esac

European Space Astronomy Centre
Camino bajo del Castillo, s/n
28692 Villanueva de la Canada
Madrid
Spain
T +34 91 8131 100
F +34 91 8131 139
www.esa.int

DOCUMENT

Solar Orbiter On board Inter-instrument Communication Via Services 3 and 20

Prepared by Luis Sanchez

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CHANGE RECORD

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1 INTRODUCTION

1.1 Scope

The purpose of this technical note is to document the agreements reached by the Solar Orbiter Instrument Teams, within the framework of the Science Operations Working Group, to exchange real time information on-board so the instruments can react autonomously to observed solar events and synchronize observations.

The present document will serve as reference for the Science Ground Segment in the definition of payload science operations and autonomous on-board reactions like coordinated burst mode triggering.

Instrument Teams are expected to document their usage of the mechanisms described here in their respective instrument documentation, in particular in their TM-TC ICDs, EID-Bs and Instrument User Manuals.

1.2 Documentation

1.2.1 Reference documents

[RD 01]	Solar Orbiter TM-TC and Packet Structure ICD, Issue 6. (SOL.S.ASTR.TN.00079)
[RD 02]	Solar Orbiter Instrument Data Management Overview for PIs, Issue 3. (SOL.S.ASTR.TN.00088)
[RD 03]	Solar Orbiter in-situ coordination: requirements, Issue 6 (15 March 2014).
[RD 04]	Remote Sensing Working Group Summary of RS Instruments' use of Service 20, Issue 1, Revision 0 (23 June 2014).

1.3 Acronyms

CSW	Central Software
EID-B	Experiment Interface Document, Part B
ICD	Interface Control Document
IIC	Inter-Instrument Communication
OBC	On-Board Computer
OBT	On-Board Time
SID	Structure ID
SOWG	Science Operations Working Group
TC	Telecommand
TM	Telemetry

2 OVERVIEW

Instruments do not communicate with each other directly, only with the OBC. For inter-instrument communication purposes, communication from each instrument to the OBC is implemented using Service 3 telemetry packets, and communication back from the OBC is established by the reception of Service 20 telecommand packets which carry parameter data from all the instruments participating in this scheme.

Note that Service 20 packets are also used as a OBC heartbeat to the payload instruments so that they can perform an autonomous transition to a safe state in case the spacecraft enters Survival Mode.

2.1 Packet TM(3,25) generation

Each instrument computes the parameters to be communicated from their observations (and, potentially, from information previously received from other instruments in the payload), and assembles a TM(3,25) packet that can be sent to the OBC at a previously agreed cadence. Upon reception of these packets the OBC extracts the parameters and places their values in the OBC datapool. The total maximum delay from TM(3,25) generation to parameter extraction is nominally 250ms (see [RD 02] section 5.3 on page 30).

2.2 Packet TM(3,25) structure

See [RD 01] section 5.4.13 on page 56.

The packet SpaceWire header has to have the correct information so it is routed to the OBC.

MOC requests that IIC TM(3,25) packets use CAT 5.

Note that the TM(3,25) packet generated for inter-instrument communication purposes has to have a different PID from other TM(3,25) packets sent to the OBC (e.g. for on-board instrument housekeeping monitoring). This is because the packets containing inter-instrument communication data will not be downlinked and, therefore, have to have a different routing on-board: Having a different CAT is not enough.

Note also that the IIC TM(3,25) packet contains a SID field in addition to the parameters that will be extracted by the OBC and placed into the OBC datapool. The value of the SID is not placed into the datapool and will not appear in the information that is distributed back to the instruments. The combination of PID+CAT+SID is used to identify the packet to the OBC as part of the IIC.

NOTE: Bit fields in all packet tables in this document are labelled with bit 0 as the MSB.

2.3 Packet TC(20,128) distribution

Up to 8 times per second (8 Hz), the OBC extracts all inter-instrument communications related parameters from the OBC datapool and assembles a TC(20, 128). This TC can contain 36 octets of platform data and up to 200 octets of instrument generated data.

The TC(20,128) can be sent to all instruments. The distribution of TC(20,128) to a particular instrument can be enabled or disabled using TC(20,1) and TC(20,2). Moreover, the period of TC(20,128) distribution to each instrument can be configured specifying a parameter in the TC(20,1) that enables the distribution with a minimum of 1 CSW cycle (125 ms) and a maximum of 65535 (8191 s approximately – a 2 bytes field). A value of zero would cause a one-shot distribution. The maximum delay from TC(20,128) generation to TC distribution is 250ms. The total nominal maximum delay for data distribution between the instruments is, therefore, 500ms (see [RD 02] section 5.3 on page 30).

2.4 Packet TC(20,128) structure

See [RD 01] section 5.21.3 on page 207.

