the risk reduction is not worth the effort for a FSW change of this magnitude.
 - b. Move the momentum monitor commanding into the science loads. While this would have reduced the risk of a Safe Mode entry in this case, it would not address any number of other potential issues if this problem were to recur. However, it does make sense to include the momentum monitor commanding in the same loads as the SIM and Grating commanding if it can be accomplished easily. A number of different approaches have been identified, all with associated hurdles/drawbacks including OFLS software changes, tool development, and/or accepting other risks (i.e. not disabling the momentum monitor during grating moves). These approaches will be investigated further to determine if any are worth implementing.
 - c. Add MTA monitoring check that verifies the quaternion in telemetry against that planned in the loads. This is still under investigation. MTA had a check like this earlier in the mission, but it was prone to false positives.
 - d. Use a script for uplink and activation of daily loads. Currently activation is done by script to ensure that the science loads cannot be activated without the vehicle loads. The script could be modified to take command load names as inputs and check the SCS states before uplink. This item is still under evaluation, but much of the desired functionality will be provided by the ONLS enhancement to check the load after time before uplink.
 - e. Add ACIS temperature monitor similar to the Propulsion Temperature Monitor, which would run SCS 107 if an over temperature was detected for the ACIS electronics. This would prevent a misconfiguration caused by a similar error, or any other source, from causing unacceptable temperatures for the ACIS electronics. Currently, keeping ACIS within thermal limits depends on the integrity of the thermal models and the mission planning process (including review and proper uplink).
 - f. Add capability for ACIS to detect a bright source on the ACIS-I array and call SCS 107 to prevent damage to the chips. This would prevent a misconfiguration caused by a similar error, or any other source, from placing a bright source on the ACIS-I array. Currently, keeping bright

sources off the ACIS-I array depends on the integrity the mission planning process (including review and proper uplink).

Conclusion:

The DOY 2014:185-187 Mission Load Segment Uplink Error has been investigated, the root causes detected, and appropriate steps taken to ensure reoccurrence is unlikely. Some follow-up actions are still under investigation, but the circumstances that led to the error have been sufficiently mitigated to allow closing the open anomaly. This write-up serves as the anomaly close-out Flight Note for this event (ref. DDTS entry OCCcm10368).