Rosetta Lander

COSAC FM

Software Interface Description

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Prepared:

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Change record:

Date	Changes
05 Dec 05	Added timing information to CFGC & UPPT
28 Sep 05	Corrected science data stream description for MS, GC & GCMS
29 July 05	Added description to words of 'Internal HK data' Corrected total number of HK words Corrected 'Column select for ADC channel' in CFGC & CSIB dump TM Changed min. length of TC_ID Extensive changes to chapter 'Science Data Stream'
24 May 05	Added detailed science data description & relative indices to HK table
22 Mar 05	Update of science data, CSIB & HK structure
30 Aug 04	Added option DPU Memory to TM MMLD
04 Aug 04	Change of HK structure
14 July 04	Minor changes to complete document
12 July 04	Extensive changes to almost every section of this document to have it comply with interfaces of new SW (120704_0931)
26 May 04	Added SSVSuccess event
19 Jan 04	Added detailed description of Backup-RAM handling
17 Dec 03	Added description of TC checksum
16 Dec 03	Reformatting of tables and drawings to comply with Office:mac
29 Aug 03	Minor updates in TC section to comply with FM SW 28.08.2003
28 July 03	update of HK correction factors
27 Jan 03	added chapter explaining the CSIB structure
23 Jan 03	added description of tags to science data format
25 Oct 02	major revision, updates in all chapters
13 July 02	updated to comply with current FM software
8 May 02	FSSV added
6 May 02	SUCG added (for debugging only)
26 Apr 02	MMLD added
28 Feb 02	UGPT changed to UDPT GPGC changed to GDPT GPMS changed to GPPT UPMS changed to UPPT GC & MS parameter tables use single TC UPMS now TC structure changed for CFGC, CFMS and UPMS
14 Feb 02	CFGC TC structure CFMS TC structure UPMS TC structure
12 Feb 02	Added Tapping station flag to mode selector field in STST

Cosac Command Set

Every experiment using the ComDPU runs in at least two different modes. First there is the 'Debug Mode' to which the system switches right after power-up. In that mode a set of commands can be issued to do maintenance work like software uploading, program patching and even direct hardware access by sending small parts of executable code.
After a predefined time in which the system does not receive one of the debug commands, it will reboot and switch into the 'Operating Mode' in which a different command set will be accepted by the ComDPU.

Debug mode:

The following table gives a brief overview of the available Debug-Monitor commands, currently implemented in the ComDPU-FM.

Name	Identifier	Parameters	Description
File Upload	DEB0	Ram-page, ram-adr, len	Starts file upload of **len** words to RAM(**page**, **adr**)
File Data	DEB1	Data(1), data(2), .., Data(len)	Array of data words to be uploaded
File End	DEB2	Checksum = sum(data(i)) MOD 0xffff	Signals end of upload, starts verification
Burn EEPROM File	DEB3	Ee-adr	Burns uploaded file into EEPROM
Boot EEPROM File	DEBD	Ee-adr	Copies code from EEPROM(**adr**) to RAM(0,0) and boots.
Execute File	DEB4		Executes prev. Uploaded file.
Burn EEPROM	DEB5	Ram-page, ram-adr, ee-adr, len	Copies RAM(**adr**, **page**) to EEPROM(**adr**)
Execute Code	DEB6	Code(1), ..., Code(n)	Directly executes given code sequence
Read EEPROM	DEB7	Ee-adr, ram-page, ram-adr, len	Copies EEPROM(**adr**) to RAM(**page**, **adr**)
Dump RAM	DEB8	Ram-page, ram-adr, len	Dumps **len** words of RAM(**page**, **adr**) to CDMS science data frame
Fill RAM	DEB9	Ram-page, ram-adr, n, pat(1), pat(2), ..., Pat(i)	Fills RAM(**page**, **adr**) with given **pat**tern **n** times
Move RAM	DEBA	Ram-page, ram-adr, dest-page, dest-adr, len	Copies **len** words from RAM(**page**, **adr**) to RAM(**page**, **adr**)
RAM Checksum	DEBB	Ram-page, ram-adr, len	Returns checksum=sum(RAM(**page**,**adr**(i)))
Boot RAM	DEBC	Ram-page, ram-adr, len	Copies code from RAM(**page**, **adr**) to RAM(0,0) and boots

A detailed description is given in the 'Rosetta Lander Common-DPU User's Manual'.

Operating mode:

After switching into the 'operating mode' the SW will accept and react to the following TCs:

Name	Identifier	Description
Start Self Test	STST	Initiates self test routines
Set GC configuration data	CFGC	Set GC configuration data for upcoming measurement cycle
Update device parameter table	UDPT	Copies updated data to predefined device parameter table
Get device parameter table	GDPT	Dumps predefined parameter table
Get Internal Housekeeping Data	GIHK	Dumps internal housekeeping data set
Set MS Configuration Data	CFMS	Set MS configuration data for upcoming measurement cycle
Update experiment parameter table	UPPT	Copies updated data to predefined parameter table
Get parameter table	GTPT	Dumps predefined MS parameter table
Start	STAC	Starts MS/GC/GC+MS/TPST measurement cycle
Get CSIB	GTIB	Dumps a copy of the CSIB
Set TPST configuration data	CFTS	Sets configuration for controlling of tapping station
Memory Load and Dump	MMLD	Dumps memory pages through science data stream
Set unit configuration	SUCG	Changes volatile settings in units flow control (debugging only)
Fire Single Shot Valve	FSSV	Sets code and initiates single shot valve

Start Self Test (STST – 0x0001):

Function: To initiate self tests

Format:

Word	Content	Description	
0	x x 00 0000 0000 0001	OCPL: 1 = if successful, 0 = disabled Execution Report: 1 = disabled Identifier for TC (STST)	
1	0x0001	Selector word	MS self test
	0x0002		GC self test
	0x0004		DPU memory test
	0x0008		Mass memory test
	0x0010		Oven test
	0x0020		Tapping station
2	-	currently not used	
3	-	c.n.u.	
4	-	c.n.u.	
5	-	c.n.u.	
6	0x0000-0x000f	DPU memory test: start page	
7	0x0000-0xffff	DPU memory test pattern	
8	0x0000-0x002f	MM test: start page	
9	0x0001-0x0030	MM test: number of pages	
10	-	c.n.u.	
11	-	c.n.u.	
12	-	c.n.u.	
13	0x0000-0x00ff	Oven temperature	
14	0x0000	Terminal	Side
	0xffff		Main
15	0x0000	Direction	CS1.d7 = 0
	0xffff		CS1.d7 = 1
16	varies	Checksum	
17-31	currently not used – set to zero		

Checks: -

Processing: Processing of this TC may take some time, depending on the number of self tests to be performed.

Self test	Duration
MS	< 1 min
GC	< 2 min
DPU	< 1 min
Mass Memory	< 5 min
Oven	< 2 min
Tapping Station	< 5 min

Verification: TM packet issued, ID: 0x06

Notes: Several tests can be initiated in parallel by setting the respective bits in the Selector Word (Word1). Time to process command will increase (see table above)!
Performing the MM-Test will overwrite and delete all science data currently held in the mass memory!
DPU memory page 1 is used as a queue for TM packets by the operating system. Per-

forming memory tests on this page will have undesired effects; pending TM packets can be overwritten!
If the OCPL-flag is set, the request will only be raised if all individual tests have been performed successfully.

Send GC configuration data (CFGC – 0x0002):

Function: To update the configuration of the GC

Format:

Word	Content	Description	
0	x x 00 0000 0000 0002	OCPL: 1 = if successful, 0 = disabled Execution Report: 1 = disabled Identifier for TC CFGC	
1	0x0000	HK sweeping	false
	0xffff		true
2	0x0000	Continue	false
	0xffff		true
3	0x0000-0x001f	Duration of measurement cycle 00001 : 1,12 min 00010 : 2,23 min 00100 : 4,47 min 01000 : 8,95 min 10000 : 17,89 min	
4	0x0000	Helium tank select	tank 1
	0xffff		tank 2
5	0x0000-0xffff	Duration of injection (msec)	
6	0x000f	Sample	cal. gas
	0x00f0		oven
	0x0f00		tenax
7	$0xc_4c_3c_2c_1$	Column select for ADC channel	$0 \le c_1 \le 7$
			$0 \le c_2 \le 7$
			$0 \le c_3 \le 7$
			$0 \le c_4 \le 7$
8	0x0000-0x00ff	CHP (column head pressure)	
9	varies	checksum	
10-31	currently not used – set to zero		

Checks: -

Processing: This is performed immediately.

Verification: Bit 15 in HK System Status 1 (Word11) is set after upload

Notes: This TC must be issued prior to a GC measurement cycle.
If the OCPL-flag is set, the request will be raised unconditionally after TC execution.
The table layout is harder to fix than solving the Rubik's cube in less than 20 seconds…

Update device parameter table: (UDPT – 0x0003)

Function: To update the parameter table for the Tapping Station and Oven

Format:

Word	Content	Description			
0	x x 00 0000 0000 0003	OCPL: 1 = if successful, 0 = disabled Execution Report: 1 = disabled Identifier for TC UDPT			
1	0x000f	Tapping Station	Position	Flag	Store in RAM
	0x00f0				Store in EEPROM
	0x0000				Do not copy
2	0x0000-0xffff			Values	Open
3	0x0000-0xffff				Contacts closed
4	0x0000-0xffff				Main terminal closed
5	0x0000-0xffff				Side terminal closed
6	0x0000-0xffff				Upper
7	0x0000-0xffff				Lower
8	0x000f		Control	Flag	Store in RAM
	0x00f0				Store in EEPROM
	0x0000				Do not copy
9	0x0000			Do not update Backup RAM	false
	0xffff				true
10	0x0000			Ignore SD2 status	false
	0xffff				true
11	0x0000-0xffff			Timeout value (msec)	
12	0x0000			Auto calibration	false
	0xffff				true
13	0x000f	Oven	Flag		Store in RAM
	0x00f0				Store in EEPROM
	0x0000				Do not copy
14-21	0x0000-0x00ff		Temperature array, one value for each oven		
22	0x0000-0xffff		Pipe heater cycles (n-1)		
23	0x0000-0xffff		Pipe heater delay in seconds		
24-29	0x0000-0xffff		unused		
30	varies	Checksum			
31	currently not used – set to zero				

Checks: -

Processing: This is performed immediately.

Verification: -

Notes: Two independent data sets (TPST/Oven) can be transmitted to the DPU. Depending on the settings of the corresponding 'Flag' parameter (Word1, Word13), one can choose to direct the uploaded data into RAM and/or EEPROM.
If the OCPL-flag is set, the request will be raised unconditionally after TC execution.

Get device parameter table: (GDPT – 0x0004)

Function: To acquire a copy a the parameter table for the Tapping Station and Oven

Format:

Word	Content	Description	
0	x x 00 0000 0000 0004	OCPL: 1 = if successful, 0 = disabled Execution Report: 1 = disabled Identifier for TC GDPT	
1	0x000f	Mode flag	get parameter table from RAM
	0x00f0		get parameter table from EEPROM
2	varies	Checksum	
3-31	currently not used – set to zero		

Checks: -

Processing: This is performed immediately.

Verification: TM packet issued, ID: 0x04

Notes: The mode flag (Word1) is used to select the source of this parameter table, RAM or EEPROM.
If the OCPL-flag is set, the request will be raised unconditionally after TC execution.

