

RPW Science Data

Convention, dissemination & archiving

Outlines

- RPW science data convention
- RPW science data products
- RPW science data dissemination & archiving plan
- RPW science data exploitation tools

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Science data convention: context

- Science data convention (format, file naming, processing level, metadata) has been defined by the Modeling and Data Analysis Working Group (MADAWG) of Solar Orbiter [SOL-SGS-TN-0009]*

- In summary:
  - CDF format for all in-situ instruments (FITS for remote-sensing)
  - Same data processing level and file naming convention for the in-situ and remote-sensing

- **Additional convention specific to RPW has been defined [ROC-PRO-DAT-NTT-00006-LES]**

** Available at https://issues.cosmos.esa.int/solarorbiterwiki/display/SOSP/SOC+Documents?preview=/5801215/12192432/SOL-SGS-TN-0009_2_2_MetadataStandard.pdf*

RPW data processing levels (1/2)

Level	Description	Source	Users
LZ	Raw RPW telemetry (TM) as delivered by the Solar Orbiter Mission Operation Centre (MOC). ApID-separated, sorted, cleaned. Binary packet data encapsulated in XML files, as returned by the Data Dissemination System (DDS) of the MOC. Daily XML format files.	MOC	ROC
L0	« Raw » data, unpacked and decompressed data Daily HDF5 format files.	ROC	ROC
HK	Uncompressed and decommuted HK, engineering values, UTC-tagged. Daily SOC-compliant CDFs, 1 file per sub-system.	ROC	ROC, RPW lead-CoI teams
L1	Uncompressed and decommutated L0 + UTC-tagged, waveform and spectral data in telemetry units (uncalibrated) in spacecraft coordinate system. Data affinity group. E + B components in the same files. Daily SOC-compliant CDFs, Quik Look and daily/orbital summary plots	ROC	ROC, RPW lead-CoI teams, Solar Orbiter instrument PI teams, ESAC data archive centre, CDPP data archive centre
L1R	Same than L1, but only for waveform products and including information to link data with the associated calibration table. Separated E and B Waveform products.	ROC	ROC, RPW lead-CoI teams
L2	L1 + waveform and spectral data in fully calibrated physical units [V, mV/m, nT, W/m^2/Hz, nT^2/Hz] in spacecraft and heliophysical coordinates systems. Separated E and B Waveform products. Daily SOC-compliant CDFs, Quik Look and daily/orbital summary plots	ROC, using the RPW Calibration Software (RCS)	ROC, RPW lead-CoI teams, Solar Orbiter instrument PI teams, ESAC data archive centre, CDPP data archive centre
L3	L2 + VxB removal for DC E-field measurement, offsets and corrections with data quality flags. Poynting flux. Plasma density. Spacecraft potential. Merged B. Merged density and temperature. Goniopolarimetry. Daily SOC-compliant CDFs, Science data plots.	RPW sub-systems teams	ROC, RPW lead-CoI teams, Solar Orbiter instrument PI teams, ESAC data archive centre, CDPP data archive centre
L4	Event time tags and parameters	TBD	TBD

RPW data processing levels (2/2)

Level	Description	Source	Users
CAL	Calibration table data in CDFs	RCS teams	ROC, RPW lead-CoI teams, Solar Orbiter instrument PI teams, ESAC data archive centre
ANC	Ancillary data in SPICE kernels and CDFs	SOC	ROC, RPW lead-CoI teams, CDDP data archive centre (TBC)
LL01	LL engineering data, output of the LL pipeline Specific CDF format files	SOC (from RPW Low Latency Data Pipeline) ROC (backup instance)	SOC, ROC, Solar Orbiter instrument PI teams
LL02	Operational LL data, enhanced with S/C HK Specific CDF format files	SOC	SOC, ROC, Solar Orbiter instrument PI teams
LL03	Visualisation of operational LL data, in “quicklook” format Data in PNG or JPG2000 (TBC)	SOC	SOC, ROC, Solar Orbiter instrument PI teams

- Low Latency data (LLD) are not science data, but used for operations (e.g., Bias sweeping and SBM event data selection for RPW) — 64 bits/s (692 kB/day)
- SOC will supply a Web page to view LLD, but might be restricted to instrument teams (i.e., ROC for RPW)
- LLD generated at SOC will be retrieved asap by the ROC and make available to the RPW teams.

