



Data format and metadata definition for the ROC-SGSE data

Ref: ROC-TST-GSE-NTT-00017-LES
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SOLAR ORBITER



RPW Operation Centre

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ROC-TST-GSE-NTT-00017-LES
Iss.02, Rev.02

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Change Record

Issue	Rev.	Date	Authors	Modifications
0	0	12/10/2014	X.Bonnin	First draft
0	1	05/02/2015	X.Bonnin	Second draft
0	2	09/07/2015	X.Bonnin	Third draft
1	0	08/09/2015	X.Bonnin	First release
1	1	06/10/2015	X.Bonnin	Update the data processing level definition and the data set list
1	2	28/10/2015	X.Bonnin	<ul style="list-style-type: none"> - New update of the data processing level definition. - Update the file naming convention and the CDF global attributes to be compliant with the definition at Solar Orbiter level. - BITMASK becomes QUALITY_BITMASK - Add appendices about skeleton cdf and cal. table. management.
1	3	20/11/2015	X.Bonnin	<ul style="list-style-type: none"> - Add ANC and LL01 data processing levels. - Specify if a CDF attribute is updated or not by the ROC or S/W teams. - Attribute lists are sorted in alphabetical order. - Add "Test_launched_date", "Test_terminated_date" and "Test_description_global" attributes. - Rename "Test_date" in "Test_creation_date". - Remove "Test_config_id", "Test_temp_id", "Test_request_name" and "JOB_UUID" global attributes - "Acknowledgment", "ROC_REFERENCE" and "Skeleton_version" global attributes become mandatory.
2	0	18/02/2016	X.Bonnin	<ul style="list-style-type: none"> - Rename file reference to ROC-TST-GSE-NTT-00017-LES - Add RD8 reference document - TIME_MIN and TIME_MAX are CDF_DOUBLE in Julian day - Add the L0 structure section



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				<ul style="list-style-type: none"> - Add NUM_L1 and NUM_L2r zVariables - Change the L2 level to L2s - Add section about the Epoch structure
2	1	01/06/2016	X.Bonnin	<ul style="list-style-type: none"> - Update Data versioning section - Add section about the EGSE stimuli processing - Add "General convention" sub-section in "ROC-SGSE CDF data description" section. - Add sections about "Epoch" variable and "FILLVAL" attribute - Rename stimuli data set ROC-SGSE_AUX_MEB-EGSE-STIM-VOLT - Rename NUM_L1 into L1_REC_NUM - Remove NUM_L2R - Add DELTA_MINUS_PLUS - Rename "CDF data description" section in "ROC-SGSE CDF data description" - Modify SKELETON_PARENT attribute definition - Rename "ROC_REFERENCE" attribute to "APPLICABLE" - "TIME_BASE" attribute for Epoch becomes "J2000"
2	2	14/03/2019	X.Bonnin	<ul style="list-style-type: none"> - Description and list of ROC-SGSE data products have been moved to the "ROC Data Products" (ROC-DAT-PRO-NTT-0006-LES) document - Reference to "L2R" data processing level has been removed - "L2S" data processing level definition has not been used anymore - All CDF global attributes are of CDF_CHAR data type - Metadata specific to RPW data products have been defined in ROC Data Products" document - Conventions for CDF attributes and variables already defined in [AD1] have been deleted - "Test_temp_degrees" and "Test_request_id" global attributes have



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				<p>been removed</p> <ul style="list-style-type: none"> - "POST_GAP_FLAG ", "QUALITY_BITMASK" and "QUALITY_FLAG" CDF zVariables are ignored by the ROC-SGSE and can be left empty - Add "ADS" as a possible data provider for ROC-SGSE - Change the file naming convention - "ROC Data Products" becomes a reference document - Fix minor changes (rename first section to "Context and philosophy", move the CDF generation mechanism annex in the ROC Data Products document, remove Epoch variable structure description annex)
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Acronym List

Acronym	Definition
AC	Alternating Current
AIT/AIV	Assembly Integration Tests / Validation
AWG	Arbitrary Waveform Generator
CCSDS	Consultative Committee for Space Data Systems
CDF	Common Data Format
CUC	CCSDS Unsegmented time Code
dB	Decibel
DC	Direct Current
EGSE	Electrical Ground Support Equipment
HDF5	Hierarchical Data Format 5
HF	High Frequency
IACG	Inter-Agency Consultative Group
ICD	Interface Control Document
IDB	Instrument Database
ISTP	International Solar Terrestrial Program