3 PAYLOAD AGREEMENTS

3.1 Generation cadence

The following IIC TM(3,25) generation cadences have been agreed by the instruments (with the exception of SPICE, which currently does not have plans to participate in this inter-instrument communications mechanism:

Instrument	Generation cadence
EPD	1 Hz
MAG	8 Hz
RPW	1 Hz
SWA	0.25 Hz
EUI	1 Hz
METIS	1 Hz
PHI	1 Hz
SOLOHI	1 Hz
STIX	1 Hz
SPICE	-

3.2 Distribution cadence

The instruments have agreed on receiving TC(20,128) packets with a cadence of 1 Hz.

Instrument	Generation cadence
EPD	1 Hz
MAG	1 Hz
RPW	1 Hz
SWA	8 Hz
EUI	1 Hz
METIS	1 Hz
PHI	1 Hz
SOLOHI	1 Hz
STIX	1 Hz
SPICE	1 Hz

All instruments will receive TC(20,128) packets even if not participating in inter-instrument communications, as they also serve as OBC heartbeat (see [RD 02] section 5.3 on page 30).

3.3 Heartbeat/data validity indicator

All instruments have agreed on a common definition of an instrument-level heartbeat within the service 20 data that can be used to identify stale data. Each instrument will include, at the beginning of the IIC TM(3,25) packet data, a 4 byte parameter built copying the 4 byte OBT Coarse Time Field, which has a resolution of 1 second.

3.4 Spare fields

TC(20,128) packets can contain up to 200 octets of instrument data. The instruments have agreed on using the full capacity of TC(20,128) instrument data, allocating spare octets wherever necessary, including spare octets for SPICE which does not plan to participate in inter-instrument communications at present time.

The general principle has been to define the spares in advance, already including them as part of the IIC TM(3,25) packets data fields, so it will be possible to add new parameters later without the need of moving the location of already existing parameters. Spare parameters for SPICE will be allocated at the end of the TC(20,128) data field to provide maximum flexibility on the OBC handling of this mechanism.

NOTE: Spare bytes were allocated first to SPICE, in an amount comparable to the nominal assignment per instrument. Then the rest of the spare bytes were distributed to the instruments already making use of IIC. And last, the allocations were adjusted so SPICE does not have an assignment larger than the other instruments

Allocations were agreed during SOWG#5 and are considered final.

4 PARAMETERS REQUESTED FROM THE PLATFORM

The platform parameters that can be included as part of a TC(20,128) packet are those already present in the OBC datapool. There are 36 octets reserved in TC(20,128) for this purpose.

Byte	Bit	Field	Description
1-2	0	Thruster firing flag	1 = thruster firing expected with 5s 0 = no thruster firing
	1	Not used	Undefined
	2	Solar array steering flag	1 = solar array movement 0 = no movement
	3-15	Commandable flags	Content TBC (2 bytes)
3-6		Parameter indicating current AOCS mode	TBC NONE = 1 SASM_A = 2 SASM_B = 3 SASM_C = 4 SASM_D = 5 SASM_E = 6 SASM_H = 7 SASM_P = 8 SASM_R = 9 SASM_S = 10 WSM_E = 11 WSM_S = 12 WSM_P = 13 NCM_T = 14 NCM_G = 15 NCM_S = 16 NCM_F = 17 NCM_O = 18 NCM_D = 19 OCM_P = 20 OCM_M = 21 OCM_F = 22 OCM_T = 23 (4 bytes)
7		AOCS convergence flag	1=NCM-F performance met (1 byte Boolean)
8-11		Roll rate	Roll rate around Xsc wrt inertial frame expressed in SC frame (rad/s) (4 bytes float)
12-15		Roll angle	Roll angle component of the AOCS Estimated Attitude Quaternion: angle around Xsc wrt J2000 inertial reference frame (units TBC) (4 bytes float)
16-19		Reaction Wheel 1 speed	Rad/s (4 bytes float)
20-23		Reaction Wheel 2 speed	Rad/s (4 bytes float)
24-27		Reaction Wheel 3 speed	Rad/s (4 bytes float)
28-31		Reaction Wheel 4 speed	Rad/s (4 bytes float)

32		Validity of RW1 speed	0 = not valid 1 = valid (1 byte Boolean)
33		Validity of RW2 speed	0 = not valid 1 = valid (1 byte Boolean)
34		Validity of RW3 speed	0 = not valid 1 = valid (1 byte Boolean)
35		Validity of RW4 speed	0 = not valid 1 = valid (1 byte Boolean)
36		Spare	Undefined (1 byte)

Source: IIC Test Meeting Response to Actions 11 and 12 by ADS (Email of 23 Sep 2016)

5 SERVICE 3: IIC TM(3,25) PACKET CONTENTS

5.1 EPD

5.1.1 Content generation

EPD will provide:

- Electron flux at 40, 60, 100 and 200 keV: For every electron channel EPD will provide 256 levels of approximate flux using 8 bits for each direction (sunward and anti-sunward, north and south). This will require 32 bits per channel.
- Proton flux at 500 keV: EPD will also provide proton flux in order to evaluate the proton contamination of the electron channels. Data will have the same format: 256 levels of approximate flux using 8 bits for each direction, requiring 32 bits in total.
- A data validity indicator.
- A burst mode bit indicator for each EPD sensor, using one byte.
- A heartbeat field which will be the OBT Coarse Time Field.

