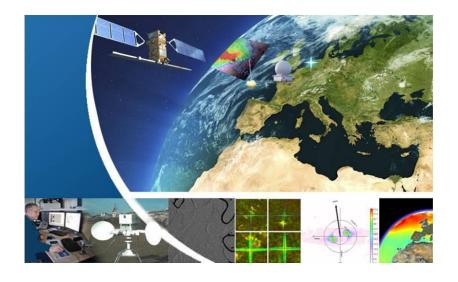






Sentinel-1 Level-0 Data Decoding Package



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1 Introduction

The Sentinel-1 (S-1) Instrument Processing Facility (IPF) is responsible for generating the complete family of Level-1 and Level-2 operation products [AD-1], starting from Level-0 products.

The purpose of this note is to gather in one place all the documentation necessary to decode S-1 Level-0 products. In addition to the documentation, it provides a sample of Level-0 product with the associated RAW decoded data in order to support the users.



2 Documentation

- AD- 1 * S-1 level-0 product format specification
- AD- 2 * Sentinel-1 SAR Space Packet Protocol Data Unit, S1-IF-ASD-PL-0007
- AD- 3 * Sentinel-1 SAR Instrument Calibration and Characterization Plan, S1-PL-ASD-PL-0001

(*) Latest version of the document is available on the S-1 product handbook web pages: https://sentinel.esa.int/web/sentinel/user-guides/sentinel-1-sar/document-library



3 Level-0 Product Format Specification

3.1 Product structure

The format of the Level-O products is described [AD- 1]. The Level-O product is simply a folder-based structure packaging several components as depicted in Figure 1.

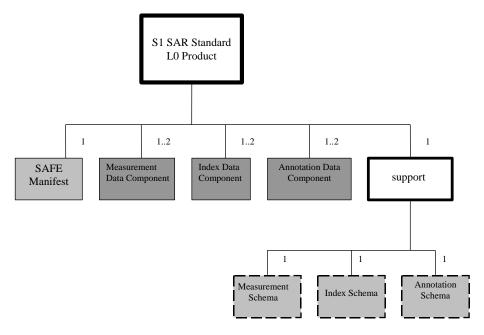


Figure 1: Standard Level-0 product structure

As described in Figure 1, a Sentinel-1 SAR Standard LO Product consists of the following components:

- A Manifest (XML File) describing the overall context and content
- Measurement Data Components MDC (Binary Files); One or two files containing the raw measurement data, in the form of the stream of downlinked Instrument Source Packets [AD- 2]. In the case of dual polarisation product two files are provided
- Annotation Data Components SDC (Binary Files) composed by one record for each ISP; each
 record contains annotations (related to ISP timing, ISP reconstruction process, Virtual Channel ID
 etc.). There is on ADC for each MDC
- Index Data Components IDC (Binary Files), each associated to a MDC and containing the description (bytes location, time, size etc.) of the logical blocks of data in which the corresponding Measurement Data Component can be divided.
- Representation Data Components RDC (Measurement Schema, Index Schema, Annotation Schema); XML Schema files, annotated with SDF mark-ups, that describe the Representation Information (format and content) of every Data Component (Measurement, Index or Annotation) of the Sentinel-1 LO Product; they are used to access, validate and manipulate data. They are contained in a dedicated folder (named "support") within the product.

The SAR echo packets to be decoded are provided in the MDC and are simply Instrument Source Packets. The decoding of Instrument Source Packets is described in section 4.

For a complete view of the Level-O product the user shall further read [AD-1].



3.2 Level-0 slices

Finally the Level-0 products are provided as slices of predefined slice length and overlap. The length of a level-0 slice is given by the sum between the slice length and overlap provided in the table below. This is true for all slices but for the 1st and last which are specific cases.

Acquisition Mode	SM		IW		EW		WV	
Product Type	Slice length	Slice overlap	Slice length	Slice overlap	Slice length	Slice overlap	Slice length	Slice overlap
SLC	25s	7.7s	25s	7.4s	60s	8.2s	N/A	
GRD	25s	7.7s	25s	7.4s	60s	8.2s	N/A	
OCN	25s	7.7s	25s	7.4s	60s	8.2s	N	//A

Table 1: Nominal Slice Length and Overlap for Slicing Scenario

The slice parameters should be taken as for information only as the PDGS might implement slightly different overlap (shorter or longer) according to the verification step that will take place after launch. The slice length instead represents the final size of the Level-1 product that shouldn't be updated.

