SOLAR ORBITER **RPW** **ROC**

RPW Ground Segment

RPW Data Validation and Verification Plan

ROC-GEN-SCI-PLN-00077-LES
Iss.01, Rev.00

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1	0	20/12/2019	X.Bonnin, S.Lion	First issue

Acronym List

Acronym	Definition	Acronym	Definition

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1 GENERAL

1.1 Scope of the Document

The RPW Data Validation and Verification Plan (DVVP) presents the activities to perform the validation and the verification of the RPW data produced by the RPW Operations Centre (ROC).

The DVVP is a part of the ROC Validation and Verification Plan (RVVP) [AD1].

The validation and verification activities related to the science performance and calibration of the instrument are outside of the scope of this document.

The formal validation of the RPW Low Latency data (LLD) products is operated by the Solar Orbiter Science Operation Centre (SOC), with the support of the ROC team. In consequence, the LLD validation activity is not described in the DVVP.

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	ROC-GEN-SYS-PLN-00040-LES/2/2	ROC Validation and Verification Plan (RVVP)	S.Lion, X.Bonnin	20/12/2019
AD2				
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	SOL-SGS-TN-0009/2/4	Metadata Definition for Solar Orbiter Science Data	SOC and MADAWG teams	02/09/2019
RD2	ROC-GEN-OTH-NTT-00045-LES/1/1	ROC Glossary of terms	X.Bonnin	08/11/2018
RD3		SOLO-RPW-TN-1989-CNES Calibration test Report	RPW team	TBD
RD4	ROC-PRO-DAT-NTT-00075-LES/1/0	Solar Orbiter RPW Data Product Description Document (DPDD)	X.Bonnin, J.Soucek	
RD5	SOL-SGS-PL-0009	Solar Orbiter Archive Plan	P.Osuna	
RD6	ROC-PRO-DAT-NTT-00006-LES/1/2	ROC Data Products (RDP)	X.Bonnin	
RD7	ROC-GEN-MGT-PLN-00013-LES/1/4	ROC Project Management Plan (PMP)	X.Bonnin	17/11/2017
RD8	SOLO-RPWSY-PT-1235-CNES/1/0	RPW Instrument Calibration Plan	M.Maskimo vic E.Guilhem B.Pontet Y.de	11/12/2014

			Conchy Analysers teams	
RD9	ROC-GEN-SYS-PLN-00015-LES/2/3	ROC Software Development Plan (SDP)	X.Bonnin	17/11/2017

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2 INTRODUCTION

2.1 Context

The ROC is in charge of the data production for the RPW instrument on-board Solar Orbiter. Especially, the centre shall deliver full-calibrated RPW science data to the Solar Orbiter Archive (SOAR) [RD5], located at the European Space Astronomy Centre (ESAC) in Madrid, Spain.

In this context, the ROC shall:

- Perform RPW data validation to ensure the compliance with the expected requirements. This activity shall be scheduled during specific campaigns, in agreement with the Solar Orbiter and RPW ground segment development planning.

- Implement workflows to verify the science data consistency and science quality. This activity shall be done as a continuous task during the in-flight exploitation of the RPW instrument, starting during the cruise phase.

Section 3 and 4 present respectively the plan related to the RPW science data validation and verification.

2.2 Perimeter

The data validation and verification processes gather all of the RPW science data, from the L0 to the L3 data processing levels (see [RD1] for the data processing level definition).

Nevertheless, intermediate data products, i.e., LZ, HK and L1R (see [RD6] for details), will be also generated but are not expected, at this stage of the project, to be delivered to the SOAR. Since they are directly involved in the RPW science data production, their validation and verification are also presented in the DVVP.

2.3 Definitions

2.3.1 Terminology

The definitions of terms used in the present document, e.g., validation, verification, are listed in the ROC glossary of terms [RD3].

In the framework of this document:

- The ROC (team) defines the people in charge the RPW data processing activities at LESIA.

- The RPW data software teams define the people in charge of developing and/or maintaining the software that generates RPW data products. This definition includes here the Lead CoI teams in charge of delivering to the ROC, the RPW Calibration Software (RCS). The RCS will be run by the ROC team at LESIA to produce RPW data files at levels L1R et L2.

2.3.2 RPW data and metadata definition

The standards related to the Solar Orbiter science products are defined in [RD1], including the convention for the file naming, data processing levels and metadata. The RPW science data

products to be archived in the SOAR are presented in the RPW Data Product Description Document (DPDD) [RD5].

