2.17_V2.0 CLOSE ACIS DOOR ON ORBIT
(in 4 shots)

Last Revised: September 30,1999
Filename: close_door

BRIEF FUNCTIONAL DESCRIPTION:
The ACIS camera housing door was planned to be opened only once on orbit; however recent events dictate that the SOT/FOT should develop a procedure to close the door. The door mechanism uses the same paraffin actuators as the big vent valve mechanism. Extreme caution must be exercised with these actuators, from the ACIS Long Form Functional Test Procedure document:

> *Because the Optical Blocking Filters are fragile and cannot withstand much differential pressure, mechanism motions may only be initiated when the differential pressure is less than 1 torr. Be safe; check both transducers. The mechanisms are driven by Starsys hot wax actuators. Power is applied directly from the space craft bus to heat the wax and, therefore, the time for a given motion to complete is dependent upon the bus voltage. To avoid failure of an actuator due to overheating–which would occur if the completion-of-motion switches failed, for instance–we monitor the actuator temperature. If the actuator temperature exceeds 135C, a command to abort the motion should be sent. Recovery from such a condition is never routine; no further motions should be attempted without thorough analysis of the procedural failure. It is also imperative that the commanded actuator be allowed to cool below 50C before the opposing actuator is commanded, lest the afore-mentioned egregious situation occur. It is not an error to command a valve open which is already open, etc., since the PSMC logic will know from the motion switches that the mechanism is already in the commanded state and not (falsely) apply power to the actuator.*

The side A HW serial digitial TLM has an extra bit to monitor the status of the actuator. However, the logic which determines the value of this bit is sufficiently obtuse, that it is typically easier to use side B. The peak temperature of the actuator should be 100 ± 10 C; damage can occur if the temperature exceeds 135 C. An on-board regulator disconnects the voltage if the temperature reaches 130 C. Therefore, ground intervention to abort the actuator motion should not be necessary or even possible, but is maintained as a backup to this automatic cutoff. As the actuator warms above 70 C, it begins to move and the door closed bit should switch to one. **At the time of writing, it is anticipated that the door will not be completely closed but will be left in a "cracked-open" position. This procedure does NOT warm up the detector housing to room temperature like the door opening procedure does.**

The door close actuator will be cycled four times nominally before the door motion is complete. A library of SCSs will be pre-built by the FOT which will contain the necessary commands to operate the actuator with heating cycle durations ranging from 50 – 200 s. Each SCS will contain the actuator heater on command, the appropriate time delay, the actuator heater off command, a 1 s delay, and another actuator off command . The FOT will also have the actuator heater off command queued up and ready to be sent as quickly as possible in case of an emergency. The first cycle is intended to be long enough to just melt the wax and have the plunger of the actuator move a small amount. The initial temperature of the actuator for the first cycle will be -32 C. The following cycles will be inititated after the actuator temperature read less than $+30$ C. Therefore, the first cycle begins with a significantly colder temperature than the suceeding cycles. The second cycle is intended to melt the wax, trip the "closed" limit switch (so that it reads "NCLO" for not closed) and rotate the shaft by a few degrees without beginning to close the door. The third cycle is intended to melt the wax and rotate the shaft by enough that the door closes to 35 ± 5 degrees. The last cycle is intended to close the door to a desired shaft rotation angle of 10 ± 5 degrees. During the execution of the procedure, the SOT will decide on the appropriate duration for each heating cycle and instruct the FOT to uplink the appropriate SCS.

After each one of these cycles, the desired motion may not be observed. If this is the case, a contingency procedure may be called for. The contingency procedures which have been prepared are to repeat the heating cycle with a different duration than one of the planned 4 heating cycles (all times will be available in 5s increments) and simply to turn off the heater (hopefully this is unnecessary).

The sequence of actions will be:

1. start a DEA HKP run if necessary
2. switch spacecraft telemetry format to 4
3. enable the door mechanism side B and verify actuator temperatures
4. Execute first heating cycle
5. Verify expected behavior (the temperature and motion of the actuator)
6. Monitor actuator cooldow
7. Decide if next heating cycle time is correct, if yes proceed, if no execute contingency
8. Execute second heating cycle
9. Verify expected behavior
10. Monitor actuator cooldow
11. Decide if next heating cycle time is correct, if yes proceed, if no execute contingency
12. Execute third heating cycle
13. Verify expected behavior
14. Monitor actuator cooldow
15. Decide if next heating cycle time is correct, if yes proceed, if no execute contingency
16. Execute fourth heating cycle
17. Verify expected behavior
18. Monitor actuator cooldow
19. disable the door mechanism B
20. switch spacecraft telemetry format to 1 or 2

ASSUMED INSTRUMENT STATE:
Assumes the small and big vent valves have been open for many days.
Assumes that the instrument is in the canonical thermal standy state [**Note the DH temperature is -60 C, not room temperature as in the door opening procedure**].
Assumes the DA heater on side B is on.
Assumes that the RCTU starts in format 1 or 2, is swithced to format 4 for the door opening and is then put back into format 1 or 2.

