

## ***GRAS Product Guide***

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EUMETSAT  
Am Kavalleriesand 31, D-64295 Darmstadt, Germany  
Tel: +49 6151 807-7  
Fax: +49 6151 807 555 Telex: 419 320 metsat d  
<http://www.eumetsat.int>



Welcome to the GRAS Product Guide. As a potential user of GRAS products, you will find here information to familiarise you with the GRAS instrument, the data processing, end-product contents and format, and potential usage and applications.

A supplement of appendices applicable to all the Product Guides is also available. This contains a product summary and details of generic data, as well as information on the Metop operational orbit, and a list of acronyms and abbreviations.

The supplement is accessible under Document Reference: EUM/OPS-EPS/MAN/08/0034 or electronically via the following Hummingbird link:

[DOCSLIB-#198621-Common Appendices for EPS Product Guides](#)

## Document Change Record

| Version/Date   | Section                                  | Description of change  |
|----------------|--|--|
| v1 11/09/2006  | Full document                            | First issue of the document.   |
| v2 31/08/2007  | Full document                            | Update to reflect start of Metop/GRAS.   |
| v2A 14/11/2007 | Section 6<br>Appendices. F,G             | Sec. 6.1.1: Added reference after “EPS Native format”.<br>Sec. 6.2: Thinned product added to WMO-EUMETCast dissemination in Table 6.1, and to text in Sec. 6.2.1.<br>Timeliness added to WMO row in Table 6.1.<br>App. F,G: First sentence rewritten to be more meaningful for external user.  |
| v2B 18/04/2008 | Sections 6,8<br>Appendices A, B,<br>F, G | Sec. 6,8, App. B: Correction of several typos and hyperlinks.<br>App. A: Acronym PFV added.<br>App. F,G: Table added summarising record contents for each product format version. Other general layout improvements, typo corrections and deletion of duplicate tables.  |
| v2C 28/05/2009 | Full document                            | Document restructured - App. F & G renamed as Sec. 9 & 10, and common appendices removed to keep as separate document.<br>Sec. 2.3: Four references added SCD7,8,9,10.<br>Sec. 3: Configuration history information updated, with addition of Table 3-2 PPF software versions.<br>Sec. 5.1: EPSView description replaced by text on available generic tools.<br>Sec. 8: Added reference to EUMETSAT Product Validation Reports webpage.<br>Sec. 9 & 10: Updates to bitfield table contents descriptions for NDF_BITS, ATM_MULTIPATH and SSD_AVAILABILITY to make them correspond to the descriptions in the GRAS Product Format Specification.<br>Various minor editorial updates, correction of typos and hyperlinks. |

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## 1 INTRODUCTION

This document provides a top-level overview of the GRAS instrument and its data processing system, from instrument build to product validation. The document is primarily aimed at those unfamiliar with GRAS. As such the reader is provided with a high-level description of all the relevant components of the GRAS system with references to more detailed information in case this is required.

[GRAS products overview](#) provides an overview of the GRAS instrument and the data processing system. The GRAS instrument and basic operating principles are introduced in [The GRAS instrument](#). A short description of the instrument hardware is provided in [GRAS hardware](#), followed by a summary of the [Data packet structure and basic instrument operation](#).

The Level 0 to 1b processor, part of the Core Ground Segment (CGS) located at EUMETSAT in Darmstadt, is described in [GRAS system concept](#) and in the [Level 0 to 1b data processing](#). A functional breakdown of the main components of the Level 0 to 1b data processor is given. A summary of the expected product accuracies is provided in [Level 1b product summary](#) and an overview of the Level 0, 1a and 1b product formats in [GRAS product formats and dissemination](#). [Level 1b to 2 data processing](#) describes the operational Level 2 products produced under the responsibility of the GRAS Meteorology Satellite Application Facility (GRAS SAF). This includes a brief discussion of the GRAS SAF consortium, as well as links to further information.

In [GRAS products validation and monitoring](#) a summary of GRAS in-orbit monitoring, verification and validation activities is provided. The overall objectives of in-flight GRAS characterisation, calibration and validation activities are listed in [Objectives](#). GRAS in-orbit instrument verification, carried out under the responsibility of ESA, is discussed in [GRAS in-orbit verification](#). Long-term instrument monitoring activities are briefly discussed in [Instrument monitoring](#). Atmospheric profile verification and validation activities, carried out centrally at EUMETSAT in support of Level 1 validation, are discussed in [Validation](#). Level 2 operational product validation services are provided by the GRAS SAF; these are listed in [Validation of GRAS SAF products](#) followed by a brief discussion of the role of the EUMETSAT/ESA Research Announcement of Opportunity in product calibration and validation activities in [Scientific activities carried out via the EPS/Metop RAO](#).

A list of acronyms is provided in Appendix E: Acronyms and Abbreviations **Error! Reference source not found.**

### Acknowledgements

The authors wish to acknowledge the invaluable contributions of the GRAS project team at ESTEC, the GRAS SAF project team, and colleagues at EUMETSAT without whom a successful GRAS flying on Metop would not be possible.

## 2 REFERENCE DOCUMENTS

The following documents have been used to compile the information in this guide. Some of them are referenced within the text, others are provided here for further reading.

### 2.1 EPS programme documents

|        |  |                                  |
|--------|--|----------------------------------|
| [RD1]  | EPS End User Requirements Document                     | EUM.EPS.MIS.REQ.93.001           |
| [RD2]  | EPS Core Ground Segment Requirements Documents         | EPS.CGS.REQ.95327                |
| [RD3]  | EPS Generic Product Format Specification               | EPS.GGS.SPE.96167                |
| [RD4]  | Metop GRAS Instrument In-Orbit Verification Plan       | MO.PL.ESA.GR.0419                |
| [RD5]  | GRAS Level 1 Product Generation Function Specification | EPS.SYS.SPE.990010               |
| [RD6]  | GRAS Level 1 Product Format Specification              | EPS.MIS.SPE.97234                |
| [RD7]  | GRAS Requirements Specification                        | MO.RS.MMT.GR.0001                |
| [RD8]  | GRAS Calibration and Validation Plan                   | EUM/OPS/SYS/PLN/01/013           |
| [RD9]  | EPS/Metop Research Announcement of Opportunity         | EUM/STG/42/03/DOC/06             |
| [RD10] | U-MARF LEO Format Descriptions                         | EUM/OPS/USR/06/1855 <sup>†</sup> |
| [RD11] | EPS Product file naming for EUMETCast                  | EUM/OPS-EPS-TEN/07/0012          |
| [RD12] | GRAS EPS-PFS Data Reading Introduction                 | EUM/MET/MAN/06/0267              |

<sup>†</sup> Future versions of this document will be available on the EUMETSAT [UMARF webpages](#).

See [www.eumetsat.int](http://www.eumetsat.int) for more information on the project.

### 2.2 SAF documents

|       |   |                           |
|-------|---|---------------------------|
| [GS1] | GRAS Meteorology SAF User Requirements  | SAF/GRAS/METOFFICE/RQ/URD |
| [GS2] | GRAS Meteorology SAF Validation Strategy  | SAF/GRAS/DMI/RQ/ST        |
| [GS3] | GRAS Meteorology SAF The Radio Occultation Processing Package (ROPP), An Overview | SAF/GRAS/METO/UG/ROPP     |

### 2.3 Papers, reports and other technical documentation

|        |  |   |
|--------|--|---|
| [SCD1] | Observing Earth's Atmosphere with Radio Occultation Measurements using GPS | Kursinski, E., G. Hajj, K. Hardy, J. Schofield, R. Linfield<br><i>J. Geophys. Res.</i> , 102, 23429-23465, 1997 |
|--------|--|---|



- |         |  |   |
|---------|--|---|
| [SCD2]  | The radio occultation experiment aboard CHAMP: Operational data analysis and validation of vertical atmospheric profiles | Wickert, J., T. Schmidt, G. Beyerle, R. König, Ch. Reigber and N. Jakowski<br><i>J. Met. Soc. Japan</i> , Special issue 'Application of GPS Remote Sensing to Meteorology and Related Fields', 82(1B), 381-395, 2004            |
| [SCD3]  | Applications of COSMIC to Meteorology and Climate  | Anthes, R., C. Rocken and Y.H. Kuo<br><i>Terrestrial, Atmospheric and Ocean Sciences</i> , 11 (1), 115-156, 2000  |
| [SCD4]  | World Meteorological Organization Manual on Codes  | WMO - No. 306   |
| [SCD5]  | NOAA KLM User's Guide  | <a href="http://www2.ncdc.noaa.gov/docs/klm">www2.ncdc.noaa.gov/docs/klm</a>  |
| [SCD6]  | GRAS Level 1b Product Validation with 1D-Var Retrieval   | Marquardt, C., S. Healy, J.-P. Luntama, E. McKernan<br><i>EUMETSAT Technical Memorandum</i> No. 12, Feb 2005  |
| [SCD7]  | An introduction to the EUMETSAT polar system   | Klaes, K. D., et al.<br><i>Bull. Amer. Meteor. Soc.</i> , 88(7), 1085–1096, doi: 10.1175/BAMS-88-7-1085, 2007   |
| [SCD8]  | Prospects of the EPS GRAS mission for operational atmospheric applications   | Luntama, J.-P., G. Kirchengast, M. Borsche, U. Foelsche, A. Steiner, S. Healy, A. von Engel, E. O'Clerigh, and C. Marquardt<br><i>Bull. Amer. Meteor. Soc.</i> , in press, 89(12), 1863-1875, doi: 10.1175/2008BAMS2399.1, 2008 |
| [SCD9]  | Smoothing and Differentiation of Data by Simplified Least Squares Procedures   | A. Savitzky and Golay, M.J.E<br><i>Analytical Chemistry</i> , Vol. 36, pp. 1627-1639, 1964  |
| [SCD10] | Application Hints for Savitzky-Golay Digital Smoothing Filters   | M.U.A. Bromba and H. Ziegler<br><i>Analytical Chemistry</i> , Vol. 53, pp. 1583-1586, 1981  |

### 3 GRAS PRODUCTS CONFIGURATION HISTORY

In the following tables the current versions on the operational Ground Segment are shown on a white background.

| Date introduced | Product format version |              | PFS version | PGS version | Comments |
|-----------------|------------------------|--------------|-------------|-------------|----------|
|                 | Major number           | Minor number |             |             |          |
| 18/06/2007      | 10                     | 0            | 6.6 / v7B   | 6.4 / v6D   |          |

**Table 3-1: GRAS document versions**

| GRAS software version | Date introduced on GS1 | Comments  |
|-----------------------|------------------------|---|
| 2.8                   | 21/02/2008             | Cal/Val Phase   |
| 2.10                  | 15/04/2008             | Operational configuration, sensing start time 12:27 UTC |
| 2.11                  | 28/05/2008             | Sensing start time 11:48 UTC                            |
| 2.12                  | 07/11/2008             | Sensing start time 05:48 UTC                            |

**Table 3-2: GRAS PPF software versions**

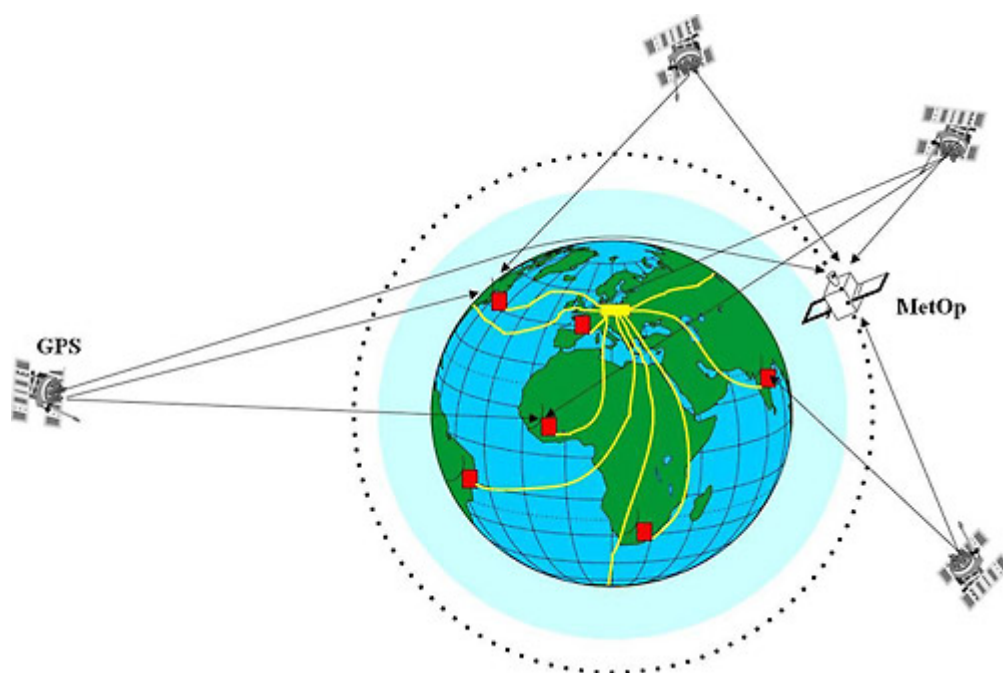
## 4 GRAS PRODUCTS OVERVIEW

### 4.1 The GRAS instrument

The GRAS instrument provides radio occultation measurements in support of the EUMETSAT Polar System (EPS) mission objectives of operational meteorology and climate monitoring. The radio occultation technique was originally used to study the atmospheres of Venus, Mars and other outer planets. Applying this measurement principle to the Earth's atmosphere was made possible with the installation of the GPS satellites.

#### 4.1.1 Measurement principle

GRAS is a radio occultation instrument, using GPS satellite signals in a limb viewing geometry to derive initially bending angle profiles. Further processing of these profiles provides refractivity, temperature, pressure and water vapour profiles. The observation geometry is shown in the following picture.



**Figure 4-1: GRAS geometry and measurement principle**

The GPS signal is refracted away from a straight line as it passes through the atmosphere. The strength of the refraction depends on the atmospheric density which in turn is mainly driven by pressure and temperature, coupled through the hydrostatic equation. Hence, radio occultation provides accurate temperature profiles at altitudes above about 8 km. In the lower parts of the troposphere, water vapour also affects the refraction of the ray, thus information on the water vapour is also provided here.

The processing also requires precise knowledge on the GPS and Metop orbits. The accurate GPS orbits are provided by a Ground Support Network (GSN), indicated by the red squares in the picture above. The Metop precise orbit is determined within the EUMETSAT processing.

For further information, please refer to the following articles: [SCD1], [SCD2], [SCD3].

#### **4.1.2 GRAS hardware**

Several papers and ESA bulletins provide information on the Metop satellite and the GRAS instrument, e.g. [SCD7], [SCD8], ESA Bull. No. [\[102\]](#), [\[127\]](#). Please refer to these publications for further information.

#### **4.1.3 Data packet structure and basic instrument operation**

GRAS tracks setting and rising GPS satellites; it uses three independent antenna/receiver chains to track these satellites:

- Zenith: used for real-time navigation, up to 8 GPS satellites simultaneously
- Velocity: used for rising occultations, up to 2 GPS satellites simultaneously
- Anti-Velocity: used for setting occultations, up to 2 GPS satellites simultaneously

The instrument has three operating modes:

- **STANDBY:** initial mode of instrument. Instrument is initialised with the almanac data of the GPS satellites constellation. No measurements are taken.
- **NAVIGATION:** Initially, the instrument uses the previously uploaded almanac data and an initial position, velocity and time to determine which GPS satellites it shall acquire and track. Based on these satellites, a navigation solution is calculated and the instrument continues to update its current position. Data packets are generated from the zenith antenna.
- **OCCULTATION:** In addition to navigation mode, GRAS acquires and tracks satellites on the velocity and anti-velocity antenna. Data packets containing navigation and occultation data are generated.