File naming convention

source_level_descriptor_datetime_version_freefield.extension

Field	Description	Mandatory / Optional
source	Identifies the data as from Solar Orbiter. Content will be 'solo' (TBD).	Mandatory
level	Processing level. Content will either be L0, L1, L2, L3, LL01, LL02, LL03, ... according to the Solar Orbiter data processing level standard in Sect. 2.1.2.	Mandatory
descriptor	The instrument, and if appropriate the sensor/detector and/or data product, each separated by a hyphen. Including the instrument is mandatory. Detector and data product information can be included (or not) as required, e.g. metis, swa-eas-pad or epd-flux are all valid descriptors. However, the descriptor must **uniquely identify the type of data in the file**, for example EUI FSI images taken in different wavelengths cannot have only eui-fsi as their descriptor. Level 3 data derived from multiple instruments will have 'multi' as the first part of descriptor. The meaning of the descriptor for ancillary (and planning) data is slightly different, i.e. <creating actor> + '-' + <product>	Mandatory
datetime	The timestamp of the data in the file, i.e. the UTC at which the observation was made by the spacecraft. Formatted according to Sect. 2.1.3.1 below. The same date and time should be reflected in the metadata (e.g. in FITS keywords DATE_BEG and, if applicable, DATE_END). L0 data are special in the sense that no OBT-to-UTC conversion has taken place yet, so their filename will contain datetime fields in OBT (see Sect. 2.1.3.1).	Mandatory
version	The version of the file, formatted as capital V + 2-character incremental number padded with 0. Again, version numbers in L0 files are more flexible.	Mandatory
free field	An optional field of which the format is free, but decimal points or underscores cannot be used.	Optional
extension	File extension: '.fits' for all FITS files, '.cdf' for all CDF, '.jp2' for JPEG2000 files (more extensions might be added later). Simple ASCII text files must also have an extension '.txt'.	Mandatory

- « solo_L1_RPW-TDS-SURV-RSWF_20220201_V02.cdf »
- « solo_L2_RPW-LFR-SBM1-CWF_20220325T045630-20220325T081259_V01.cdf »

Expected CDF zVars

NAME	DESCRIPTION	TYPE	LEVEL	DATA TYPE	COMMENT
EPOCH	Primary time variable as defined in the section 1.1.2	M	All	CDF_TIME_TT2000	See http://spdf.gsfc.nasa.gov/istp_guide/variables.html#Epoch.
EPOCH_i	i-th time variable as defined in the section 1.1.2	M	All	CDF_TIME_TT2000	Only mandatory for multiple temporal resolutions.
SCET	Onboard S/C time	P	L1, LL	CDF_REAL8	
ACQUISTION_TIME	Time of acquisition as returned in the instrument packet data	O	L1, LL	TBD	Not necessarily the same than SCET
JULIAN_DAY	Time in julian days	O	L2, L3	CDF_REAL8	
SYNCHRO_FLAG	Flag to check instrument time synchronisation	O	L1, LL	CDF_UINT1	e.g., Check time synchronisation between the RPW DPU time and sub-systems times.
QUALITY_FLAG	Human readable high level parameter	P	All	CDF_UINT1	Can apply to one or several science parameters
QUALITY_BITMASK	Computer readable quality parameter	P	All	CDF_UINT2	Can apply to one or several science parameters
POST_GAP_FLAG	Flag that indicates data gap in the records.	O	All	CDF_UINT1	See http://spdf.gsfc.nasa.gov/istp_guide/variables.html#Post%20Gap%20Flag
INTERPOL_FLAG	Flag that indicates if the current record is real or interpolated	O	All	CDF_UINT1	
SC_HCI_POS	S/C Cartesian coordinates in the HCI system.	P	L2, L3	TBD	Only mandatory for low cadence, level 2/3.
SC_HEE_POS	S/C Cartesian coordinates in the HEE system	O	L2, L3	TBD	Only mandatory for low cadence, level 2/3.
SBM_FLAG	Flag that indicated if a SBM mode is currently on/off.	O	All	CDF_UINT1	