SPECIAL INITIAL CONDITIONS:
The waiver that releases Paul of all responsibility in the case that the door never opens again must be signed by Martin Weisskopf, Chandra Project Scientist, Gordon Garmire, ACIS Principal Investigator, Mark Bautz, ACIS Project Scientist, and Harvey Tannanbaum, CSC Director.

OPERATIONAL CONSTRAINTS/CAUTIONS:
The small and big vent valves must already be open.
The open and close mechanism must not be enabled at the same time.
CARD ACIS-002
CARD ACIS-007

REFERENCES:
ACIS Long Form Functional Test Procedure (36-01301.01)

see associated contingency procedures

CHANGE HISTORY:

V1.0

- initial version, copied from the 2.10 Door Open procedure

V1.1

- added pulse durations and expected shaft rotation angles from email from Ed Boughan
- changed expected starting temperature of actuator housing temperatures 1OAHAT and 1OAHBT in step 3.2 to -30 and -32 C

V1.2

- updated the expected durations, maximum temperatures, and shaft rotation angles of the heating cycles
- updated the text description to be consistent with the procedure

V2.0

- ACIS team signed-off version
- added Bob's comments that the procedure is run with the DH at -60 C, not room temperature as the door opening procedure.

Table 1: **Close ACIS Door on Orbit**

Step #	Title (Revision 2.17_V2.0)	Time Req (m)	Command Description	Command Mnemonic	Telemetry Description	Telemetry Mnemonic	Expected Value	Units
1	Start DEA HK if necessary							
1.1	Load Board 11 DEA HK	1	loadDeaBlock	WD00001024				
1.2	Start DEA Hkp run	1	startDEA	XDZ0000005				
2	Switch to tlm fmt 4							
2.1	Switch to tlm fmt 4	2						
3	Enable Door Mechanism							
3.1	Enable door mech. B	1	Door enable B	1MCMDBEN	Enable Side B	1MDBUBON	ENB	
3.2	Verify Actuator temps	10			Door Close Act. T B	1MAHCBT	< 30	C
					Door Open Act. T B	1MAHOBT	< 30	C
					Act. Housing T B	1OAHBT	-32 ± 2	C
					Door Open Act. Tlow	1OAHAT	-30 ± 2	C
3.3	Verify Shaft rotation	1			Shaft Rotation	1DACTAT	71.5 ± 2	
3.4	Verify limit switches	1			Door Open B	1MEOPBOP	OPEN	
					Door Close B	1MECLBCL	NCLO	
4	First Heating Cycle							
4.1	SOT selects duration	2.0						
4.2	FOT uplinks SCS	2.0						
4.3	FOT enables SCS	2.0						
4.4	FOT executes SCS	2.0						
	Close door side B	1.9	Door Close On B	1MCDRBON	Close Drive On/Off	1MCDRBCL	ON	
	Turn off Close drive B		Door Close Off B	1MCDRBOF	Door Close Drive B	1MCDRBCL	OFF	
	Turn off Close drive B		Door Close Off B	1MCDRBOF	Door Close Drive B	1MCDRBCL	OFF	
4.5	Turn off Close drive B	1	Door Close Off B	1MCDRBOF	Door Close Drive B	1MCDRBCL	OFF	
5	Verify expected behavior							
5.1	Verify Actuator temps	10			Door Close Act. T B	1MAHCBT	~ 66.0	C
5.2	Verify Shaft rotation	1			Shaft Rotation	1DACTAT	70.0 ± 5	
5.3	Verify limit switches	1			Door Open B	1MEOPBOP	OPEN	
					Door Close B	1MECLBCL	NCLO	
6	Monitor Actuator Cooldown							