Get internal housekeeping data: (GIHK – 0x0005)

Function: To acquire a copy a the internal HK data

Format:

Word	Content	Description	
0	x x 00 0000 0000 0005	OCPL: 1 = if successful, 0 = disabled Execution Report: 1 = disabled Identifier for TC GIHK	
1	0x0000	Acquire new values	False
	0xffff		True; Power switch 1&2 on!
2	varies	Checksum	
3-31	currently not used – set to zero		

Checks: -

Processing: This is performed immediately.

Verification: TM packet issued, ID: 0x03 within 5 sec.

Notes: Setting the mode flag (Word1) to TRUE will initiate the update of the HK data prior to a downlink. Power switches 1 and 2 will be activated for 5 seconds.
If the OCPL-flag is set, the request will be raised unconditionally after TC execution.

Send MS configuration data: (CFMS – 0x0006)

Function: To update the MS configuration data

Format:

Word	Content	Description	
0	x x 00 0000 0000 0006	OCPL: 1 = if successful, 0 = disabled Execution Report: 1 = disabled Identifier for TC CFMS	
1	0x0000	HK sweeping	False
	0xffff		true
2	0x0000	Accumulate	false
	0xffff		true
3	0x0001	Cathode	Filament #1
	0x0002		Filament #2
	0x0004		Filament #3
	0x0008		Filament #4
4	0x0000-0x00ff	Emission current	
5	0x0000-0x00ff	Detector voltage	
6	0x0000	Resolution	low
	0xffff		high
7	0x0000	Frequency	1 KHz
	0xffff		4 KHz
8	0x0000	Run calibration	false
	0xffff		true
9	0x000f	Sample	cal. gas
	0x00f0		oven
	0x0f00		sniffing
10	varies	Checksum	
11-31	currently not used – set to zero		

Checks: -

Processing: This is performed immediately.

Verification: Bit 14 in HK System Status 1 (Word11) is set after upload

Notes: This TC must be issued prior to a MS measurement.
If the OCPL-flag is set, the request will be raised unconditionally after TC execution.

Update experiment parameter table: (UPPT – 0x0007)

Function: To update the experiment parameter table

Format:

Word	Content	Description			
0	x x 00 0000 0000 0007	OCPL: 1 = if successful, 0 = disabled Execution Report: 1 = disabled Identifier for TC UPPT			
1	0x000f	MS	Flag	Store in RAM	
	0x00f0			Store in EEPROM	
	0x0000			Do not use	
2	0x0000-0x1e00		Values	Duration of measurement 0001 : 8,4s / 2,1s 0010 : 16,8s / 4,19s 0100 : 33,5s / 8,4s 1000 : 67,1s / 16,8s	
3	0x0000			Use auto calibration values	false
	0xffff				true

4	0x0000-0xffff			Pressure calibration gas	
5	0x0000			Mode	Single
	0xffff				Multi
6	0x0000-0x00ff			Timeout	
7	0x0000-0x00ff			Delay for gas flow – not used	
8	0x0000-0x00ff			Voltages	U1 (correct1)
9	0x0000-0x00ff				U2 (correct2)
10	0x0000-0x00ff				U3 (ab_x)
11	0x0000-0x00ff				U4 (ab_y)
12	0x0000-0x007f			Time 31,25 ns/bit	T0 (R1_on) off: 2125 ns later
13	0x0000-0x3fff				T1 (R2_on1)
14	0x0000-0x3fff				T2 (R2_off)
15	0x0000-0x3fff				T3 (R2_on2)
16	0x0000-0x3fff				T4 (R2_off2)
17	0x0000-0xffff				T5 (not used)
18	0x0000-0x000f			Detector start delay 0001 : +32 µs 0010 : +64 µs 0100 : +128 µs 1000 : +256 µs	
19	0x0000-0xffff			Number of data words to copy	
20	0x000f	GC	Flag	Store in RAM	
	0x00f0			Store in EEPROM	
	0x0000			Do not use	
21-28	0x0000-0x00ff		Values	Array of 8 column temp values	
29	0x0000-0xffff			Number of data words to copy	
30	0xttnn			Seconds to heat Tenax (0 <= tt <= 255) Seconds to heat GC (0 <= nn <= 255)	
31	varies	checksum			

Checks: -

Processing: This is performed immediately.

Verification: -

Notes: Two independent data sets (MS/GC) can be transmitted to the DPU. Depending on the settings of the corresponding 'Flag' parameter, one can choose to direct the upload into RAM or EEPROM.
If the OCPL-flag is set, the request will be raised unconditionally after TC execution.

Get parameter table: (GTPT – 0x0008)

Function: To retrieve a copy of the experiment parameter table

Format:

Word	Content	Description	
0	x x 00 0000 0000 0008	OCPL: 1 = if successful, 0 = disabled Execution Report: 1 = disabled Identifier for TC GTPT	
1	0x000f	Mode	Get RAM parameter table
	0x00f0		Get EEPROM parameter table
2	varies	checksum	
3-31	currently not used – set to zero		

Checks: -

Processing: This is performed immediately.

Verification: TM packet issued, ID: 0x05

Notes: The mode flag (Word1) is used to select the source of the parameter table, RAM or EEPROM.
If the OCPL-flag is set, the request will be raised unconditionally after TC execution.

Start Action: (STAC – 0x0009)

Function: To start the selected action

Format:

Word	Content	Description	
0	x x 00 0000 0000 0009	OCPL: 1 = if successful, 0 = disabled Execution Report: 1 = disabled Identifier for TC STAC	
1	0x0000	MS	-
	0xffff		start
2	0x0000	GC	-
	0xffff		start
3	0x0000	GCMS	-
	0xffff		start
4	0x0000	TPST	-
	0xffff		start
5	0x0000-0xffff	Number of cycles	
6	0x0000	Issue OCPL at EOD (end of data transmission)	false
	0xffff		true
7	varies	checksum	
8-31	currently not used – set to zero		

Checks: Prior to calling the individual routine, the software checks if the matching configuration has been uploaded to the unit. If this fails, an event packet will be issued: Packet ID: 0x07, bit 14 set in Error Flag (Word1).

Processing: This is performed immediately.

Verification: Bit 13-15 in HK System Status 1 (Word11) mirror the valid configurations.

Notes: The Parameter 'Number of cycles' (Word5) is not used by the routines controlling the Tapping Station.
If the OCPL-flag is set, the SW will raise a request to CDMS once the chosen action has been executed successfully.
Parameter 6 (Issue OCPL at EOD) can be set to have the SW generate an OCPL at the end of a data transmission. This can be used to have CDMS branch to another AMST item once the SW has finished transmitting all science data and it's safe to turn it off.

Get CSIB: (GTIB – 0x000a)

Function: To download a copy of the 'Configuration and Status Info Block' (CSIB) currently held in RAM.

Format:

Data word	Content	Description
0	x x 00 0000 0000 000a	OCPL: 1 = raise after execution, 0 = disabled Execution Report: 1 = disabled Identifier for TC GTIB
1	0x000a	checksum
2-31	currently not used – set to zero	

Checks: -

Processing: This is performed immediately.

Verification: In response to this TC a CSIB Dump TM packet (ID: 0xb) will be issued.

Notes: If the OCPL-flag is set, the request will be raised unconditionally after TC execution.

Set TPST configuration data: (CFTS – 0x000b)

Function: To update parameters used in the Tapping Station controlling routines of the flight software.

Format:

Word	Content	Description	
0	x x 00 0000 0000 000b	OCPL: 1 = raise after execution, 0 = disabled Execution Report: 1 = disabled, 0 = enabled Identifier for TC CFTS	
1	0x0000	Direct controlling	False
	0xffff		True
2	0x0000	Position information	Use Position ID
	0xffff		Use Position value
3	0x0000	Position ID	Open
	0x0001		Contacts closed
	0x0002		Main terminal closed
	0x0003		Side terminal closed
	0x0004		Upper
	0x0005		Lower
4	0x0000-0xffff	Position value	
5	0x0000	Direction	CS1.D7 = 0
	0xffff		CS1.D7 = 1
6	tttt	Time to drive Tapping station	Time in sec.
7	0x0000	Start calibration of TPST	False
	0xffff		True
8	varies	Checksum	
9-31	currently not used – set to zero		

Checks: -

Processing: Parameters are taken from TC and copied into the internal memory. This is performed immediately.

Verification: Bit 13 in HK System Status 1 (Word11)

Notes: By using a 'Position Value' (Word4) instead of a 'Position ID' (Word3), the SW routines controlling the Tapping Station will not check whether this value is outside the adjustable range of the TPST. If the commanded value can not be reached within a timeout, an event packet will be issued: Packet ID: `0x07`, Event ID: `0x0a`.
Upon reception of this event packet, the operator shall check the position of the TPST in the unit's HK telemetry to prevent problems while interoperating with the carrousel.
If the OCPL-flag is set, the request will be raised unconditionally after TC execution.

Memory Load and Dump: (MMLD – 0x000c)

Function: To dump data from specified memory locations

Format:

Word	Content	Description	
0	x x 00 0000 0000 000c	OCPL: 1 = raise after execution, 0 = disabled Execution Report: 1 = disabled Identifier for TC MMLD	
1	0x000f	Action	Dump memory
	0x00f0		Load memory (not implemented)
2	0x0000	Memory selector	Nothing selected
	0x000f		Mass Memory
	0x00f0		GC memory
	0x0f00		MS/TDC memory
	0xf000		DPU memory
3	0x0000-0xffff	Length	
4	0x0000-0xffff	Address	
5	0x0000-0xffff	Page	
6-30	0x0000-0xffff	Data	
31	varies	Checksum	

Checks: -

Processing: The specified number of blocks (126 words each) (see Word3) from the chosen memory area (see Word2) are loaded into memory, formatted into TM packets and issued to CDMS. This is performed immediately.

Verification: Issue of one Memory Dump TM (ID: 0x9), followed by a number (see Word3) of Raw Packet TM (ID: 0xa)

Notes: The action 'Load memory' is currently not implemented, settings will be ignored.
If the OCPL-flag is set, the request will be raised unconditionally after TC execution.

Send Unit Configuration: (SUCG – 0x000d)

Function: To set unit configuration parameters

Format:

Word	Content	Description	
0	x x 00 0000 0000 000d	OCPL: 1 = raise after execution, 0 = disabled Execution Report: 1 = disabled Identifier for TC SUCG	
1	0x0000	Update PWR$OFF Over-write	false
	0xffff		true
2	0x0001	PWR$OFF Overwrite	PS1
	0x0002		PS2
	0x0004		PS3 (not used)
	0x0008		PS4
	0x0010		Mass Memory
3	0x0000	Use PWR$ON parameter	false
	0xffff		true
4	0x0000	Function to be called	PWR$OFF
	0xffff		PWR$ON
5	0x0001	PWR$ON	PS1
	0x0002		PS2
	0x0004		PS3 (not used)
	0x0008		PS4
	0x0010		Mass Memory
6	0x0000	Update Options	false
	0xffff		true
7	0x0000	Overwrite G3 Check	false
	0xffff		true
8	0x0000	MM read twice	false
	0xffff		true
9	0x0000	Eeprom refresh	false
	0xffff		true
10	0x0000	Update Options	false
	0xffff		true
11	0x0000	Reset MM read pointer	false
	0xffff		true
12	0x0000	MM auto dump	false
	0xffff		true
13	0x0000	MM full reset	false
	0xffff		true
14	0x0000	Reset sequence counters	false
	0xffff		true
15-30	0x0000		
31	varies	Checksum	

Checks: -

Processing: The values held in memory are overwritten by the parameters in this TC. This is performed immediately.