- M: Mandatory keywords to comply with the ISTP guidelines.
- P: Keywords we propose to be mandatory in the Solar Orbiter CDF files.
- O: Keywords in *italic* are optional and can be defined if applicable to the instrument in question.

Quality	Meaning
0	Bad data
1	Known problems, use at your own risk
2	Survey data, possibly not publication-quality
3	Good for publication, subject to PI approval
4	Excellent data which has received special treatment

QUALITY_BITMASK shall be a CDF_UINT2 flag providing a computer readable quality information. The values and meanings of QUALITY_BITMASK can differ from instrument to another and shall be reported in the instrument's dataset description document.

CDF primary time variable

Primary time variable « Epoch » gives in CDF_TIME_TT2000

It should be noted that the CDF_TIME_TT2000 data type is defined as an 8-byte signed integer with a fixed Time_Base=J2000 (Julian date 2451545.0 TT or 2000 January 1, 12h TT), Resolution=nanoseconds, Time_Scale=Terrestrial Time (TT), Units=nanoseconds, Reference_Position=Spacecraft barycenter.

Given a current list of leap seconds, conversion between TT and UTC is straightforward:

TT = TAI + 32.184s or
TT = UTC + deltaAT + 32.184s

Where deltaAT is the sum of the leap seconds since 1960; for example, for 2009, deltaAT = 34s).

Will be computed using the SPICE kernels provided by the SOC (contain OBT->UTC coefficients, leap-seconds included)

Coordinate systems

The coordinate system conventions for the CDF variables are as follows:

- Level 2 vector and tensor time series should always be presented in a scientific coordinate system. Spacecraft-centric RTN coordinates in a Cartesian representation are the preferred choice for Solar Orbiter.
- Level 1 data should be presented in instrument coordinates, together with the rotation matrix to spacecraft coordinates.
- Coordinate systems will be described using four variable attributes:
    1. COORDINATE_SYSTEM which gives the name of the coordinate system;
    2. FRAME_VELOCITY which can take either the value 'Observatory' where no corrections have been applied to the data or 'Inertial' where quantities (e.g. electric field or plasma flow velocity) have been corrected for spacecraft motion relative to an inertial frame (HCI);
    3. FRAME_ORIGIN which gives the origin of the reference frame where this is not implicit in the value of COORDINATE_SYSTEM;
    4. REPRESENTATION_i which gives the representation (['x','y','z'] for Cartesian; ['r','p','t'] for spherical polar; ['r','p','z'] for cylindrical polar) of the ith dimension of the variable.

1.1.1.2 Spacecraft position

It is suggested that at least the low cadence, normal mode, Level 2 files should also include the spacecraft position as a variable. This should be expressed in HCI Cartesian Coordinates and be treated in the same way as any other variable.

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RPW science data sets

- Each RPW data set uniquely identified in the ROC system (i.e., dataset ID)
- 1 CDF skeleton table per RPW L1/L2 data set
- Daily files (except for SBM1/SBM2 event data)
- Science CDF zVars must be as much as possible the same, between L1 and L2 data and between similar products (e.g., LFR CWF and TDS LFM CWF). For instance:
  - WF data products (i) have 1 CDF record per sample for CWF and 1 CDF record per snapshot for SWF. (ii) Are divided into two distinct E and B products at level 2 (but the main structure should not change).
  - Same units (V, nT, m, $W/m^2/Hz$, etc.)
- Summary plots will be also generated (listing and description in progress)
- List of RPW datasets given in "RPW Data Products" doc. [ROC-PRO-DATA-NTT-00006-LES]
- List of RPW dataset CDF skeletons is archived in https://gitlab.obspm.fr/ROC/DataPool (restricted access)