Generally, the pseudo-noise code is tracked for navigation while the carrier phase is tracked to allow for atmospheric demodulation. The main measurement data provided by GRAS are:

- L1/L2 carrier phase
- L1/L2 code phase
- L1/L2 P code phase
- L1 C/A, L1/L2 P amplitude measurements

Additionally, ancillary data is provided for e.g. ephemeris, instrument monitoring.

The instrument provides the following raw packets:

- GPS
- Extended Navigation
- Temperature and Voltage
- Noise
- Gain & Histogram
- Tracking State
- Raw Sampling
- Single Frequency Carrier
- Dual Frequency Carrier
- C/A Code Phase

- C/A, P1, P2 Code Phase
- Navigation Data Frame Dump

These will be pre-structured and run through the measurement reassembly to provide instrument products:

- GPS
- Position, Velocity and Time
- Temperature and Voltage
- Amplitude and Noise
- Tracking State
- Carrier Phase
- Code Phase
- Navigation Data Bits

GRAS operates in two tracking states: closed-loop and open loop (called raw sampling). For closed-loop tracking, the carrier phase is phase locked to the received GPS signal. For open loop tracking, carrier phase is measured relative to an on-board Doppler model. Default for closed-loop tracking is 50 Hz, and 1 kHz for open loop tracking. Tracking data is provided from about 80 km down to the surface. Switching between closed and open loop is generally performed automatically based on the tracking of the P code; once this is lost, open loop tracking will start.

## 4.2 GRAS system concept

The Product Generation Facility (PGF) interacts with the Core Ground Segment (CGS) M&C functionality by means of the Product Generation Environment (PGE). The PGE provides the means by which the PGF acquires satellite and instrument data downlinked via the Command and Data Acquisition (CDA). The actual processing is performed by the Product Processing Facility (PPF) with the data provided by the PGF.

The PGE also provides the means by which data from the GRAS GSN is provided to the PGF and subsequently the PPF. Furthermore, the PGF acquires information from the GRAS/Metop POD service and the Metop satellite orbital services via the PGE.

### Inputs:

|                                   |  |
|-----------------------------------|--|
| GRAS source packets               | Correspond to the raw output data provided by the instrument as CCSDS source packets. These packets contain the GRAS measurement data in measurement data packets and housekeeping data in ancillary data packets. |
| Instrument characterisation data  | Contain instrument characterisation data to be used for correcting the impact of the instrument and spacecraft hardware on the observation data.   |
| GSN status and configuration data | Contain characterisation of the location and hardware of the fiducial stations of the GRAS GSN, and characterisation data of the currently operational GPS satellites.   |
| GSN products                      | Contains products from the GRAS Ground Support Network (GSN).  |
| Flight dynamics                   | Metop manoeuvre information, Metop CoM (centre of mass)  |

|             |  |
|-------------|--|
| information | position vector in the spacecraft reference coordinate frame as a function of time.  |
| NWP data    | NWP data about the surface level meteorological parameters at the fiducial stations. |

### Outputs:

|                               |   |
|-------------------------------|---|
| Level 0 data                  | Correspond to the Level 0 products [RD3]  |
| Level 1a data                 | Correspond to the Level 1a products [RD6]   |
| Level 1b data                 | Correspond to the Level 1b products [RD6]   |
| Occultation table             | Contains predicted GRAS measurements.   |
| Reporting/Quality Information | Corresponds to the compiled reporting information produced by the GRAS PGF that is transferred to the reporting function of the CGS. This information includes all quality information required by the Quality Control function of the CGS. |
| Monitoring Information        | Contains all regular monitoring information on the PGF, providing the G/S M&C function with the information on the status of the instrument, data, processing functions, processing platforms, links, etc.                                  |

### Controls:

|                         |  |
|-------------------------|--|
| Ground Segment Commands | This data stream corresponds to the transfer of commands generated by the G/S and controls the operation of the GRAS PGF. Note: these influence only the way the processing is done and are not related to any instrument/platform commands. |
|-------------------------|--|

### Services:

|                      |  |
|----------------------|--|
| Generic PGE services | PGE provides the PGF with all services that are needed for interference-free operations. |
|----------------------|--|

## 4.3 GRAS data processing

### 4.3.1 Level 0 to 1b data processing

The central processing facility, located at EUMETSAT headquarters in Darmstadt, is responsible for the processing of all GRAS data up to Level 1b, and delivers Level 0, Level 1a and Level 1b products to the user community. This Level 0 to 1b processing is carried out within the Core Ground Segment (CGS) by the GRAS PPF which converts raw instrument data (Level 0 data stream) into time-stamped, geolocated bending angles. Level 0, 1a and Level 1b data products, product quality and monitoring information are also generated by the CGS.

#### 4.3.1.1 Receive and validate Level 0 and auxiliary data

The receive-and-validate function, in addition to the generic checks identified in the [RD2] EPS Core Ground Segment Requirements Documents, performs the instrument-specific acceptance and checking of the input data. Its purpose is to accept the Level 0 data and to perform all checks required for validation of the input data before passing them to the

algorithmic functions. This functionality correlates Level 0 data with auxiliary data and also produces reporting statistics.

#### **4.3.1.2 Process Level 0 to Level 1a**

Level 1a processing consists of:

- GRAS measurement data pre-processing
- Measurement identification
- Instrument corrections
- Level 1a products quality check and formatting

The Level 1a processing function ingests GRAS CCSDS packets. Each CCSDS packet consists of GRAS navigation data and ancillary and measurement data from several occultations. The Level 1a processing function rearranges the GRAS CCSDS packets and pre-processes them to generate complete sequences of raw measurement data. The raw measurement data sequences are reassembled into carrier phase, amplitude, noise and code phase data.

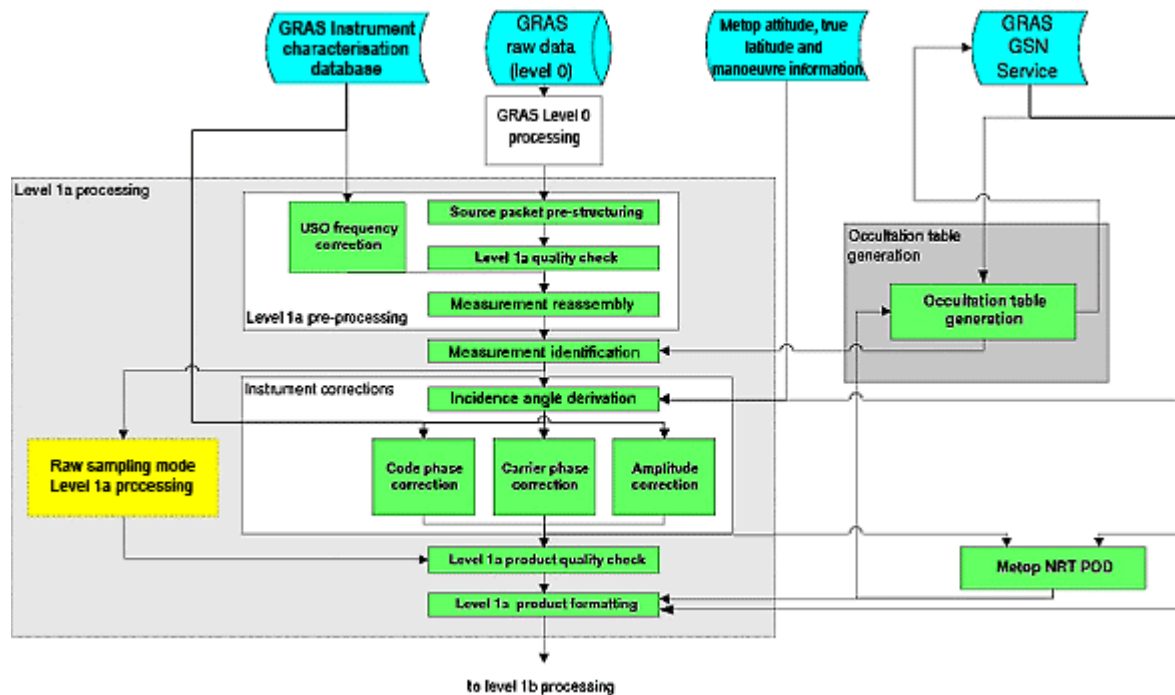
The Level 1a processing performs the identification of the measured occultations and the navigation data sequences by using the occultation and navigation identification codes from the occultation tables, and the header information in the GRAS navigation, ancillary and measurement data. The measurement identification includes identification of the antenna and receiving chain (i.e. RFCU and GEU) for each observation.

The Level 1a processing function ingests the GPS Precise Orbit Determination (POD) products provided by the GSN via the PGE. GPS POD products are used together with the on-board navigation solution included in the GRAS ancillary data to determine the incidence angle of the incoming GPS transmissions in the instrument correction function.

The Level 1a PPF uses the data from the GRAS Instrument Characterisation Database to determine the instrument correction parameters to remove the impact of the instrument on the measurement data. The phase and group delays caused by the receiving antennas, RF components and electronics are removed, and amplitude measurements are corrected for the variations of the antenna gain pattern and variations in the gain in the RF components and electronics due to temperature variations. All instrument correction functions are user selectable. The contents and the format of the GRAS Instrument Characterisation Database is provided in [RD5]. The C/A and P code phase measurements are not converted into pseudo-ranges in the Level 1a processing. However, they are corrected for the Differential Code Bias (DCB) caused by the transmitting GPS satellite and by the receiver. The corrected code phase measurements by the GRAS zenith antenna are provided to the GRAS/Metop NRT POD.

Finally, the Level 1a PPF collects all Level 1a products including the GRAS GSN and GRAS/Metop NRT POD products, performs quality checks, and formats all the products. Further information is available at [RD5].

A functional decomposition of the GRAS L1a processor is shown in the following figure.



**Figure 4-2: Level 0 to Level 1a processing steps**

#### 4.3.1.3 Process Level 1a to Level 1b

The Level 1b processing function calculates the bending angle and the impact parameter from the instrument-corrected occultation measurement data.

The Level 1b processing function performs occultation isolation to combine GRAS data for each occultation with the auxiliary data required to retrieve the bending angle profile. The pivot GPS satellite and the fiducial station supporting differencing schemes (for clock correction) have to be selected before all auxiliary data for each occultation can be filtered.

The Level 1b PPF performs several corrections to the measurement data before the actual bending angle retrieval is performed. The phase residual, which is to a good approximation the phase delay introduced by the atmosphere, is calculated by removing the geometrical distance between the transmitter and receiver antennas from the measured phase. This requires determination of the true reception and transmission times and interpolation of the satellite state vectors into these times. The corrections for relativistic effects are mostly included into the synchronisation of the measurement time stamps with the reference time provided by the GRAS GSN because the relativistic effects are included in the clock offset estimates calculated in the GPS and GRAS/Metop NRT POD. The only relativistic effect not included in the clock offset estimates is the variation in the apparent velocity of light because of the gravitational field of the Earth (Shapiro effect). This effect is taken into account in the determination of the transmission time and geometric path removal.

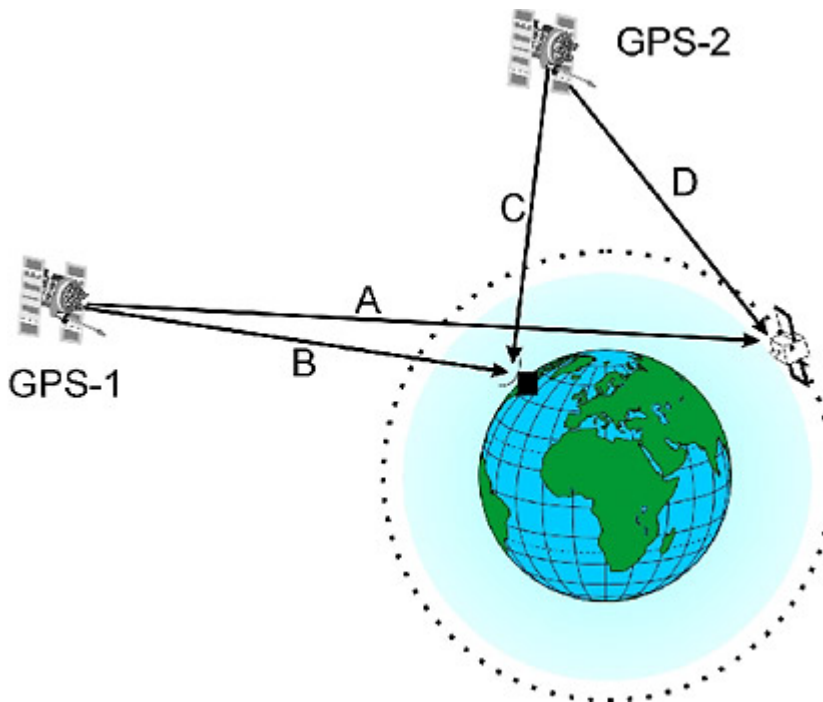
After the removal of the geometric path the measured phase residual is still wrapped around  $2\pi$ . The unwrapping of the phase is combined in this algorithm.

After the relativity correction a cycle slip detection and correction function is applied to the phase residual data.



The Level 1b PPF corrects the data provided by the Level 1a function for clock drifts on board the GPS satellite and, if necessary, the GRAS instrument. The Level 1b processing function obtains, via the PGE, for each of the ground stations supporting differencing the Sounding Support Data (SSD). GSN also provides an estimate of the Tropospheric Zenith Delay (TZD) for each fiducial station and local surface level meteorological observations (if available). TZD has to be mapped to the elevation of the occulting and pivot GPS satellites by the Level 1b PPF.

| Correction technique        | Applicability   |
|-----------------------------|---|
| No differencing (ND)        | All clocks in the observation system are considered sufficiently stable and no clock correction is required. Clock biases are removed by using bias estimates from POD.   |
| Single differencing 1 (SD1) | GPS clock is considered stable and only the impact of the GRAS clock instability is corrected for. The differencing is performed between links A and D in the figure below.   |
| Single differencing 2 (SD2) | GRAS clock is considered stable and the impact of the GPS clock instability is corrected for (current baseline scenario). The differencing is performed between links A and B in the figure below.  |
| Double differencing 1 (DD1) | All observation system clock errors are corrected for (GPS, GRAS, fiducial stations). The differencing is performed between all measurement links in the figure below.  |
| Double differencing 2 (DD2) | Similar to DD1, but two ground stations are used. One station tracks the occulting GPS satellite (GPS-1 in figure below) and the other tracks the pivot satellite (GPS-2 in figure below). The advantage is that neither station has to have visibility to both GPS satellites. The disadvantage is that the ground station clock errors are not removed. |



**Figure 4-3: Measurement links used for clock corrections**

The baseline scenario for the GRAS PPF is clock correction with SD2. DD1 and DD2 are considered as fall-back options in the case that SD2 cannot provide good product accuracy. ND and SD1 are optional differencing methods that may be applied depending on the GPS clock characteristics. The use of additional GPS satellites in the clock correction will introduce noise on the bending angle, thus ND will be used if the GRAS clock is found to be stable enough. The actual applied clock correction can be found in the Level 1b data products.

In deriving the total bending angle, the Level 1b processing function assumes a locally spherical atmosphere. The errors introduced by this assumption are reduced by applying a correction for the Earth's oblateness. The Level 1b processing function computes correction parameters for this purpose.