Verification: Power switches inside the unit can be commanded by setting the corresponding bits in Word5. The current drawn by the unit should increase/decrease respectively.
The most recent state of the power switches is mirrored in HK System Status 11 (Word11), bit 4-7

Warning: Some parameters inside this command can be used to change the control flow of internal routines. This was implemented to be used during ground test/debugging only and should not be played with during nominal operation!

Notes: If the OCPL-flag is set, the request will be raised unconditionally after TC execution.

Fire Single Shot Valve: (FSSV – 0x000e)

Function: To arm and fire the 'SSV' (Single Shot Valve)

Format:

Word	Content	Description	
0	x x 00 0000 0000 000e	OCPL: 1 = if sequence was successfully executed, 0 = disabled Execution Report, b1 = disabled Identifier for TC FSSV	
1	0x0000	Update CS1 mask	false
	0xffff		true
2	0x0001	CS1 mask	
3	0x0000	Fire Single Shot Valve	false
	0xffff		true
4	0x1810	Code	
5	varies	Checksum	
6-31	currently not used – set to zero		

Checks: Once the CS1 mask has been set (the valve has been armed), the code to fire the SSV will be checked against the preprogrammed value `0x1810`. if the check fails, the process will be stopped and an event packet issued: Packet ID: `0x07`, Event ID: `0x03`

Processing: To successfully fire the SSV, the above TC has to be issued twice following this sequence:

1. Set Word1 to TRUE and apply the CS1 mask to Word2 (all other Words = 0)
2. Set Word3 to TRUE and set Word4 to `0x1810` (all other Words = 0)

Verification: SSV armed: bit 14 in HK System Status 2 (Word12) set to 1
SSV fired: bit 14 & 15 in HK System Status 2 (Word12) set to 1

Warning: This TC should **never be issued** during ground tests with the FM model!

Notes: If the OCPL-flag is set, the request will be raised **only** after having successfully executed the complete sequence to open the valve!

How to calculate the TC checksum

All of the above listed TCs are checksum protected to prevent the software from executing a command if its data was invalidated during the upload process. In compliance with CDMS the simply 'sum-over-all' checksum of all the data inside a TC is used:

$$chksum = \sum_{i=0}^{n-1} TC[i]$$

$$TC[n] = checksum \wedge 65535$$

$$1 \le n \le 31$$

Equation 1

Upon reception of a TC the software first calculates the checksum given in Equation 1 for the data received and executes the command if the calculated checksum passes the comparison with the one

stored in the TC. If this check fails, the software will skip the execution of the command and immediately issues the Error TM (ID: 0x7), see page 22.

Science Data Format:

To comply with the science data collection mechanism defined by the CDMS, COSAC will format its collected data into packages of 128 words each. Due to the fact that other data (output from test routines, memory dumps, ...) will have to be transmitted using the same 'data channel', special data structures were defined to mark a difference between those data sets.

The basic structure is rather simple. Every packet is divided into 2 sections, a header and a data section.

Word	Section
0 - n	Header section
n+1 - 127	data section

The first word of every header section is used as an identifier for the information held in the data section.

At present there are 11 different header sections defined:

Identifier	Description	Length
0x0001	science parameter (deprecated)	2
0x0002	science data	2
0x0003	internal HK data	2
0x0004	Device parameter table	2
0x0005	Experiment parameter table	2
0x0006	test results	2
0x0007	error messages	3
0x0008	TPST report	2
0x0009	Memory Dump	6
0x000a	Raw data	2
0x000b	Copy of CSIB-CFG	3
0x000c	TC Execution report	2

The remaining space in every 128 word long data set forms the 'data section', which is basically an array of 16 bit long data words of variable length.

Description of science data frame structures:

Science Parameter: (0x0001)

Function: Header of Science Data Stream

Format:

Word	Content	Section
0	Identifier(0x0001)	Header
1	Sequence Length	
2-127	CSIB	Data

Notes: The 16-bit value in 'Sequence Length' (Word1) contains the overall number of packets belonging to the current science data stream. Since one packet holds a total number of 128 16-bit words, the maximum length of a COSAC science data stream is limited to app. 16 Mbytes.
'CSIB' (word2-96) holds a copy of the 'Info Status Block' (see page 33) which is attached to the science data stream to link the data and the parameters used during the measurement cycle.

This data packet format has been deprecated and will not be used any longer!
CSIB data is now added to the science data stream directly.

Science Data: (0x0002)

Function: Wrapper for science data

Format:

Word	Content	Section
0	Identifier(0x0002)	Header
1	Sequence Counter	
2-127	Data Array	Data

Notes: The 'Sequence Counter' (Word1) is used to uniquely identify the position of the current data frame.
The 'Data Array' (Word2-127) contains the raw science data words in consecutive order. The structure of the science data is described in section 'Science Data Stream ', page 28.

Internal HK data: (0x0003)

Function: To hold the complete set of HK values

Format:

Word	Content																
	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	Packet ID = 0x0003
1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Sequence Counter
2-65	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	HK values, see Table 4 HK Values
66	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	Allocated BackupRAM size of Cosac inside CDMS memory, 0 ≤ x ≤ 0xffff
67	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	Checksum of Science Data packet as received from CDMS, 0 ≤ x ≤ 0xffff
68	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	Offset & Length of stored TC, 0 ≤ x ≤ 0xffff, see CDMS SSpec
69	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	Currently scheduled SSIF Request Code, 0 ≤ x ≤ 0x0a, see CDMS SSpec

70	d d d d d d d d d d d d d d d d	last CDMS Service System Status, 0 ≤ x ≤ 0xffff, see CDMS SSpec
71	d d d d d d d d d d d d d d d d	**last CDMS Mode (RMOD)** CDMS Mode SSCLK Frequency Current AMST ID
72	d d d d d d d d d d d d d d d d	**Trigger word** Dest. Unit Trigger Word Field
73	d d d d d d d d d d d d d d d d	Allocated Science Data Volume 0 ≤ x ≤ 0xffff, see CDMS SSpec
74	d d d d d d d d d d d d d d d d	**$MMFirstInit?** First init. of Mass Memory needed? 0x0000 = false, 0xffff = true
75	d d d d d d d d d d d d d d d d	**$MMRdCntHigh** Mass Memory read counter high address, 0 ≤ x ≤ 0xffff
76	d d d d d d d d d d d d d d d d	**$MMRdCntLow** Mass Memory read counter low address, 0 ≤ x ≤ 0xffff
77	d d d d d d d d d d d d d d d d	**MMADRH** Mass Memory SW addr counter, high
78	d d d d d d d d d d d d d d d d	**MMADRL** Mass Memory SW addr counter, low
79	d d d d d d d d d d d d d d d d	**mm$flush** Flag if MM flush is needed 0x0000 = false, 0xffff = true
80	d d d d d d d d d d d d d d d d	**$rFR** Frame read index, 0 ≤ x ≤ 0xffff
81	d d d d d d d d d d d d d d d d	**$wFR** Frame write index, 0 ≤ x ≤ 0xffff
82	d d d d d d d d d d d d d d d d	**$pFR** current frame index, 0 ≤ x ≤ 0xffff
83	d d d d d d d d d d d d d d d d	**$rMMFR** Mass Memory frame read index, 0 ≤ x ≤ 0xffff
84	d d d d d d d d d d d d d d d d	**$wMMFR** Mass Memory frame write index, 0 ≤ x ≤ 0xffff
85	d d d d d d d d d d d d d d d d	**$pMMFR** current Mass Memory frame index, 0 ≤ x ≤ 0xffff
86	d d d d d d d d d d d d d d d d	**$idleCnt** Idle task counter, 0 ≤ x ≤ 0xffff
87	d d d d d d d d d d d d d d d d	**$sd2status** copy of SD2 carousel status, 0xf000 = SD2 Ready
88	d d d d d d d d d d d d d d d d	**$MMDUMP** Mass Memory auto-dump, 0x0000 = false, 0xffff = true
89	d d d d d d d d d d d d d d d d	**TDCMODE** mode in which the TDC is operated in
90	d d d d d d d d d d d d d d d d	**$DPUadr** First faulty address of DPU memory, default : 0X000

	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0	
91	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	**$EODATA** Create OCPL when MM empty 0x0000 = false, 0xffff = true
92	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	**$EOM** End of measurement 0x0000 = false, 0xffff = true
93	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	**$TDCSKIP** TDC produced time-out 0x0000 = false, 0xffff = true
94	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	**$GCSKIP** GC produced time-out 0x0000 = false, 0xffff = true
95	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	**gvSTAC.RESULT** Result of last action 0x0000 = NOK, 0xffff = OK
96-105	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	**Service System Status** Copy of CDMS Service System Status, see CDMS SSpec

Notes: -

Device parameter table: (0x0004)

Function: To hold a copy of the device parameter table

Format:

Word	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0	Content
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	Packet ID = 0x0004
1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Sequence Counter
2	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	**Location Identifier** Spare EEPROM RAM
3	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	TPST: Position Open
4	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	TPST: Position Contacts Closed
5	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	TPST: Position Main Terminal Closed
6	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	TPST: Position Side Terminal Closed
7	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	TPST: Position Upper
8	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	TPST: Position Lower
9	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	**Location Identifier** Spare EEPROM RAM
10	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	TPST: Use of Backup Ram
11	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	TPST: Ignore SD2 Status

12	d d d d d d d d d d d d d d d d	TPST: Timeout Value
13	d d d d d d d d d d d d d d d d	TPST: Create Report
14	0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1	**Location Identifier** Spare EEPROM RAM
15	d d d d d d d d d d d d d d d d	Temperature[0]
16	d d d d d d d d d d d d d d d d	Temperature[1]
17	d d d d d d d d d d d d d d d d	Temperature[2]
18	d d d d d d d d d d d d d d d d	Temperature[3]
19	d d d d d d d d d d d d d d d d	Temperature[4]
20	d d d d d d d d d d d d d d d d	Temperature[5]
21	d d d d d d d d d d d d d d d d	Temperature[6]
22	d d d d d d d d d d d d d d d d	Temperature[7]
23	d d d d d d d d d d d d d d d d	Heating Time[0]
24	d d d d d d d d d d d d d d d d	Heating Time[1]
25	d d d d d d d d d d d d d d d d	Heating Time[2]
26	d d d d d d d d d d d d d d d d	Heating Time[3]
27	d d d d d d d d d d d d d d d d	Heating Time[4]
28	d d d d d d d d d d d d d d d d	Heating Time[5]
29	d d d d d d d d d d d d d d d d	Heating Time[6]
30	d d d d d d d d d d d d d d d d	Heating Time[7]

Notes: -

Experiment parameter table: (0x0005)

Function: To hold a copy of the experiment parameter table

Format:

Word	Content	
	F E D C B A 9 8 7 6 5 4 3 2 1 0	
0	0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1	Packet ID = 0x0005
1	x x x x x x x x x x x x x x x x	Sequence Counter
2	0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1	**Location Identifier** Spare EEPROM RAM
3	d d d d d d d d d d d d d d d d	MS: Duration
4	d d d d d d d d d d d d d d d d	MS: Use auto calibration values
5	d d d d d d d d d d d d d d d d	MS: Pressure calibration gas