Ancillary data

- Primary ancillary data delivered by the SOC as SPICE kernels [SOL-SGS-TN-0017]*:
  - SolO state vector (position and orbital velocity) — 1 single file per validity range
  - SolO attitude— "As-planned" and "as-flown" files per validity range
  - Time conversion between SCET and UTC
  - Scientific/spacecraft/instrument frames transformation and instrument FOVs
- SOC will also produce ancillary data files in CDF
- Ancillary data available via the GFTS (only PI teams access), SOC LLD Web tools, ESA SPICE SFTP and in the ESAC Solar Orbiter Archive
- A priori, ROC does not plan to generate ancillary data, but specific files (CDF or SPICE kernels) to store electrical antenna vectors (physical and effective) are envisaged (TBC)

** See https://issues.cosmos.esa.int/solarorbiterwiki/display/SOSP/SOC+Documents?preview=/5801215/22184323/SOL-SGS-TN-0017_ANCData_0.2.pdf*

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Data dissemination & archiving plan

During proprietary period (3 months)

- At LESIA via the ROC HTTPS server — All RPW preliminary L1, L2, CAL and HK data + quicklooks available at D + TBD hours, to the SolO PI teams and RPW Lead CoI teams
- At ESAC via Solar Orbiter science data archive centre — preliminary L1, L2 and CAL available within D + TBD hours, to the SolO PI teams only
- At CDPP - To be discussed

Public period

- At LESIA via the ROC HTTPS server — All RPW data downlinked at D - 3 months
- At ESAC via Solar Orbiter science data archive centre
- At CDPP - L1 and L2 CDFs and possibly some or all of the L3 datasets (TBC) + quicklooks

Links to RPW data servers will be listed in the RPW LESIA Web portal (http://rpw.lesia.obspm.fr/about-data/)

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RPW science data exploitation tools

Web tools

- ESAC data archive tools (for RPW data archived at ESAC)
- CDPP tools (for RPW data archived at CDPP)
- Autoplot through a DAS server at LESIA (TBC)
- VESPA through a EPN-TAP service at LESIA (TBC)

User Libraries

- MASER4PY (Python 3 library)
- MASER4IDL (IDL library)
- Sunpy (TBC)
- SPEDAS (TBC)

Links to RPW science data tools will be listed in the RPW LESIA Web portal (http://rpw.lesia.obspm.fr/software/)

References

- RPW LESIA Web portal - http://rpw.lesia.obspm.fr/
- Solar Orbiter SOC Public Wiki - https://issues.cosmos.esa.int/solarorbiterwiki/display/SOSP/Solar+Orbiter+SOC+Public
- ESAC science data archive - https://www.cosmos.esa.int/web/esdc
- CDPP - http://www.cdpp.eu/
- Autoplot - http://www.autoplot.org/
- VESPA - http://voparis-europlanet-new.obspm.fr/planetary/data/epn/query/all/
- MASER4PY - https://pypi.python.org/pypi/maser4py
- MASER4IDL - https://github.com/maserlib/maser4idl
- Sunpy - http://sunpy.org/
- SPEDAS - http://spedas.org/wiki/index.php?title=Main_Page
- NASA CDF Web page - https://cdf.gsfc.nasa.gov/

Extra slides

RPW data set concept

RPW data set

- RPW data set definition:
  - Must be generated by the RSS
  - Must be uniquely identified with a ROC DS ID in the RSS
  - Must follow the convention defined in [RD10] (e.g., 1 CDF skeleton per data set)
- ROC DS ID organized by source, level, receiver, mode and science products, using the CDF global attributes:
  - SOLO_L2_RPW-LFR-SBM1-BP1