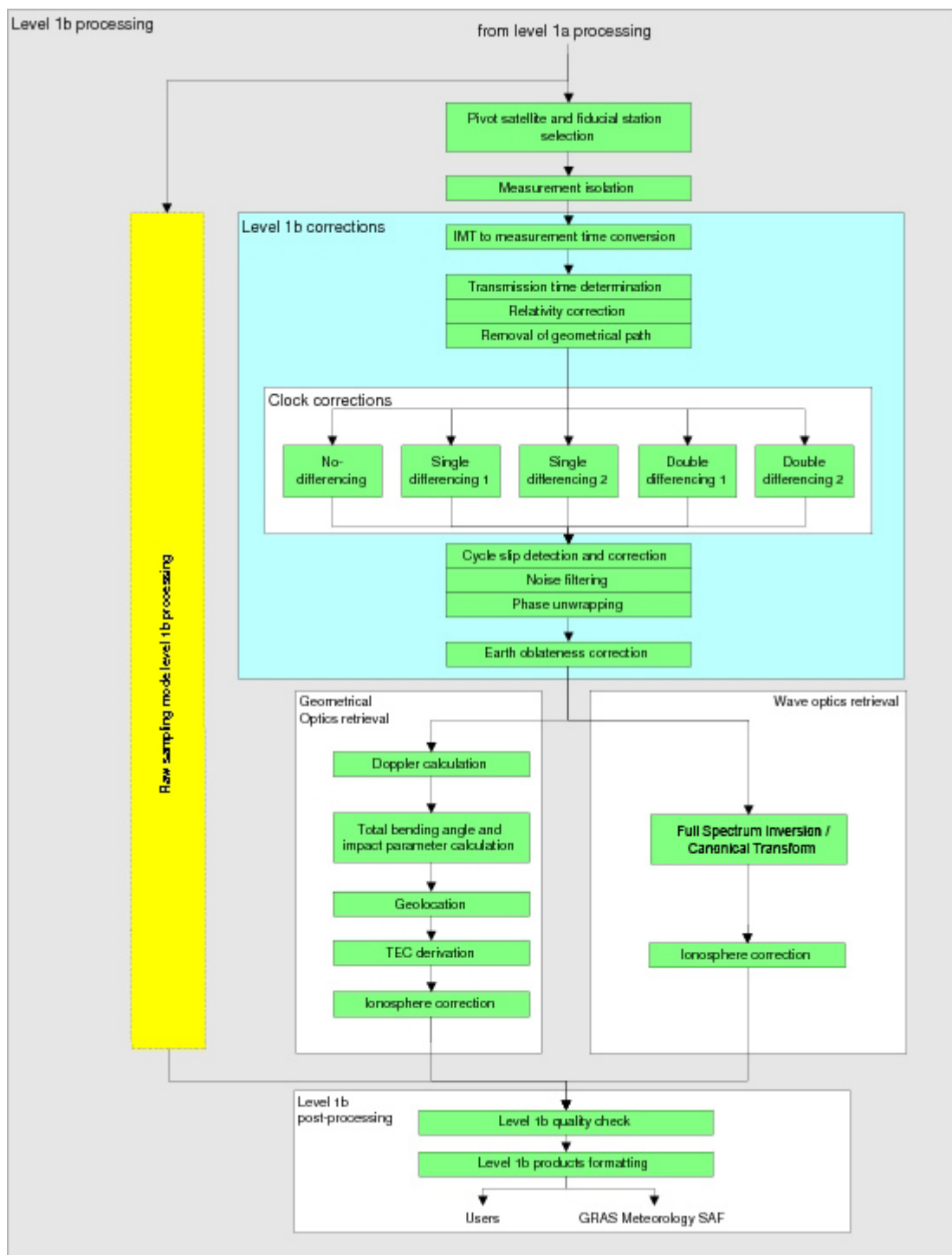
The derived phases of the occultation data are corrupted by high-frequency noise. The Level 1b processing function therefore low-pass filters the derived phase data. The filtering function is based on Savitzky-Golay (see [SCD9], [SCD10]).

The Level 1b processing function computes the Doppler shift (as a time derivative) for the phase residual observations in the occultation. It retrieves the bending angle as a function of the impact parameter by using the Geometrical Optics (GO) approximation. Additionally, Wave Optics (WO) processing is applied to parts of the measurement, using phases and amplitudes to derive a bending angle profile. GO is applied to the whole measured profile and WO to the lower part of the profile to detect and remove the impact of atmospheric multipath.

The frequency-independent neutral bending angle is computed by correcting for ionospheric dispersion, by applying a linear combination of the bending angles at two frequencies. Bending angle bias is calculated and a correction is applied if necessary. The Level 1b processing function also derives the total electron content (TEC) along the ray path. Error

characterisation is performed for all Level 1b products. For the raw sampling mode the Level 1b processing algorithm is to be defined.

Further information is available at [RD5]. A functional decomposition of the GRAS L1a processor is shown in the following figure.



**Figure 4-4: Level 1a to Level 1b processing steps**

#### 4.3.1.4 Occultation table generation

The Occultation Table Generation function produces a table containing all occultations and navigation measurements theoretically visible for the GRAS receiver for a time period of 24-36 hours. The table includes the pseudo random noise (PRN) code numbers of the occulting GPS satellites and the PRN numbers of the GPS satellites visible for the GRAS zenith antenna (GZA). An occultation and navigation measurement identification number is applied to each measurement.

Occultation table generation is based on predicted GPS and Metop orbits provided by the GSN and GRAS/Metop POD, respectively.

#### 4.3.2 Level 1b product summary

A summary of the expected 1b products and their corresponding relative errors is given in the table below.

| Parameter                 | Performance                                   |
|---------------------------|---|
| No. of occultations / day | > 500   |
| Measurement range         | 1 - 80 km                                     |
| Bending angle error       | < 1.0 $\mu$ rad or 0.4% (whichever is larger) |
| Sampling rate             | 50 Hz (closed-loop), 1 kHz (open loop)        |
| Timeliness                | 2 h 15 min                                    |

**Table 4-1: Expected GRAS Level 1b products and performance**

#### 4.3.3 GRAS SAF Level 1b to 2 data processing

The responsibility for extraction of meteorological or geophysical (Level 2) products from GRAS lies with the GRAS Meteorology Satellite Application Facility (GRAS SAF) [\[GRAS SAF\]](#). The development of the GRAS SAF was started in 1999 and is coordinated by the Danish Meteorological Institute (DMI) in Copenhagen. The GRAS SAF consortium comprises:

- Danish Meteorological Institute (DMI), host institute, Denmark
- Met Office, UK
- Institut D'Estudis Espacials de Catalunya, Spain
- ECMWF, UK (new partner in the CDOP phase)

As part of the distributed element of the EUMETSAT Applications Ground Segment, the GRAS SAF provides operational services to end-users, e.g. real-time or off-line product services, data management and related user services, including coordination of and support to relevant research and development. The SAF Visiting Scientist Programme allows involvement of scientific experts external to the SAF Consortium.

The GRAS SAF produces two different Level 2 products; one is provided in Near Real Time (NRT) [\[see NRT product\]](#), the other within 30 days [\[see offline product\]](#). For further information on the products etc., please refer to the [GRAS SAF website](#).

## **5 DATA VIEWING AND READING**

Readers for the native EPS format GRAS Level 1b products are available online at the EUMETSAT website on the [Useful Programs & Tools](#) page.

Tools to read HDF formats are TBD, but it is intended that the products can be read using standard HDF libraries. For more information on HDF5 formats in general, see the [HDF5 webpages](#).

Software capable of reading the WMO formats is available from a variety of sources, including [ECMWF](#).

A description of how to read, plot and convert EPS format into NetCDF using Python is given in *GRAS EPS-PFS Data Reading Introduction* [RD12] which may be [downloaded as a PDF](#).

## **6 GRAS PRODUCT FORMATS AND DISSEMINATION**

A description of the dissemination means for EPS products and formats is provided in the following paragraphs, focusing down on GRAS products and their formats.

### **6.1 EPS products available dissemination means**

*Note that this section about dissemination means of EPS products in general could be removed when that info is available on the EPS website.*

#### **6.1.1 Satellite Direct Broadcast Service**

Instrument and ancillary data acquired by the Metop satellites will be broadcast and received by authorised users in real-time via:

- High Resolution Picture Transmission (HRPT) - transmission of data from all Metop instruments in full resolution.

The data will be received by local reception stations. It is the responsibility of the user to procure and install a local reception station. Specification documentation for a EUMETSAT-based HRPT Reference User Station is available for information on the EUMETSAT webpage [Metop – AHRPT](#).

The output format of the EUMETSAT HRPT Reference User Station is Level 0 products in the EPS Native format [RD3].

The broadcast data are encrypted. To get authorisation to access the data, users need to register with the EUMETSAT User Services and will receive the data decryption information.

Data from the NOAA payload are also broadcast and received by local users via the HRPT mechanism. For details on the NOAA HRPT system, the reader is referred to the [NOAA KLM User's Guide](#) [SCD5].

#### **6.1.2 EUMETCast**

Global EPS products at different processing levels are distributed in near real-time via EUMETSAT's Data Distribution System (EUMETCast). EUMETCast utilises the services of a satellite operator and telecommunications provider to distribute data files using Digital Video Broadcast (DVB) to a wide audience located within the geographical coverage zone which includes most of Europe and certain areas in Africa.

Within the current EUMETCast configuration, the multicast system is based upon a client/server system with the server side implemented at the EUMETCast uplink site (Usingen, Germany) and the client side installed on the individual EUMETCast reception stations. The telecommunications suppliers provide the DVB multicast distribution mechanism. Data/product files are transferred via a dedicated communications line from EUMETSAT to the uplink facility. These files are encoded and transmitted to a geostationary communications satellite for broadcast to user receiving stations. Each receiving station decodes the signal and recreates the data/products according to a defined directory and file name structure. A single reception station can receive any combination of the provided services.

A typical EUMETCast reception station comprises a standard PC with DVB card inserted and a satellite off-set antenna fitted with a digital universal V/H LNB. In addition, users require the multicast client software, which can be obtained via the EUMETSAT User Services.

More detailed information on this service can be found on the EUMETSAT webpage [EUMETCast Dissemination Scheme](#).

Products distributed on EUMETCast can be formatted in a variety of formats, including EPS native format and the WMO formats (e.g. BUFR and GRIB).

### **6.1.3 GTS/RMDCN**

A subset of EPS products is disseminated additionally in near real-time via the Global Telecommunication System (GTS). The GTS is the World Meteorological Organization integrated network of point-to-point circuits and multi-point circuits which interconnect meteorological telecommunication centres. Its purpose is to enable an efficient exchange of meteorological data and products in a timely and reliable way to meet the needs of World, Regional and National Meteorological Centres. The circuits of the GTS are composed of a combination of terrestrial and satellite telecommunication links. Meteorological Telecommunication Centres are responsible for receiving data and relaying them selectively on GTS circuits. The GTS is organised on a three-level basis, namely:

- The Main Telecommunication Network, linking together 3 world meteorological centres and 15 regional telecommunication hubs.
- The Regional Meteorological Telecommunication Networks, consisting of an integrated network of circuits interconnecting meteorological centres in a region, which are complemented by radio broadcasts where necessary. In Europe, the GTS network is supported by the Regional Meteorological Data Communication Network (RMDCN).
- The National Meteorological Telecommunication Networks, which extend the GTS network down to national level.

More detailed information on this service can be found on the WMO website [www.wmo.int](http://www.wmo.int).

Products distributed on the GTS are in official WMO formats, e.g. BUFR or GRIB.

### **6.1.4 UMARF**

All EPS products and auxiliary data are normally archived and made available to users from the EUMETSAT Unified Meteorological Archive and Retrieval Facility (UMARF) upon request.

The UMARF can be accessed through the EUMETSAT webpage [Archive Services](#). Access is through a web interface through which the users are able to browse and order products, manage their user profile, retrieve products, documentation and software libraries, get help, etc.

UMARF features include geographical and time sub-setting and image preview. EPS products archived in the UMARF can be accessed in a variety of formats, including EPS native format and HDF.

## 6.2 GRAS products dissemination

Table 6.1 summarises the different dissemination means and formats for all GRAS Level 1 products available to users.

| Format                | Real-Time Direct Broadcast                        | Near-Real-Time dissemination on EUMETCast (timeliness)                 | Near-Real-Time dissemination on GTS (timeliness) | UMARF retrieval (timeliness)                   |
|-----------------------|---|--|--|--|
| Metop raw data format | GRAS HRPT raw data stream and Metop Admin message | --   | --   | --   |
| EPS native format     | --  | GRAS Level 1b (2 h 15 min)   | --   | GRAS Level 1a (8-9 h)<br>GRAS Level 1b (8-9 h) |
| HDF                   | --  | --   | --   | (TBC)  |
| WMO (BUFR)            | --  | GRAS Level 1b (2 h 15 min)<br><br>GRAS Level 1b (thinned) (2 h 15 min) | GRAS Level 1b (thinned) (2 h 15 min)             | --   |

*‘Timeliness’ refers to the elapsed time between sensing and dissemination.*

**Table 6-1: Summary of dissemination means and formats for GRAS products**

Note: The BUFR thinned data on GTS is much smaller in quantity than the full data on EUMETCast.

Real-time broadcast of GRAS raw data is not covered in this guide. It is noted though for information that the raw data streams mentioned in the table above indicate what is broadcast by the platform. Depending on the reception system used (i.e., the HRPT local reception system), different formats of this raw data stream are produced. This depends on the local reception station provider. For Metop HRPT stations, the Reference User Station has been developed to produce EPS Native Level 0 format products.

Although available through the UMARF, GRAS Level 0 products are not considered as an end-user product, hence they are not addressed in this guide either.

### 6.2.1 Near real-time dissemination

The GRAS Level 1 Products disseminated to users in near real-time are:



- GRAS Level 1b products (full + thinned), with a timeliness of 2 h 15 min from sensing

The dissemination granularity for Level 1 data covers one to several occultations within a time window of about 3 minutes.

### **6.2.2 Archive retrieval**

The GRAS Level 1 & 2 Products available from the UMARF are:

- GRAS Level 1a
- GRAS Level 1b
- GRAS Level 2 (from GRAS SAF)

The products are archived as full-dump products, but sub-setting capabilities are provided by the UMARF to the user in the retrieval step. The products are available for the users in the UMARF 8 to 9 hours after sensing.

## **6.3 GRAS EPS product format**

### **6.3.1 The EPS native formats**

#### **6.3.1.1 General overview of the EPS generic product format**

All products in EPS native format are structured and defined according to an EPS Generic Product Format. This format is not GRAS specific. The general product section breakdown is given, and the following sections will focus on how this generic format is further applied to GRAS products.

This description is not aimed at supporting the writing of reader software for the GRAS or other EPS products, because readers and product extraction tools are already available (see Section 5). The intention of this and the following sections is to provide enough information to be able to use such available tools and to interpret the retrieved information.

For users interested in writing their own product readers for one or several GRAS products in EPS native format, we refer them to the detailed format specifications provided in [RD6].

The general structure of the products is broken down in sections, which contain one or more records of different classes. Every single record is accompanied by a Generic Record Header (GRH), which contains the metadata necessary to uniquely identify the record type and occurrence within the product. The following general structure is followed by all EPS products, where all the sections occur always in the given order.