The SID used for the IIC TM(3,25) packets will be 100.

5.1.2 Generation cadence

EPD will generate IIC TM(3,25) packets at 1 Hz.

5.1.3 EPD IIC TM(3,25) data field structure

PID=100
CAT=5
SID=100
Length: 30 bytes

Byte	Bit	Field	Description
1 2 3 4		Heartbeat	OBT Coarse Time Field (4 bytes)
5	0 1 2 3 4 5 6 7	Electrons Sun Electrons ASun Electrons North Electrons South Protons Sun Protons ASun Protons North Protons South	1 = data is valid (refreshed from the last second).

6 7 8 9		ElecFlux40	(4 bytes)
10 11 12 13		ElecFlux60	(4 bytes)
14 15 16 17		ElecFlux100	(4 bytes)
18 19 20 21		ElecFlux200	(4 bytes)
22 23 24 25		Prot500	(4 bytes)
26	0 1 2 3 4 5 6 7	Burst T1 Burst T2 Burst T3 Burst T4 Burst T5 Burst T6 Burst T7 SIS	Bit 0-6: Indicate the burst mode type involving EPT-HET1, EPT-HET2 and STEP. Bit 7: Indicates SIS is activated in burst mode.
27 28 29 30		Spare	Undefined

Ref: SO-EPD-PO-IF-0003, Issue 2, Rev.8

5.2 EUI

5.2.1 Content generation

EUI will provide flare detection information. It is possible that the detection parameters (e.g. thresholds) will need to be fine-tuned in flight. This could be done during the commissioning phase. However, the size of the Sun will not be representative and the instruments won't be at their nominal temperatures, which may affect the detection.

The detections will be broadcast in service 20 packets. The "ON" flag will however not be a guarantee that the corresponding data will indeed be sent to the ground. This flag means that at the time of detection the data is considered interesting by EUI and that EUI wants to have to have it telemetered down. However, the priority of image sequences can be changed manually from the ground.

5.2.2 Generation cadence

EUI will generate IIC TM(3,25) packets at 1 Hz.

5.2.3 EUI IIC TM(3,25) data field structure

PID=57
CAT=5
SID=10
Length: 23 bytes of parameters for S20 distribution

Byte	Bit	Field	Description
1 2 3 4		Heartbeat	OBT Coarse Time Field (4 bytes)
5	0-2 3 4 5 6 7	Spare FSI174/304Filter Mechanism Move FlareCloseHRI FlareDataToSOB OffLimb	Undefined 1//0 (1 bit) 1/0 (1 bit; 1=moving) 1/0 (1 bit) 1/0 (1 bit) 1/0 (1 bit; 1=off-limb)
6 7 8 9		SecondsEvent	Time of occurrence last event Coarse Time Field of OBT at detection (4 bytes)
10		FlareTrigPosX	uint (1 byte)
11		FlareTrigPosY	uint (1 byte)
12 13		Brightness	uint (2 bytes)
14 15 16 17 18 19 20 21 22 23		Spares	Undefined

5.3 MAG

5.3.1 Content generation

MAG will provide values of the magnetic field vector which will be used by RPW, EPD and SWA to determine pitch angle information and detect shocks and other transients. The quality of these vectors is unclear: it is intended that they will provided in spacecraft coordinates and a calibration matrix uploaded periodically, but real time calibration cannot be performed.

Flag bits will be monitored by other instruments (e.g. SWA) to determine whether they should enter their own burst mode.

MAG also implements an internal shock detection algorithm and produce a shock trigger similar to the one delivered by RPW. This flag may be used by RPW, MAG and EPD in case of malfunction of the RPW detection flag.

5.3.2 Generation cadence

MAG will generate IIC TM(3,25) packets at 8 Hz.

5.3.3 MAG IIC TM(3,25) data field structure

PID=65
CAT=5
SID=20
Length: 20 bytes of parameters for S20 distribution

Byte	Bit	Field	Description
1 2 3 4		Heartbeat	OBT Coarse Time Field (4 bytes, unsigned int)
5 6		Primary X component (transposed to SC axes)	62.5 pT/bit, fixed point (2 bytes, signed int)
7 8		Primary Y component (transposed to SC axes)	62.5 pT/bit, fixed point (2 bytes, signed int)
9 10		Primary Z component (transposed to SC axes)	62.5 pT/bit, fixed point (2 bytes, signed int)
11	0-1 2 3-7	MAG Primary Range Spare MAG mode of operation	0= +/-50000 nT (2 bits) 1= +/- 128 nT 2= +/-512 nT 3= +/-2048 nT Undefined (1 bit) (5 bits, unsigned int)
12	0-4 5-7	Spare MAG trigger source	Undefined (5 bits) 1=internal trigger (3 bits) 2=external trigger 4=command trigger
13-16		Last internal burst trigger start (Coarse Time)	Time of last burst mode entry as OBT Coarse Time Field (4 bytes, unsigned int)
17-18		Last internal burst trigger start (Fine Time)	Time of last burst mode entry as OBT Fine Time (2 bytes, unsigned int)
19-20		Spare	Undefined