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LF	Low Frequency
MD5	Message Digest 5
MEB	Main Electronic Box
MSB	Most Significant Bit
PA	Pre-Amplifier
PALISADE	Parsing Library and Structural Description
PDS	Planetary Data System
RCS	RPW Calibration Software
ROC	RPW Operation Centre
RPL	RPW Packet Parsing Library
RPW	Radio and Plasma Waves instrument
SCM	Search Coil Magnetometer
SGS	Science Ground Segment
SGSE	Software Ground Support Equipment
SHA	Secure Hash Algorithm
SOC	Science Operation Centre
TDS	Time Domain Sampler
THR	Thermal Noise and High Frequency Receivers
SWF	Snapshot Waveform
UCD	Unified Content Descriptor
UUID	Universal Unique Identifier
XML	eXtended Markup Language



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1 GENERAL

1.1 Scope of the Document

This document presents the standards for the RPW data produced by the RPW Operation Centre SGSE (ROC-SGSE) [RD1]. It specifies the data format, file naming convention, metadata and the data processing levels to be applied.

The present document tailors and extends the standards defined at Solar Orbiter level in [AD1] and at RPW level in [AD2].

1.2 Applicable Documents

This document responds to the requirements of the documents listed in the following table:

Mark	Reference/Iss/Rev	Title of the document	Authors	Date
AD1	SOL-SGS-TN-00009/2/2	Metadata Definition for Solar Orbiter Science Data	SOC team	23/07/2015
AD2	ROC-PRO-DAT-NTT-00006-LES/1/2	ROC Data Products (RDP)	X.Bonnin	14/03/2019
AD3				
AD4				
AD5				

1.3 Reference Documents

This document is based on the documents listed in the following table:

Mark	Reference/Iss/Rev	Title of the document	Authors	Date
RD1	ROC-TST-GSE-SPC-00004-LES/00/02	ROC-SGSE Description	X.Bonnin	06/11/2015
RD2	Deleted			
RD3	http://spdf.gsfc.nasa.gov/istp_guide/	ISTP/IACG Guidelines Page	NASA CDF team	December 2008
RD4	cdf36ifd.pdf	CDF Internal Format Description	NASA/GSFC	02/02/2015
RD5	Parametres_EGSE_ROC.pdf	Lists des paramètres des stimuli E-GSE	Daniel Dias	17/06/2015
RD6	ROC-OPS-PIP-NTT-00008-LES/1/1	RPW Engineering Guidelines	X.Bonnin	January 06, 2015
RD7	HDF5_Users_Guide.pdf/1/8.16	HDF5 User's Guide	X.Bonnin	November, 2015
RD8	http://www.ivoa.net/documents/latest/UCD.html	An IVOA Standard for Unified Content Descriptors	IVOA UCD group	August, 2005
RD9	White Paper -	White Paper	Todd	July 12,



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	Supporting CDF in PDS4-v4.pdf	Supporting CDF in PDS4	King, Joseph Mafi	2013
RD10	CCSDS 301.0-B-3/Issue 3	Time Code Format	CCSDS consortium	January 2002
RD11	http://www.lesia.obspm.fr/PALISADE.html	PALISADE	Loïc Gueguen	22/04/2015
RD12	ROC-TST-GSE-ICD-00023-LES/2/1	RPW Calibration Software ICD	Manuel Duarte	18/11/2015
RD13	RPW-SYS-MEB-GSE-TN-001014-LES/1/4	E-GSE User Manual	Daniel Dias	27/04/2016
RD14	RPW-SYS-MEB-GSE-SPC-00125-LES/1/1	RPW MEB GSE Description	Loic Gueguen	26/11/2012
RD15	ROC-GEN-SYS-NTT-00019-LES/2/1	ROC Engineering Guidelines for External Users (REGU)	Xavier Bonnin	14/03/2019
RD16				



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2 CONTEXT AND PHILOSOPHY

The ROC shall deliver a specific SGSE for visualizing and analysing RPW data produced during on-ground calibration tests at the RPW system level. This so-called “RPW Operation Centre Ground Tests SGSE” (hereafter called ROC-SGSE), will be developed at the LESIA, then be deployed and run on both the LESIA and CNES sites during tests.

The ROC-SGSE is designed to process input test log and stimuli data from the MEB GSE [RD14] and MEB E-GSE [RD13] respectively.

The ROC-SGSE will be divided into two main components:

- A data processing pipeline in back-end, which retrieves and processes, input stimuli, information about tests and the corresponding RPW packet data stored in the MEB GSE database.
- Front-end visualization tools allowing users to plot and to analyze data processed by the back-end pipeline in a standard way.

A detailed description of the ROC-SGSE software design can be found in [RD1].