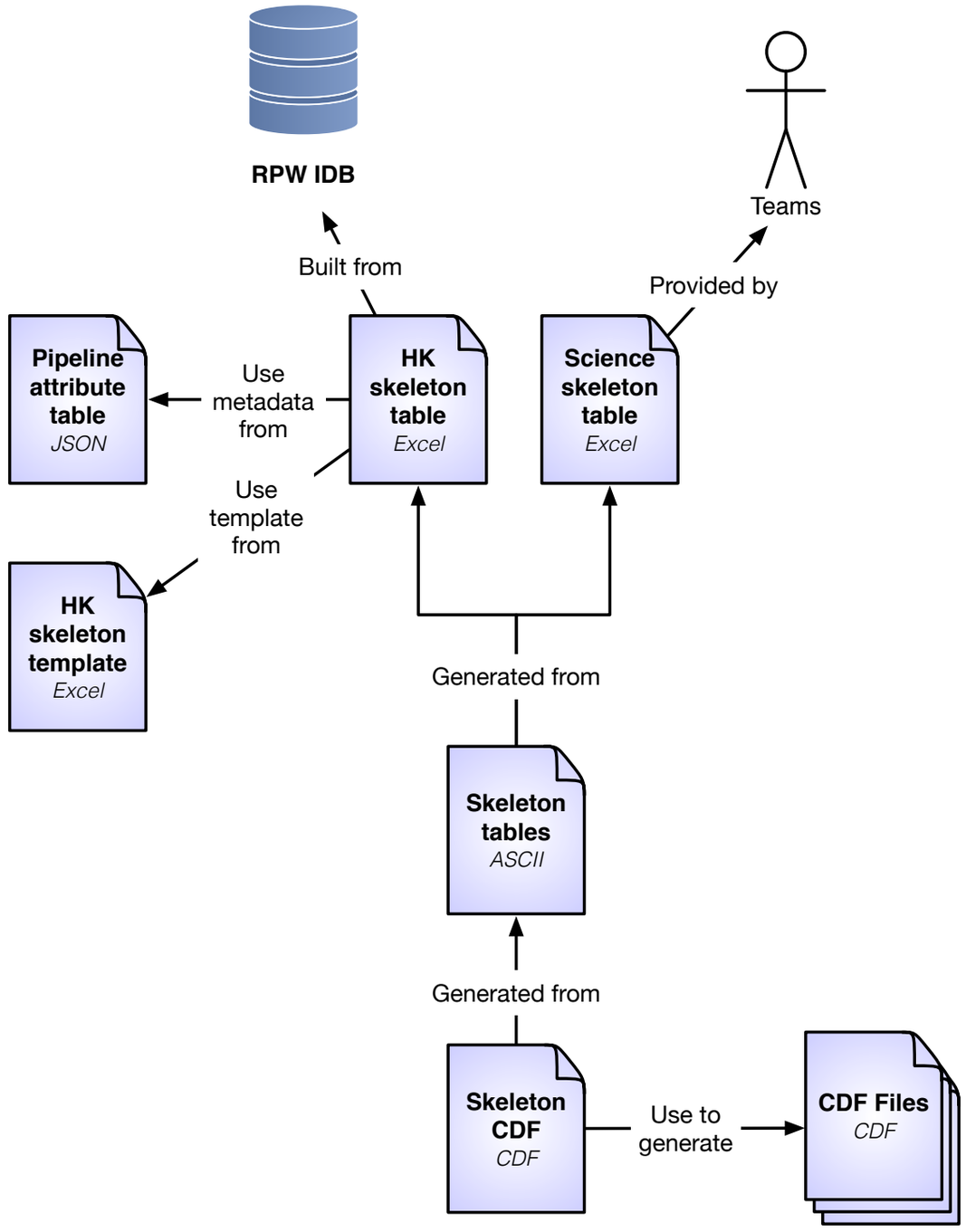


- Descriptor based on instrument-receiver/sensor-mode-producttype
- All of the RPW data sets to produced during the mission is listed in the *rpw_datasets_iss01_rev00.xlsx [RD13]*
- Concept already applied for the ROC-SGSE tool during EM2/PFM calibrations campaigns