Ref: SOL-MAG-TMTCICD, Issue 2, Revision

5.4 METIS

5.4.1 Content generation

METIS will provide information about the detection of Coronal Mass Ejections (CMEs). The METIS CME detection algorithm monitors the total intensity in eight sectors aligned the instrument (or S/C) frame of reference. METIS will run its event detection on difference images of the same polarizer position. The algorithm is similar but significantly different that the one implemented on SECCHI COR2. COR2 uses macro-pixels and total brightness images computed on-board from double exposures. As for EUI, the detection parameters will need to be fine-tuned in flight. As for the other instruments, the effect of the varying angular size of the Sun (size of FOV with respect to the solar disk size) on the detections needs to be assessed. The range of heliocentric distances selected by the FOV of METIS varies with S/C-Sun distance. This means, e.g. that when the S/C is at 0.5 AU METIS can start detecting a CME, and raise the relevant flag, a a higher heliocentric distance in the corona than at 0.28 AU. In addition, the stray-light pattern may also vary.

5.4.2 Generation cadence

METIS will generate IIC TM(3,25) packets at 1 Hz.

5.4.3 METIS IIC TM(3,25) data field structure

PID=69
CAT=5
SID=20
Length: 20 bytes of parameters for S20 distribution

Byte	Bit	Field	Description
1 2 3 4		Heartbeat	OBT Coarse Time Field (4 bytes)
5 6 7 8		Detection time	OBT Coarse Time Field at initial detection time (4 bytes)
9	0-3 4 5 6 7	Config ID UVDA_ON VLDA_ON Spare New data	4 bits (see table below) 1/0 (1: on = UV detector operative) 1/0 (1: on = VL detector operative) Undefined 1/0 (1: new data en bytes 5-20)

10	0-3 4 5 6 7	Spare UV_Flux Enabled VL_Flux Enabled SEP Flag Enabled CME Flag Enabled	Undefined 1: Sun Disk Monitoring is enabled for UV detector 1: Sun Disk Monitoring is enabled for VL detector 1: SEP detection algorithm is running 1: CME detection algorithm is running
11	0-2 3 4 5 6 7	Spare UV_Flux Event VL_Flux Event CME EXT Halo CME flag Major CME flag	Undefined 1: Sun in UV detector FOV. 1: Sun in VL detector FOV Implementation TBC (SEP storm hitting VL detector) 1: Criteria for halo CME met (see below Major CME) 1: The running difference computed by METIS in at least one sector exceeds the 'Major CME' threshold. NOTE: If METIS detects a CME, it normally changes observing mode into "CMEOBS". However there are some situations where METIS detects and event but it does not switch in the expected high cadence mode (for instance, if METIS has already reached the maximum number of observable CMEs). In these cases other instruments can continue to use METIS flag monitoring the status of this bit.
12		Time interval	Time since last evaluation of the CME flag. It indicates the temporal interval between two frame acquisitions having the same polarization used by the CME detection algorithm to compute the running differences. Seconds (1 byte)
13		Sector #1 Brightness	It provides a coarse 8-bit coded estimate of the mean brightness computed on sector #1. 0: not available (1 byte)
14		Sector #2 Brightness	(1 byte)
15		Sector #3 brightness	(1 byte)
16		Sector #4 brightness	(1 byte)
17		Sector #5 brightness	(1 byte)
18		Sector #6 brightness	(1 byte)
19		Sector #7 brightness	(1 byte)
20		Sector #8 brightness	(1 byte)

METIS Config ID	Description
F	Not observing
0	NOMINAL
4	CMEOBS
8	VL_FP (aka FLUCTS)
9	TEMP-NOISE
10	PCU OFFSET

5.5 PHI

5.5.1 Content generation

PHI will provide two parameters containing the pointing stability obtained from the correlation functions of the PHI Image Stabilization System (ISS). PHI will generate updating content (specifically OBT Heartbeat) even if the ISS is off.

5.5.2 Generation cadence

PHI will generate IIC TM(3,25) packets at 1 Hz.