Additional LZ, HK and L1R intermediate data products are described in the ROC Data Products (RDP) document [RD6].

2.4 RPW data processing approach

The data validation and verification activities are deeply linked to the RPW data processing.

The RPW data processing key personnel responsibilities are presented in the ROC Project Management Plan (PMP) [RD7] and the software development/application strategy in the ROC Software Development Plan (SDP) [RD9].

The overall approach is:
- The ROC shall be in charge of producing LZ, L0, L1, HK and related quicklooks data products at LESIA.
- The L1R and L2 data products will be generated by the ROC at LESIA, running the dedicated RPW Calibration Software (RCS) delivered by the Lead CoI teams in charge.
- The L3 data products will be produced by the teams in charge, and then delivered to the ROC.

The ROC will be the single point of contact with the European Space Agency (ESA), concerning the RPW telemetry (TM) raw data retrieval, and with the Solar Orbiter data distribution and archive centres.

3 RPW DATA VALIDATION PLAN

3.1 Data validation approach overview

The RPW data validation can be decomposed in two processes:

- Validation of the data technical specification – hereafter also named "technical validation", which shall ensure the data format and metadata are compliant with the expected definition [RD1, RD6]. This process can be fully automated, as explained in the section 3.3.

- Validation of the data science content – hereafter also named "science validation" -, which shall ensure that the data science content is as expected, i.e., calibration and science quality. This task cannot be fully automated and will require human intervention.

The table below gives for each RPW data processing level, the **Table 1. RPW data validation processes.** expected validation processes.

The data validation activity shall be performed during dedicated test campaigns, as presented in the section 3.4.

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3.2 Responsibilities

The ROC will have the overall responsibilities of the RPW data validation. Especially, it shall:

- Write the RVVP and DVVP

- Write the test plans, as well as the tests and validation reports related to the data validation campaigns

- Provide expected inputs to perform the data validation at levels LZ to L2.

- Prepare and run the tests during the validation campaigns

- Perform the full validation of the RPW LZ, L0, L1 and HK data products.

- Perform the technical validation for the RPW LZ, L0, L1, L1R, L2 and HK data products.

The RPW data software teams shall:

- Participate to the validation campaigns, by providing the expected inputs and support the ROC in the analysis of the tests results and possible anomaly investigations.

- Ensure the calibration for their RPW equipment, as specified in [RD8]

- Perform the science validation of their L1R and L2 data products

- Perform the technical and science validation of their L3 data products

- Write test reports related to the L1R/L2/L3 science validation

- Verify the campaign validation reports

The RPW PI shall approve the DVVP and science data validation reports generated after each campaign.

3.3 Proposed implementation

The RPW data validation activity shall be described in details at each step of the validation into the dedicated campaign test plan, as explained in the RVVP.

Nevertheless the overall implementation shall:

- Use the ROC infrastructure at LESIA to perform the technical validation at levels LZ, L0, L1, L1R, L2 and HK.

- Use the RPW data software teams infrastructure to perform the science validation at levels L1R, L2 and L3.

3.3.1 RPW data technical validation implementation

The data technical validation will consist of running the data technical verification process (see section 0) on well-identified and representative enough RPW data samples.

The choice of the RPW data samples will depend of the validation campaign objectives.

3.3.2 RPW data science validation implementation

The RPW L1R, L2 and L3 data science validation shall be done by the RPW data software teams.

It shall be done from L1 and extra (e.g., HK, L1R, ANC) data products generated and distributed by the ROC.

Mainly run the science verification process + perform/verify/validate/ calibrations using the first data acquired on-board during the commissioning and cruise phase.

Science data calibration validation:

- For on-ground calibration already done during PFM calibration campaigns, see [RD3]

- For in-flight calibration, calibration plan is detailed in [RD8]

Science data quality validation:

- Science data quality validation for on-ground products is not relevant. Nevertheless validate the science data quality processes for in-flight verification/validation.

- In-flight science data quality validation --> validate the process and ensure that data quality is as expected from the first data acquired on-board during the commissioning and cruise phase.

3.4 Schedule

According to the RVVP, the following data validation campaigns shall be scheduled:

- On-ground (before launch):
  - RSS3VC: This campaign will be a "rehearsal" of the RSS4VC. It will only involve the ROC team and only concern a partial set of LZ, L0, L1 and HK data products.
  - RSS4VC: This campaign shall validate the LZ to L2 data technical specification. The procedures to operate the science data verification will be also validated during this campaign, with the support of the RCS teams. But no formal data science validation will be performed, since ground calibration campaigns [RD3] have already permitted to define a first version of calibration tables.