6	d d d d d d d d d d d d d d d d	MS: Mode
7	d d d d d d d d d d d d d d d d	MS: Gas Flow Delay
8	d d d d d d d d d d d d d d d d	MS: U[0]
9	d d d d d d d d d d d d d d d d	MS: U[1]
10	d d d d d d d d d d d d d d d d	MS: U[2]
11	d d d d d d d d d d d d d d d d	MS: U[3]
12	d d d d d d d d d d d d d d d d	MS: T[0]
13	d d d d d d d d d d d d d d d d	MS: T[1]
14	d d d d d d d d d d d d d d d d	MS: T[2]
15	d d d d d d d d d d d d d d d d	MS: T[3]
16	d d d d d d d d d d d d d d d d	MS: T[4]
17	d d d d d d d d d d d d d d d d	MS: T[5]
18	d d d d d d d d d d d d d d d d	MS: T[6]
19	d d d d d d d d d d d d d d d d	MS: Detector Start Delay
20	d d d d d d d d d d d d d d d d	MS: Words to copy from Science Data
21	0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1	**Location Identifier** Spare EEPROM RAM
22	d d d d d d d d d d d d d d d d	GC: Temperature Column 0
23	d d d d d d d d d d d d d d d d	GC: Temperature Column 1
24	d d d d d d d d d d d d d d d d	GC: Temperature Column 2
25	d d d d d d d d d d d d d d d d	GC: Temperature Column 3
26	d d d d d d d d d d d d d d d d	GC: Temperature Column 4
27	d d d d d d d d d d d d d d d d	GC: Temperature Column 5
28	d d d d d d d d d d d d d d d d	GC: Temperature Column 6
29	d d d d d d d d d d d d d d d d	GC: Temperature Column 7
30	d d d d d d d d d d d d d d d d	GC: Words to copy from Science Data
31	d d d d d d d d d d d d d d d d	GC: Time to heat Tenax (sec)

Notes: **-**

Test results: (0x0006)

Function: To hold test results

Format:

Word	Content
	F E D C B A 9 8 7 6 5 4 3 2 1 0

0	0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0	Packet ID = 0x0006
1	x x x x x x x x x x x x x x x x	Sequence Counter
2	0 0 d d d d d d 0 0 d d d d d d	**Test result bitmap** Test result: Tapping Station Test result: Oven Test result: Mass Memory Test result: DPU Memory Test result: GC Test result: MS Test performed: Tapping Station Test performed: Oven Test performed: Mass Memory Test performed: DPU Memory Test performed: GC Test performed: MS
3	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	not used
4	d d d d d d d d d d d d d d d d	Mass Memory: address low
5	d d d d d d d d d d d d d d d d	Mass Memory: address high
6	d d d d d d d d d d d d d d d d	DPU Memory: address
7	d d d d d d d d d d d d d d d d	DPU Memory: page
8	d d d d d d d d d d d d d d d d	MS: low
9	d d d d d d d d d d d d d d d d	MS: high
10	d d d d d d d d d d d d d d d d	Columns: abs(8 gcadc(t_0-t_1))
11	d d d d d d d d d d d d d d d d	Columns: abs(9 gcadc(t_0-t_1))
12	d d d d d d d d d d d d d d d d	Columns: abs(10 gcadc(t_0-t_1))
13	d d d d d d d d d d d d d d d d	Columns: abs(11 gcadc(t_0-t_1))
14	d d d d d d d d d d d d d d d d	Columns: abs(12 gcadc(t_0-t_1))
15	d d d d d d d d d d d d d d d d	Columns: abs(13 gcadc(t_0-t_1))
16	d d d d d d d d d d d d d d d d	Columns: abs(14 gcadc(t_0-t_1))
17	d d d d d d d d d d d d d d d d	Columns: abs(15 gcadc(t_0-t_1))
18	d d d d d d d d d d d d d d d d	Oven: 2 msadc(t_0)
19	d d d d d d d d d d d d d d d d	Oven: 2 msadc(t_1)
20-67	d d d d d d d d d d d d d d d d	MM: Error count(page)
68 - 127	d d d d d d d d d d d d d d d d	TPST: Position & Oven Profile

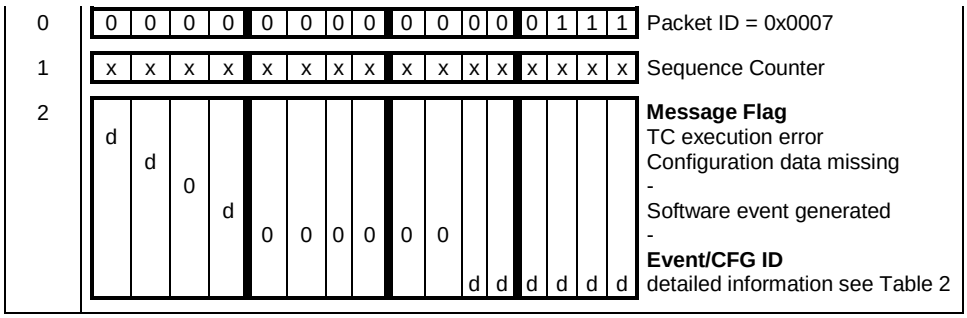
Notes: -

System messages: (0x0007)

Function: To hold system messages

Format:

Word	Description
	F E D C B A 9 8 7 6 5 4 3 2 1 0



Message Flag	Description	Value
System_Event	Event was generated by software	0x1000
Error_CFG	Process started without uploading of configuration data	0x4000
Error_TC	Error occurred during TC execution	0x8000

Table 1: Description of Error Flags

Event ID	Description	Value
HE_Pressure	Helium pressure did not stabilize within given timeout	0x0001
TDCCal	Timeout occurred during calibration of TDC (MS)	0x0002
SSVNotArmed	Trying to fire Single Shot Valve without arming it first	0x0003
HVFailedAfterPoweron4	High Voltage could not be switched on (MS)	0x0004
GCZeroCycles	Number of cycles set to zero at beginning of measurement	0x0005
MSZeroCycles	Number of cycles set to zero at beginning of measurement	0x0006
SD2NotReady	Trying to drive the Tapping Station although SD2 signals 'Not Ready'	0x0007
CSIBInvalid	Timestamp of CSIB copy was found invalid at boot time	0x0008
HWMissing	SW is unable to read HW registers	0x0009
TPSTTimeOut	Driving of Tapping Station was stopped by time-out	0x000a
SSVSuccess	Single Shot Valve successfully opened	0x000b
EepromRefresh	TC to automatically refresh the EEPROM was executed	0x000c
TDCTimeout	TDC produced timeout	0x000d
GCTimeout	GC produced timeout	0x000e
SMP.GCTENAX	Temperature of Tenax capsule didn't change within timeout	0x0011
SMP.GCOVEN	Reserved	0x0012
SMP.GCCALGAS	Pressure of calibration gas did not reach threshold within timeout	0x0013
SMP.MSSNIFFING	Reserved	0x0014
SMP.MSOVEN	Reserved	0x0015
SMP.MSCALGAS	Pressure of calibration gas did not reach threshold within timeout	0x0016

Table 2: Description of Event IDs

Notes: **-**

Tapping Station report: (0x0008)

Function: To hold data captured by the routines controlling the Tapping Station

Format

Word	Content
0	F E D C B A 9 8 7 6 5 4 3 2 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 Packet ID = 0x0008

1	x x x x x x x x x x x x x x x x	Sequence Counter
2	d d d d d d d d d d d d d d d d	**Potentiometer value** at start position
3	d d d d d d d d d d d d d d d d	**Oven temperature** at start position
4	d d d d d d d d d d d d d d d d	**Potentiometer value** at stop position
5	d d d d d d d d d d d d d d d d	**Oven temperature** at stop position
6	d d d d d d d d d d d d d d d d	**Last position of Tapping Station** read by controlling routines[OK2]
7	d d d d d d d d d d d d d d d d	**Status of SD2** (copy from BackupRAM)
8-10	d d d d d d d d d d d d d d d d	not used
11-17	d d d d d d d d d d d d d d d d	**TPST configuration data** (copy from CSIB)
18-23	d d d d d d d d d d d d d d d d	not used
24-47	d d d d d d d d d d d d d d d d	**copy of COSAC BackupRAM data**

Notes: The SW is configured to issue this report by default.

Memory Dump: (0x0009)

Function: To hold header information for memory dumps

Format

Word	Content	
	F E D C B A 9 8 7 6 5 4 3 2 1 0	
0	0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1	Packet ID = 0x0009
1	x x x x x x x x x x x x x x x x	Sequence Counter
2		**Memory selector**
	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	not selected
	0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1	Mass Memory
	0 0 0 0 0 0 0 0 1 1 1 1 0 0 0 0	GC Memory
	0 0 0 0 1 1 1 1 0 0 0 0 0 0 0 0	MS/TDC Memory
	0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0	DPU Memory
3	d d d d d d d d d d d d d d d d	Length
4	d d d d d d d d d d d d d d d d	Address
5	d d d d d d d d d d d d d d d d	Page
6	d d d d d d d d d d d d d d d d	Address

Notes: -

Raw packet: (`0x000a`)

Function: To hold raw data during memory dumps

Format

Word	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0	Content
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	Packet ID = 0x000a
1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Sequence Counter
2-127	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	Data

Notes: -

CSIB Dump: (`0x000b`)

Function: To hold a copy of the CSIB (configuration data for Tapping Station, GC & MS)

Format

Word	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0	Content
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	Packet ID = 0x000b
1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Sequence Counter
2	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	**Length of CSIB** in words
3																	**TPST: Direct controlling**
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	disabled
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	enabled
4																	**TPST: Position information**
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	LUT
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Value
5																	**TPST: Position ID**
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Open
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	Contacts closed
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	Main Terminal closed
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	Side Terminal closed
	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	Upper position
	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	Lower position
5	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	**TPST: Position value** potentiometer value
6																	**TPST: Direction**
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	CS1.D7 = 0
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	CS1.D7 = 1
7	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	**TPST: Time to drive** (sec)
8																	**TPST: Start calibration**
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	False
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	True
9-31	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	**TPST: reserved**

32	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	**MS: HK sweeping** disabled enabled
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**MS: continue flag** (not supported)
34	0	0	0	0	0	0	0	0	0	0	0	0	0	d	d	d	**MS: Cathode** number to be selected
35	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	**MS: Emission current**
36	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	**MS: Detector voltage**
37	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	**MS: Resolution**
38	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	**MS: Frequency**
39	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	**MS: Emission current**
40	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	**MS: Run calibration** False True
41	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	**MS: Sniffing mode** disabled enabled
42-61	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	**MS: reserved**
62	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	**GC: HK sweeping** disabled enabled
63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**GC: continue flag** (not supported)
64	0	0	0	0	0	0	0	0	0	0	0	d	d	d	d	d	**GC: Duration of measure-ment**
65	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	**GC: Helium tank selected** Tank 1 Tank 2
65	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	**GC: Duration of injection** (msec)
66	0 0 0	0 0 0	0 0 0	0 0 0	0 0 1	0 0 1	0 0 1	0 0 1	0 1 0	0 1 0	0 1 0	0 1 0	1 0 0	1 0 0	1 0 0	1 0 0	**GC: Sample** Calibration gas Oven Tenax
67	0 0 0 d	0 0 0 d	0 0 0 d	0 0 0 d	0 0 d 0	0 0 d 0	0 0 d 0	0 0 d 0	0 d 0 0	0 d 0 0	0 d 0 0	0 d 0 0	d 0 0 0	d 0 0 0	d 0 0 0	d 0 0 0	**GC: Column selection** Column #1 (0 ≤ x ≤ 7) Column #2 (0 ≤ x ≤ 7) Column #3 (0 ≤ x ≤ 7) Column #4 (0 ≤ x ≤ 7)
68	0	0	0	0	0	0	0	0	d	d	d	d	d	d	d	d	**GC: Column head pressure**
69-90	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	**GC: reserved**

Notes: -

Execution report: (`0x000c`)

Function: To hold a TC Execution Report

Format

Word	Content																
	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	Packet ID = 0x000c
1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Sequence Counter
2-3	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	LOBT Start of execution
4-5	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	LOBT End of execution
6-7	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	Execution time, (31,25 msec/cnt)
8	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	Counter of already executed TCs
9	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	gcSTAC.RESULT, -1 = successful
10-14	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	not used
15	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	SSADR : Subsystem Address T/R : Transmit/Receive bit ACTC: Action Code/Subaddress WRDC: Word Count
16-47	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	Copy of TC

Notes: The SW is configured to issue this packet after having executed any TC. This default behavior can by overwritten by setting the corresponding bit in the identifier word of any TC.