5.5.3 PHI IIC TM(3,25) data field structure

PID=74
CAT=5
SID=6
Length: 14 bytes of parameters for S20 distribution

Byte	Bit	Field	Description
1 2 3 4		Heartbeat	OBT Coarse Time Field (4 bytes)
5		Image quality flags:	
	0	ISS data valid	(1 bit)
	1	Telescope in use	(1 bit)
	2-3	ISS status	(2 bits: off, calibration, open loop, close loop)
	4	ISS out-of-bound conditions increased since last update	(1 bit)
	5-7	Spares	Undefined
6 7		The mean jitter	arcsec (2 bytes)
8 9		The RMS jitter	arcsec (2 bytes)
10 11		The maximum jitter	arcsec (2 bytes)
12 13		The minimum jitter	arcsec (2 bytes)
14		Spare	Undefined

5.6 RPW

5.6.1 Content generation

RPW will provide the spacecraft potential given by the Bias Unit, to be used by SWA; a shock trigger, “SBM1 events”, including trigger time plus quality factor: this will set to 1 during 15 minutes, starting nominally 6 minutes (configurable, max 10 minutes) after shock passage but shall be compatible with the SWA rolling buffer size. Also a Type III trigger, “SBM2 events”, including trigger time plus quality factor too. It is expected that the other in-situ instruments (EPD, MAG, SWA) will make use of the shock trigger, and MAG and EPD of the type III trigger and Langmuir waves flag.

5.6.2 Generation cadence

RPW will generate IIC TM(3,25) packets at 1 Hz. The wavefront snapshot will be updated every 300 s.

5.6.3 RPW IIC TM(3,25) data field structure

PID=81
CAT=5
SID=6
Length: 33 bytes of parameters for S20 distribution

Byte	Bit	Field	Description
1 2 3 4		Heartbeat	OBT Coarse Time Field (4 bytes, unsigned)
5	0 1 2 3 4 5 6 7	V_SC_STATUS SMB1 FLAG SMB2 FLAG1 SMB2 FLAG2 WF_SYN_STATUS SBM1 ENABLED SBM2 ENABLED LWI_STATUS	(1 bit) 1= available (1 bit) 1= shock detected (1 bit) 1= SMB2 event detected (1 bit) 1= SMB2 event confirmed (1 bit) 1= available (1 bit) 1= detection enabled (1 bit) 1= detection enabled (1 bit) 1= Langmuir wave indicator available
6 7		V_SC (Local SC potential)	(2 bytes, unsigned integer)
8 9		SBM1_QF (trigger quality factor)	(2 bytes, unsigned integer)
10 11 12 13 14 15		SBM1_TIME (trigger time)	OBT (6 bytes, CUC format)

16 17		SMB2_QF (trigger quality factor)	(2 bytes, unsigned integer)
18 19 20 21 22 23		SBM2 time (trigger time)	OBT (6 bytes, CUC format)
24 25 26 27 28 29		WF_SYN_TIME (wavefront snapshot synchro absolute time)	OBT (6 bytes, CUC format)
30 31		LWI_MAX_E (Max E field amplitude)	(2 bytes, unsigned integer)
32		LWI_MED_FREQ	(1 byte, unsigned integer)
33		LWI_NR_EVENTS	(1 byte, unsigned integer)

Ref: RPW-SYS-MEB-DPS-ICD-000211-LES, Issue 3, Rev 10

5.7 SOLOHI

5.7.1 Content generation

SOLOHI will provide information about the instrument status.

5.7.2 Generation cadence

SOLOHI will generate IIC TM(3,25) packets at 1 Hz.

5.7.3 SOLOHI IIC TM(3,25) data field structure

PID=84
CAT=5
SID=5
Length: 14 bytes of parameters for S20 distribution

Byte	Bit	Field	Description
1 2 3 4		Heartbeat	OBT Coarse Time Field (4 bytes)
5	0 1 2 3-6 7	Power-off Request Power-cycle Request Telemetry mode Spare Door Actuation Armed	(1 bit) (1 bit) (1 bit) Undefined (1 bit)

6	0-1 2 3 4 5 6 7	Door Encoders TL Detector Status TR Detector Status BR Detector Status BL Detector Status Observing Status Inter-instrument Campaign	(2 bits) (1 bit) (1 bit) (1 bit) (1 bit) (1 bit) (1 bit)
7 8		Header count	(2 bytes)
9 10 11 12 13 14		Spare	Undefined

5.8 STIX

5.8.1 Content generation

STIX will use a dedicated sub-collimator (grid) to detect flares and broadcast the corresponding information to indicate current level and location of solar activity. The location accuracy of the flare will be of the order of 1 arcminute. The flag will be updated no more frequently than once every 4 or 8 seconds TBD, an interval that can be set via TC. The latency will also be 4 or 8 seconds TBD, which can also be set via TC. However the OBT heartbeat will be updated every packet.

STIX will provide (x,y) coordinates of flare locations relative to current spacecraft pointing. A GOES-class flare size parameter will also be included, as well as a non-thermal size parameter. Positions and sizes will update in real time; size parameters below a TBD value will denote the lack of a current flare.

5.8.2 Generation cadence

STIX will generate IIC TM(3,25) packets at 1 Hz.