CDF skeleton workflow

CDF skeleton philosophy

- CDF data files produced using CDF template files called « CDF skeleton » (or « master CDF »)
- ROC and RPW teams produces Excel format files which are converted into CDF skeleton, using a dedicated program*
- CDF skeletons of HK are automatically generated from the Instrument database (IDB) by the ROC-SGSE
- There is one skeleton per ROC data set
- List of ROC-SGSE CDF skeletons are stored in the ROC SVN repository
- Structure and content of the CDF skeleton automatically check by a dedicated program* (in progress)



* https://github.com/maserlib/maser4py

ROC-TST-GSE-NTT-00017-LES_Iss02_Rev01

RPW L2 science data production responsibilities overview

Software	Team in charge	Inputs	Outpus
THR_CALBAR	THR	L1 THR	L2 THR
TDS_CALBA	TDS	L1 TDS	L2 TDS, except waveforms *L1R LFR waveforms*
LFR_CALBUT	LFR	L1 LFR	L2 LFR (except waveforms) *L1R LFR waveforms*
BICAS	BIAS	*L1R TDS/LFR E waveforms (TBC)*	*L2 TDS/LFR E waveforms*
SCMCAL	SCM	*L1R TDS/LFR B waveforms*	*L2 TDS/LFR B waveforms*

THR_CALBAR current products

Input ID	Output ID	Structure
SOLO_L1_RPW-TNR-SURV	SOLO_L2_RPW-TNR-SURV	1 CDF record per spectrum (4 * 32 freq.)
SOLO_L1_RPW-HFR-SURV	SOLO_L2_RPW-HFR-SURV	1 CDF record per sample (1 freq.)
Specific products for B data?		

- All of the RPW data sets listed in the *rpw_datasets_iss01_rev00.xlsx [RD13]*
- Concept already applied for the ROC-SGSE tool during EM2/PFM calibrations campaigns

TDS_CALBA current products

Input ID	Output ID	Structure
SOLO_L1_RPW-TDS-SURV-RSWF	SOLO_L1R_RPW-TDS-SURV-RSWF	1 CDF record per SWF
SOLO_L1_RPW-TDS-SURV-TSWF	SOLO_L1R_RPW-TDS-SURV-TSWF	1 CDF record per SWF
SOLO_L1_RPW-TDS-SURV-HIST1D	SOLO_L2_RPW-TDS-SURV-HIST1D	1 CDF record per HIST1D
SOLO_L1_RPW-TDS-SURV-HIST2D	SOLO_L2_RPW-TDS-SURV-HIST2D	1 CDF record per HIST2D
SOLO_L1_RPW-TDS-SURV-STAT	SOLO_L2_RPW-TDS-SURV-STAT	1 CDF record per STAT
SOLO_L1_RPW-TDS-SURV-MAMP	SOLO_L2_RPW-TDS-SURV-MAMP	1 CDF record per MAMP
SOLO_L1_RPW-TDS-LFM-RSWF	SOLO_L1R_RPW-TDS-LFM-RSWF-E SOLO_L1R_RPW-TDS-LFM-RSWF-B	1 CDF record per SWF
SOLO_L1_RPW-TDS-LFM-CWF	SOLO_L1R_RPW-TDS-LFM-CWF-E SOLO_L1R_RPW-TDS-LFM-CWF-B	1 CDF record per WF sample
SOLO_L1_RPW-TDS-LFM-SM SOLO_L1_RPW-TDS-LFM-PSD	SOLO_L2_RPW-TDS-LFM-PSDSM	1 CDF record per SM/PSD
SOLO_L1_RPW-TDS-SBM1-RSWF	SOLO_L1R_RPW-TDS-SBM1-RSWF-E SOLO_L1R_RPW-TDS-SBM1-RSWF-B	1 CDF record per SWF
SOLO_L1_RPW-TDS-SBM2-TSWF	SOLO_L1R_RPW-TDS-SBM2-TSWF-E SOLO_L1R_RPW-TDS-SBM2-TSWF-B	1 CDF record per SWF