**Header Section**, containing metadata applicable to the entire product. The header section may contain two records, the Main Product Header Record (MPHR) and the Secondary Product Header Record (SPHR). This is the only section that contains ASCII records; the rest of the product is in binary.

**Pointer Section**, containing pointer information to navigate within the product. It consists of a series of Internal Pointer Records (IPR), which include pointers to records within the Global Auxiliary Data, Variable Auxiliary Data and Body Sections that follow.

**Global Auxiliary Data Section**, containing information on the auxiliary data that have been used or produced during the processing of the product and applies to the whole length of the

product. There can be zero or more records in this section, and they can be of two classes: Global External Auxiliary Data Record (GEADR), containing an ASCII pointer to the source of the auxiliary data used, and Global Internal Auxiliary Data Record (GIADR), containing the auxiliary data used itself. Note: not used for GRAS.

**Variable Auxiliary Data Section**, containing information on the auxiliary data that have been used or produced during the process of the product and may vary within a product, but with a frequency in any case less than the measurement data itself. There can be zero or more records in this section, and they can be of two classes: Variable External Auxiliary Data Record (VEADR), containing an ASCII pointer to the source of the auxiliary data used, and Variable Internal Auxiliary Data Record (VIADR), containing the auxiliary data used itself. Note: VEADR not used for GRAS.

**Body Section**, which is usually the main bulk of the product and contains the raw or processed instrument data and associated information. This section contains time-ordered Measurement Data Records (MDR). A particular type of MDR can occur to indicate the location of an unexpected data gap within any product, the Dummy Measurement Data Record (DMDR).

The format of the MPHR, IPRs, GEADR, VEADR and DMDRs is common to all products, while the other records can be of different formats and contents, and identified as of different sub-classes for different products. Every record consists of a series of fields, which can have different data types. See Appendix C for all possible data types.

It is important to note that GEADR and VEADR records are included in the products to support processing configuration control for EUMETSAT at product level. They point to the name of auxiliary data files used in the processing, but they are not of any interest or use to the end-user for the utilisation of the products.

Two types of records deserve special description because they are key to navigating within the products, namely the GRH and the IPR. Their format and the meaning of their fields are detailed in Appendix D.

Table 6-2 gives an example of the general structure of the Generic Product Format.

| Section                  | RECORD CLASS                               | RECORD SUBCLASS | START TIME | STOP TIME |
|--------------------------|--|-----------------|------------|-----------|
| HEADER SECTION           | MAIN PRODUCT HEADER RECORD                 |                 | T1         | T6        |
|                          | SECONDARY PRODUCT HEADER RECORD            |                 | T1         | T6        |
| INTERNAL POINTER SECTION | INTERNAL POINTER RECORD (GEADR Subclass A) |                 | T1         | T6        |
|                          | INTERNAL POINTER RECORD (GEADR Subclass B) |                 | T1         | T6        |
|                          | INTERNAL POINTER RECORD (GIADR Subclass A) |                 | T1         | T6        |
|                          | INTERNAL POINTER RECORD (GIADR Subclass B) |                 | T1         | T6        |
|                          |  |                 | T1         | T6        |
|                          |  |                 | T1         | T6        |
|                          |  |                 | T1         | T6        |

| Section                         | RECORD CLASS                               | RECORD SUBCLASS | START TIME | STOP TIME |
|---------------------------------|--|-----------------|------------|-----------|
|                                 | INTERNAL POINTER RECORD (GIADR Subclass C) |                 | T1         | T6        |
|                                 | INTERNAL POINTER RECORD (VEADR Subclass A) |                 | T1         | T6        |
|                                 | INTERNAL POINTER RECORD (VEADR Subclass B) |                 | T1         | T6        |
|                                 | INTERNAL POINTER RECORD (VEADR Subclass C) |                 | T1         | T6        |
|                                 | INTERNAL POINTER RECORD (VIADR Subclass A) |                 | T1         | T6        |
|                                 | INTERNAL POINTER RECORD (VIADR Subclass B) |                 | T1         | T6        |
|                                 | INTERNAL POINTER RECORD (VIADR Subclass C) |                 | T1         | T6        |
|                                 | INTERNAL POINTER RECORD (MDR Subclass A)   |                 | T1         | T6        |
|                                 | INTERNAL POINTER RECORD (MDR Subclass B)   |                 | T1         | T6        |
|                                 | INTERNAL POINTER RECORD (MDR DUMMY)        |                 | T1         | T6        |
|                                 | INTERNAL POINTER RECORD (MDR Subclass A)   |                 | T1         | T6        |
|                                 | INTERNAL POINTER RECORD (MDR Subclass B)   |                 | T1         | T6        |
| GLOBAL AUXILIARY DATA SECTION   | GLOBAL INTERNAL AUXILIARY DATA RECORD      | SUBCLASS A      | T1         | T6        |
|                                 | GLOBAL INTERNAL AUXILIARY DATA RECORD      | SUBCLASS B      | T1         | T6        |
|                                 | GLOBAL INTERNAL AUXILIARY DATA RECORD      | SUBCLASS A      | T1         | T6        |
|                                 | GLOBAL INTERNAL AUXILIARY DATA RECORD      | SUBCLASS B      | T1         | T6        |
|                                 | GLOBAL INTERNAL AUXILIARY DATA RECORD      | SUBCLASS C      | T1         | T6        |
| VARIABLE AUXILIARY DATA SECTION | VARIABLE INTERNAL AUXILIARY DATA RECORD    | SUBCLASS A      | T1         | T6        |
|                                 | VARIABLE INTERNAL AUXILIARY DATA RECORD    | SUBCLASS B      | T1         | T3        |
|                                 | VARIABLE INTERNAL AUXILIARY DATA RECORD    | SUBCLASS B      | T3         | T6        |
|                                 | VARIABLE INTERNAL AUXILIARY DATA RECORD    | SUBCLASS C      | T1         | T5        |
|                                 | VARIABLE INTERNAL AUXILIARY DATA RECORD    | SUBCLASS C      | T5         | T6        |
|                                 | VARIABLE INTERNAL AUXILIARY DATA RECORD    | SUBCLASS A      | T1         | T2        |
|                                 | VARIABLE INTERNAL AUXILIARY DATA RECORD    | SUBCLASS A      | T2         | T4        |
|                                 | VARIABLE INTERNAL AUXILIARY DATA RECORD    | SUBCLASS A      | T4         | T6        |

| Section      | RECORD CLASS                            | RECORD SUBCLASS | START TIME | STOP TIME |
|--------------|---|-----------------|------------|-----------|
|              | DATA RECORD                             | SUBCLASS B      | T1         | T6        |
|              | VARIABLE INTERNAL AUXILIARY DATA RECORD | SUBCLASS C      | T1         | T6        |
|              | VARIABLE INTERNAL AUXILIARY DATA RECORD |                 |            |           |
|              | VARIABLE INTERNAL AUXILIARY DATA RECORD |                 |            |           |
|              | VARIABLE INTERNAL AUXILIARY DATA RECORD |                 |            |           |
|              | VARIABLE INTERNAL AUXILIARY DATA RECORD |                 |            |           |
|              | VARIABLE INTERNAL AUXILIARY DATA RECORD |                 |            |           |
| BODY SECTION | MEASUREMENT DATA RECORD                 | SUBCLASS A      | T1         | T2        |
|              | MEASUREMENT DATA RECORD                 | SUBCLASS B      | T2         | T3        |
|              | MEASUREMENT DATA RECORD                 | DUMMY           | T3         | T4        |
|              | MEASUREMENT DATA RECORD                 | SUBCLASS A      | T4         | T5        |
|              | MEASUREMENT DATA RECORD                 | SUBCLASS B      | T5         | T6        |

**Table 6-2: Generalised schematic of the generic product format**

### 6.3.1.2 Granularity of the EPS products

The Full EPS product is produced by processing a dump of data. This is the product size used to archive in the UMARF.

In addition, the Regional EPS product is a full product that has been passed through a geographical filter. This may happen, for example, during the retrieval of the product from the UMARF.

Finally, the Product Dissemination Unit (PDU) is the near-real-time dissemination of the full product, and is typically of 3 minutes duration. A PDU is often referred to as a product ‘granule’.

The EPS Generic Product Format has been defined to apply to any length of sensing. That means that the same generic format described above applies to a 3-minute duration granule, half an orbit or a full dump of data. The length in time of the product is contained in the MPHR.

### 6.3.1.3 Product format version control

Every record class and sub-class has an associated record version number contained in its corresponding GRH. In addition, each product has a format version number, which is stored in the MPHR.

### 6.3.1.4 Product naming convention

The file naming convention for EPS products in EPS native format provides a product name that uniquely identifies any product and provides a summary of its contents. The field contents in a product name correspond to those in the MPHR.

```
<INSTRUMENT_ID>_<PRODUCT_TYPE>_<PROCESSING_LEVEL>_<SPACECRAFT_ID>_
<SENSING_START>_<SENSING_END>_<PROCESSING_MODE>_<DISPOSITION_MODE>_
<PROCESSING_TIME>
```

| Product Name Field / MPHR Field | Description                                     | Size in Characters |
|---------------------------------|---|--------------------|
| INSTRUMENT_ID                   | Instrument identification                       | 4                  |
| PRODUCT_TYPE                    | Product Type                                    | 3                  |
| PROCESSING_LEVEL                | Processing Level identification                 | 2                  |
| SPACECRAFT_ID                   | Spacecraft identification                       | 3                  |
| SENSING_START                   | UTC Time of start of Sensing Data               | 15                 |
| SENSING_END                     | UTC Time of end of Sensing Data                 | 15                 |
| PROCESSING_MODE                 | Identification of the mode of processing        | 1                  |
| DISPOSITION_MODE                | Identification of the type of processing        | 1                  |
| PROCESSING_TIME                 | UTC time at start of processing for the product | 15                 |

**Table 6-3: EPS Product name fields and their correspondence with MPHR fields**

For the GRAS products, the resulting product file names are as follows:

| Product       | Product name          |
|---------------|-----------------------|
| GRAS Level 1a | GRAS_xxx_1A_Mnn_<...> |
| GRAS Level 1b | GRAS_xxx_1B_Mnn_<...> |

**Table 6-4: Generic GRAS product names**

### 6.3.2 GRAS Level 1a products

GRAS Level 1a products (see [RD5]) contain reformatted raw instrument data along with all supplementary data needed for further processing, including geolocation and quality flags. The full information is available in Section 9.

| Section           | Record class | Record subclasses / Remarks   |
|-------------------|--------------|---|
| Header            | MPHR         |   |
|                   | SPHR         |   |
| Pointer           | IPR          | (One per target class)  |
| Global Aux Data   | GEADR        | None for GRAS   |
|                   | GIADR        | None for GRAS   |
| Variable Aux Data | VIADR        | Occulting GPS NRT orbit arc<br>Earth orientation parameters<br>Tropospheric delay product<br>Ground station clock bias estimate<br>Ground station clock offset estimates<br>Sounding support measurements<br>GPS tracking data<br>Occultation table<br>GSN quality report<br>Metop NRT orbit arc<br>Metop attitude data<br>Metop clock offset estimates |
| Body              | MDR          | Information generally on a per PDU basis, see MDR-1a-... in Section 9.14 etc.<br>(Granularity: generally one per PDU)   |

**Table 6-5: Generalised format of GRAS Level 1a products**

Typical product size for one full orbit is about 250 MB.

### 6.3.3 GRAS Level 1b products

GRAS Level 1b products (see [RD5]) contain information on a per occultation basis, along with auxiliary information such as geolocation, quality flags, etc. The full information is available in Section 10.

| Section           | Record class | Record subclasses / Remarks                        |
|-------------------|--------------|--|
| Header            | MPHR         |  |
|                   | SPHR         | (same as in Level 1a product)                      |
| Pointer           | IPR          | One per target class                               |
| Global Aux Data   | GEADR        | as defined [RD3]                                   |
|                   | GIADR        | as defined [RD3]                                   |
| Variable Aux Data | VIADR        | GPS orbit arc<br>Occulting GPS clock bias estimate |

|      |     |   |
|------|-----|---|
|      |     | Tropospheric delay products for fiducial stations<br>Clock offset estimates for fiducial stations<br>Metop NRT orbit arc<br>Metop clock bias estimation<br>Earth orientation parameters<br>Metop attitude information |
| Body | MDR | Information on a per occultation basis, see MDR-1b in Section 10.11<br>(Granularity: one per occultation)   |

**Table 6-6: Generalised format of GRAS Level 1b products**

Typical product size for one full orbit is about 180 MB.

#### 6.4 The HDF format

The contents and formats of the individual fields of the GRAS-2 Level 1b HDF5 products are the same as for the EPS native format.

Detailed format descriptions are provided in [RD10]. The products retrieved from the UMARF have the same name as the original EPS formatted ones, with the extension appended:

‘.h5’ for HDF5 formatted products

‘.nat’ for products in the native EPS format

Tools to read HDF formats are TBD, but it is intended that the products can be read using standard HDF libraries. For more information on HDF5 formats in general, see the [HDF5 webpages](#).

#### 6.5 The WMO formats

The GRAS Level 1b products available in WMO (BUFR) format are summarised in the table below.

| Product               | Bulletin header   | Originating station | Descriptor sequence   |
|-----------------------|---|---------------------|---|
| GRAS Level 1b         | N/A   | N/A                 | 3-10-026<br>[Descriptor 3-10-026 is the standard for radio occultation data.] |
| GRAS Level 1b thinned | IEGXii (ii from 01 to 89)<br>[ii is incremented for successive occultations ending in the same minute.] | EUMP                | 3-10-026  |

**Table 6-7: GRAS Level 1b products available in WMO (BUFR) format**

The full format description of these products is available in the [WMO Manual on Codes \[SCD4\]](#).

The names of the GRAS Level 1b products distributed on EUMETCast are specified in [RD11]. They follow the pattern:

`gras_yyyymmdd_hhmmss_metopa_nnnnn_eps_o[_thn].l1_bufr`

where:

yyymmdd stands for the UTC year, month, day of the data end sensing time  
hhmmss stands for the UTC hour, minute, second of the data end sensing time  
nnnnn is the orbit number  
\_thn denotes a thinned product

GRAS vertical profiles regularly contain several thousand samples because the instrument samples at a frequency of 50 Hz and an occultation can often last more than 60 seconds. The GTS is currently not able to cope with the resulting large BUFR files, hence a thinned BUFR product is generated and distributed only on GTS. The thinning reduces the number of vertical levels to currently 247, using a simple linear interpolation in log(bending angle). The same thinning algorithm is also used at the GRAS SAF to thin Level 2 products.

There will be one occultation per GTS bulletin, and the GTS data will not be compressed. The full data on EUMETCast may have multiple occultations within a BUFR message and will be compressed.



## **7 GRAS PRODUCTS PROCESSING ALGORITHMS**

This section will be completed later. For now, please refer to the Product Generation Function Specifications [RD5].

## **8 GRAS PRODUCTS VALIDATION AND MONITORING**

*For more recent information, please check for relevant documents on the EUMETSAT webpage [Product Validation Reports](#).*

### **8.1 Objectives**

The overall objective of the GRAS characterisation, calibration and validation activities is to ensure that, after the commissioning phase and thereafter during the mission lifetime, the GRAS instrument achieves its expected performance with respect to the GRAS requirements specification [RD7], and that the products satisfy the EPS end-user requirements specified in [RD1]. A further objective is that the GRAS product accuracy will continuously improve as far as possible to satisfy the evolving state-of-the-art user requirements. The following specific objectives determine the product Cal/Val activities for GRAS:

- full verification of instrument performance through monitoring of the GRAS instrument
- calibration and characterisation of the GRAS instrument taking into account possible long-term changes in instrument performance in-flight
- provision of confidence-checked and verified GRAS Level 1 products
- provision of validated GRAS Level 1b products
- revision of product generation processing algorithms and required data sets, to ensure that the products first meet, and then exceed, user expectations.