- In-flight (after launch):
  - RSS5VC: This campaign shall validate first science data acquired during the commissioning phase. It should be organized just before the beginning of the Cruise Phase.
  - At least one other data validation campaign should be planned before the beginning of the nominal phase.

3.5 RPW data validation support infrastructure

The technical validation of the RPW data at levels LZ, L0, L1, L2 and HK will be performed at LESIA using tailored instances of the ROC data verification infrastructure (see section **Erreur ! Source du renvoi introuvable.**).

One instance shall be deployed for each campaign.

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4 RPW DATA VERIFICATION PLAN

4.1 Data verification approach overview

The RPW data verification shall be a routine activity planned during the Solar Orbiter mission. The data verification process shall be validated during the commissioning phase (expect for SBM1/SBM2 data), and fully operational at the end of the cruise phase, i.e., before the beginning of the nominal phase.

It shall consist of checking:

- Data integrity (i.e., checksum)

- Metadata and format standards compliance, according to the Solar Orbiter [RD1] and ROC [RD6] standards respectively.

- Calibration

- Data quality

According to the validation approach presented in the section 3.1, the two first verifications – hereafter called "technical verification" - can be fully automated, and the two last verifications as "science verification".

4.2 Responsibilities

The overall responsibilities about these activities are given in the PMP [RD7].

The ROC team shall be in charge of:

- Performing the technical verification of the RPW LZ, L0, L1, L1R, L2 and HK data products.

- Providing the inputs required by the teams in charge to define the science data quality. Especially, computing the QUALITY_BITMASK value in the RPW L1 CDF data files.

The RPW data software teams shall be in charge of:

- Ensuring the science verification for the L1R, L2 and L3 data files generated with their software.

- Computing the QUALITY_FLAG index value for the L1R, L2 and L3 data files generated with their software.

- Ensuring the technical verification for their L3 data products.

4.3 Proposed implementation

4.3.1 Implementation overview

Except for the L3 level, the RPW data technical verification shall be done at LESIA using the RPW data processing pipeline of the ROC (RODP). In the nominal case, the ROC pipeline should perform these verifications systematically after each RPW data file creation.

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The RPW data software teams shall do the L1R, L2 and L3 science verification.

The table below gives an overview of the expected verification processes for each RPW data processing levels. Each process is described in more details in the next sections.

RPW Data processing level	Data verification processes	Type of process
LZ	Data integrity Metadata and format standards compliance [RD6]	Fully automated process performed by the RODP
L0	Data integrity Metadata and format standards compliance [RD1]	Fully automated process performed by the RODP
HK	Data integrity Metadata and format standards compliance [RD6]	Fully automated process performed by the RODP
L1	Data integrity Metadata and format standards compliance [RD1]	Fully automated process performed by the RODP
L1R	Data integrity Metadata and format standards compliance [RD6]	Fully automated process performed by the ROC
L2	Data integrity Metadata and format standards compliance [RD1]	Fully automated process performed by the RODP
	Calibration	Manual process performed by the teams in charge with the support infrastructure
	Data quality	Manual process performed by the teams in charge with the support infrastructure
L3	Data integrity Metadata and format standards compliance	Manual process performed by the teams in charge with the support infrastructure
	Calibration / Computation	Performed by the teams in charge with the support infrastructure
	Data quality	Performed by the teams in charge with the support infrastructure

4.3.2 Technical verification

4.3.2.1 Common verification mechanisms

Except for L3, the state of the technical verification shall be automatically flagged by the ROC pipeline, using the dedicated "VALIDATE" metadata as follows:

- VALIDATE = 0, data file has not been verified

- VALIDATE = 1, data integrity verification has been done successfully

- VALIDATE = 2, metadata and format verification have been done successfully

The value of the "VALIDATE" metadata shall condition the delivery of the RPW data products to the Solar Orbiter data archive centres.

4.3.2.2 Data integrity verification

The data integrity verification shall be the first check to be run just after the file creation.

It consists of performing a checksum operation just after the production of each data product file. This check shall:
- Apply the CDF checksum mechanism for the CDF format files, i.e., L1, L1R, L2 and HK
- Apply the XML schema validation mechanism for the XML format files, i.e., LZ.
- Apply the Fletcher32 checksum mechanism (TBC) for the HDF5 format files; i.e., L0.