According to user requirements for test data visualization, the front-end tools shall be able to monitor the following data:

- RPW housekeeping parameters (HK) as well as verification and event report data
- RPW unpacked and uncompressed science telemetry data (TM) in engineering units
- RPW calibrated science data at receiver and sensor levels. The sensor level does not include the electrical antennas, which will be not available during the calibration tests.
- Stimuli data (SD) generated by the RPW EGSE
- RPW unpacked and uncompressed telecommands data (TC) in engineering units
- Information about tests

All of these data need to be processed by the ROC-SGSE pipeline before visualization. Especially, the RPW calibrated science data shall be produced using the dedicated RPW Calibration Software (RCS) delivered by analyser/sensor teams. The way the RCS execution is managed by the ROC-SGSE is described in [RD12].

Section 3 defines the data formats and processing levels to be applied in the framework of the ROC-SGSE. Section 4 describes the specific metadata to be found in the CDF data files.

3 DATA FORMAT AND PROCESSING LEVEL DEFINITION

3.1 RPW data processing level definition

The definition of the Solar Orbiter RPW data processing level provided in [AD1] shall be applied for the ROC-SGSE data products, but with the following tailoring in mind:

- Additional RPW LZ, L1R and HK data processing levels defined in [AD2] shall be also applicable for the ROC-SGSE.
- LZ level data products are the input test log data files generated by the MEB GSE.
- L0 level data products can also contain RPW TC packets as saved in the MEB GSE test log files.



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- The L2 level data is partially calibrated, since no electrical antenna is connected to the MEB during ground tests. The L2 data physical units are the same than the input stimuli injected by the E-GSE at system level.
- The E-GSE input stimuli data are labelled as “ANC” level.
- No L3 level data is planned to be produced by the ROC-SGSE.
- No ancillary data related to Solar Orbiter (i.e., attitude, orbit, coordinate frame, etc.) will be processed by the ROC-SGSE.

3.2 Data file formats

All of the data files produced by the ROC-SGSE shall be saved in CDF format files [RD4], except the L0 RPW data file written in HDF5 [RD7].

The MEB GSE test log and E-GSE stimuli data files are provided in the XML format.

N.B. The ROC-SGSE will also implement the capability of request test log data from the MEB GSE database directly. In this case, test log XML format file will be re-built by the pipeline from entries returned by the MEB GSE database.

3.3 Data versioning

The data versioning shall comply the conventions defined in [AD1]. It shall be identified using a 2-digits integer (e.g., “02”) as a version number, and be incremented by 1 each time a new version is released.

In production, the first version of the data shall always be “01”.

Then, a new version shall be incremented each time a given data file has to be re-processed. It typically happens when at least one of the following items is modified:

- The version of the parent file(s) used to produce the data
- The data structure (i.e., corresponding CDF skeleton or XML schema)
- The associated calibration table(s).
- The version of the S/W used to produce the data

In order to keep track of possible changes, the version dependencies shall be reported into the data file using dedicated attributes.

3.4 File naming convention

The file naming convention defined in [AD1] shall be applied to the ROC-SGSE data files, as followed:

`<Source_name>_<Level>_<Descriptor>_<Datetime>_V<Data_version>_<Free_field>.ext`

Where:

- “<Source_name>” shall be the prefix of the “Source_name” global attribute in lowercase, i.e., “solo”.



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- “<Level>” shall be the data processing level, as defined in the prefix of the “Level” global attribute. Possible values are “LZ”, “L0”, “L1”, “L1R”, “L2”, “HK”, “CAL”, “LL01”, “LL02”, “LL03” or “ANC”.
- “<Descriptor>” shall be the prefix of the “Descriptor” global attribute in lowercase, e.g., “RPW-LFR-SURV-RSWF”.
- “<Datetime>” shall be a time range of the form <Test_launched_date>-<Test_terminated_date>, providing the date and time as defined in the “Test_launched_date” and “Test_terminated_date” attributes respectively. The date/time format specified in [AD1] shall be applied here.
- “<Data_version>” shall be a 2-digits integer indicates the version number of the file, as defined in the “Data_version” attribute.
- “<Free_field>” shall be of the form “<Provider>-<Test_id>”, providing the prefix of the “Provider” attribute in lowercase, .e.g., “les”, “cne” or “ads”, and the first seven characters of the “Test_id” global attribute.
- The file extension “.ext” can be “cdf”, “h5”, or “xml” depending of the data level.

For instance, the CDF filename of the L1 RPW LFR SWF data in survey mode, produced by the CNES instance of the ROC-SGSE during the Test #9de409f shall be:

```
solo_L1_rpw-lfr-swf-surv_20161208T062300-20161208T071530_cne-  
9de409f_v01.cdf
```

The ROC-SGSE CDF attributes are defined in the section 4.3.