Science Data Stream

The flight software multiplexes different sets of information into a single science data stream, which then is formatted into records and sent to the CDMS. A unique tag identifies individual fields inside the data stream, allowing particular fields to be present or absent.

Unless otherwise stated, all information is transferred in 16-bit words (notation: $[value]_{16}$), MSB first.

Currently the following tags are defined:

TAG: **CSIB_CFG_ID** (0x4344 - ´CD´)
Description: Configuration data section of CSIB
Field length: fixed, 90 (0x5a) words
Format: $[CSIB\_CFG\_ID]_{16}$ $[length]_{16}$ $[CSIB]_{16}${length}
Reference: struct CSIB_CFG, page 40

TAG: **CSIB_PAR_ID** (0x5044 - ´PD´)
Description: Parameter data section of CSIB
Field length: fixed, 55 (0x37) words
Format: $[CSIB\_PAR\_ID]_{16}$ $[length]_{16}$ $[data]_{16}${length}
Reference: struct CSIB_PAR, page 40

TAG: **HK_ID** (0x484B - ´HK´)
Description: Copy of internal HK buffer
Field length: fixed, 106 (0x6A) words
Format: $[HK\_ID]_{16}$ $[length]_{16}$ $[data]_{16}${length}
Reference: struct COSACHK, page 38

TAG: **TC_ID** (0x5443 - ´TC´)
Description: Copy of TC initiating the measurement
Field length: variable, $3 \leq length \leq 32$ words
Format: $[TC\_ID]_{16}$ $[length]_{16}$ $[data]_{16}${length}
Reference: see section ‘Cosac Command Set’

TAG: **TIME_ID** (0x5449 - ´TI´)
Description: Lander Onboard Time
Field length: fixed, 2 (0x02) words
Format: $[TIME\_ID]_{16}$ $[High(LOBT)]_{16}$ $[Low(LOBT)]_{16}$

TAG: **ADC_MS_ID** (0x414D - ´AM´)
Description: Analog MS housekeeping values
signed 16-bit values, channel 0 to 15 (ms_adc)
Field length: fixed, 16 (0x10) words
Format: $[ADC\_MS\_ID]_{16}$ $[ms\_adc(0)]_{16}$ $[ms\_adc(1)]_{16}$ ... $[ms\_adc(15)]_{16}$
Reference: struct HK_MS, page 37

TAG: **ADC_GC_ID** (0x4147 - ´AG´)
Description: Analog GC housekeeping values
signed 16-bit values, channel 0 to 15 (gc_adc)
Field length: fixed, 16 (0x10) words
Format: $[ADC\_GC\_ID]_{16}$ $[gc\_adc(0)]_{16}$ $[gc\_adc(1)]_{16}$ ... $[gc\_adc(15)]_{16}$
Reference: struct HK_GC, page 37

TAG: **GC_ID** (0x4743 - ´GC´)
Description: GC science data, 12-bit unsigned values, column multiplexed

Field length: variable, length follows tag
Format: $[GC\_ID]_{16}$ $[length]_{16}$ $[Low(LOBT)]_{16}$ $[High(LOBT)]_{16}$
($[[col_a]_{16}[col_b]_{16}[col_c]_{16}[col_d]_{16}](t_n)$ $[[col_A]_{16}[col_B]_{16}[col_C]_{16}[col_D]_{16}](t_n)){(length-2)/8}$
Two sets of four 16-bit words each, where $col_K = h * col_k$, $0 \le k=K \le 7$
$0 \le col_x \le 0x0fff$
time series in binary format, $\Delta t_s \approx 0{,}032768s$
Reference: The column/channel assignment is not fixed and needs to be uploaded by TC (CFGC, word 7). The column selection word is mirrored in CSIB_CFG, see CONFIGURATIONGC on page 39.

TAG: **MS_ID** (0x4D53 - ´MS´)
Description: MS science data, 16-bit unsigned values
Field length: variable, length follows tag
Format: $[MS\_ID]_{16}$ $[length]_{16}$ $[Low(LOBT)]_{16}$ $[High(LOBT)]_{16}$ $[data]_{16}${length-2}
$[data]_{16}(n) = cnt(t_n)$, $0 \le cnt_x \le 0xffff$, $0 \le n <$ length-2
time series in binary format

$$t_s = \begin{cases} 1ns, \text{ high resolution} \\ 2ns, \text{ low resolution} \end{cases}$$

Calibration: to perform a coarse mass calibration, the following formulas are provided:

$$amu \approx \left(pos \times 0.0011656 - 0.4225\right)^2$$

Equation 2 Mass calibration for high resolution spectrum

$$amu \approx \left(pos \times 0.002333 - 0.4306\right)^2$$

Equation 3 Mass calibration for low resolution spectrum

The resolution (high/low) is a parameter and needs to be uploaded prior to any MS measurement. Its current setting is mirrored in the data structure preceded by the tag **CSIB_CFG_ID** (struct CSIB_CFG, page 40).

Note:
The order in which the on-board software adds the tagged chunks of information to the science data stream shall be considered arbitrary and might change with a new SW release. This should be taken into account when designing SW parsers to decode the science data stream.

Here is an overview of the composition and order of tags for the individual science data streams generated by the current on-board software:

MS:

[TC_ID][CSIB_CFG_ID][CSIB_PAR_ID][HK_ID][ADC_MS_ID]?([TIME_ID][ADC_MS_ID]*[MS_ID]?){n}

Possible variations:

If the parameter 'HK sweeping' in TC CFMS is **not set**, no [ADC_MS_ID] will be present in the science data stream. This parameter can be found inside [CSIB_CFG_ID], for details see CONFIGURATIONMS on page 39. The structure entry HWSweeping is a simple software flag, 0x0000 representing false, 0xffff representing true.

[TC_ID][CSIB_CFG_ID][CSIB_PAR_ID][HK_ID]([TIME_ID][MS_ID]?){n}

With the parameter 'Accumulate' set in TC CFMS, [MS_ID] will be available only once at the end of the data stream. The parameter can be read from [CSIB_CFG_ID], for details see CONFIGURATIONMS on page 39. The structure entry 'Accumulate' is a software flag; 0x0000 representing false, 0xffff representing true.
[TC_ID][CSIB_CFG_ID][CSIB_PAR_ID][HK_ID][ADC_MS_ID]?([TIME_ID][ADC_MS_ID]*){n}[MS_ID]

GC:

[TC_ID][CSIB_CFG_ID][CSIB_PAR_ID][HK_ID][ADC_GC_ID]*([ADC_GC_ID]*[GC_ID]?){n}

Note:
The time-stamp must be read from the [GC_ID] directly, since [TIME_ID] is missing from the GC data stream.

Possible variations:
If the parameter 'HK sweeping' in TC CFGC is **not set**, no [ADC_GC_ID] will be present in the science data stream. This parameter is stored in [CSIB_CFG_ID], see CONFIGURATIONGC on page 39. The structure entry 'HWSweeping' is a software flag; 0x0000 representing false, 0xffff representing true.
[TC_ID][CSIB_CFG_ID][CSIB_PAR_ID][HK_ID]([GC_ID]?){n}

GCMS:

[TC_ID][CSIB_CFG_ID][CSIB_PAR_ID][HK_ID][ADC_GC_ID]*[ADC_MS_ID]?
([ADC_GC_ID][TIME_ID][ADC_MS_ID]*[MS_ID]){k}[GC_ID]

Possible variations:
If the parameter 'HK sweeping' in TC CFMS and TC CFGC is **not set** the science data stream will look like this:
[TC_ID][CSIB_CFG_ID][CSIB_PAR_ID][HK_ID]([ADC_GC_ID][TIME_ID][MS_ID]){k}[GC_ID]

If the parameter 'HK sweeping' is **set** in TC CFMS and **cleared** in TC CFGC the science data stream will look like this:
[TC_ID][CSIB_CFG_ID][CSIB_PAR_ID][HK_ID][ADC_MS_ID]
([ADC_GC_ID][TIME_ID][ADC_MS_ID]*[MS_ID]){k}[GC_ID]

If the parameter 'HK sweeping' is **cleared** in TC CFMS but **set** in TC CFGC the science data stream will look like this:
[TC_ID][CSIB_CFG_ID][CSIB_PAR_ID][HK_ID][ADC_GC_ID]*
([ADC_GC_ID][TIME_ID][MS_ID]){k}[GC_ID]

$0 < k \leq 0xffff$, where k represents the number of MS spectra measured while the complete GC measurement took place. Unfortunately, the value of k depends on several parameters and can not simply be read from the data stream. Software should parse the stream until the [GC_ID] has been reached.

For all of the above:
$0 < n \leq 0xffff$, where n represents the value of the parameter 'Number of cycles' in TC STAC, mirrored in [TC_ID].

A science data stream can be interrupted and therefore will be incomplete, if the measurement is stopped due to internal error checking by the on-board software! If this is the case, the TM packet 'System message' will be issued providing further information.

+ : The plus sign indicates that the preceding tag must be present at least once.

* : The asterisk indicates that the preceding tag may be present zero, one, or more times.

? : The question mark indicates that the preceding tag may be present at most once.

{i} : The preceding tag is repeated i times.

Example:
In Figure 1 the user data words of the first two packets of a COSAC science data stream are shown. (See the description for the science data wrapper structure on page 16.)

Following the internal packet identifier and sequence counter is the first tag: 0x4344, CSIB_CFG_ID. This tag identifies the start of the first field of this data stream, having a total field length of 90 words (0x50), in which a copy of the CSIB is stored (see page 33).

The next field starts with the identifier ADC_MS_ID (0x414d) and holds the data captured by the ADC on the MS board. Values in here are stored in ascending order; corresponding to the ADC channel number they were acquired with (0…15) during initialisation of this measurement. This field is repeated 6 more times followed by the next field's identifier (MS_ID (0x4d53)) and length in words (502 (0x1f6)). The following two values are used to store the LOBT (Lander On Board Time), the time when the measurement was taken. Low word first, followed by the middle word. The remaining 500 16-bit values, not completely shown in this example, hold the science data measured by the MS.