5.8.3 STIX IIC TM(3,25) data field structure

PID=94
CAT=5
SID=4
Length: 16 bytes of parameters for S20 distribution

Byte	Bit	Field	Description
1 2 3 4		Heartbeat	OBT Coarse Time Field (4 bytes uint)
5	0-2	Thermal flare index	0: no flare detected 1: minor event (threshold ~B1) 2: small event (threshold ~C1) 3: moderate event (threshold ~M1, attenuator activated) 4: major event (threshold ~X1, attenuator activated and high count rate)
	3-4	Non-thermal flare index	0: no significant non-thermal index 1: weak non-thermal flux detected (> ~30 photons/s/cm2) 2: significant non-thermal flux (> ~300 photons/s/cm2)
	5-6	Location status word	0: no location available 1: using previous location estimate 2: new location value
	7	Spare	Undefined (defaults to zero)
6		Z location	(1 byte signed char) Unit: arcmins. SC Z offset component of source from SC +X (equiv to –ve rotn around SC +Y)
7		Y location	(1 byte signed char) Unit: arcmins. SC Y offset component of source from SC +X (equiv to +ve rotn around SC +Z)
8 9 10 11		Flare duration	Elapsed seconds since last time flare status was zero. I.e. time since the current flare began. If there is no flare **in progress** then =0. (4 bytes uint)
12 13 14 15	0	Attenuator motion flag	1: motion in last second (4 bytes uint)
16		Spare	Undefined (1 byte)

5.9 SWA

5.9.1 Content generation

SWA will provide proton density information, solar wind velocity and flags indicating whether each of the three sensors is in burst mode or not. The density and velocity data will be used by RPW in determining its shock burst trigger. All in-situ instrument will use the RPW shock trigger. Also, the flags provided will be monitored by other instruments (e.g. MAG) to determine whether they should enter their own burst mode.

5.9.2 Generation cadence

SWA will generate IIC TM(3,25) packets at 0.25 Hz (every 4 seconds).

5.9.3 SWA IIC TM(3,25) data field structure

PID=95
CAT=5
SID=255
Length: 16 bytes of parameters for S20 distribution

Byte	Bit	Field	Description
1 2 3 4		Heartbeat	OBT Coarse Time Field (4 bytes)
5 6		PAS proton density parameter	(2 bytes)
7 8		Solar wind velocity X component	(2 bytes)
9 10		Solar wind velocity Y component	(2 bytes)
11 12		Solar wind velocity Z component	(2 bytes)
13 14 15 16		Spare	Undefined

Ref: SO-SWA-DPU_CD-IC-003, Issue 2_draft

5.10 SPICE

5.10.1 Content generation

SPICE does not have any current plans to use inter-instrument communications via this mechanism but it has defined the corresponding PID, CAT and SID in case it will use it in the future. Note that SPICE will still receive TC(20,128) packets for use as OBC heartbeat and to obtain information about the status of its feed-through door.

5.10.2 Generation cadence

SPICE does not currently plan to generate any IIC TM(3,25) packets.

5.10.3 SPICE IIC TM(3,25) data field structure

PID=88
CAT=5
SID=7
Length: 14 bytes of parameters for S20 distribution

Byte	Bit	Field	Description
1-14		Spare	Undefined

6 SERVICE 20: TC(20,128) PACKET CONTENTS

6.1 Summary of data field allocations

Element	Defined	Spares	Total
Spacecraft	31	5	36
EPD	26	4	30
EUI	21	2	23
MAG	18	2	20
METIS	18	2	20
PHI	9	5	14
RPW	33	0	33
SOLOHI	8	6	14
STIX	11	5	16
SWA	12	4	16
SPICE	0	14	14
Total			236

6.2 TC(20,128) data field overview

Byte	Field	Length
1-36	Spacecraft data	(36 bytes)
37-66	EPD	(30 bytes)
67-89	EUI	(23 bytes)
90-109	MAG	(20 bytes)
110-129	METIS	(20 bytes)
130-143	PHI	(14 bytes)
144-176	RPW	(33 bytes)
177-190	SOLOHI	(14 bytes)
191-206	STIX	(16 bytes)
207-222	SWA	(16 bytes)
223-236	SPICE	(14 bytes)