It can be expected that corrections to the GRAS processing will periodically require a reprocessing of the complete data set during routine operations to ensure the consistency of the long-term data record.

### **8.2 GRAS in-orbit verification**

GRAS In-Orbit Verification (GRAS IOV) has been carried out under the responsibility of the European Space Agency (ESA). GRAS passed the test review board on 23 January 2007 and the hardware is considered operational. The primary objective of GRAS IOV was to verify that the instrument meets its functional and performance requirements. This has been achieved by exercising specific instrument operations, first via manual commanding and then using dedicated test timelines, and by analysis of raw data from the S bands using dedicated test tools. Demonstration of this nominal instrument performance is a prerequisite for successful GRAS IOV and Commissioning Phase Hand-over Reviews. In addition, GRAS IOV activities provide significant input to the planning of commissioning phase and routine operations. The specific functional and performance tests carried out during IOV are fully detailed in [RD4].

### **8.3 Instrument monitoring**

Verification of the correct functioning of the GRAS instrument requires continuous instrument monitoring activities. These activities start during the commissioning phase, specifically during in-orbit verification of the instrument function and performance, and continue during the remainder of the commissioning phase (which partly ends with a Product Validation Board review) and during routine operations [RD4]. Furthermore, instrument characteristics might change during the GRAS lifetime, e.g. caused by software upgrades.

Operational instrument monitoring is performed in the Cal/Val Facility (CVF) at EUMETSAT, a dedicated calibration and validation network for all Metop instruments, as part of the calibration and validation activities. GRAS-specific parameters (such as tracking state and number of tracked occultations) are monitored to assure the instrument's health. A very basic instrument monitoring is also performed by the Quality Control Facility within the Core Ground Segment at EUMETSAT.

## **8.4 Validation**

A general overview of the GRAS calibration and validation activities is given in [RD8]. Validation can be separated into two parts, the so-called Precise Orbit Determination (POD) and the profile validation.

### **8.4.1 Precise Orbit Determination validation**

The data processing requires accurate knowledge of the GPS and Metop satellite positions and velocities.

GPS satellite positions and velocities are provided by the Ground Support Network (GSN), a service that provides GPS state vectors, clock offset estimates and ground-based measurements from a network of globally distributed fiducial stations. This service is provided by [ESA/ESOC](#). The accuracy of the GPS orbits provided by the GSN is validated by comparing them to International GNSS Service (IGS) orbits. Additionally, the timeliness and completeness of the GSN data is monitored.

Metop satellite positions are calculated based on the GRAS navigation measurements and the GSN data in near real-time. Validation of this calculated orbit is done in the CVF within a batch process, using the ESOC Navigation Package for Earth Observation Satellites (NAPEOS) software. Additionally, several further validation approaches are performed/planned:

- Navigation measurements covering dedicated time periods are provided to external partners, and the orbits calculated at these partner institutions are compared to the in-house ones.
- Navigation measurements provided by other radio occultation instruments can be run through the in-house processing and compared to the external orbits.
- The in-house Flight Dynamics Facility provides less accurate Metop orbits which should agree within the error bounds.
- The GRAS receiver provides a less accurate on-board solution which should agree within the error bounds.

### **8.4.2 Atmospheric profile validation**

For a good description of the validation strategy for GRAS see EUMETSAT Technical Memorandum 12 [SCD6].

Level 1b profiles as provided by GRAS contain, among other parameters, bending angle over impact parameters. These bending angles represent the main measurements that are assimilated at NWP centres. (Note: NWP centres might also choose to assimilate refractivity profiles as provided by the GRAS SAF.) Except for other radio occultation instruments,

bending angles are generally not measured, thus a continuous, operational validation of these profiles is problematic. Hence the core validation process is based on a one-dimensional variational assimilation (1DVar) approach. This provides bending angles along with robust statistics for the GRAS validation. Additionally, temperature, pressure and humidity profiles (which present the main information that is extracted from radio occultation measurements by NWP centre assimilation) are provided by the 1DVar. The availability of these profiles allows further validation of the GRAS measurements by comparing them to instruments providing these profiles, such as radiosondes or Lidar. Hence, the validation is partly based on the variables which are of main interest to the NWP centres.

#### **8.4.2.1 1DVar validation**

The tool for these activities is the Radio Occultation Processing Package (ROPP) software tool [GS3]. It uses a 1DVar approach to derive temperature, water vapour and pressure profiles from bending angles; background information is taken generally from the ECMWF. A so-called forward model maps the atmospheric state (ECMWF profiles) onto measurement state (bending angle profiles), hence validation can be performed in measurement space and in atmospheric state space for all available occultations.

Routine instrument monitoring and validation are based on the 1DVar output:

- “Noise characteristics” statistics: although not a direct 1DVar product, these are required as input and are monitored.
- “Convergence and Cost” statistics: output of the 1DVar processing giving information on assumed input errors.
- “Observation minus Background” statistics: performed in measurement space, showing the difference between the forward propagated ECMWF background state and the actual GRAS measurement.
- “Observation minus Solution” statistics: performed in measurement space, showing the difference between the forward propagated 1DVar solution and the actual GRAS measurement.

#### **8.4.2.2 Radio occultation instrument validation**

This validation is performed continuously by collocating GRAS measurements with other available external radio occultation missions. Possible missions are the COSMIC constellation, see e.g. [SCD3], or the CHAMP mission [SCD2]. Direct validation of bending angles is possible with this approach, but it also allows the EUMETSAT processing to be validated by using raw measurements from these external missions, running them through the POD and the profile generation, and validating the generated profiles with the external ones. Note that this validation will not allow all GRAS measurements to be accommodated since it relies on collocation.

#### **8.4.2.3 Radiosonde validation**

Radiosondes provide temperature, pressure and humidity profiles. These could be used to generate a refractivity and bending angle profile for validation. Although, as mentioned above, the 1DVar output can also be used to validate directly in atmospheric parameter space,

note that this validation will not allow all GRAS measurements to be accommodated since it relies on collocation.

#### **8.4.2.4 Lidar validation**

Lidar instruments generally provide temperature profiles in the upper atmosphere. These can be used for temperature validation. Note that this validation will not allow all GRAS measurements to be accommodated since it relies on collocation.

### **8.5 Validation of GRAS SAF products**

As noted above, validation of GRAS SAF products is under the responsibility of the GRAS SAF itself. The validation activities planned by the GRAS SAF are described in detail at [GS1], [GS2]. They comprise:

- system performance: observation delay, availability, data quality assessment using NWP profiles
- product validation: global statistics with respect to NWP (separation into land/sea, latitude bands, regions, rising/setting)
- validation using other measurements: such as radiosondes, other radio occultations
- validation campaigns: high resolution radiosondes, lidars

Validation results from these activities, and also the diagnostic quantities produced in the generation of Level 2 products, provide valuable feedback to the Level 1 validation activities. Similarly, Level 1 verification and validation activities provide necessary input to the GRAS SAF validation activities.

### **8.6 Scientific activities carried out via the EPS/Metop RAO**

An EPS/Metop Research Announcement of Opportunity (RAO) to be coordinated by EUMETSAT and ESA was started. The primary objectives of the Announcement of Opportunity are:


- stimulating relevant research in all domains of Earth Sciences, and structured dialogue and interactions between the selected investigators and the EUMETSAT operational users;
- identifying support to calibration and validation activities, complementing and enhancing calibration and validation activities planned by EUMETSAT;
- investigation of innovative research algorithms and demonstration of new geophysical products and of their relevance to research.


Several selected RAOs provide scientific support to GRAS calibration and validation activities. Further details can be found in the *EPS/Metop Research Announcement of Opportunity* [RD9].

## 9 RECORD DESCRIPTION OF THE GRAS LEVEL 1A PRODUCTS

This GRAS 1a description corresponds to the GRAS Level 1 PFS [RD6] Issue v7B and the Generic PFS [RD3] Issue v7B.

In the tables below, coloured items have the following meanings:

 Compound data type, which consists of at least two basic or other compound data types. The name of the compound data type is shown first, followed by a list of the items contained within it.

 Dimension parameter for variable product fields.

### Summary of Product Format Version record contents history

|                             | PFV = 10.0     |
|-----------------------------|----------------|
| Record name                 | Record version |
| mphr                        | 2              |
| sphr                        | 3              |
| viadr-1a-gps-pod            | 3              |
| viadr-1a-eop                | 5              |
| viadr-1a-tzd                | 3              |
| viadr-1a-gps-clock          | 3              |
| viadr-1a-station-clock      | 3              |
| viadr-1a-ssd                | 3              |
| viadr-1a-occultation-table  | 3              |
| viadr-1a-gsn-quality-report | 3              |

|                           |   |
|---------------------------|---|
| viadr-1a-metop-pod        | 3 |
| viadr-1a-metop-attitude   | 3 |
| viadr-1a-metop-clock      | 3 |
| mdr-1a-onboard-navigation | 3 |
| mdr-1a-gain               | 3 |
| mdr-1a-temperature        | 3 |
| mdr-1a-tracking-state     | 3 |
| mdr-1a-ephemeris          | 3 |
| mdr-1a-occ-noise          | 3 |
| mdr-1a-zenith-noise       | 3 |
| mdr-1a-occultation-data   | 4 |
| mdr-1a-navigation-data    | 4 |
| mdr-1a-nav-frame          | 3 |
| mdr-1a-gras-monitoring    | 4 |

If more than one version of a record exists, all versions are described below.

**Contents:**

- MPHR ( name 'mphr', class 1, subclass 0, version 2 )
- SPHR ( name 'sphr', class 2, subclass 1, version 3 )
- VIADR ( name 'viadr-1a-gps-pod', class 7, subclass 1, version 3 )
- VIADR ( name 'viadr-1a-eop', class 7, subclass 2, version 5 )
- VIADR ( name 'viadr-1a-tzd', class 7, subclass 3, version 3 )
- VIADR ( name 'viadr-1a-gps-clock', class 7, subclass 4, version 3 )

- VIADR ( name 'viadr-1a-station-clock', class 7, subclass 5, version 3 )
- VIADR ( name 'viadr-1a-ssd', class 7, subclass 6, version 3 )
- VIADR ( name 'viadr-1a-occultation-table', class 7, subclass 8, version 3 )
- VIADR ( name 'viadr-1a-gsn-quality-report', class 7, subclass 9, version 3 )
- VIADR ( name 'viadr-1a-metop-pod', class 7, subclass 10, version 3 )
- VIADR ( name 'viadr-1a-metop-attitude', class 7, subclass 11, version 3 )
- VIADR ( name 'viadr-1a-metop-clock', class 7, subclass 12, version 3 )
- MDR ( name 'mdr-1a-onboard-navigation', class 8, subclass 1, version 3 )
- MDR ( name 'mdr-1a-gain', class 8, subclass 2, version 3 )
- MDR ( name 'mdr-1a-temperature', class 8, subclass 3, version 3 )
- MDR ( name 'mdr-1a-tracking-state', class 8, subclass 4, version 3 )
- MDR ( name 'mdr-1a-ephemeris', class 8, subclass 5, version 3 )
- MDR ( name 'mdr-1a-occ-noise', class 8, subclass 6, version 3 )
- MDR ( name 'mdr-1a-zenith-noise', class 8, subclass 7, version 3 )
- MDR ( name 'mdr-1a-occultation-data', class 8, subclass 8, version 4 )
- MDR ( name 'mdr-1a-navigation-data', class 8, subclass 9, version 4 )
- MDR ( name 'mdr-1a-nav-frame', class 8, subclass 10, version 3 )
- MDR ( name 'mdr-1a-gras-monitoring', class 8, subclass 11, version 4 )

Certain record types with formats common to all products (IPR, DMDR, GEADR, VEADR) are not included below, since they are not relevant to the average user. If required, details of these records can be found in the Generic PFS [RD3].

Note: An entry of 'var' in the 'Field size' or 'Offset' columns below indicates that the entry cannot be specified exactly because of variable dimensions. To compute field sizes and offsets, please see the PFS for more detailed information.



## 9.1 MPHR ( name 'mphr', class 1, subclass 0, version 2 )

| Name                  | Description   | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|-----------------------|---|----------------|-------|------|------|------|------|----------|-----------|------------|--------|
| RECORD_HEADER         | Generic Record Header   |                |       | 1    | 1    | 1    | 1    | REC_HEAD | 20        | 20         | 0      |
| Product Details       |   |                |       |      |      |      |      |          |           |            |        |
| PRODUCT_NAME          | Complete name of the product  |                |       | 1    | 1    | 1    | 1    | string   | 67        | 100        | 20     |
| PARENT_PRODUCT_NAME_1 | Name of the parent product from which this product has been produced. For Level 0 products, this field is filled with lower case x's.   |                |       | 1    | 1    | 1    | 1    | string   | 67        | 100        | 120    |
| PARENT_PRODUCT_NAME_2 | Name of the parent product from which this product has been produced. For Level 0 products or products for which this is not appropriate, this field is filled with lower case x's. |                |       | 1    | 1    | 1    | 1    | string   | 67        | 100        | 220    |
| PARENT_PRODUCT_NAME_3 | Name of the parent product from which this product has been produced. For Level 0 products or products for which this is not appropriate, this field is filled with lower case x's. |                |       | 1    | 1    | 1    | 1    | string   | 67        | 100        | 320    |
| PARENT_PRODUCT_NAME_4 | Name of the parent product from which this product has been produced. For Level 0 products or products for which this is not  |                |       | 1    | 1    | 1    | 1    | string   | 67        | 100        | 420    |

| Name                              | Description  | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|-----------------------------------|--|----------------|-------|------|------|------|------|------------|-----------|------------|--------|
|                                   | appropriate, this field is filled with lower case x's.   |                |       |      |      |      |      |            |           |            |        |
| <a href="#">INSTRUMENT_ID</a>     | Instrument identification  |                |       | 1    | 1    | 1    | 1    | enumerated | 4         | 37         | 520    |
| <a href="#">INSTRUMENT_MODEL</a>  | Instrument Model identification  |                |       | 1    | 1    | 1    | 1    | enumerated | 3         | 36         | 557    |
| <a href="#">PRODUCT_TYPE</a>      | Product Type   |                |       | 1    | 1    | 1    | 1    | enumerated | 3         | 36         | 593    |
| <a href="#">PROCESSING_LEVEL</a>  | Processing Level Identification  |                |       | 1    | 1    | 1    | 1    | enumerated | 2         | 35         | 629    |
| <a href="#">SPACECRAFT_ID</a>     | Spacecraft identification  |                |       | 1    | 1    | 1    | 1    | enumerated | 3         | 36         | 664    |
| SENSING_START                     | UTC Time of start of sensing data in this object (PDU, ROI or Full Product)  |                |       | 1    | 1    | 1    | 1    | time       | 15        | 48         | 700    |
| SENSING_END                       | UTC Time of end of sensing data in this object (PDU, ROI or Full Product)  |                |       | 1    | 1    | 1    | 1    | time       | 15        | 48         | 748    |
| SENSING_START_THEORETICAL         | Theoretical UTC Time of start of sensing data in the dump from which this object is derived. This data is the predicted start time at the MPF level. |                |       | 1    | 1    | 1    | 1    | time       | 15        | 48         | 796    |
| SENSING_END_THEORETICAL           | Theoretical UTC Time of end of sensing data in the dump from which this object is derived. This data is the predicted end time at the MPF level.     |                |       | 1    | 1    | 1    | 1    | time       | 15        | 48         | 844    |
| <a href="#">PROCESSING_CENTRE</a> | Processing Centre Identification   |                |       | 1    | 1    | 1    | 1    | enumerated | 4         | 37         | 892    |
| PROCESSOR_MAJOR_VERSION           | Processing chain major version number  |                |       | 1    | 1    | 1    | 1    | uinteger   | 5         | 38         | 929    |