4 ROC-SGSE CDF DATA STANDARD DESCRIPTION

The standards to be applied to the ROC-SGSE CDF data products are presented in this section.

CDF variables, global and variable attributes are divided in 2 types:

- M: Mandatory keywords.
- O: Keywords in *italic* are optional.

4.1 General convention

The following rules shall be applied concerning the CDF format files produced by the ROC-SGSE:

- MSB (Network) encoding for all values.
- Include CDF Tool compliant metadata.
- Include ISTP/IACG compliant metadata.
- Use single file CDF.
- No compression (file or variable).
- No fragmented variables (all data for a variable must be contiguous in the file).
- No sparse variables.
- All data values are physical (data for all dimensions in a variable are written).
- No unused records. (No superfluous, non decodable records).
- Use only zVariables (rVariables are not recommended by the CDF standard and should be considered deprecate. Also, multiple variable reads can be performed only if variables are of the same type.)

**ROC-TST-GSE-NTT-00017-
LES_Iss02_Rev02(Data_Format_Metadata_Definition_for_ROC-
SGSE).draft.docx**



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- No virtual (calculated) variables.
- All data records are physical (record variance for data variables is "VARY")
- CDF MD5 CHECKSUM option shall be set.
- Any CDF file shall be produced from a given Master CDF file, using the CDF skeleton mechanism described in [AD2].

N.B. Most of these rules inherit from the ISTEP guidelines [RD3] and the CDF format requirements for the NASA Planetary Data System (PDS) data archiving [RD9].

4.2 CDF variables

In a CDF format file, each data parameter (e.g., time, flux, etc.) is represented by a given CDF variable. This CDF variable is identified by its name and a list of given variable attribute.

According to the ISTEP guidelines, there are 3 types of CDF variables:

- "Data", which corresponds to the variables of primary importance (e.g, density, magnetic fields, flux).
- "Support_data", which corresponds to the variables of secondary importance (e.g., time, frequency, energy_bands).
- "Metadata", which provides labels for "data" and "support_data" types (e.g., "Bx, By, Bz" labels for a magnetic field components "data" variable).

4.2.1 General conventions

The general conventions for the CDF variables of the RPW on-ground data sets are:

- Except "Epoch", all CDF variable names shall contain capital letters only and shall not exceed 63 characters.
- CDF variables shall be described using the appropriated variable attributes (see "Variable attributes" section below).

4.2.2 Time conventions

The time variable convention defined in [AD1] shall be applied for the ROC-SGSE CDF data products.

N.B. In the latter case it is assumed that the Spacecraft Elapsed Time (SCET) is simulated by the GSE, based on the local time scale and reference. Especially no time drifting correction is thus applied to compute the CDF_TIME_TT2000 Epoch variable values, but the leap seconds shall be included.

4.2.1 Coordinate system conventions

There is no specific convention related to the coordinate systems. Especially, no coordinate system attribute or variable as defined in [AD1] shall be required in the ROC-SGSE data products. These entries shall be ignored by the ROC-SGSE.

4.2.2 Data quality conventions

QUALITY_FLAG and QUALITY_BITMASK variables can be left empty for the ROC-SGSE CDF data products.

4.2.3 Data gap conventions

POST_GAP_FLAG CDF variable can be left empty for the ROC-SGSE CDF data products.



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4.2.4 Expected CDF variables

The list of the expected CDF variables can be found in [AD1] and [AD2]. Table below gives the variables specific to the ROC-SGSE.

4.3 CDF global attributes

Global attributes defined in [AD1, RD2] shall be also found in the ROC-SGSE CDF data products.

Nevertheless, specific rules shall be applied for the following attributes:

Name	Description	Type	Default value	Comment
File_naming_convention	File naming convention built from the global attributes prefix values, without the extension (“.cdf”)	O	Shall be “<Source_name>_<Level>_<Descriptor>_<Datetime>_V<Data_version>_<Free_field>” See section 3.4	Can be used to build automatically the name of the CDF file, or to check the compliance.
Generated_by	The generating data entity (e.g., person, team, institute).	M	“The RPW Operation Centre (ROC)”	
<i>Provider</i>	Name of the data provider	M	“LES>Laboratoire d’Etudes Spatiales et d’Instrumentation en Astrophysique” (if the data has been provided by the LESIA), “CNE>Centre National d’Etudes Spatiales” (if the data has been provided by the CNES GSE) “ADS>Airbus Defense and Space” (if the data has been provided by ADS)	Initially provided by the ROC in the HK and L1 files. The value shall be just copied by team S/W in their data products.