Table 2: (CONT) **Close ACIS Door on Orbit**

Step #	Telemetry EGSE	Other Verifier	Crit	Description	Notes	RT Con	Tlm Fmt	Min Alt	SIM Pos
1									
1.1	Check cmdResult == OK		B	Load Fullhouse DEA housekeeping			1or2		
	commandEcho 225			parameter block into slot 4					
1.2	deaHousekeepingData		B	get FP temp.			1or2		
	commandEcho 18								
2									
2.1				Spacecraft command		Y	4		
3									
3.1			2	should be one == enabled		Y	4		
3.2			2	thermistor not sensitive below 30 C		Y	4		
			2				4		
			2				4		
			2			Y	4		
3.3			2	should be open !		Y	4		
3.4			2	should be zero==open		Y	4		
			2	should be one==not closed			4		
4									
4.1				SOT calls out duration and name of SCS, expectation is 140 s		Y	4		
4.2				FOT uplinks specified SCS into appropriate slot		Y	4		
4.3				spacecraft command		Y	4		
4.4				spacecraft command, heating cycle starts		Y	4		
			2	heater on for 140 s					
			2	Off command sent twice by SCS with 1s delay.					
			2						
4.5			2	FOT has command queued in scratchpad		Y	4		
				and ready to be sent immediately					
5									
5.1			2			Y	4		
5.2			2	should be open !		Y	4		
5.3			2	should be zero==open		Y	4		
			2	should be one==not closed					
6									

Table 1: **Close ACIS Door on Orbit (Page 2)**

Step #	Title (Revision 2.17_V2.0)	Time Req (m)	Command Description	Command Mnemonic	Telemetry Description	Telemetry Mnemonic	Expected Value	Units
6.1	Monitor actuator temp	45			Door Close Act. T B	1MAHCBT	< 30	C
7	Decision for next heating cycle							
7.1	Does previous cycle need repeating ?	2						
8	Second Heating Cycle							
8.1	SOT selects duration	2.0						
8.2	FOT uplinks SCS	2.0						
8.3	FOT enables SCS	2.0						
8.4	FOT executes SCS	2.0						
	Close door side B	2.1	Door Close On B On	1MCDRBON	Close Drive On/Off	1MCDRBCL	ON	
	Turn off Close drive B		Door Close Off B	1MCDRBOF	Door Close Drive B	1MCDRBCL	OFF	
	Turn off Close drive B		Door Close Off B	1MCDRBOF	Door Close Drive B	1MCDRBCL	OFF	
8.5	Turn off Close drive B	1	Door Close Off B	1MCDRBOF	Door Close Drive B	1MCDRBCL	OFF	
9	Verify expected behavior							
9.1	Verify Actuator temps	10			Door Close Act. T B	1MAHCBT	~ 71.0	C
9.2	Verify Shaft rotation	1			Shaft Rotation	1DACTAT	65 ± 5	
9.3	Verify limit switches	1			Door Open B	1MEOPBOP	NOPE	
					Door Close B	1MECLBCL	NCLO	
10	Monitor Actuator Cooldown							
10.1	Monitor actuator temp	45			Door Close Act. T B	1MAHCBT	< 30	C
11	Decision for next heating cycle							
11.1	Does previous cycle need repeating ?	2						
12	Third Heating Cycle							
12.1	SOT selects duration	2.0						
12.2	FOT uplinks SCS	2.0						
12.3	FOT enables SCS	2.0						
12.4	FOT executes SCS	2.0						
	Close door side B	2.3	Door Close On B	1MCDRBON	Close Drive On/Off	1MCDRBCL	ON	
	Turn off Close drive B		Door Close Off B	1MCDRBOF	Door Close Drive B	1MCDRBCL	OFF	
	Turn off Close drive B		Door Close Off B	1MCDRBOF	Door Close Drive B	1MCDRBCL	OFF	

Table 2: (CONT) **Close ACIS Door on Orbit (Page 2)**

Step #	Telemetry EGSE	Other Verifier	Crit	Description	Notes	RT Con	Tlm Fmt	Min Alt	SIM Pos
6.1			2	Wait for actuator to drop below 30 C.		Y	4		
7									
7.1				If yes go back to step #6, If no proceed to step #10		Y	4		
8									
8.1				SOT calls out duration and name of SCS, expectation is 100 s		Y	4		
8.2				FOT uplinks specified SCS into appropriate slot		Y	4		
8.3				spacecraft command		Y	4		
8.4				spacecraft command, heating cycle starts		Y	4		
			2	heater on for 100 s					
			2	Off command sent twice by SCS with 1s delay.					
			2						
8.5			2	FOT has command queued in scratchpad and ready to be sent immediately		Y	4		
9									
9.1			2			Y	4		
9.2			2	should be 65 ± 5 degrees		Y	4		
9.3			2	should be one == not open		Y	4		
			2	should be one==not closed					
10									
10.1			2	Wait for actuator to drop below 30 C.		Y	4		
11									
11.1				If yes go back to step #10, If no proceed to step #14		Y	4		
12									
12.1				SOT calls out duration and name of SCS, expectation is 135 s		Y	4		
12.2				FOT uplinks specified SCS into appropriate slot		Y	4		
12.3				spacecraft command		Y	4		
12.4				spacecraft command, heating cycle starts		Y	4		
			2	heater on for 135 s					
			2	Off command sent twice by SCS with 1s delay.					
			2						