LFR_CALBUT current products

Input ID	Output ID	Structure
SOLO_L1_RPW-LFR-SURV-ASM	SOLO_L2_RPW-LFR-SURV-ASM	1 CDF record per ASM
SOLO_L1_RPW-LFR-SURV-BP1	SOLO_L2_RPW-LFR-SURV-BP1	1 CDF record per BP1
SOLO_L1_RPW-LFR-SURV-BP2	SOLO_L2_RPW-LFR-SURV-BP2	1 CDF record per BP2
SOLO_L1_RPW-LFR-SURV-CWF	SOLO_L1R_RPW-LFR-SURV-CWF-E SOLO_L1R_RPW-LFR-SURV-CWF-B	1 CDF record per WF sample
SOLO_L1_RPW-LFR-SURV-SWF	SOLO_L1R_RPW-LFR-SURV-SWF-E SOLO_L1R_RPW-LFR-SURV-SWF-B	1 CDF record per SWF
SOLO_L1_RPW-LFR-SBM1-CWF	SOLO_L1R_RPW-LFR-SBM1-CWF-E SOLO_L1R_RPW-LFR-SBM1-CWF-B	1 CDF record per WF sample
SOLO_L1_RPW-LFR-SBM1-BP1	SOLO_L2_RPW-LFR-SBM1-BP1	1 CDF record per BP1
SOLO_L1_RPW-LFR-SBM1-BP2	SOLO_L2_RPW-LFR-SBM1-BP2	1 CDF record per BP2
SOLO_L1_RPW-LFR-SBM2-CWF	SOLO_L1R_RPW-LFR-SBM2-CWF-E SOLO_L1R_RPW-LFR-SBM2-CWF-B	1 CDF record per WF sample
SOLO_L1_RPW-LFR-SBM2-BP1	SOLO_L2_RPW-LFR-SBM2-BP1	1 CDF record per BP1
SOLO_L1_RPW-LFR-SBM2-BP2	SOLO_L2_RPW-LFR-SBM2-BP2	1 CDF record per BP2

SCMCAL current products

Input ID	Output ID	Structure
SOLO_L1R_RPW-LFR-SURV-CWF-B	SOLO_L2_RPW-LFR-SURV-CWF-B	1 CDF record per WF sample
SOLO_L1R_RPW-LFR-SURV-SWF-B	SOLO_L2_RPW-LFR-SURV-SWF-B	1 CDF record per SWF
SOLO_L1R_RPW-LFR-SBM1-CWF-B	SOLO_L2_RPW-LFR-SBM1-CWF-B	1 CDF record per WF sample
SOLO_L1R_RPW-LFR-SBM2-CWF-B	SOLO_L2_RPW-LFR-SBM2-CWF-B	1 CDF record per WF sample
SOLO_L1R_RPW-TDS-SURV-RSWF-B	SOLO_L2_RPW-TDS-SURV-RSWF-B	1 CDF record per SWF
SOLO_L1R_RPW-TDS-SURV-TSWF-B	SOLO_L2_RPW-TDS-SURV-TSWF-B	1 CDF record per SWF
SOLO_L1R_RPW-TDS-LFM-RSWF-B	SOLO_L2_RPW-TDS-LFM-RSWF-B	1 CDF record per SWF
SOLO_L1R_RPW-TDS-SBM1-RSWF-B	SOLO_L2_RPW-TDS-SBM1-RSWF-B	1 CDF record per SWF
SOLO_L1R_RPW-TDS-SBM2-TSWF-B	SOLO_L2_RPW-TDS-SBM2-TSWF-B	1 CDF record per SWF
SOLO_L1R_RPW-TDS-LFM-CWF-B	SOLO_L2_RPW-TDS-LFM-CWF-B	1 CDF record per WF sample