| Name                                     | Description   | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|--|---|----------------|-------|------|------|------|------|------------|-----------|------------|--------|
| PROCESSOR_MINOR_VERSION                  | Processing chain minor version number                             |                |       | 1    | 1    | 1    | 1    | uinteger   | 5         | 38         | 967    |
| FORMAT_MAJOR_VERSION                     | Dataset Format Major Version number                               |                |       | 1    | 1    | 1    | 1    | uinteger   | 5         | 38         | 1005   |
| FORMAT_MINOR_VERSION                     | Dataset Format Minor Version number                               |                |       | 1    | 1    | 1    | 1    | uinteger   | 5         | 38         | 1043   |
| PROCESSING_TIME_START                    | UTC time of the processing at start of processing for the product |                |       | 1    | 1    | 1    | 1    | time       | 15        | 48         | 1081   |
| PROCESSING_TIME_END                      | UTC time of the processing at end of processing for the product   |                |       | 1    | 1    | 1    | 1    | time       | 15        | 48         | 1129   |
| <a href="#">PROCESSING_MODE</a>          | Identification of the mode of processing                          |                |       | 1    | 1    | 1    | 1    | enumerated | 1         | 34         | 1177   |
| <a href="#">DISPOSITION_MODE</a>         | Identification of the disposition mode                            |                |       | 1    | 1    | 1    | 1    | enumerated | 1         | 34         | 1211   |
| <a href="#">RECEIVING_GROUND_STATION</a> | Acquisition Station Identification                                |                |       | 1    | 1    | 1    | 1    | enumerated | 3         | 36         | 1245   |
| RECEIVE_TIME_START                       | UTC time of the reception at CDA for first Data Item              |                |       | 1    | 1    | 1    | 1    | time       | 15        | 48         | 1281   |
| RECEIVE_TIME_END                         | UTC time of the reception at CDA for last Data Item               |                |       | 1    | 1    | 1    | 1    | time       | 15        | 48         | 1329   |
| ORBIT_START                              | Start Orbit Number, counted incrementally since launch            |                |       | 1    | 1    | 1    | 1    | uinteger   | 5         | 38         | 1377   |
| ORBIT_END                                | Stop Orbit Number   |                |       | 1    | 1    | 1    | 1    | uinteger   | 5         | 38         | 1415   |
| ACTUAL_PRODUCT_SIZE                      | Size of the complete product                                      |                | bytes | 1    | 1    | 1    | 1    | uinteger   | 11        | 44         | 1453   |
| <b>ASCENDING NODE ORBIT PARAMETERS</b>   |   |                |       |      |      |      |      |            |           |            |        |
| STATE_VECTOR_TIME                        | Epoch time (in UTC) of the orbital                                |                | UTC   | 1    | 1    | 1    | 1    | longtime   | 18        | 51         | 1497   |

| Name             | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type    | Type size | Field size | Offset |
|------------------|--|-----------------|-------|------|------|------|------|---------|-----------|------------|--------|
|                  | elements and the orbit state vector. this corresponds to the time of crossing the ascending node for ORBIT_START |                 |       |      |      |      |      |         |           |            |        |
| SEMI_MAJOR_AXIS  | Semi major axis of orbit at time of the ascending node crossing.   |                 | mm    | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1548   |
| ECCENTRICITY     | Orbit eccentricity at time of the ascending node crossing  | 10 <sup>6</sup> |       | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1592   |
| INCLINATION      | Orbit inclination at time of the ascending node crossing   | 10 <sup>3</sup> | deg   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1636   |
| PERIGEE_ARGUMENT | Argument of perigee at time of the ascending node crossing   | 10 <sup>3</sup> | deg   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1680   |
| RIGHT_ASCENSION  | Right ascension at time of the ascending node crossing   | 10 <sup>3</sup> | deg   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1724   |
| MEAN_ANOMALY     | Mean anomaly at time of the ascending node crossing  | 10 <sup>3</sup> | deg   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1768   |
| X_POSITION       | X position of the orbit state vector in the orbit frame at ascending node  | 10 <sup>3</sup> | m     | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1812   |
| Y_POSITION       | Y position of the orbit state vector in the orbit frame at ascending node  | 10 <sup>3</sup> | m     | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1856   |
| Z_POSITION       | Z position of the orbit state vector in the orbit frame at ascending node  | 10 <sup>3</sup> | m     | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1900   |
| X_VELOCITY       | X velocity of the orbit state vector in the orbit frame at ascending   | 10 <sup>3</sup> | m/s   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1944   |

| Name                          | Description   | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type    | Type size | Field size | Offset |
|-------------------------------|---|-----------------|-------|------|------|------|------|---------|-----------|------------|--------|
|                               | node  |                 |       |      |      |      |      |         |           |            |        |
| Y_VELOCITY                    | Y velocity of the orbit state vector in the orbit frame at ascending node                 | 10 <sup>3</sup> | m/s   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1988   |
| Z_VELOCITY                    | Z velocity of the orbit state vector in the orbit frame at ascending node                 | 10 <sup>3</sup> | m/s   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2032   |
| EARTH_SUN_DISTANCE_RATIO      | Earth-Sun distance ratio - ratio of current Earth-Sun distance to Mean Earth-Sun distance |                 |       | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2076   |
| LOCATION_TOLERANCE_RADIAL     | Nadir Earth location tolerance radial   |                 | m     | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2120   |
| LOCATION_TOLERANCE_CROSSTRACK | Nadir Earth location tolerance cross-track  |                 | m     | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2164   |
| LOCATION_TOLERANCE_ALONGTRACK | Nadir Earth location tolerance along-track  |                 | m     | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2208   |
| YAW_ERROR                     | Constant Yaw attitude error   | 10 <sup>3</sup> | deg   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2252   |
| ROLL_ERROR                    | Constant Roll attitude error  | 10 <sup>3</sup> | deg   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2296   |
| PITCH_ERROR                   | Constant Pitch attitude error   | 10 <sup>3</sup> | deg   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2340   |
| <b>LOCATION SUMMARY</b>       |   |                 |       |      |      |      |      |         |           |            |        |
| SUBSAT_LATITUDE_START         | Latitude of sub-satellite point at start of the data set                                  | 10 <sup>3</sup> | Deg   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2384   |
| SUBSAT_LONGITUDE_START        | Longitude of sub-satellite point at start of the data set                                 | 10 <sup>3</sup> | Deg   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2428   |
| SUBSAT_LATITUDE_END           | Latitude of sub-satellite point at end of the data set                                    | 10 <sup>3</sup> | Deg   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2472   |

| Name                    | Description   | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|-------------------------|---|-----------------|-------|------|------|------|------|----------|-----------|------------|--------|
| SUBSAT_LONGITUDE_END    | Longitude of sub-satellite point at end of the data set   | 10 <sup>3</sup> | Deg   | 1    | 1    | 1    | 1    | integer  | 11        | 44         | 2516   |
| Leap Second Information |   |                 |       |      |      |      |      |          |           |            |        |
| LEAP_SECOND             | Occurrence of Leap second within the product. Field is set to -1, 0 or +1 dependent upon occurrence of leap second and direction. |                 |       | 1    | 1    | 1    | 1    | integer  | 2         | 35         | 2560   |
| LEAP_SECOND_UTC         | UTC time of occurrence of the Leap Second (If no leap second in the product, value is null)                                       |                 |       | 1    | 1    | 1    | 1    | time     | 15        | 48         | 2595   |
| Record counts           |   |                 |       |      |      |      |      |          |           |            |        |
| TOTAL_RECORDS           | Total count of all records in the product   |                 |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 2643   |
| TOTAL_MPHR              | Total count of all MPHRS in product (should always be 1!)   |                 |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 2682   |
| TOTAL_SPHR              | Total count of all SPHRs in product (should be 0 or 1 only)   |                 |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 2721   |
| TOTAL_IPR               | Total count of all IPRs in the product  |                 |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 2760   |
| TOTAL_GEADR             | Total count of all GEADRs in the product  |                 |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 2799   |
| TOTAL_GIADR             | Total count of all GIADRs in the product  |                 |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 2838   |
| TOTAL_VEADR             | Total count of all VEADRs in the product  |                 |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 2877   |
| TOTAL_VIADR             | Total count of all VIADRs in the  |                 |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 2916   |

| Name                                      | Description  | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|---|--|----------------|-------|------|------|------|------|----------|-----------|------------|--------|
|   | product  |                |       |      |      |      |      |          |           |            |        |
| TOTAL_MDR                                 | Total count of all MDRs in the product   |                |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 2955   |
| <b>Record Based Generic Quality Flags</b> |  |                |       |      |      |      |      |          |           |            |        |
| COUNT_DEGRADED_INST_MDR                   | Count of MDRs with degradation due to instrument problems  |                |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 2994   |
| COUNT_DEGRADED_PROC_MDR                   | Count of MDRs with degradation due to processing problems  |                |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 3033   |
| COUNT_DEGRADED_INST_MDR_BLOCKS            | Count of the number of blocks of MDRs degraded due to degraded instrument  |                |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 3072   |
| COUNT_DEGRADED_PROC_MDR_BLOCKS            | Count of the number of blocks of MDRs degraded due to degraded processing  |                |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 3111   |
| <b>Time Based Generic Quality Flags</b>   |  |                |       |      |      |      |      |          |           |            |        |
| DURATION_OF_PRODUCT                       | The duration of the product in milliseconds  |                | ms    | 1    | 1    | 1    | 1    | uinteger | 8         | 41         | 3150   |
| MILLISECONDS_OF_DATA_PRESENT              | The total amount of data present in the product  |                | ms    | 1    | 1    | 1    | 1    | uinteger | 8         | 41         | 3191   |
| MILLISECONDS_OF_DATA_MISSING              | The total amount of data missing from the product  |                | ms    | 1    | 1    | 1    | 1    | uinteger | 8         | 41         | 3232   |
| <b>Regional Product Information</b>       |  |                |       |      |      |      |      |          |           |            |        |
| SUBSETTED_PRODUCT                         | Set when product has been subset (e.g. geographically subset using a region of interest filter). Implies the presence of one or more UMARF |                |       | 1    | 1    | 1    | 1    | boolean  | 1         | 34         | 3273   |

| Name        | Description   | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type | Type size | Field size | Offset |
|-------------|---|----------------|-------|------|------|------|------|------|-----------|------------|--------|
|             | GIADRs in GAD section for product retrieved from UMARF. |                |       |      |      |      |      |      |           |            |        |
| Total: 3307 |   |                |       |      |      |      |      |      |           |            |        |

## 9.2 SPHR ( name 'sphr', class 2, subclass 1, version 3 )

| Name                           | Description  | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|--------------------------------|--|----------------|-------|------|------|------|------|------------|-----------|------------|--------|
| RECORD_HEADER                  | Generic Record Header  |                |       | 1    | 1    | 1    | 1    | REC_HEAD   | 20        | 20         | 0      |
| GOBS_VER                       | Gras Onboard Software version number   |                |       | 1    | 1    | 1    | 1    | string     | 40        | 73         | 20     |
| <a href="#">GRAS_ID</a>        | GRAS instrument identification   |                |       | 1    | 1    | 1    | 1    | enumerated | 3         | 36         | 93     |
| <a href="#">EARTH_MODEL_ID</a> | Earth model identification   |                |       | 1    | 1    | 1    | 1    | enumerated | 3         | 36         | 129    |
| METOP_MANOEUVRE_FLAG           | Metop manoeuvre flag   |                |       | 1    | 1    | 1    | 1    | boolean    | 1         | 34         | 165    |
| METOP_MANOEUVRE_START          | Start time of the manoeuvre  |                | s     | 1    | 1    | 1    | 1    | longtime   | 18        | 51         | 199    |
| METOP_MANOEUVRE_END            | End time of the manoeuvre  |                | s     | 1    | 1    | 1    | 1    | longtime   | 18        | 51         | 250    |
| MANOEUVRE_IMP_END              | Time from the end of the manoeuvre after which the manoeuvre does not any more affect the MDRs |                | s     | 1    | 1    | 1    | 1    | integer    | 10        | 43         | 301    |
| Total: 344                     |  |                |       |      |      |      |      |            |           |            |        |



### 9.3 VIADR ( name 'viadr-1a-gps-pod', class 7, subclass 1, version 3 )

| Name                         | Description                                    | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|------------------------------|--|-----------------|-------|------|------|------|------|------------|-----------|------------|--------|
| RECORD_HEADER                | Generic Record Header                          |                 |       | 1    | 1    | 1    | 1    | REC_HEAD   | 20        | 20         | 0      |
| GPS_NRT_orbit_arc            |  |                 |       |      |      |      |      |            |           |            |        |
| START_VALIDITY               | Start time of the record validity              | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 20     |
| END_VALIDITY                 | End time of the record validity                | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 28     |
| SAMPLE_INTERVAL              | Time sample interval used in solution          |                 | s     | 1    | 1    | 1    | 1    | uinteger2  | 2         | 2          | 36     |
| NUMBER_SATELLITE             | Number of satellites in solution               |                 |       | 1    | 1    | 1    | 1    | uinteger1  | 1         | 1          | 38     |
| <a href="#">PRODUCT_TYPE</a> | NRT or enhanced POD product                    |                 |       | 1    | 1    | 1    | 1    | enumerated | 1         | 1          | 39     |
| NUMBER_OF_SATELLITES         | Number of GPS satellites, N                    |                 |       | 1    | 1    | 1    | 1    | uinteger1  | 1         | 1          | 40     |
| GPS_ID                       | GPS satellite identification                   |                 |       | N    | 1    | 1    | 1    | uinteger1  | 1         | var        | 41     |
| POSITION_UNCERTAINTY_X       | Satellite position x uncertainty               | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| POSITION_UNCERTAINTY_Y       | Satellite position y uncertainty               | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| POSITION_UNCERTAINTY_Z       | Satellite position z uncertainty               | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| VELOCITY_UNCERTAINTY_X       | Satellite velocity x uncertainty               | 10 <sup>6</sup> | m/s   | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| VELOCITY_UNCERTAINTY_Y       | Satellite velocity y uncertainty               | 10 <sup>6</sup> | m/s   | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| VELOCITY_UNCERTAINTY_Z       | Satellite velocity z uncertainty               | 10 <sup>6</sup> | m/s   | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| CLOCK_OFFSET_UNCERTAINTY     | Satellite transmitter clock offset uncertainty | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |

| Name                    | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type             | Type size | Field size | Offset |
|-------------------------|--|-----------------|-------|------|------|------|------|------------------|-----------|------------|--------|
| CLOCK_DRIFT_UNCERTAINTY | Satellite transmitter clock rate of change uncertainty | 10 <sup>9</sup> | s/s   | N    | 1    | 1    | 1    | integer8         | 8         | var        | var    |
| NUMBER_OF_EPOCHS        | Number of epochs for each GPS satellite, M             |                 |       | N    | 1    | 1    | 1    | uinteger2        | 2         | var        | var    |
| GPS_ORBIT_ARC           |  |                 |       | M    | N    | 1    | 1    | GPS_STATE_VECTOR | 72        | var        | var    |
| EPOCH_TIME              | Time stamp in reference time                           | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8        | 8         | 8          |        |
| SATELLITE_POSITION_X    | Satellite position x at epoch time                     | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8         | 8         | 8          |        |
| SATELLITE_POSITION_Y    | Satellite position y at epoch time                     | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8         | 8         | 8          |        |
| SATELLITE_POSITION_Z    | Satellite position z at epoch time                     | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8         | 8         | 8          |        |
| SATELLITE_VELOCITY_X    | Satellite velocity v <sub>x</sub> at epoch time        | 10 <sup>6</sup> | m/s   | 1    | 1    | 1    | 1    | integer8         | 8         | 8          |        |
| SATELLITE_VELOCITY_Y    | Satellite velocity v <sub>y</sub> at epoch time        | 10 <sup>6</sup> | m/s   | 1    | 1    | 1    | 1    | integer8         | 8         | 8          |        |
| SATELLITE_VELOCITY_Z    | Satellite velocity v <sub>z</sub> at epoch time        | 10 <sup>6</sup> | m/s   | 1    | 1    | 1    | 1    | integer8         | 8         | 8          |        |
| CLOCK_OFFSET            | Clock offset   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | integer8         | 8         | 8          |        |
| CLOCK_DRIFT             | Satellite transmitter clock rate of change             | 10 <sup>9</sup> | s/s   | 1    | 1    | 1    | 1    | integer8         | 8         | 8          |        |
| Total: var              |  |                 |       |      |      |      |      |                  |           |            |        |