Table 1: **Close ACIS Door on Orbit (Page 3)**

Step #	Title (Revision 2.17_V2.0)	Time Req (m)	Command Description	Command Mnemonic	Telemetry Description	Telemetry Mnemonic	Expected Value	Units
12.5	Turn off Close drive B	1	Door Close Off B	1MCDRBOF	Door Close Drive B	1MCDRBCL	OFF	
13	Verify expected behavior							
13.1	Verify Actuator temps	10			Door Close Act. T B	1MAHCBT	~ 85.0	C
13.2	Verify Shaft rotation	2			Shaft Rotation	1DACTAT	35 ± 5	
13.3	Verify limit switches	2			Door Close B	1MEOPBOP	NOPE	
					Door Close B	1MECLBCL	NCLO	
14	Monitor Actuator Cooldown							
14.1	Monitor actuator temp	30			Door Close Act. T B	1MAHCBT	< 30	C
15	Decision for next heating cycle							
15.1	Is the shaft rotation angle $<$ 40 degrees ?	2						
16	Fourth Heating Cycle							
16.1	SOT selects duration	2.0						
16.2	FOT uplinks SCS	2.0						
16.3	FOT enables SCS	2.0						
16.4	FOT executes SCS	2.0						
	Close door side B	4.1	Door Close On B	1MCDRBON	Close Drive On/Off	1MCDRBCL	ON	
	Turn off Close drive B		Door Close Off B	1MCDRBOF	Door Close Drive B	1MCDRBCL	OFF	
	Turn off Close drive B		Door Close Off B	1MCDRBOF	Door Close Drive B	1MCDRBCL	OFF	
16.5	Turn off Close drive B	1	Door Close Off B	1MCDRBOF	Door Close Drive B	1MCDRBCL	OFF	
17	Verify expected behavior							
17.1	Verify Actuator temps	2			Door Close Act. T B	1MAHCBT	~ 98.0	C
17.2	Verify Shaft rotation	2			Shaft Rotation	1DACTAT	10 ± 5	
17.3	Verify limit switches	2			Door Open B	1MEOPBOP	NOPE	
					Door Close B	1MECLBCL	NCLO	
18	Monitor Actuator Cooldown							
18.1	Monitor actuator temp	30			Door Close Act. T B	1MAHCBT	< 30	C
19	Disable drive B							
19.1	Disable drive B	2	Door Disable B	1MCMDBDS	Door Enable B	1MDBUBON	OFF	

Table 2: (CONT) **Close ACIS Door on Orbit (Page 3)**

Step #	Telemetry EGSE	Other Verifier	Crit	Description	Notes	RT Con	Tlm Fmt	Min Alt	SIM Pos
12.5			2	FOT has command queued in scratchpad and ready to be sent immediately		Y	4		
13									
13.1			2			Y	4		
13.2			2	should be 35±5 degrees		Y	4		
13.3			2	should be one == not open		Y	4		
			1	should be one==not closed					
14									
14.1			2	Wait for actuator to drop below 30 C.		Y	4		
15									
15.1				If no, **GO TO STEP 21, DISABLE THE ACTUATOR, AND EXIT THIS PROCEDURE !** If yes proceed to #18.		Y	4		
16									
16.1				SOT calls out duration and name of SCS, expectation is 170 s		Y	4		
16.2				FOT uplinks specified SCS into appropriate slot		Y	4		
16.3				spacecraft command		Y	4		
16.4				spacecraft command, heating cycle starts		Y	4		
			2	heater on for 170 s					
			2	off command sent twice					
			2	by SCS with 1s delay					
16.5			2	FOT has command queued in scratchpad and ready to be sent immediately		Y	4		
17									
17.1			2			Y	4		
17.2			1	should be 10±5 degrees		Y	4		
17.3			1	should be one==not open		Y	4		
			1	should be one==not closed			4		
18									
18.1			1	Wait for actuator to drop below 30 C.		Y	4		
19									
19.1			2			Y	4		

Table 1: **Close ACIS Door on Orbit (Page 4)**

Step #	Title (Revision 2.17_V2.0)	Time Req (m)	Command Description	Command Mnemonic	Telemetry Description	Telemetry Mnemonic	Expected Value	Units
20	Switch to tlm fmt 1or2							
20.1	Switch to tlm fmt 1or2	2						
	Total Time	267.4						

Table 2: (CONT) **Close ACIS Door on Orbit (Page 4)**

Step #	Telemetry EGSE	Other Verifier	Crit	Description	Notes	RT Con	Tlm Fmt	Min Alt	SIM Pos
20									
20.1				Spacecraft command		Y	1or2		