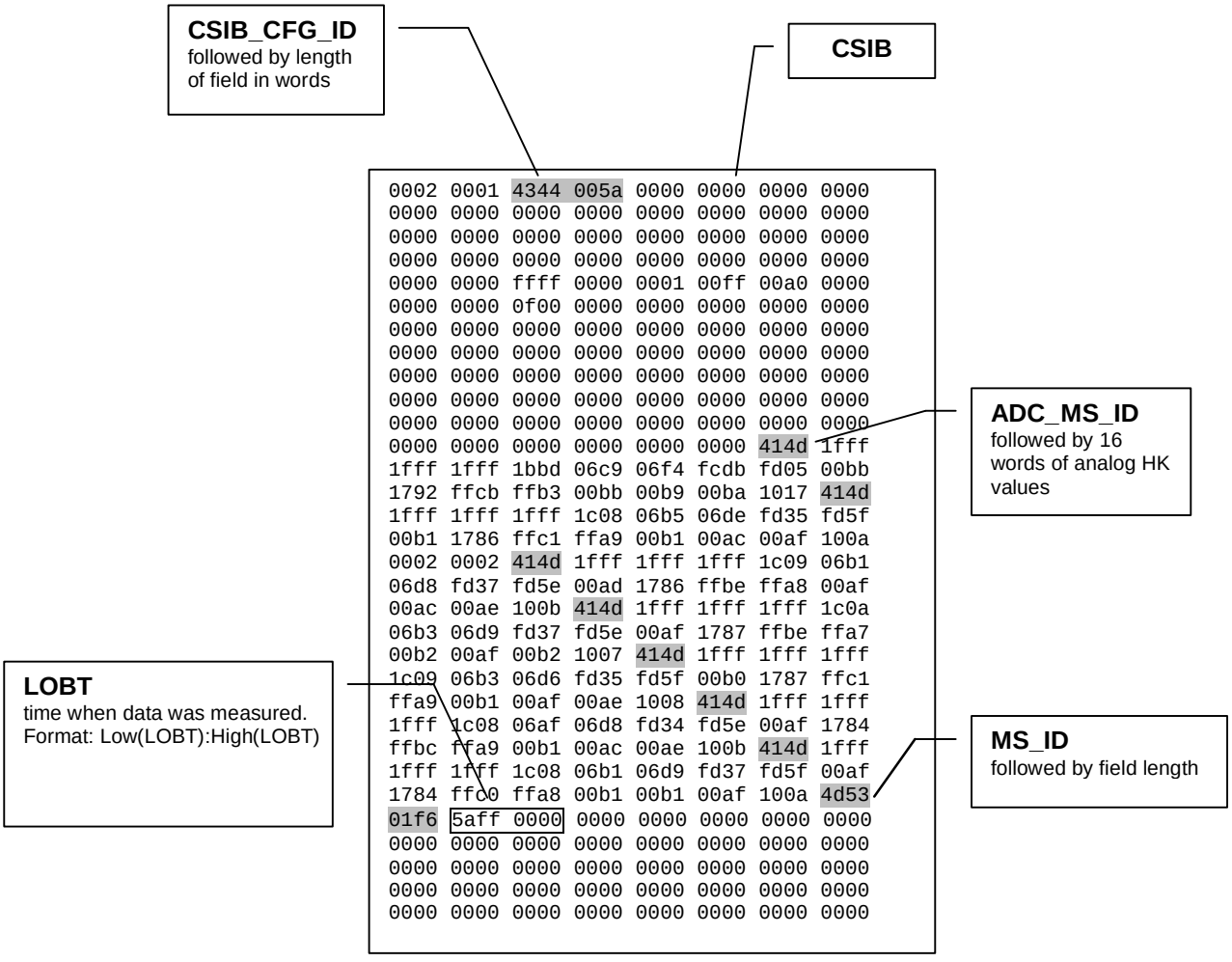


Figure 1: Tagged stream structure example

Interaction with Lander units

The CDMS onboard the Rosetta Lander supports the interaction of units by providing a special service called Backup-RAM. This memory area is located inside the CDMS memory and is spilt into sections of different sizes. The internal memory layout of these areas is up to the units, CDMS provides an interface for the units to gain to the information stored inside. There are even a few data access restrictions added to this mechanism: units have full access to their corresponding memory area, but may only read other unit's data.

COSAC Backup-RAM allocation and initialization deadlock

In the current flight software version SD2 is the only unit COSAC is exchanging status information with: SD2 checks the status of the Tapping Station to be 'open' before trying to drive its carousel, COSAC in return reads the status of the SD2 carousel before performing any Tapping Station positioning and updates it accordingly after having performed it.

Table 3 shows the Backup-RAM map and values used in the current COSAC FM software. Only the first five words of the allocated memory area are used to store values in. The first word holds the status information for the Tapping Station, the second word just mirrors the value read from the Backup-RAM of SD2 and is currently not used by COSAC. The third word is a copy of the last value read from the Tapping Station potentiometer updated by varies controlling routines. Word 3 & 4 hold the Lander Onboard time (LOBT) when the backup RAM data was formatted and transferred to CDMS. Information stored in the remaining memory places is undocumented and should not be used by other instruments!

Word	**0**	**1**	**2**	**3-4**
Description	Tapping Station Status	Carousel Position set point	Tapping Station Position	Lander Onboard Time (LOBT)
Value(s)	`0x0000` = BUSY `0xffff` = OPEN `0xaaaa` = CLOSED	Read from SD2 Backup-RAM, varies	Last value read from Tapping Station potentiometer, varies	LOBT with 1/32 sec resolution, see CDMS DDD for details.

Table 3 Backup-RAM allocation and value declaration

The mechanism described above offers a nice way to prevent the units from taking any damage during unwanted parallel operations, but produces a deadlock at initialization time:
COSAC will never drive the Tapping Station without reading 'SD2 Ready' in word 0 of SD2's Backup-RAM and SD2 will never start to turn its carousel without finding COSAC's Tapping Station status to be set to 'TPST.OPEN'. In order to update this status information, COSAC needs to perform a so-called 'Tapping Station Calibration', but will never run this routine automatically at boot time without reading 'ready' from SD2. What we have here is a nice little deadlock situation…

To get around this problem, it's necessary to manually initialize/modify 'the other unit's' status information. Inspecting a HK telemetry packet, in which the current position of the Tapping Station is contained, can easily do this. After having successfully compared this value to the preprogrammed 'open position', it can be decided to manually set the Tapping Station status to 'TPST.OPEN' using CDMS commands to write into word 0 of the COSAC Backup-RAM area.

Situations in which COSAC changes the Tapping Station status

In this chapter we will have a closer look at when the information in the Backup-RAM area is changed programmatically and what kind of transitions are performed.

Calibrating the Tapping Station

The interface to control the Tapping Station is quite simple as there are only two parameters available: time and direction. The motor direction can be switched from clockwise to counter-clockwise and the time

allows keeping the motor running for a specified duration to have it reach a desired position, which can be read from the laser-calibrated potentiometer. The only difficulty is that these positions aren't unique and one cannot rely on the motor directions to be the same after having crossed either the lower or upper turning point of the oven-closure mechanism.
To compensate for this problem the controlling software can be commanded to run the so-called 'Calibration of the Tapping Station', during which the current direction of the motor will be synchronized with the desired up/down direction of the oven-closure mechanism.

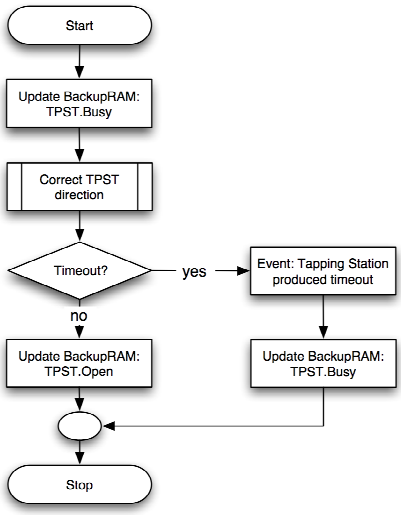


Figure 2 Calibrating the Tapping Station

At the beginning of this procedure, which can be initiated by TC, the software sets the Backup-RAM status information to 'TPST.BUSY' in order to prevent SD2 from turning the carousel. This value will be written into the Backup-RAM whenever the Tapping Station is being operated or has stopped in an undefined state.
Once the calibration has been performed, the software will check if a timeout occurred during this operation and if so, will issue the event 'Tapping Station produced timeout' to signal the failure to the operator. The Backup-RAM status information will remain to be set to 'TPST.BUSY'. If the calibration has been performed successfully (the timeout did not occur), it will be changed to 'TPST.OPEN' instead.

This calibration is initiated automatically after booting the software (1 min after unit switch-on or by TC), the Tapping Station will be in 'open position' once it has been successfully performed (without timeout). If, for whatever reasons, the software crashes during a science cycle with the Tapping Station closed, it is enough to power-cycle the unit in order to have it automatically opened again.

This calibration can be initiated manually by sending the corresponding TC, CFTS, with parameter 7 set to TRUE (see page 12).

Driving the Tapping Station

The flow chart displayed in Figure 3 shows the operational sequence with respect to changes made to the Backup-RAM.

Before performing any movement of the Tapping Station, the software will acquire the current SD2 carousel status and will stop the sequence immediately if this is found to be different from the expected value, 'SD2.READY' (0xf000). In this case, the low-level routines will issue the event packet: Packet ID: 0x07, Event ID: 0x07. If the carousel status value equals 'SD2.READY', SD2 signals that the Tapping Station is free to be positioned, so the next step for the COSAC SW is to set its status to 'TPST.BUSY' to prevent SD2 from turning the carousel while the Tapping Station is being operated. If the positioning failed with a time-out, it will be signalled by the generation of an event packet: Packet ID: 0x07, Event ID: 0x0a and the status will remain set to 'TPST.BUSY'. In case of a successful positioning, this value will be changed to either 'TPST.OPEN' or 'TPST.CLOSED', depending on the actual position measured.

Driving the Tapping Station can be initiated by TC (see CFTS, page 12), where the position is given either as the potentiometer value or as an index to a predefined value stored inside the flight software.

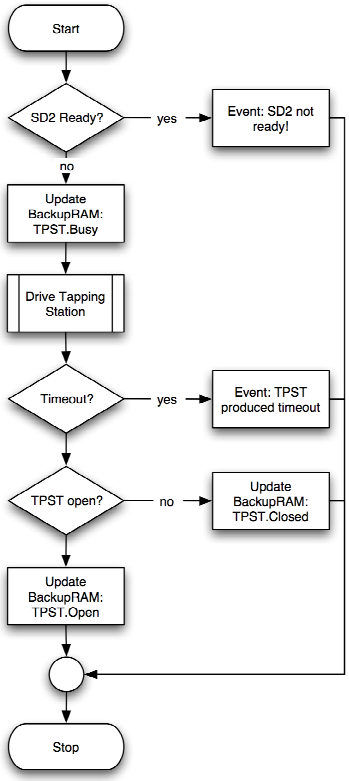


Figure 3 Driving the Tapping Station

Operational hint: The software is configured to issue a so-called 'Tapping Station Report' (see page 23), in which the potentiometer value and oven temperature, read before and after the positioning, are stored, along with a copy of the unit's BackupRAM content.