## 9.4 VIADR ( name 'viadr-1a-eop', class 7, subclass 2, version 5 )

| Name                         | Description                        | Scaling factor  | Units  | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset     |
|------------------------------|------------------------------------|-----------------|--------|------|------|------|------|-----------|-----------|------------|------------|
| RECORD_HEADER                | Generic Record Header              |                 |        | 1    | 1    | 1    | 1    | REC_HEAD  | 20        | 20         | 0          |
| NUM_EPOCHS                   | Number of EOP epochs, N            |                 |        | 1    | 1    | 1    | 1    | integer2  | 2         | 2          | 20         |
| Earth_Orientation_Parameters |                                    |                 |        |      |      |      |      |           |           |            |            |
| EPOCH                        | Start time of the record validity  | 10 <sup>9</sup> | s      | N    | 1    | 1    | 1    | uinteger8 | 8         | var        | 22         |
| X_POLE                       | x-pole                             | 10 <sup>6</sup> | arcsec | N    | 1    | 1    | 1    | integer8  | 8         | var        | var        |
| Y_POLE                       | y-pole                             | 10 <sup>6</sup> | arcsec | N    | 1    | 1    | 1    | integer8  | 8         | var        | var        |
| DUT1                         | UT1-UTC                            | 10 <sup>6</sup> | s      | N    | 1    | 1    | 1    | integer8  | 8         | var        | var        |
| EOP_STATUS                   | Final or predicted EOP products    |                 |        | N    | 1    | 1    | 1    | boolean   | 1         | var        | var        |
| D_psi                        | Celestial pole offset in longitude | 10 <sup>6</sup> | arcsec | N    | 1    | 1    | 1    | integer8  | 8         | var        | var        |
| D_eps                        | Celestial pole offset in obliquity | 10 <sup>6</sup> | arcsec | N    | 1    | 1    | 1    | integer8  | 8         | var        | var        |
| DX_POLE                      | Uncertainty in X-Pole              | 10 <sup>6</sup> | arcsec | N    | 1    | 1    | 1    | integer8  | 8         | var        | var        |
| DY_POLE                      | Uncertainty in Y-Pole              | 10 <sup>6</sup> | arcsec | N    | 1    | 1    | 1    | integer8  | 8         | var        | var        |
| DLOD                         | Uncertainty in Length of day (LOD) | 10 <sup>6</sup> | s      | N    | 1    | 1    | 1    | integer8  | 8         | var        | var        |
|                              |                                    |                 |        |      |      |      |      |           |           |            | Total: var |

## 9.5 VIADR ( name 'viadr-1a-tzd', class 7, subclass 3, version 3 )

| Name                         | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|------------------------------|--|-----------------|-------|------|------|------|------|------------|-----------|------------|--------|
| RECORD_HEADER                | Generic Record Header                                |                 |       | 1    | 1    | 1    | 1    | REC_HEAD   | 20        | 20         | 0      |
| Tropospheric_delay_product   |  |                 |       |      |      |      |      |            |           |            |        |
| START_VALIDITY               | Start time of the record validity                    | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 20     |
| END_VALIDITY                 | End time of the record validity                      | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 28     |
| STATION_NUMBER               | Number of stations in interval                       |                 |       | 1    | 1    | 1    | 1    | uinteger2  | 2         | 2          | 36     |
| <a href="#">PRODUCT_TYPE</a> | NRT or enhanced POD product                          |                 |       | 1    | 1    | 1    | 1    | enumerated | 1         | 1          | 38     |
| TROPOS_NUMBER_PARAMETERS     | Number of tropospheric parameters for the stations   |                 |       | 1    | 1    | 1    | 1    | uinteger2  | 2         | 2          | 39     |
| TROPOS_ESTIMATE_INTERVAL     | Estimation interval                                  | 10 <sup>6</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 41     |
| NUMBER_OF_STATIONS           | Number of fiducial stations, M                       |                 |       | 1    | 1    | 1    | 1    | uinteger2  | 2         | 2          | 49     |
| STATION_ID                   | Ground station identification                        |                 |       | M    | 1    | 1    | 1    | string     | 4         | var        | 51     |
| NUM_EPOCHS                   | Number of epochs, T                                  |                 |       | M    | 1    | 1    | 1    | uinteger2  | 2         | var        | var    |
| STATION_TZD_ESTIMATES        |  |                 |       | T    | M    | 1    | 1    | TROP_DELAY | 72        | var        | var    |
| EPOCH_TIME                   | Time stamp in reference time                         | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          |        |
| MEASURED_SURFACE_PRESSURE    | Measured surface pressure at the station location    | 10 <sup>3</sup> | mbar  | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          |        |
| MEASURED_SURFACE_TEMPERATURE | Measured surface temperature at the station location | 10 <sup>3</sup> | K     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          |        |
| MEASURED_PARTIAL_WV_PRESSURE | Measured partial pressure of                         | 10 <sup>3</sup> | mbar  | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          |        |

| Name                            | Description   | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|---------------------------------|---|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
|                                 | the water vapour at surface at the station location                     |                 |       |      |      |      |      |           |           |            |        |
| NWP_SURFACE_PRESSURE            | NWP surface pressure at the station location                            | 10 <sup>3</sup> | mbar  | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          |        |
| NWP_SURFACE_TEMPERATURE         | NWP surface temperature at the station location                         | 10 <sup>3</sup> | K     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          |        |
| NWP_PARTIAL_WV_PRESSURE         | Partial pressure of the water vapour at surface at the station location | 10 <sup>3</sup> | mbar  | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          |        |
| TROP0S_ZENITH_DELAY             | Zenith tropospheric delay estimate from the GSN                         | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          |        |
| TROPOS_ZENITH_DELAY_UNCERTAINTY | Uncertainty in zenith tropospheric delay estimate                       | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8  | 8         | 8          |        |
| Total: var                      |   |                 |       |      |      |      |      |           |           |            |        |

## 9.6 VIADR ( name 'viadr-1a-gps-clock', class 7, subclass 4, version 3 )

| Name                         | Description                              | Scaling factor   | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset     |
|------------------------------|--|------------------|-------|------|------|------|------|------------|-----------|------------|------------|
| RECORD_HEADER                | Generic Record Header                    |                  |       | 1    | 1    | 1    | 1    | REC_HEAD   | 20        | 20         | 0          |
| GPS_clock_bias_estimates     |  |                  |       |      |      |      |      |            |           |            |            |
| START_VALIDITY               | Start time of the record validity        | 10 <sup>9</sup>  | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 20         |
| END_VALIDITY                 | End time of the record validity          | 10 <sup>9</sup>  | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 28         |
| SAMPLE_INTERVAL              | Time sample interval used in solution    |                  | s     | 1    | 1    | 1    | 1    | uinteger2  | 2         | 2          | 36         |
| GPS_NUMBER                   | Number of satellites in solution         |                  |       | 1    | 1    | 1    | 1    | uinteger1  | 1         | 1          | 38         |
| <a href="#">PRODUCT_TYPE</a> | NRT or enhanced POD product              |                  |       | 1    | 1    | 1    | 1    | enumerated | 1         | 1          | 39         |
| NUMBER_OF_SATELLITES         | Number of GPS satellites, M              |                  |       | 1    | 1    | 1    | 1    | uinteger1  | 1         | 1          | 40         |
| GPS_ID                       | GPS satellite identification             |                  |       | M    | 1    | 1    | 1    | uinteger1  | 1         | var        | 41         |
| CLOCK_QUALITY                | Quality indicator for each GPS satellite |                  |       | M    | 1    | 1    | 1    | uinteger8  | 8         | var        | var        |
| NUM_EPOCHS                   | Number of clock solution epochs, N       |                  |       | M    | 1    | 1    | 1    | integer2   | 2         | var        | var        |
| GPS_CLOCK_OFFSETS            |  |                  |       | N    | M    | 1    | 1    | GPS_CLOCKS | 16        | var        | var        |
| EPOCH_TIME                   | Time stamp in reference time             | 10 <sup>9</sup>  | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          |            |
| GPS_CLOCK_OFFSET             | Clock offset estimate                    | 10 <sup>20</sup> | s     | 1    | 1    | 1    | 1    | integer8   | 8         | 8          |            |
|                              |  |                  |       |      |      |      |      |            |           |            | Total: var |

## 9.7 VIADR ( name 'viadr-1a-station-clock', class 7, subclass 5, version 3 )

| Name                                  | Description                        | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type           | Type size | Field size | Offset |
|---------------------------------------|------------------------------------|-----------------|-------|------|------|------|------|----------------|-----------|------------|--------|
| RECORD_HEADER                         | Generic Record Header              |                 |       | 1    | 1    | 1    | 1    | REC_HEAD       | 20        | 20         | 0      |
| Ground_station_clock_offset_estimates |                                    |                 |       |      |      |      |      |                |           |            |        |
| START_VALIDITY                        | Start time of the record validity  | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8      | 8         | 8          | 20     |
| END_VALIDITY                          | End time of the record validity    | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8      | 8         | 8          | 28     |
| ESTIMATE_INTERVAL                     | Estimation interval for clock bias |                 | s     | 1    | 1    | 1    | 1    | uinteger2      | 2         | 2          | 36     |
| STATION_NUMBER                        | Number of stations in solution     |                 |       | 1    | 1    | 1    | 1    | uinteger1      | 1         | 1          | 38     |
| <a href="#">PRODUCT_TYPE</a>          | NRT or enhanced POD product        |                 |       | 1    | 1    | 1    | 1    | enumerated     | 1         | 1          | 39     |
| NUMBER_OF_STATIONS                    | Number of fiducial stations, M     |                 |       | 1    | 1    | 1    | 1    | uinteger1      | 1         | 1          | 40     |
| STATION_ID                            | Ground station identification      |                 |       | M    | 1    | 1    | 1    | string         | 4         | var        | 41     |
| CLOCK_QUALITY                         | Quality indicator for each station |                 |       | M    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| NUM_EPOCHS                            | Number of epochs, E                |                 |       | M    | 1    | 1    | 1    | uinteger2      | 2         | var        | var    |
| STATION_CLOCK_OFFSETS                 |                                    |                 |       | E    | M    | 1    | 1    | STATION_CLOCKS | 72        | var        | var    |
| EPOCH_TIME                            | Time stamp in reference time       | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8      | 8         | 8          |        |

| Name                           | Description  | Scaling factor   | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|--------------------------------|--|------------------|-------|------|------|------|------|----------|-----------|------------|--------|
| STATION_CLOCK_OFFSET           | Clock offset   | 10 <sup>20</sup> | s     | 1    | 1    | 1    | 1    | integer8 | 8         | 8          |        |
| STATION_CLOCK_DRIFT            | Clock drift  | 10 <sup>9</sup>  | s/s   | 1    | 1    | 1    | 1    | integer8 | 8         | 8          |        |
| STATION_POSITION_MEASUREMENT_X | Position of measurement point x (ECI)                  | 10 <sup>6</sup>  | m     | 1    | 1    | 1    | 1    | integer8 | 8         | 8          |        |
| STATION_POSITION_MEASUREMENT_Y | Position of measurement point y (ECI)                  | 10 <sup>6</sup>  | m     | 1    | 1    | 1    | 1    | integer8 | 8         | 8          |        |
| STATION_POSITION_MEASUREMENT_Z | Position of measurement point z (ECI)                  | 10 <sup>6</sup>  | m     | 1    | 1    | 1    | 1    | integer8 | 8         | 8          |        |
| STATION_VELOCITY_X             | Velocity v <sub>x</sub> of the measurement point (ECI) | 10 <sup>6</sup>  | m/s   | 1    | 1    | 1    | 1    | integer8 | 8         | 8          |        |
| STATION_VELOCITY_Y             | Velocity v <sub>y</sub> of the measurement point (ECI) | 10 <sup>6</sup>  | m/s   | 1    | 1    | 1    | 1    | integer8 | 8         | 8          |        |
| STATION_VELOCITY_Z             | Velocity v <sub>z</sub> of the measurement point (ECI) | 10 <sup>6</sup>  | m/s   | 1    | 1    | 1    | 1    | integer8 | 8         | 8          |        |
| Total: var                     |  |                  |       |      |      |      |      |          |           |            |        |