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REFERENCE	Bibcode, DOI or URL	O	It shall be the reference and issue of the “ROC Data Products” document [RD15]	It should be provided if the current data is described in one or more articles.
Rules_of_use	Citability and PI access restrictions. This may point to a World Wide Web page specifying the rules of use.	M	“Data provided are restricted to the RPW consortium use only. Data access and dissemination are not authorized without the RPW PI agreement.”	
<i>Test_creation_date</i>	Date and time of creation of the test, as saved in the Creation tag of the Lz test log file.	M		Initially provided by the ROC in the HK and L1 files. The value shall be just copied by team S/W in their data products.
<i>Test_description</i>	Description of the test, as saved in the Description tag of the Lz test log file.	M		Initially provided by the ROC in the HK and L1 files. The value shall be just copied by team S/W in their data products.
<i>Test_id</i>	SHA identifier of the test. This number shall be unique and assigned by the ROC-SGSE. It	M		Initially provided by the ROC in the HK and



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	shall use the ISTP format "PREFIX>Suffix", where PREFIX is the 7 first characters of the ID. This PREFIX shall be used in the TestId field in the file naming convention.			L1 files. The value shall be just copied by team S/W in their data products.
<i>Test_launched_date</i>	Date and time when the test started, as saved in the LaunchedDate tag of the Lz test log file.	M		Initially provided by the ROC in the HK and L1 files. The value shall be just copied by team S/W in their data products.
<i>Test_log_file</i>	Name of the MEB GSE test log file	M		Initially provided by the ROC in the HK and L1 files. The value shall be just copied by team S/W in their data products.
<i>Test_name</i>	The name of the test, as saved in the TestName attribute of Lz test log file.	M		Initially provided by the ROC in the HK and L1 files. The value shall be just copied by team S/W in their data products.
<i>Test_terminated_date</i>	Date and time when the	M		Initially



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	test ended, as saved in the TerminatedDate tag of the Lz test log file.			provided by the ROC in the HK and L1 files. The value shall be just copied by team S/W in their data products.
<i>Test_uuid</i>	The universal unique identifier of the test, as saved in the Test UUID attribute of the Lz test log file. This UUID is assigned to each test by the MEB SGSE.	M		Initially provided by the ROC in the HK and L1 files. The value shall be just copied by team S/W in their data products.

Table 1. CDF global attributes.

4.4 CDF variable attributes

The definition in [AD1] and [AD2] shall be applied to ROC-SGSE CDF variable attributes.

5 APPENDICES

5.1 ROC-SGSE data set identifier naming convention

The identifier naming convention for the datasets generated by the ROC-SGSE shall be the same than for the Solar Orbiter RPW datasets written by the RODP pipeline, as defined in [AD2].

5.2 ROC-SGSE CDF format file management

5.2.1 FILLVAL variable attribute allowed values

The following table, derived from the ISTEP guidelines, gives the value to be used for the FILLVAL attribute depending of CDF variable data type.

CDF Data Type	FILLVAL value
CDF_REAL4, CDF_FLOAT	-1.0e31



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CDF_REAL8, CDF_DOUBLE	-1.0e31
CDF_BYTE	-128
CDF_INT2	-32768
CDF_INT4	-2147483648
CDF_UINT1	255
CDF_UINT2	65535
CDF_UINT4	4294967295
CDF_TIME TT2000	9999-12-31:23:59:59.999999999
CDF_EPOCH	9999-12-31:23:59:59.999
CDF_EPOCH16	9999-12-31:23:59:59.9999999999999

Table 2. FILLVAL variable attribute allowed values.

5.2.2 CDF binary file creation mechanism

The mechanism to generate CDF binary file is presented in [AD2].

The name for the ROC-SGSE skeleton/master CDF shall be the same than for the Solar Orbiter RPW datasets generated by the RODP pipeline, except that the prefix “SOLO_” shall be replaced by “ROC-SGSE_” to avoid any confusion.

5.3 RPW calibration table management

The convention related to the RPW calibration table files can be found in [AD2].

The procedure to deliver the calibration table files is specified in [RD5].

6 LIST OF TBC/TBD/TBWs

TBC/TBD/TBW			
Reference/Page/Location	Description	Type	Status



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7 DISTRIBUTION LIST

<p style="text-align: center;">LISTS</p> <p>See Contents lists in “Baghera Web”: Project’s informations / Project’s actors / RPW_actors.xls and tab with the name of the list or NAMES below</p>	Tech_LESIA
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	Tech_RPW
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