Testing the Tapping Station

The sequence shown in Figure 4 was implemented to allow the operator to perform a test of the Tapping Station, in which the motor is driven a given time and samples are taken from the potentiometer and the oven temperature at predefined intervals.

At sequence start, the software checks the status of SD2 to be 'SD2.READY'. If this is not the case, the software will issue the even packet: Packet ID: 0x07, Event ID: 0x07 and stop the sequence without moving the Tapping Station.
If the status is found to be as expected, the Backup-RAM will be set to 'TPST.BUSY' and for exactly 60 seconds the motor of the Tapping Station will be switch on. During this time the software samples the potentiometer value and the oven temperature with a frequency of 0,5 Hz to downlink them in a TM packet (see page 21) as a result of this test.

Once the test has been performed, the position of the Tapping Station is undefined and SD2 should not be granted access to the carousel! To prevent the carousel from turning the status information in the Backup-RAM remains 'TPST.BUSY'! The operator needs to manually issue the Tapping Station Calibration command in order to have it positioned in the 'open' situation.

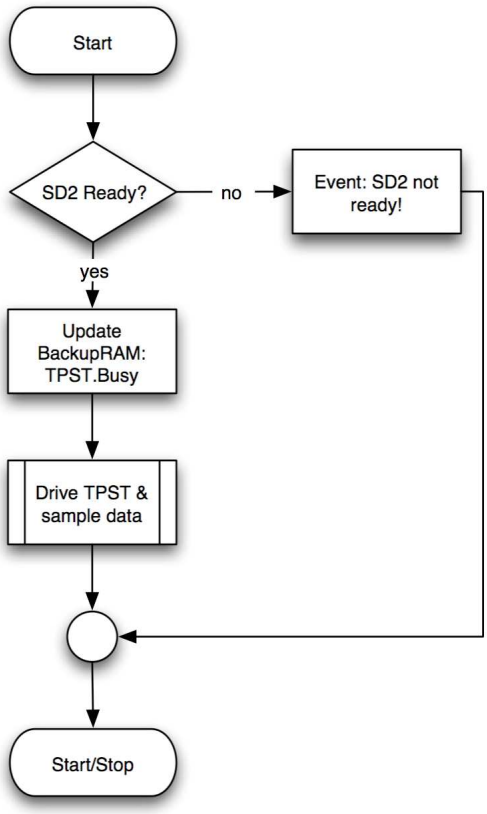


Figure 4 Testing the Tapping Station

Operational hint: The data returned in TM packet ID 6 starting at offset 67 (see page 21) can be used to update the predefined position values stored in the flight software, if the characteristic of the potentiometer changes during on-comet operations. The minimum and maximum position of the Tapping Station can be taken from the data array directly; the oven temperature values can be used to track down the remaining ones. This test needs to be run twice if both ovens shall be taken into account (see TC STST, parameter 14, page 5).

Testing the Oven

The flow chart in Figure 5 on page 36 shows the sequence used during a user initiated operation called 'Oven Test'. This simple test can be started by sending the TC STST (see page 5).

Before starting the procedure, the status of the carousel is read from the SD2 Backup-RAM. If this value is different from 'SD2.READY' the sequence returns immediately after having issued the event packet: Packet ID: 0x07, Event ID: 0x07, otherwise the Tapping Station status will be set to 'TPST.BUSY' to prevent SD2 from turning the carousel. Depending on the setting in TC STST, parameter 14, page 5) the software will drive the Tapping Station to contact the selected oven. If no time-out occurred during Tapping Station positioning, the oven will be heated for 10 seconds and its temperature measured before and after this process, followed by driving the Tapping Station into the 'open' state. On time-out the corresponding event will be issued, otherwise the position of the Tapping Station will be checked to be 'open'. If this is the case, the Backup-RAM will be set to 'TPST.Open'. If, for some reason, the position differs from 'open', the status will remain unchanged ('TPST.BUSY).

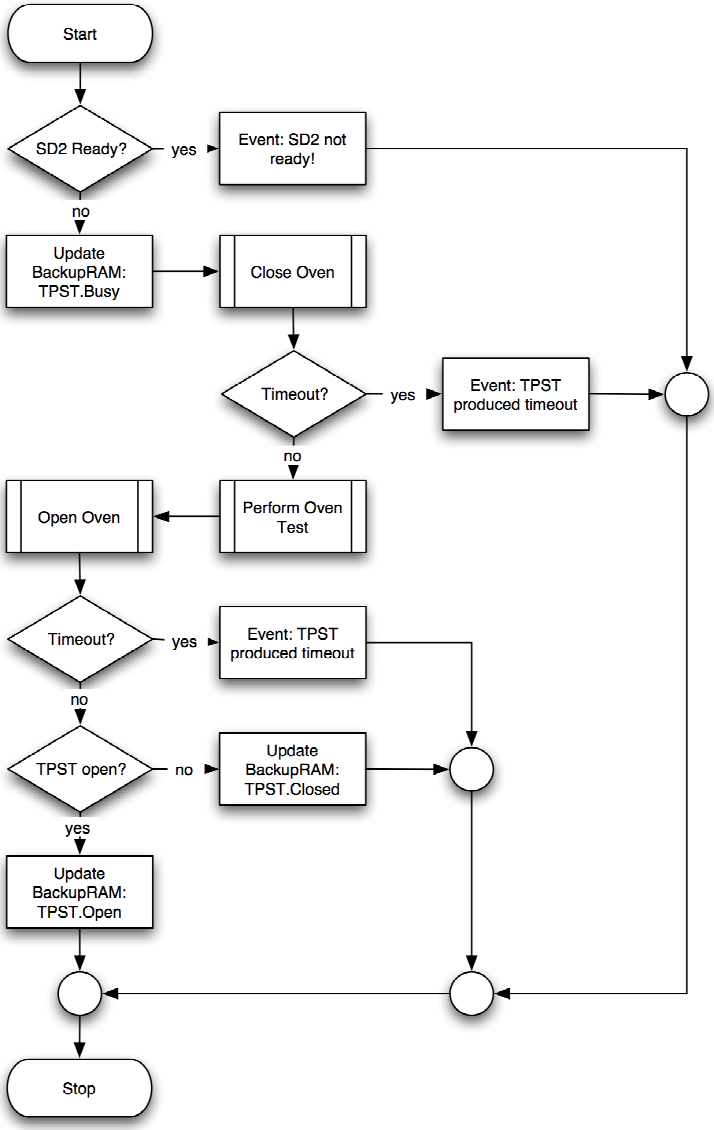


Figure 5 Testing the Oven

CSIB & HK data structures

The CSIB (Cosac Status & Information Buffer) is a memory area used by the controlling software to store permanent and volatile settings. The buffer itself will be copied from EEPROM into RAM at flight software boot time. Updates to the different sections inside the CSIB (both in EEPROM & RAM) can be done via TC (see chapter: Cosac Command Set, on page 2).

The standard C programming language was used to describe the structures of the CSIB and the HK data sets. Values used inside these structures are limited to 16-bit integer types.

```
typedef struct HK_DPU {
    short         IDPU,
                  Ip5V,
                  Im5V,
                  Ip12V,
                  Im12V,
                  SystemPwr,
                  Channel_MS,
                  Channel_GC,
                  Channel08,
                  Channel09,
                  Channel10,
                  Channel11,
                  Channel12,
                  Channel13,
                  Channel14,
                  Channel15;
}HK_DPU;

typedef struct HK_GC {
    short         PHKTank1,
                  PHKTank2,
                  PIonSourceMS,
                  TempGCBoard2,
                  TempTenax,
                  SecPresHE,
                  Channel06,
                  ValveVoltage,
                  TempCol1,
                  TempCol2,
                  TempCol3,
                  TempCol4,
                  TempCol5,
                  TempCol6,
                  TempCol7,
                  TempCol8;
}HK_GC;

typedef struct HK_MS {
    short         TempPipeA,
                  TempPipeB,
                  TempOven,
                  TempMSEBox,
                  PressCalGas,
                  PosTPST,
                  Channel06,
                  Channel07,
                  EmiCurrent,
                  MSHV1,
                  MSHV2,
                  MSHV3,
                  MSHV4,
                  MSHV5,
```

```
                MSHV6,
                MSHV7;
}HK_MS;

typedef struct HK_SW {
    unsigned short      SSIFRecCnt,
                        SSIFTransCnt,
                        SSIFStatCnt,
                        TCCnt,
                        SSIFRercCnt,
                        SSIFErrCode,
                        LOBTHigh,
                        LOBTLow,
                        BackRamPrt,
                        PresHe,
                        MSCycles,
                        GCCycles,
                        SysStat2,
                        SysStat1,
                        ErrMsg,
                        TPSTLastPos;
}HK_SW;


typedef struct COSACHK {
    HK_DPU        DPU;
    HK_GC         GC;
    HK_MS         MS;
    HK_SW         SW;
}COSACHK;


typedef struct TPSTPAR {
    unsigned short  Open,
                    ContactsClosed,
                    MainTerminalClosed,
                    SideTerminalClosed,
                    Upper,
                    Lower;
}TPSTPAR;

typedef struct TPSTCONTROL {
    unsigned short  BackupRAM,
                    IgnoreSD2Status,
                    TimeoutValue,
                    AutoCal;
}TPSTCONTROL;

typedef struct OVENPARAMETER {
    unsigned short      Temperature[8],
                        HeatingCycles,
                        HeatingDecay,
                        HeatingTime,
                        HeatingTime[5];
}OVENPARAMETER;

typedef struct TPSTPARAMETER {                  // see TC - UDPT, page 7)
    TPSTPAR         TPSTPosition;
    TPSTCONTROL     TPSTControl;
```

```
}TPSTPARAMETER;

typedef struct DEVICEPARAMETERTABLE {
    TPSTPARAMETER   TPST;
    OVENPARAMETER   Oven;
    unsigned short  stuffing;
}DEVICEPARAMETERTABLE;

typedef struct PARAMETERMS {                    // see TC - UPPT, page 9)
    unsigned short  Duration,
                    UseAutoCalibrationValues,
                    PressureCal,
                    Mode,
                    Timeout,
                    GasFlowDelay,
                    U[4],
                    T[6],
                    DetectorStartDelay,
                    WordsToCopy;
}PARAMETERMS;

typedef struct PARAMETERGC {                    // see TC - UPPT, page 9)
    unsigned short  ColumnTemp[8],
                    WordsToCopy,
                    TimeToHeatTenax;
}PARAMETERGC;

typedef struct CONFIGURATIONTPST {              // see TC - CFTS, page 12)
    unsigned short  DirectControlling,          // Flag; True/False
                    UsePositionInformation,     // Flag; True/False
                    PositionID,
                    PositionValue,
                    Direction,
                    TimeToDrive,
                    StartCalibration,
                    stuffing[23];
}CONFIGURATIONTPST;

typedef struct CONFIGURATIONMS {                // see TC - CFMS, page 8)
    unsigned short  HKSweeping,                 // Flag; True/False
                    Accumulate,                 // Flag; True/False
                    Cathode,
                    EmissionCurrent,
                    DetectorVoltage,
                    Resolution,
                    Frequency,
                    RunCalibration,
                    SniffingMode,
                    stuffing[21];
}CONFIGURATIONMS;

typedef struct CONFIGURATIONGC {                // see TC - CFGC, page 6)
    unsigned short  HKSweeping,                 // Flag; True/False
                    Continue,
                    DurationMeasurement,
                    Helium,
                    DurationInjection,
                    SampleSource,
                    ColumnSelect,
```

```
                    ColumnHeadPressure,
                    stuffing[22];
}CONFIGURATIONGC;


typedef struct MISC {                           // see TC - SUCG, page 13)
    unsigned short  PWROFFOverwrite,
                    OverwriteG3;
}MISC;

typedef struct CSIB_CFG {
    CONFIGURATIONTPST       TPSTConfiguration;
    CONFIGURATIONMS         MS;
    CONFIGURATIONGC         GC;
}CSIB_CFG;

typedef struct CSIB_PAR {
    DEVICEPARAMETERTABLE    Devices;
    PARAMETERMS             MS;
    PARAMETERGC             GC;
}CSIB_PAR;

typedef struct CSIB {
    CSIB_PAR                Parameter
    CSIB_CFG                Configuration;
    MISC                    Misc;
}CSIB;
```

COSAC Housekeeping

COSAC SW collects an overall of 106 housekeeping data words (16 bit). 64 of these are sent to CDMS during the periodical housekeeping collection (2 sec, word-by-word mode).
The remaining 42 values are used internally and are added to the science data stream. A dump of the complete HK-set can be commanded by sending TC GIHK.