The LO slicing implies that the slices available represent a portion of the data-take such that elements of the timeline will be missing for the 'middle' slices. The slice boundary is arbitrary and can happen anywhere in the timeline such e.g. a burst cycle could be incomplete. The description of the timeline is provided in the next section.



4 Instrument source packet decoding

4.1 Timeline description

In order to understand the stream of Instrument Source Packets, it is recommended to get familiar with the instrument timeline. The timeline is described in [AD- 3] where it is provided in tabular way.

Figure 2 represents (as an example) the IWS timeline, which is composed by the following three components:

- **Pre-amble**: performed once at the start of the data take. It contains noises pulses and initial calibration sequence
- Image acquisition: this contains the pattern of echoes with interleaved calibration pulses that are repeated n times. Please note that for SM it has been decided after the Commissioning Phase to remove the calibration pulses in this timeline sequence.
- **Post-amble**: performed once at the end of the data take. It contains noises pulses and the final calibration sequence

The structure of pre-amble, imaging and post-amble is valid for all modes but their content might vary.

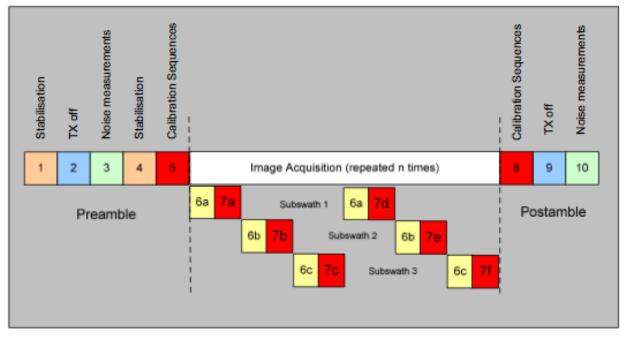


Figure 2: IWS timeline structure

4.2 Instrument source packet decoding

The MDC provides the stream of instrument source packet to be decoded to obtain the RAW data.

The source packets are composed by different type of pulses coded in different ways:

- Noise pulses: BAQ-5 encoded
- Echo pulses: FDBAQ encoded
- Calibration pulses: provided as flat number 10-bits coded, also called Bypass



The structure of the S-1 instrument source packet is described in [AD- 2]. This document provides unambiguous information for the decoding the:

- Packet Primary Header
- Packet Secondary Header: containing all the SAR related information (SWST, SWL, GPS time, PVT, etc)
- User Data Field: containing the echo, noise or calibration pulses and the way to decode them.

In particular for BAQ/FDBAQ, the document provides all the necessary tables and thresholds needed to perform the Huffman decoding and the sample reconstruction and sample alignment.

Space Packet									
Packet Primary Header							Packet Data Field		
Packet	Packet Identification		Packet Sequence Control		Packet Data	Packet Secondary	User Data Field		
Version Number	Packet Type	Secondary Header Flag	Application Process Identifier	Sequence Flags	Packet Sequence Count	Length	Header		
3 bits	1 bit	1 bit	11bits	2 bits	14 bits	16 bits	62 octets	variable length	
6 octets						:	≤ 65534 octets		
Length = Multiple of 4 Octets									

Figure 3: Overall Space Packet Format

4.2.1 Swath number mapping

The Swath Number Field of the Packet Secondary Header is of particular interest in the case of modes including several sub-swaths (IW, EW, and WV) in order to understand to which sub-swath the packet belongs. The swath number mapping is not provided in [AD- 2] as it is a configurable parameter defined in the Radar Data Base.

Mode / Purpose	ECC No	Swath	Swath No (Echo, Noise, RxCal)	Swath No (TxCal, APDNCal, EPDNCal, TACal)
Stripmap 1	1	S1	0	50
Stripmap 2	2	S2	1	51
Stripmap 3	3	S3	2	52
Stripmap 4	4	S4	3	53
Stripmap 5-N	5	S5-N	4	54
Stripmap 5-S	10	S5-S	5	55
Stripmap 6	6	S6	6	56