If the data integrity verification succeeds, then the "VALIDATE" metadata shall be set to 1.

4.3.2.3 RPW data standards compliance verification

The data standards verification shall be the second check to be run just after the file creation.

The objective is to ensure that the RPW LZ, L0, L1, L1, L2 and HK data products are compliant with the standards defined at Solar Orbiter [RD1] and ROC levels [RD6] respectively.

Only mandatory metadata and data, i.e., zVariables for CDF, Datasets for HFD5 and tags/attributes for XML shall be checked. Moreover, metadata for which a value is expected shall also be verified.

If the data standards verification succeeds, then the "VALIDATE" metadata shall be set to 2.

4.3.1 Science verification

4.3.1.1 Calibration verification

The verification of the instrument sub-system calibration is outside of the scope of this document. The teams in charge will perform this activity using dedicated tools in support.

Nevertheless, new calibration shall always lead to deliver new calibration table files to the ROC, and potentially new RCS software, as described in [RD?].

Besides, the data quality will be deeply dependant of the calibration process, which should be fully verified/validated before starting the nominal phase of the mission.

4.3.1.2 Data quality verification

The verification of the data quality is a tricky task that cannot be fully performed in an autonomous way. In practice, two mechanisms shall be implemented to support the evaluation and the verification of the data quality:
- Automated statistical threshold notifications to the ROC and teams in charge of the data verification (TBC).
- For L2 level data, automated computation of the "QUALITY_FLAG" CDF zVariable (see definition in [RD1]). The value of the "QUALITY_FLAG" zVariable will have to be defined by the RCS in an autonomous way, using the information provided by the "QUALITY_BITMASK" zVariable (see definition in [RD1]) and additional extra

data (e.g., HK). By default, the "QUALITY_FLAG" value shall be set to the "good quality" (index=4) in the L1 level data, then decreased if necessary when propagating through higher data level products.

- Manual verification by viewing quicklooks produced by the ROC at LESIA

4.4 Schedule

The data verification nominal process for a given day of data will have to be performed within the proprietary period, i.e., 3 months (==TBC==), before data has been publicly available at the Solar Orbiter data archive at ESAC.

The main RPW data production and related verification steps are:

1. Several times a day the RODP requests new RPW TM data, from the Solar Orbiter data server hosted by the European Space Operations Centre (ESOC) at Darmstadt in Germany.

2. New RPW TM data are analysed, sorted and uniquely inserted into the ROC mission database at LESIA. Verifications of the TM are also done at the step (i.e., TM packet integrity check and missing TM identification)

3. From the TM saved into the mission database, the RODP produces the RPW LZ, L0, L1, HK, L1R, L2 and related quick-look preliminary data file for a given day. This task will be performed at LESIA every 24h. The resulting RPW data files are automatically verified then made available to the RPW teams via the ROC Web site.

4. From these preliminary data files distributed by the ROC, the RCS teams can analyse and check on their side the science data, possibly upgrade and deliver to the ROC their new RCS and/or calibration tables and produce and deliver to the ROC L3 data files. The full process shall not exceed the proprietary period.

5. When the proprietary period ends, verified data (i.e., for which "VALIDATE = 2") will be sent to the Solar Orbiter data archive centres.

N.B.

- The delivery of new RCS and/or calibration tables will trigger verification process before being integrated in the production pipeline instance. The decision to use new RCS or calibration table and when to perform the switch will have to be taken jointly by the RPW PI, Lead CoI and ground segment project manager.

- The RPW data production cycle will include the possibility of performing a full or partial re-processing of data already distributed. The decision to re-process public data will have to be taken jointly by the RPW PI, Lead CoI and ground segment project manager

Step #	Verification process	Success criteria	Responsibility	Verification Results
1	Automated check of the integrity of the incoming RPW telemetry (TM) data. Missing TM are also identified at the stage.		ROC	

2	Automated check of the LZ data		ROC	
3	Automated check of the L0 data integrity (checksum) and expected format/metadata		ROC	
4	Automated check of the L1 and HK data integrity (checksum) and expected format/metadata compliance		ROC	
5.	Automated check of the L1R data integrity (checksum) and expected format/metadata compliance		ROC	
	Automated check of the L2 data integrity (checksum) and expected format/metadata compliance		ROC	

6. **Table 2. RPW data verification steps.**

5 LIST OF TBC/TBD/TBWs

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

6 DISTRIBUTION LIST

LISTS 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		
		Tech_LESIA
		Tech_MEB
		Tech_RPW
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