HK collection notes:

The 64 values are split into 2 groups, analog and digital HK values. The digital information is stored in the last 16 words; the analog values reside in the first 48 positions, which again can be split up, this time in 3 blocks of 16 values each. The first block (word 0-15) holds the values for the 16 channels read directly by switching through the MUX channels onboard the C-DPU. The next block of 16 values (word 16-31) represents the data read from the individual channels of the MUX on the GC board, followed by the data (word 32-48) acquired from the 16 channel MUX located on the MS board. The output signals of these two multiplexers are routed directly to the input channels 5 and 6 of the DPU MUX.
To read channel 2 of the MS MUX, the SW controls the DPU MUX to channel 6 and commands the MS MUX to switch its signal to input channel 2. In order to read channel 3 of the GC MUX, the SW sets the DPU MUX to channel 5 and commands the GC MUX to use channel 3.

It is important to understand, that without powering up the individual boards of the experiment, the SW will not be able to read meaningful values from the 'second row' multiplexers. This means that during operation of the experiment, the regular HK packets can contain 'meaningless' HK values, as long as the respective boards aren't powered. Luckily this concerns the GC MUX only, since the MS MUX is 'always-on'.

Although the individual HK values are acquired by CDMS at periodical intervals, the on-board SW converts all 48 analog values in one sweep, whenever the HK frame counter received from CDMS has reached 64. To prevent problems during experiment operation, this mechanism is disabled for the duration of a commanded measurement and will be automatically enabled when the on-board SW switches back into idle mode. The flag 'HK auto collection' in word 60 signals the current status.
By issuing TC GIHK with the only parameter set to 'true', the SW will enable the power switches 1 & 2 before sweeping through all 48 analog HK channels. To initialize the first HK packet, the SW is programmed to perform this action at boot time automatically.

Table shows HK values delivered to CDMS:

Unit	relative Index	Format Count	HK Value
			F E D C B A 9 8 7 6 5 4 3 2 1 0
DPU	0	0	d d d d d d d d d d d d d d d d CURRENT +5V LINE (183 µA/CNT)
	1	1	d d d d d d d d d d d d d d d d CURRENT -5V LINE (18,3 µA/CNT)
	2	2	d d d d d d d d d d d d d d d d CURRENT +12V LINE (91,5 µA/CNT)
	3	3	d d d d d d d d d d d d d d d d CURRENT -12V LINE (18,3 µA/CNT)
	4	4	d d d d d d d d d d d d d d d d SYSTEM POWER (1,46 MW/CNT)
	5	5	d d d d d d d d d d d d d d d d GC ADC INPUT
	6	6	d d d d d d d d d d d d d d d d MS ADC INPUT
	7	7	d d d d d d d d d d d d d d d d DPU MUX CHANNEL 7
	8	8	d d d d d d d d d d d d d d d d DPU MUX CHANNEL 8

	9	9	d d d d d d d d d d d d d d d d	DPU MUX CHANNEL 9
	10	10	d d d d d d d d d d d d d d d d	DPU MUX CHANNEL 10
	11	11	d d d d d d d d d d d d d d d d	DPU MUX CHANNEL 11
	12	12	d d d d d d d d d d d d d d d d	DPU MUX CHANNEL 12
	13	13	d d d d d d d d d d d d d d d d	DPU MUX CHANNEL 13
	14	14	d d d d d d d d d d d d d d d d	DPU MUX CHANNEL 14
	15	15	d d d d d d d d d d d d d d d d	VOLTAGE DPU (732 µV/CNT)
GC	0	16	d d d d d d d d d d d d d d d d	Pressure He Tank 1 (16 mbar/cnt, relative)
	1	17	d d d d d d d d d d d d d d d d	Pressure He Tank 2 (16 mbar/cnt, relative)
	2	18	d d d d d d d d d d d d d d d d	Pressure Ion Source MS, call for details! ☺
	3	19	d d d d d d d d d d d d d d d d	Temperature GC-Board2 (0,04K/cnt)
	4	20	d d d d d d d d d d d d d d d d	Temperature Tenax (0,028°C/cnt)
	5	21	d d d d d d d d d d d d d d d d	Secondary pressure HE (0,2 mBar/cnt)
	6	22	d d d d d d d d d d d d d d d d	unused
	7	23	d d d d d d d d d d d d d d d d	Voltage valve unit (45 mV/vnt)
	8	24	d d d d d d d d d d d d d d d d	Temperature Column 1 (0,014°C/cnt)
	9	25	d d d d d d d d d d d d d d d d	Temperature Column 2 (0,014°C/cnt)
	10	26	d d d d d d d d d d d d d d d d	Temperature Column 3 (0,014°C/cnt)
	11	27	d d d d d d d d d d d d d d d d	Temperature Column 4 (0,014°C/cnt)
	12	28	d d d d d d d d d d d d d d d d	Temperature Column 5 (0,014°C/cnt)
	13	29	d d d d d d d d d d d d d d d d	Temperature Column 6 (0,014°C/cnt)
	14	30	d d d d d d d d d d d d d d d d	Temperature Column 7 (0,014°C/cnt)
	15	31	d d d d d d d d d d d d d d d d	Temperature Column 8 (0,014°C/cnt)
MS	0	32	d d d d d d d d d d d d d d d d	Temperature Pipe a (main) (0,11K/cnt)
	1	33	d d d d d d d d d d d d d d d d	Temperature Pipe b (side) (0,11 K/cnt)
	2	34	d d d d d d d d d d d d d d d d	Temperature Oven (0,14°C/cnt, 970 cnt offset)
	3	35	d d d d d d d d d d d d d d d d	Temperature MS-EBox (0,04 K/cnt)
	4	36	d d d d d d d d d d d d d d d d	Pressure Calibration Gas, call for details
	5	37	d d d d d d d d d d d d d d d d	Position Tapping Station (Open ≥ 4500, OT ≈ 4710, UT ≈ 1330)
	6	38	d d d d d d d d d d d d d d d d	unused
	7	39	d d d d d d d d d d d d d d d d	unused
	8	40	d d d d d d d d d d d d d d d d	Emission current (7,3 nA/cnt)
	9	41	d d d d d d d d d d d d d d d d	MS HV 1, U detector (505 mV/cnt)
	10	42	d d d d d d d d d d d d d d d d	MS HV 2, U reflector2_4 (0,366 V/cnt)
	11	43	d d d d d d d d d d d d d d d d	MS HV 3, U reflector 2 (0,366 V/cnt)
	12	44	d d d d d d d d d d d d d d d d	MS HV 4, U reflector 1 (0,366 V/cnt)
	13	45	d d d d d d d d d d d d d d d d	MS HV 5, U lense 2 (0,366 V/cnt)
	14	46	d d d d d d d d d d d d d d d d	MS HV 6, U lense 1 (0,366 V/cnt)
	15	47	d d d d d d d d d d d d d d d d	MS HV 7, U G3 (0,366 V/cnt)
OS	0	48	d d d d d d d d d d d d d d d d	Counter for received CDMS messages

	1	49	d d d d d d d d d d d d d d d d	Counter for transmit CDMS messages
	2	50	d d d d d d d d d d d d d d d d	Counter for CDMS status messages
	3	51	d d d d d d d d d d d d d d d d	Counter for stored messages (TCs)
	4	52	d d d d d d d d d d d d d d d d	Counter for RERC messages
	5	53	d d d d d d d d d d d d d d d d	Last received SSIF error code
	6	54	d d d d d d d d d d d d d d d d	LOBT, high
	7	55	d d d d d d d d d d d d d d d d	LOBT, low
	8	56	d d d d d d d d d d d d d d d d	BackupRAM pointer
	9	57	d d d d d d d d d d d d d d d d	copy of Pressure HE (see above)
	10	58	d d d d d d d d d d d d d d d d	MS cycles
	11	59	d d d d d d d d d d d d d d d d	GC cycles
	12	60	d d 0 0 0 0 0 0 0 0 0 0 0 d d d	**System Status 2** **Single Shot Valve:** b01 = armed, b11 = fired **HK auto collection:** 0 = disabled, 1 = enabled **MM dump:** 0 = idle, 1 = in progress **MM auto dump:** 0 = disabled, 1 = enabled
	13	61	d d d d d d d d d d d d d d d d	**System Status 1** Configuration valid: bxx1 = TPST, bx1x = MS, b1xx = GC **Continue Flag** (not supported) **Waiting flag** (not supported) **System Mode:** b000 = idle, b001 = GC, b010 = MS, b011 = GCMS, b100 = Self test **Power Switch:** bxxx1 = pws1, bxx1x = pws2, bx1xx = pws3 (not used), b1xxx = pws4 **Mass Memory:** 0 = off, 1 = on **EEPROM Timestamp:** 0 = okay, 1 **=** mismatch **TPST** direction changed: 0 = false, 1 = true **SD2** ready flag: 0 = false, 1 = true
	14	62	d d d d d d d d d d d d d d d d	Error Message
	15	63	d d d d d d d d d d d d d d d d	Last read position of TPST

Table 4 HK Values

Software Compatibility Issues:

- Parameters updated for the following TCs: STAC, SUCG, UPPT
- Sequence counter added to all TM packets: change of structure for all TM packets!
- Number of HK channels increased to 64
- New TM packet introduced: Execution Report (see page 26)
- Tapping Station report is generated by default and can not be disable
- Introduced possibility to have SW raise an OCPL request upon TC execution and EOD (end of data transmission)

Outdated HK table (SW Version 280803):

HK Format Counter	HK Value
0	pressure He tank 1
1	pressure He tank 2
2	**system power**
3	temperature cold part
4	temperature warm part
5	**position of tapping station**
6	**temperature pipe a**
7	**temperature pipe b**
8	temperature of MTO
9	temperature cold part 2
10	**valve voltage**
11	system status 1
12	system status 2
13	error message
14	COSAC system time high
15	COSAC system time low