SMEI Instrument Onboard Data and

Software Update Procedure

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1. Introduction

During SMEI integration with the Coriolis spacecraft in April 2001, a number of operational issues came to light. These issues have been investigated, and an updated image of the flight software prepared.

This procedure lays out the steps required to update the boot area of non-volatile memory which contains eight copies of the SMEI flight software.

Section 4.2 of the procedure is not possible without the SMEI DHU Program Enable Key installed in the SMEI test connector, and therefore cannot be used on orbit. Sections 3 and 4.1 illustrate the mechanisms for updating the SMEI data tables and flight software images while in orbit.

2. SMEI Flight Software Issues

This section of the document outlines the problems resolved in the October 2001 update to the SMEI flight software.

2.1 Pre-defined Camera Configuration 8 Causing Watchdog Timer Reset

SMEI flight software has to perform CCD data binning onboard, and hence the design decision was to process pixel data only at the end of a line. This means that the amount of processing done as a single chunk is strongly dependant on the binning mode.

Mode 8 is an unbinned mode, and hence has the longest time spent processing data into image packets. This time was very marginal with respect to the software watchdog timer in the data handling unit. During integration and test of the Flight Model, the beating of the data processing with other processes running on the DHU caused this watchdog time to be exceeded, and the DHU processor automatically rebooted.

Addition of a watchdog timer reset at a key point before the line pixel processing has resolved this particular reboot problem.

A small adjustment was also made to the telemetry montoring of the watchdog timer. Instead of taking a single snapshot, the digital monitor housekeeping now reflects the maximum value reached since the last SMEI mode change. This provides a good indication of the margin on the watchdog timer, and tests using the Engineering Model DHU and the Flight Spare Camera have demonstrated than an adequate watchdog timer margin is present at all times.

2.2 High Flat-Field Calibration Levels

During the functional testing after connecting SMEI electrically to the spacecraft, it was noticed that flat-field calibration levels in the CCD images were much higher than during standalone testing. Analysis of the data showed that only alternate images were being taken, and hence the exposure time was 8 seconds, rather than the nominal 4 second period.

Examination of the CCD Sequencer waveform tables supplied by Rutherford Appleton Laboratory showed that image readout time took marginally over 4 seconds. The use of a highly accurate 1Hz signal from the spacecraft exposed this negative timing margin, and meant every other image was lost.

This was not seen with the SMEI EGSE, as the EGSE PC produced a 1Hz signal which was subsequently shown to be slightly slower than nominal.

Corrective action was taken to decrease the image readout time, and testing with an accurate 1Hz signal has verified correct operation, with an adequate timing margin (~ 40ms) over the 4s nominal exposure time.

2.3 1553B Bus Communications Hybrid Setup Robustness

As part of the additional testing performed over the summer, a weakness in the boot sequence of the SMEI flight software was identified. The 1553B bus communications hybrid is configured through a 4 kiloword configuration table loaded into the hybrid memory.

Only a single table was stored in the data e^{2}prom, and it would be possible, though unlikely, in the case of a flight software crash, or operator commanding error, for this table to be overwritten, and communications between the spacecraft and the DHU in use at the time to be permanently lost.

It was decided to add a second copy of the configuration table, and with this copy being on a different 16K page, the possibility of corrupting both tables becomes much less likely.

The selection of the configuration table copy to be used depends on which of the eight copies of the e^{2}prom boot code is in use, which in turn can be selected by repeated issue of the RELAY_CMD_SELECT_A (or RELAY_CMD_SELECT_B) command.

3. Data E²Prom Update

SMEI contains 512 kilowords of non-volatile data storage space. This area is divided into 32 16 kiloword pages, used as described in the table below.

Page Selector	Usage	Patch File
0x40	Command Interpreter Tables, Region of Interest Tables, S-Band Pixel Sample Maps, 1553 Hybrid Configuration Table (Legacy)	page40.pat
0x41	Camera Waveform Generator ASIC Tables	page41.pat
0x42	Flight Software Patch Storage Page	
0x43	Pre-defined Camera Observation Mode Tables	page43.pat
0x44	Spare / Temporary Boot Area Storage Space	
0x45	Spare	
0x46	1553 Hybrid Configuration Table (Redundant Copy 1)	page46.pat
0x47	1553 Hybrid Configuration Table (Redundant Copy 2)	page47.pat
0x48 - 0x4F	Camera 1 Flat Fielding Data Tables	
0x50 - 0x57	Camera 2 Flat Fielding Data Tables	
0x58 - 0x5F	Camera 3 Flat Fielding Data Tables	

Table 1. SMEI DHU Data Memory Pages

A number of patch files are supplied for the October 2001 update, and each one updates the corresponding 16 kiloword data page. Each patch contains approximately 600 individual commands to SMEI, in the patch file format specified in Appendix A.

To apply a patch file, SMEI should be turned on, and running nominally in configuration mode.