	1			
IWS	8	IW1	10	60
		IW2	11	61
		IW3	12	62
EWS	32	EW1	20	70
		EW2	21	71
		EW3	22	72
		EW4	23	73
		EW5	24	74
EWS 1 100MHz Cal	32	EW1	25	75
EWS 2 100MHz Cal	32	EW2	26	76
EWS 3 100MHz Cal	32	EW3	27	77
EWS 4 100MHz Cal	32	EW4	28	78
EWS 5 100MHz Cal	32	EW5	29	79
Wave	9	WV1	30	80
		WV2	31	81
Wave 1 100MHz Cal	9	WV1	32	82
Wave 2 100MHz Cal	9	WV2	33	83
Stripmap 1 100MHz Cal	1	S1	36	86
Stripmap 2 100MHz Cal	2	S2	37	87
Stripmap 3 100MHz Cal	3	S3	38	88
Stripmap 4 100MHz Cal	4	S4	39	89
Stripmap 5-N 100MHz Cal	5	S5-N	40	90
Stripmap 5-S 100MHz Cal	10	S5-S	41	91
Stripmap 6 100MHz Cal	6	S6	42	92
IWS 1 100MHz Cal	8	IW1	43	93
IWS 2 100MHz Cal	8	IW2	44	94
IWS 3 100MHz Cal	8	IW3	45	95
	1	<u> </u>	<u> </u>	



5 Test data definition

5.1 Description

In order to support the decoding of Level-O products, two reference products are provided:

- SM/S3: representing a complete acquisition sequence pre-amble, imaging sequence, post-amble
 - Level-0 in Sentinel-1 format:
 - RAW decoded:
 - S1B_S3_RAW__0SDV_20200615T162409_20200615T162435_022046_029D76_F 3E6.TIFF
- IW: this represent a standard slice thus the pre and post-ambles are missing
 - Level-0 in Sentinel-1 format:
 - RAW decoded:
 - S1A_IW_RAW__0SDV_20200608T101309_20200608T101341_032924_03D05A_A5
 OC.TIFF

5.2 Format description

The RAW decoded product is an <u>internal</u> product not systematically generated by the PDGS. It is a folder-based product composed by:

Measurement files. The RAW decoder "de-multiplexes" the data such that each combination of subswath/polarisation is provided in a separate channel/file. The format used is the TIFF format. Please note that in order to support files of large volume (>4GB) the bigtiff¹ representation might be used. This is the case for the S2 products provided.

Annotation XML files providing key information. An example of RAW decoded XML annotation is provided in section 5.3.

For example, for an IW dual polarisation product composed by 3 sub-swaths and 2 polarisation, six TIFF files are provided. Each TIFF file is associated with an XML file giving key information from the secondary packet header decoding (sub-swath, polarisation, SWST, SWL, state vectors...).

5.3 Access details

The RAW decoded product and the native RAW data can be downloaded here: https://nasext.cls.fr/sharing/jybkQ83QE

using following password: S1LODECODING



¹ http://bigtiff.org/, http://www.awaresystems.be/imaging/tiff/bigtiff.html

6 Example of RAW decode annotation

```
<AresysXmlDoc xmlns:at="aresysTypes">
 <NumberOfChannels>1</NumberOfChannels>
 <VersionNumber>2.1</VersionNumber>
 <Description/>
 <Channel Number="1" Total="1">
  <RasterInfo>
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F 0001</FileName>
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  <Samples>23838</Samples>
  <HeaderOffsetBytes>0</HeaderOffsetBytes>
  <RowPrefixBytes>4</RowPrefixBytes>
  <ByteOrder>LITTLEENDIAN</ByteOrder>
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  </RasterInfo>
  <DataSetInfo>
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  </DataSetInfo>
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  <Polarization>V/V</Polarization>
  <Rank>9</Rank>
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  <AzimuthSteeringRatePol>
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   <val N="3">o</val>
  </AzimuthSteeringRatePol>
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  <RxGain>0.630957</RxGain>
  </SwathInfo>
  <SamplingConstants>
  <frg_hz unit="Hz">64345238.1257143</frg_hz>
  <Brg_hz unit="Hz">56590000</Brg_hz>
  <faz_hz unit="Hz">1717.12897387804</faz_hz>
  <Baz_hz unit="Hz">1717.12897387804</Baz_hz>
  </SamplingConstants>
  <AcquisitionTimeLine>
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```



```
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<MaxQ>48.6251029968262</MaxQ>
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<SumQ>109334733.601135</SumQ>
<Sum2I>40915645611.0155</Sum2I>
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<StdDevI>10.5546311621151</StdDevI>
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 <AzimuthStartTime unit="Utc">08-JUN-2020 10:13:17.340461730957/AzimuthStartTime>
</Burst>
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</Burst>
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</Burst>
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```



```
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</pSV_m>
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</yaw deg>
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 <val N="47">-0.0505641587639251</val>
</pitch_deg>
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 <val N="47">-30.1114455997135</val>
</roll_deg>
 <referenceFrame>ZERODOPPLER</referenceFrame>
```





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