BICAS current products

Input ID	Output ID	Structure
SOLO_L1R_RPW-LFR-SURV-CWF-E	SOLO_L2_RPW-LFR-SURV-CWF-E	1 CDF record per WF sample
SOLO_L1R_RPW-LFR-SURV-SWF-E	SOLO_L2_RPW-LFR-SURV-SWF-E	1 CDF record per SWF
SOLO_L1R_RPW-LFR-SBM1-CWF-E	SOLO_L2_RPW-LFR-SBM1-CWF-E	1 CDF record per WF sample
SOLO_L1R_RPW-LFR-SBM2-CWF-E	SOLO_L2_RPW-LFR-SBM2-CWF-E	1 CDF record per WF sample
SOLO_L1R_RPW-TDS-SURV-RSWF-E	SOLO_L2_RPW-TDS-SURV-RSWF-E	1 CDF record per SWF
SOLO_L1R_RPW-TDS-SURV-TSWF-E	SOLO_L2_RPW-TDS-SURV-TSWF-E	1 CDF record per SWF
SOLO_L1R_RPW-TDS-LFM-RSWF-E	SOLO_L2_RPW-TDS-LFM-RSWF-E	1 CDF record per SWF
SOLO_L1R_RPW-TDS-SBM1-RSWF-E	SOLO_L2_RPW-TDS-SBM1-RSWF-E	1 CDF record per SWF
SOLO_L1R_RPW-TDS-SBM2-TSWF-E	SOLO_L2_RPW-TDS-SBM2-TSWF-E	1 CDF record per SWF
SOLO_L1R_RPW-TDS-LFM-CWF-E	SOLO_L2_RPW-TDS-LFM-CWF-E	1 CDF record per WF sample

S/C coordinates

3.4.2.1 SOLO_SRF – "Spacecraft Coordinates"

SOLO_SRF (Solar Orbiter Spacecraft Reference Frame) is the name of the reference frame that is commonly referred to as spacecraft coordinates and is defined in [RD9]. It is a

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Cartesian frame centred on the point of intersection of the launcher longitudinal axis with the separation plane between the launcher and the composite, and has the following components:

- X points along the longitudinal axis of the spacecraft, positive towards the heat shield.
- Z points perpendicular to the launcher interface plane, positive towards the face of the spacecraft containing the MGA and one of the RPW antennae.
- Y completes the right handed set.

By default, assuming no off-points or rolls, SOLO_SRF_X will point towards the centre of the Sun; SOLO_SRF_Z will point normal to the plane of the orbit, positive towards solar north; SOLO_SRF_Y will complete the right-handed set, opposing the direction of motion of the spacecraft.

SOC ancillary CDF

4.1 Spacecraft Orbit Digest

SOC will produce a single 'orbit digest' file for the entire mission from the Solar Orbiter SPK, which in turn will be based on the OEM orbit file produced by the Solar Orbiter MOC at ESOC. Since, between GAMs, Solar Orbiter's orbit is essentially ballistic, it is anticipated that this file will not need to be updated with high cadence, and as such a new version will be nominally be issued after launch and after each GAM.

The orbit digest will follow the Solar Orbiter metadata standard and its filename will have the format:

```
solo_ANC_soc-orbit_YYYYMMDD-YYYYMMDD_V01.cdf
```

Where YYYYMMDD-YYYYMMDD represents the start date and end date of the coverage of the file.

The orbit digest will contain the following parameters at 1-hour resolution:

- HCI Position, XYZ, km.
- HCI Velocity, XYZ, km/s.
- HEE Position XYZ, km.
- Spacecraft Heliocentric distance.
- Spacecraft Heliographic latitude.
- Spacecraft HCI longitude.
- Spacecraft Carrington Heliographic longitude.
- Angle between Sun-spacecraft line and its projection on the ecliptic plane.
- Angle between projection of Sun-spacecraft line on the ecliptic plane and the Sun-Earth line.

The ecliptic of J2000 will be used in defining the orbit digest file. See APPENDIX B for the definition of the HCI, HEE and Carrington Heliographic coordinate systems.