The patch files will transfer SMEI into patch mode, then upload and commit the data to the data e²proms. Once all the data is committed, SMEI will be returned to configuration mode.

The SMEI DHU can accept patch upload commands at the maximum supported commanding rate of the spacecraft, ie upto 5 commands per second.

Any increase in the rejected command counter returned from SMEI must suspend transmission of any remaining commands in the patch file, pending user input.

Issuing a patch commit command must be confirmed by the script file processor before being transmitted.

Perform the following procedure for both DHU A and DHU B.

1. Switch on SMEI, and enter configuration mode by issuing SM_DHU_COLD.Upload the page46.pat patch file to SMEI. Verify the command count is 64 when complete. Upload the page47.pat patch file to SMEI. Verify the command count is 127 when complete.

2. Upload the page40.pat patch file to SMEI. Verify the command count is 190 when complete.

3. Upload the page41.pat patch file to SMEI. Verify the command count is 253 when complete.

4. Upload the page43.pat patch file to SMEI. Verify the command count is 60 when complete.

5. Switch off SMEI.

4. Boot E²Prom Software Image Update

The procedure for this is a three step process. First, a software image capable of writing to the boot e²prom must be uploaded and enabled. This software image is referred to as the Loader. Once this is complete, the new october 2001 flight software image must be uploaded, and a specially formatted patch commit command issued to commit the image to the boot e²prom. When this is successfully completed, the temporary loader is removed from the data e²proms.

The following three procedures must be repeated for DHU A and DHU B.

4.1 Phase 1 Software Upload

In the same way that the data e²proms were updated in section 3, uploading a new software image is done as follows:

1. Switch on SMEI, and enter configuration mode by issuing the SM_DHU_COLD command. Ensure everything is operating correctly.

2. Upload the loader.pat patch file to SMEI. This will put SMEI into patch mode, and upload the new loader software image into data page 0x42. The file will return SMEI to configuration mode when it is complete. Verify the command count is 37 when complete.

3. Re-enter patch mode by issuing SM_ENBL_PTCH and then SM_GOTO_PTCH, and issue the SM_PATCH_ACT command, with the correct checksum for the newly uploaded software image. This checksum is in the comment fields at the start of the patch file.

4. Power down SMEI, and at the test conductor's discretion, the spacecraft. Fit the SMEI DHU Program Enable Key to the DHU test connector (J3), and ensure that the watchdog disable switch is in the on position, and the diagnostic LED box is plugged into the correct socket for the DHU being updated. See Appendix C for more information about the program enable key.

5. Switch on SMEI, and verify the software revision number in the housekeeping shows 16. This is the SW_REL telemetry point.

6. Issue SM_DHU_COLD and verify that the software revision number changes to 64. The DHU does not start running a software image in page 0x42 until coldstart is issued. This is to permit recovery in the unlikely case that a corrupted software image in page 0x42 of the data e²proms still passes the checksum test.

7. Verify telemetry is showing nominal operation. Ensure the timestamps are increasing, analogue and digital monitors are returning appropriate values, etc. Note that this software image does not contain support for observing mode.

8. Power down SMEI.

Note that the script upload software should prompt the operator before issuing SM_PATCH_CMT commands, and should suspend operation if the SMEI rejected command count is non-zero. It is not critical for the rejected command count to be checked 'real-time', but the operator should check these telemetry points before issuing SM_PATCH_CMT commands.

The above procedure is how on-orbit software revisions are made. A new image is loaded into data page 0x42, and enabled. At the next DHU restart, the software image in started when SM_DHU_COLD is issued.

4.2 Phase 2 Boot Image Upload

For the October 2001 update, this operation will follow on directly after the steps performed in the phase 1 procedure. Note that the procedure in section 3 must have been successfully completed before this procedure is run.

1. If the SMEI DHU Program Enable Key is not fitted to the DHU test connector (J3), power down SMEI, and at the test conductor's discretion, the spacecraft. Fit the key, and ensure that the boot e²prom write-enable switch is in the enabled position, and the diagnostic LED box is plugged into the correct socket for the DHU being updated. See Appendix C for more information about the program enable key.Power on SMEI, and issue SM_DHU_COLD. Verify telemetry is showing nominal operation, and the software revision telemetry point SW_REL shows 64.

2. Upload the smei39-32.pat patch file to SMEI. This file will put SMEI into patch mode, and upload the new flight software image into data page 0x44. The file will return SMEI to configuration mode when it is complete. Verify the command count is 7 when complete.

3. Re-enter patch mode by issuing SM_ENBL_PTCH and SM_GOTO_PTCH, and then issue SM_PATCH_DEA. This will disable the phase 1 software from being executed after the next restart of SMEI.

4. Issue the SM_PATCH_CMT command, with parameters shown in the comments in the patch file. This will copy the new flight software image from data page 0x44 to all 8 flight software image areas in the boot e^{2}prom. During the e^{2}prom update, SMEI will disable all 1553 communications and enter a minimal operating mode. The only diagnostics available during this process are shown on the LED box. See Appendix B for the expected patterns.