6.3 TC(20,128) data field structure

PLATFORM SECTION			
Byte	Bit	Field	Description
1-2	0 1 2 3-15	Thruster firing flag Spare Solar Array steering flag Commandable flags	1 = thruster firing expected with 5s 0 = no thruster firing Undefined 1 = solar array movement 0 = no movement Content TBC (2 bytes)
3-6		AOCS mode	Parameter indicating current AOCS mode (4 bytes)
7		AOCS convergence flag	Flag indicates performance of AOCS mode is achieved (1=NCM-F performance met)
8-11		Roll rate	Roll rate around Xsc wrt inertial frame expressed in SC frame (rad/s) (4 bytes float)
12-15		Roll angle	Roll angle component of the AOCS Estimated Attitude Quaternion: angle around Xsc wrt J2000 inertial reference frame. Units TBC (4 bytes float)
16-19		RW 1 speed	rad/s (4 bytes float)
20-23		RW 2 speed	rad/s (4 bytes float)
24-27		RW 3 speed	rad/s (4 bytes float)
28-31		RW 4 speed	rad/s (4 bytes float)
32		Validity of RW1 speed	1: valid (1 bit Boolean)
33		Validity of RW2 speed	1: valid (1 bit Boolean)
34		Validity of RW3 speed	1: valid (1 bit Boolean)
35		Validity of RW4 speed	1: valid (1 bit Boolean)
36		Spare	Undefined
EPD SECTION			
Byte	Bit	Field	Description
37-40		Heartbeat	OBT Coarse Time Field (4 bytes)
41	0 1 2 3 4 5 6 7	Electrons Sun Electrons ASun Electrons North Electrons South Protons Sun Protons ASun Protons North Protons South	1 = data is valid (refreshed from the last second).
42-45		ElecFlux40	(4 bytes)
46-49		ElecFlux60	(4 bytes)
50-53		ElecFlux100	(4 bytes)
54-57		ElecFlux200	(4 bytes)

58-61		Prot500	(4 bytes)
62	0 1 2 3 4 5 6 7	Burst T1 Burst T2 Burst T3 Burst T4 Burst T5 Burst T6 Burst T7 SIS	Bit 0-6: Indicate the burst mode type involving EPT-HET1, EPT-HET2 and STEP. Bit 7: Indicates SIS is activated in burst mode.
63-66		Spare	Undefined
EUI SECTION			
Byte	Bit	Field	Description
67-70		Heartbeat	OBT Coarse Time Field (4 bytes)
71	0-2 3 4 5 6 7	Spare FSI171/304Filter Mechanism Move FlareCloseHRI FlareDataToSOB OffLimb	Undefined 1/0 (1 bit) 1/0 (1 bit) 1: moving 1/0 (1 bit) 1/0 (1 bit) 1/0 (1 bit; 1=off-limb)
72-75		SecondsEvent	Time of occurrence last event (4 bytes; Coarse Time Field of OBT at detection)
76		FlareTrigPosX	(1 byte uint)
77		FlareTrigPosY	(1 byte uint)
78-79		Brightness	(2 bytes uint)
80-89		Spare	Undefined
MAG SECTION			
Byte	Bit	Field	Description
90-93		Heartbeat	OBT Coarse Time Field (4 bytes, unsigned int)
94-95		Primary X component (transposed to SC axes)	62.5 pT/bit, fixed point (2 bytes, signed int)
96-97		Primary Y component (transposed to SC axes)	62.5 pT/bit, fixed point (2 bytes, signed int)
98-99		Primary Z component (transposed to SC axes)	62.5 pT/bit, fixed point (2 bytes, signed int)
100	0-1 2 3-7	MAG Primary Range Spare MAG mode of operation	0= +/-50000 nT (2 bits) 1= +/- 128 nT 2= +/-512 nT 3= +/-2048 nT Undefined (1 bit) (5 bits, unsigned int)
101	0-4 5-7	Spare MAG trigger source	Undefined (5 bits) 1=internal trigger (3 bits) 2=external trigger 4=command trigger

102-105		Last internal burst trigger start (Coarse Time)	Time of last burst mode entry as OBT Coarse Time Field (4 bytes, unsigned int)
106-107		Last internal burst trigger start (Fine Time)	Time of last burst mode entry as OBT Fine Time (2 bytes, unsigned int)
108-109		Spare	Undefined
METIS SECTION			
Byte	Bit	Field	Description
110-113		Heartbeat	OBT Coarse Time Field (4 bytes)
114-117		Detection time	OBT Coarse Time Field at detection time (4 bytes)
118	0-3 4 5 6 7	Config ID UVDA_ON VLDA_ON Spare New data	4 bits (see table in METIS section) 1/0 (1: on) 1/0 (1: on) Undefined 1/0 (1: new data en bytes 5-20)
119	0-3 4 5 6 7	Spare UV_Flux Enabled VL_Flux Enabled SEP Flag Enabled CME Flag Enabled	Undefined 1: Sun Disk Monitoring is enabled for UV detector 1: Sun Disk Monitoring is enabled for VL detector 1: SEP detection algorithm is running 1: CME detection algorithm is running
120	0-2 3 4 5 6 7	Spare UV_Flux Event VL_Flux Event CME_EXT Halo flag Major CME flag	Undefined 1: Sun in UV detector FOV 1: Sun in VL detector FOV 1: TBC (SEP storm hitting VL detector) 1: Criteria for halo CME met 1: Criteria for Major CME threshold met
121		Time Interval	Time since last evaluation of CME flag in seconds (1 byte)
122		Sector #1 brightness	(1 byte)
123		Sector #2 brightness	(1 byte)
124		Sector #3 brightness	(1 byte)
125		Sector #4 brightness	(1 byte)
126		Sector #5 brightness	(1 byte)
127		Sector #6 brightness	(1 byte)
128		Sector #7 brightness	(1 byte)
129		Sector #8 brightness	(1 byte)
PHI SECTION			
Byte	Bit	Field	Description
130-13		Heartbeat	OBT Coarse Time Field (4 bytes)