5. Power down SMEI.

6. Change the watchdog disable and boot e^{2}prom write-enable switch to the disabled position. If this is the second DHU, the program enable key should be removed at this point. The spacecraft may be powered off before the program key removal, at the test conductor's discretion.

7. Switch on SMEI, and verify the software revision number shows 32.

8. Issue SM_DHU_COLD, and verify the software revision number remains at 32.

9. Switch off SMEI.

This part of the procedure updates the 8 flight software images stored in the boot e^{2}prom. During the DHU power-up sequence, one of these 8 images is loaded, and should configure SMEI for operation. In the event that a software image become corrupted, the DHU will attempt to start using the next software image after either an internal watchdog timer reset, or a RELAY_CMD_SELECT_A (or RELAY_CMD_SELECT_B) command.

4.3 Phase 3 E^{2}Prom Clearing

This part of the procedure removes the extraneous data from the onboard software after the successful boot software update.

1. Switch SMEI on, and enter configuration mode using SM_DHU_COLD.

2. Upload the clear.pat patch file to SMEI. This file will put SMEI into patch mode, and zero-fill data pages 0x42 and 0x44 after their earlier use. The file will return SMEI to configuration mode when it is complete. Verify the command count is 39 when complete.

3. Run the SMEI IST on the DHU side which has just been updated.

A. SMEI Patch File Format And Handling

The patch files for this update are in a simple ASCII format as specified below.

- Commands are represented by 32 16-bit hexadecimal words separated by a single space

- Comment lines start with the # character in the first column

- Automated 5 second (minimum) delays are represented as a command with all 32 words set to *0000*.

- SM_PATCH_CMT commands must present the operator with a confirmation dialog before issuing the command. These can be identified as the first word of the command is *ff44*.

Shown below is an extract of a patch file. Note that the command lines have wrapped in this document, but do not in the patch file. I have used three dots to indicate a skipped section of the file.

```
# Patch Configuring Page 0x40 (Commands, ROI, Spans)
#
# On (Y-M-D) 2001-10-08 at 12:00:00 UCT
#
# Enable patch mode
ff02 34ff 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
# Goto patch mode
ff03 4343 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
# Upload 0x1000 words to patch buffer offset 0000
ff43 7994 0000 0001 0002 0003 0004 0000 0015 0000 0015 0013 0014 0000 0000 0000 0000 0016 0000 0000 0000 0000
0000 0000 0000 0000 0000 0000 0000 0000 0000 0000

0043 0620 001d 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
0000 0000 0000 0000 0000 0000 0000 0000 0000 0000

0143 e274 003a 0000 0000 0000 0000 0000 0000 001a 0000 0000 0015 0015 0000 0015 0015 0015 0000 0000 0000 0000
0000 0000 0000 0000 0015 0015 0015 0015 0015 0015

0243 9e7c 0057 0015 0000 0015 0000 0015 0000 0015 0000 0000 0000 0015 0015 0015 0015 0015 0015 0015 0000 0015
0000 0015 0000 0015 0000 0000 0000 0015 0015 0015

0343 eaf3 0074 0015 0015 0015 0015 0000 0015 0000 0015 0000 0015 0000 0000 0001 0002 0003 0004 0000 0015 0000
0006 0013 0014 001f 0000 0000 0000 0016 0000 0000
                                         .
                                         .
                                         .
# Commit 0x1000 words to bank:offset 40:0000
ff44 71a6 0000 1000 0040 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
# Pause for 5 seconds for the commit to complete
0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
                                         .
                                         .
                                         .
# Goto config mode
ff05 7ada 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
```

B. Diagnostic LED Patterns During Boot E^{2}Prom Update

The SMEI EGSE includes a diagnostic LED box with 8 LEDs. These are controlled with a simple two-wire interface from the test connector on the DHU (J3). The following table presents the expected patterns during the update process.

Phase	Pattern	Notes
Writing boot image X	1100 0 xxx	There are 8 boot images, from X=0 to X=7.
Completed Successfully	1100 0 111 0011 0 111	The display alternates between the two patterns shown.
Error writing image X	1001 0 xxx 0110 0 xxx	The display alternates between the two patterns shown. Recovery should be possible by booting one of the other images and re-trying the procedure.

Table 2. Diagnostic LED Display

Figure 1. SMEI EGSE Diagnostic LED Box

C. SMEI DHU Program Enable Key

The pictures below show the SMEI DHU Program Enable Key.

Figure 2. Program Enable Key Back

Figure 3. Program Enable Key Front

In figure 2, the connector on the left is for DHU Processor Board A, and the centrally located connector is for DHU Processor Board B.

Figure 4 shows two switches on the side of the Program Enable Key.

Switch 1 is the watchdog disableand boot e^{2}prom write enable switch for DHU A, and should always be left in the off position except when indicated in the procedure.

Switch 2 performs the same function for DHU B.

Figure 4. Write Enable And Watchdog Switches