134		Image quality flags:	
	0	ISS data valid	(1 bit)
	1	Telescope in use	(1 bit)
	2-3	ISS status	(2 bits: off, calibration, open loop, close loop)
	4	ISS out-of-bounds conditions increased since last update	(1 bit)
	5-7	Spares	Undefined
135-136		The mean jitter	arcsec (2 bytes)
137-138		The RMS jitter	arcsec (2 bytes)
139-140		The maximum jitter	arcsec (2 bytes)
148-142		The minimum jitter	arcsec (2 bytes)
143		Spare	Undefined
RPW SECTION			
Byte	Bit	Field	Description
144-147		Heartbeat	OBT Coarse Time Field (4 bytes, unsigned)
148	0	V_SC_STATUS	(1 bit) 1= available
	1	SMB1 FLAG	(1 bit) 1= shock detected
	2	SMB2 FLAG1	(1 bit) 1= SMB2 event detected
	3	SMB2 FLAG2	(1 bit) 1= SMB2 event confirmed
	4	WF_SYN_STATUS	(1 bit) 1= available
	5	SBM1 ENABLED	(1 bit) 1= detection enabled
	6	SBM2 ENABLED	(1 bit) 1= detection enabled
	7	LWI_STATUS	(1 bit) 1= Langmuir wave indicator available
149-150		V_SC (Local SC potential)	(2 bytes, unsigned integer)
151-152		SBM1_QF (trigger quality factor)	(2 bytes, unsigned integer)
153-158		SBM1_TIME (trigger time)	OBT (6 bytes, CUC format)
159-160		SMB2_QF (trigger quality factor)	(2 bytes, unsigned integer)
161-166		SBM2 time (trigger time)	OBT (6 bytes, CUC format)
167-172		WF_SYN_TIME (wavefront snapshot synchro absolute time)	OBT (6 bytes, CUC format)
173-174		LWI_MAX_E (Max E field amplitude)	(2 bytes, unsigned integer)
175		LWI_MED_FREQ	(1 byte, unsigned integer)
176		LWI_NR_EVENTS	(1 byte, unsigned integer)
SOLOHI SECTION			
Byte	Bit	Field	Description
177-180		Heartbeat	OBT Coarse Time Field (4 bytes)

181	0 1 2 3-6 7	Power-off Request Power-cycle Request Telemetry mode Spare Door Actuation Armed	(1 bit) (1 bit) (1 bit) Undefined (1 bit)
182	0-1 2 3 4 5 6 7	Door Encoders TL Detector Status TR Detector Status BR Detector Status BL Detector Status Observing Status Inter-instrument Campaign	(2 bits) (1 bit) (1 bit) (1 bit) (1 bit) (1 bit) (1 bit)
183-184		Header count	(2 bytes)
185-190		Spare	Undefined
STIX SECTION			
Byte	Bit	Field	Description
191-194		Heartbeat	OBT Coarse Time Field (4 bytes)
195	0-2 3-4 5-6 7	Thermal flare index Non-thermal flare index Location status word Spare	0: no flare detected 1: minor event (threshold ~B1) 2: small event (threshold ~C1) 3: moderate event (threshold ~M1, attenuator activated) 4: major event (threshold ~X1, attenuator activated and high count rate) 0: no significant non-thermal index 1: weak non-thermal flux detected (> ~30 photons/s/cm2) 2: significant non-thermal flux (> ~300 photons/s/cm2) 0: no location available 1: using previous location estimate 2: new location value Undefined (defaults to zero)
196		Z location	Unit: arcmins. SC Z offset component of source from SC +X (equiv to –ve rotn around SC +Y) (1 byte signed char)
197		Y location	Unit: arcmins. SC Y offset component of source from SC +X (equiv to +ve rotn around SC +Z) (1 byte signed char)
198-201		Flare duration	Elapsed seconds since last time flare status was zero. I.e. time since the current flare began. If there is no flare **in progress** then =0. (4 bytes uint)
202-205		Attenuator motion flag	1: motion in last second (4 bytes uint)
206		Spare	Undefined
SWA SECTION			
Byte	Bit	Field	Description
207-210		Heartbeat	OBT Coarse Time Field (4 bytes)
211-212		PAS proton density parameter	(2 bytes)

213-214		Solar wind velocity X component	(2 bytes)
215-216		Solar wind velocity Y component	(2 bytes)
217-218		Solar wind velocity Z component	(2 bytes)
219-222		Spare	Undefined
SPICE SECTION			
Byte	Bit	Field	Description
223-236		Spare	Undefined

7 INSTRUMENT REACTIONS UPON RECEPTION OF SERVICE 20 PACKETS

7.1 Event reporting

7.2 Overview of instrument dependencies

7.3 Downloading consistent datasets

To be written.

END OF DOCUMENT