## 9.8 VIADR ( name 'viadr-1a-ssd', class 7, subclass 6, version 3 )

| Name                          | Description                   | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|-------------------------------|-------------------------------|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| RECORD_HEADER                 | Generic Record Header         |                 |       | 1    | 1    | 1    | 1    | REC_HEAD  | 20        | 20         | 0      |
| Sounding_support_measurements |                               |                 |       |      |      |      |      |           |           |            |        |
| MEASUREMENT_START             | Start time of measurement arc | 10 <sup>6</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 20     |
| MEASUREMENT_END               | End time of measurement arc   | 10 <sup>6</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 28     |



| Name                        | Description  | Scaling factor  | Units  | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|-----------------------------|--|-----------------|--------|------|------|------|------|------------|-----------|------------|--------|
| MEASUREMENT_SAMPLE_INTERVAL | Sampling interval used in tracking                           |                 | s      | 1    | 1    | 1    | 1    | uinteger1  | 1         | 1          | 36     |
| NUMBER_OF_OCCULTATIONS      | Number of occultations, J                                    |                 |        | 1    | 1    | 1    | 1    | uinteger1  | 1         | 1          | 37     |
| OCCULTATION_ID              | Occultation identification                                   |                 |        | J    | 1    | 1    | 1    | string     | 32        | var        | 38     |
| NUMBER_OF_STATIONS          | Number of stations capable of supporting this occultation, K |                 |        | J    | 1    | 1    | 1    | uinteger1  | 1         | var        | var    |
| STATION_ID                  | Ground station identification                                |                 |        | K    | J    | 1    | 1    | string     | 4         | var        | var    |
| NUM_GPS                     | Number of GPS satellites measured by the station, P          |                 |        | K    | J    | 1    | 1    | uinteger1  | 1         | var        | var    |
| GPS_ID                      | GPS PRN number   |                 |        | P    | K    | J    | 1    | uinteger1  | 1         | var        | var    |
| GPS_TYPE                    | Occulting or pivot satellite                                 |                 |        | P    | K    | J    | 1    | boolean    | 1         | var        | var    |
| PIVOT_REC                   | Pivot satellite recommendation<br>1st, 2nd,...               |                 |        | P    | K    | J    | 1    | uinteger1  | 1         | var        | var    |
| NUM_EPOCHS                  | Number of SSD epochs, S                                      |                 |        | P    | K    | J    | 1    | uinteger1  | 1         | var        | var    |
| GPS_SSD_DATA                |  |                 |        | S    | P    | K    | J    | SSD_SAMPLE | 72        | var        | var    |
| EPOCH_TIME                  | Time stamp in reference time                                 | 10 <sup>9</sup> | s      | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          |        |
| C1                          | C/A code pseudorange   |                 | m      | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          |        |
| L1C1                        | C/A-based carrier phase at L1                                | 10 <sup>6</sup> | cycles | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          |        |
| P1                          | Y1-codeless pseudorange at L1                                | 10 <sup>6</sup> | m      | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          |        |
| L1P1                        | Y1-codeless-based phase at L1                                | 10 <sup>6</sup> | cycles | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          |        |
| P2                          | Y2-codeless pseudorange at L2                                | 10 <sup>6</sup> | m      | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          |        |
| L2P2                        | Y2-codeless-based phase at L2                                | 10 <sup>6</sup> | cycles | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          |        |
| S1                          | SNR in L1  | 10 <sup>3</sup> | dB     | 1    | 1    | 1    | 1    | integer8   | 8         | 8          |        |

| Name       | Description | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|------------|-------------|-----------------|-------|------|------|------|------|----------|-----------|------------|--------|
| S2         | SNR in L2   | 10 <sup>3</sup> | dB    | 1    | 1    | 1    | 1    | integer8 | 8         | 8          |        |
| Total: var |             |                 |       |      |      |      |      |          |           |            |        |

## 9.9 VIADR ( name 'viadr-1a-occultation-table', class 7, subclass 8, version 3 )

| Name  | Description                            | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|---|--|-----------------|-------|------|------|------|------|------------|-----------|------------|--------|
| RECORD_HEADER   | Generic Record Header                  |                 |       | 1    | 1    | 1    | 1    | REC_HEAD   | 20        | 20         | 0      |
| Occultation_table   |  |                 |       |      |      |      |      |            |           |            |        |
| START_VALIDITY  | Start time of the record validity      | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 20     |
| END_VALIDITY  | End time of the record validity        | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 28     |
| TABLE_ID  | Table id number                        |                 |       | 1    | 1    | 1    | 1    | uinteger4  | 4         | 4          | 36     |
| Measurement_characterisation_(for_each_predicted_measurement) |  |                 |       |      |      |      |      |            |           |            |        |
| NUMBER_OF_MEASUREMENTS  | Number of predicted measurements, N    |                 |       | 1    | 1    | 1    | 1    | uinteger2  | 2         | 2          | 40     |
| MEASUREMENT_ID  | Id number of the predicted measurement |                 |       | N    | 1    | 1    | 1    | string     | 32        | var        | 42     |
| MEASUREMENT_START   | Measurement start time                 | 10 <sup>6</sup> | s     | N    | 1    | 1    | 1    | uinteger8  | 8         | var        | var    |
| MEASUREMENT_END   | Measurement end time                   | 10 <sup>6</sup> | s     | N    | 1    | 1    | 1    | uinteger8  | 8         | var        | var    |
| MEASUREMENT_DURATION  | Length of the measurement              |                 | s     | N    | 1    | 1    | 1    | uinteger2  | 2         | var        | var    |
| GPS_ID  | Measured GPS PRN number                |                 |       | N    | 1    | 1    | 1    | uinteger1  | 1         | var        | var    |
| <a href="#">MEASUREMENT_TYPE</a>                              | Raisin/setting/navigation              |                 |       | N    | 1    | 1    | 1    | enumerated | 1         | var        | var    |
| INCIDENCE_AZIMUTH   | Azimuth angle of the incoming          | 10 <sup>3</sup> | deg   | N    | 1    | 1    | 1    | integer4   | 4         | var        | var    |

| Name  | Description                                  | Scaling factor  | Units  | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|---|--|-----------------|--------|------|------|------|------|-----------|-----------|------------|--------|
|   | ray  |                 |        |      |      |      |      |           |           |            |        |
| INCIDENCE_ELEVATION                             | Elevation angle of the incoming ray          | 10 <sup>3</sup> | deg    | N    | 1    | 1    | 1    | integer4  | 4         | var        | var    |
| GEOLOCATION_SLTH_START                          | SLTH start value used for geolocation        | 10 <sup>3</sup> | m      | N    | 1    | 1    | 1    | integer4  | 4         | var        | var    |
| GEOLOCATION_SLTH_END                            | SLTH end value used for geolocation          | 10 <sup>3</sup> | m      | N    | 1    | 1    | 1    | integer4  | 4         | var        | var    |
| PRED_START_LAT                                  | Predicted start latitude of the measurement  | 10 <sup>3</sup> | degree | N    | 1    | 1    | 1    | integer4  | 4         | var        | var    |
| PRED_START_LONG                                 | Predicted start longitude of the measurement | 10 <sup>3</sup> | degree | N    | 1    | 1    | 1    | integer4  | 4         | var        | var    |
| PRED_END_LAT                                    | Predicted end latitude of the measurement    | 10 <sup>3</sup> | degree | N    | 1    | 1    | 1    | integer4  | 4         | var        | var    |
| PRED_END_LONG                                   | Predicted end longitude of the measurement   | 10 <sup>3</sup> | degree | N    | 1    | 1    | 1    | integer4  | 4         | var        | var    |
| Metop_state_vector_(once_per_occultation_table) |  |                 |        |      |      |      |      |           |           |            |        |
| METOP_SAMPLE_INTERVAL                           | Time sample interval of the state vectors    |                 | s      | 1    | 1    | 1    | 1    | uinteger2 | 2         | 2          | var    |
| NUMBER_OF_METOP_EPOCHS                          | Number of state vector epochs, M             |                 |        | 1    | 1    | 1    | 1    | uinteger2 | 2         | 2          | var    |
| EPOCH_TIME                                      | Time stamp in reference time                 | 10 <sup>6</sup> | s      | M    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| SATELLITE_POSITION_X                            | Satellite position x at epoch time           | 10 <sup>6</sup> | m      | M    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| SATELLITE_POSITION_Y                            | Satellite position y at epoch time           | 10 <sup>6</sup> | m      | M    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| SATELLITE_POSITION_Z                            | Satellite position z at epoch time           | 10 <sup>6</sup> | m      | M    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| SATELLITE_VELOCITY_X                            | Satellite velocity x at epoch time           | 10 <sup>6</sup> | m/s    | M    | 1    | 1    | 1    | integer8  | 8         | var        | var    |

| Name  | Description                               | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type            | Type size | Field size | Offset     |
|---|---|-----------------|-------|------|------|------|------|-----------------|-----------|------------|------------|
| SATELLITE_VELOCITY_Y                          | Satellite velocity y at epoch time        | 10 <sup>6</sup> | m/s   | M    | 1    | 1    | 1    | integer8        | 8         | var        | var        |
| SATELLITE_VELOCITY_Z                          | Satellite velocity z at epoch time        | 10 <sup>6</sup> | m/s   | M    | 1    | 1    | 1    | integer8        | 8         | var        | var        |
| GPS_state_vector_(once_per_occultation_table) |   |                 |       |      |      |      |      |                 |           |            |            |
| GPS_SAMPLE_INTERVAL                           | Time sample interval of the state vectors |                 | s     | 1    | 1    | 1    | 1    | uinteger2       | 2         | 2          | var        |
| NUMBER_OF_GPS                                 | Number of GPS satellites, G               |                 |       | 1    | 1    | 1    | 1    | uinteger1       | 1         | 1          | var        |
| GPS_ID_STATE                                  | GPS PRN number                            |                 |       | G    | 1    | 1    | 1    | uinteger1       | 1         | var        | var        |
| NUMBER_OF_GPS_EPOCHS                          | Number of state vector epochs, E          |                 |       | G    | 1    | 1    | 1    | uinteger2       | 2         | var        | var        |
| STATE_VECTOR                                  |   |                 |       | E    | G    | 1    | 1    | GPS_STATE_SHORT | 56        | var        | var        |
| EPOCH_TIME                                    | Time stamp in reference time              | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8       | 8         | 8          |            |
| SATELLITE_POSITION_X                          | Satellite position x at epoch time        | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8        | 8         | 8          |            |
| SATELLITE_POSITION_Y                          | Satellite position y at epoch time        | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8        | 8         | 8          |            |
| SATELLITE_POSITION_Z                          | Satellite position z at epoch time        | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8        | 8         | 8          |            |
| SATELLITE_VELOCITY_X                          | Satellite velocity v_x at epoch time      | 10 <sup>6</sup> | m/s   | 1    | 1    | 1    | 1    | integer8        | 8         | 8          |            |
| SATELLITE_VELOCITY_Y                          | Satellite velocity v_y at epoch time      | 10 <sup>6</sup> | m/s   | 1    | 1    | 1    | 1    | integer8        | 8         | 8          |            |
| SATELLITE_VELOCITY_Z                          | Satellite velocity v_z at epoch time      | 10 <sup>6</sup> | m/s   | 1    | 1    | 1    | 1    | integer8        | 8         | 8          |            |
|   |   |                 |       |      |      |      |      |                 |           |            | Total: var |

## 9.10 VIADR ( name 'viadr-1a-gsn-quality-report', class 7, subclass 9, version 3 )

| Name                 | Description   | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|----------------------|---|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| RECORD_HEADER        | Generic Record Header   |                 |       | 1    | 1    | 1    | 1    | REC_HEAD  | 20        | 20         | 0      |
| GSN_Quality_report   |   |                 |       |      |      |      |      |           |           |            |        |
| START_VALIDITY       | Start time of the record validity                                     | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 20     |
| END_VALIDITY         | End time of the record validity                                       | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 28     |
| GENERATION_TIME      | File generation time  | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 36     |
| PAST_TIME_START      | Start time of the past data   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 44     |
| PAST_TIME_END        | End time of the past data   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 52     |
| GLOBAL_SA            | Global SA setting of the GPS system                                   |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 60     |
| SA_CHANGE_EPOCH      | Epoch of the global SA status change                                  | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 61     |
| STAT_NUM_GPS         | Number of GPS satellites that status information is provided for, A   |                 |       | 1    | 1    | 1    | 1    | uinteger1 | 1         | 1          | 69     |
| STAT_GPS_ID          | GPS PRN number  |                 |       | A    | 1    | 1    | 1    | uinteger1 | 1         | var        | 70     |
| GPS_MANOEUVRE_EPOCHS | Number of manoeuvre epochs for the GPS satellite, B                   |                 |       | A    | 1    | 1    | 1    | uinteger2 | 2         | var        | var    |
| GPS_MANOEUVRE_START  | Start time of the GPS manoeuvre                                       | 10 <sup>9</sup> | s     | B    | A    | 1    | 1    | uinteger8 | 8         | var        | var    |
| GPS_MANOEUVRE_END    | End time of the GPS manoeuvre   | 10 <sup>9</sup> | s     | B    | A    | 1    | 1    | uinteger8 | 8         | var        | var    |
| GPS_ECLIPSE_EPOCHS   | Number of eclipse epochs for the GPS satellite, L                     |                 |       | A    | 1    | 1    | 1    | uinteger2 | 2         | var        | var    |
| GPS_ECLIPSE_START    | Start time of the GPS eclipse   | 10 <sup>9</sup> | s     | L    | A    | 1    | 1    | uinteger8 | 8         | var        | var    |
| GPS_ECLIPSE_END      | End time of the GPS eclipse   | 10 <sup>9</sup> | s     | L    | A    | 1    | 1    | uinteger8 | 8         | var        | var    |
| GPS_SA_EPOCHS        | Number of Selective Availability (SA) epochs for the GPS satellite, M |                 |       | A    | 1    | 1    | 1    | uinteger2 | 2         | var        | var    |

| Name                       | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|----------------------------|--|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| GPS_SA_STATUS              | SA status of the GPS satellite   |                 |       | M    | A    | 1    | 1    | boolean   | 1         | var        | var    |
| GPS_SA_EPOCH               | Epoch of the SA status change  | 10 <sup>9</sup> | s     | M    | A    | 1    | 1    | uinteger8 | 8         | var        | var    |
| STAT_NUM_STATIONS          | Number of fiducial stations that status information is provided for, C         |                 |       | 1    | 1    | 1    | 1    | uinteger1 | 1         | 1          | var    |
| STAT_STATION_ID            | Station ID   |                 |       | C    | 1    | 1    | 1    | string    | 4         | var        | var    |
| STAT_OUTAGE_EPOCHS         | Number of station outage epochs, D   |                 |       | C    | 1    | 1    | 1    | uinteger2 | 2         | var        | var    |
| OUTAGE_PAST_START          | Start time of the past outage of the station                                   | 10 <sup>9</sup> | s     | D    | C    | 1    | 1    | uinteger8 | 8         | var        | var    |
| OUTAGE_PAST_END            | End time of the past outage of the station                                     | 10 <sup>9</sup> | s     | D    | C    | 1    | 1    | uinteger8 | 8         | var        | var    |
| STAT_PLANNED_OUTAGE_EPOCHS | Number of station planned outage epochs, N                                     |                 |       | C    | 1    | 1    | 1    | uinteger2 | 2         | var        | var    |
| OUTAGE_PLANNED_START       | Start time of the planned outage of the station                                | 10 <sup>9</sup> | s     | N    | C    | 1    | 1    | uinteger8 | 8         | var        | var    |
| OUTAGE_PLANNED_END         | End time of the planned outage of the station                                  | 10 <sup>9</sup> | s     | N    | C    | 1    | 1    | uinteger8 | 8         | var        | var    |
| NUM_PERIOD_ORB_QUALITY     | Number of periods that the orbit quality is provided, E                        |                 |       | 1    | 1    | 1    | 1    | uinteger2 | 2         | 2          | var    |
| ORB_COMPARISON_START       | Start time of the orbit comparison   | 10 <sup>9</sup> | s     | E    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| ORB_COMPARISON_END         | End time of the orbit comparison   | 10 <sup>9</sup> | s     | E    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| ORB_REF_FILE_NAME          | Name of the reference file   |                 |       | E    | 1    | 1    | 1    | string    | 88        | var        | var    |
| ORB_OVERALL_RMS            | Overall RMS difference   | 10 <sup>6</sup> | m     | E    | 1    | 1    | 1    | integer4  | 4         | var        | var    |
| ORB_OVERALL_WRMS           | Weighted overall RMS difference  | 10 <sup>6</sup> | m     | E    | 1    | 1    | 1    | integer4  | 4         | var        | var    |
| NUM_GPS_ORB_QUALITY        | Number of GPS satellites that the orbit quality information is provided for, F |                 |       | E    | 1    | 1    | 1    | uinteger1 | 1         | var        | var    |

| Name                      | Description   | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|---------------------------|---|----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| ORB_GPS_ID                | GPS PRN number  |                |       | F    | E    | 1    | 1    | uinteger1 | 1         | var        | var    |
| ORB_ALONG_RMS             | RMS difference along track  | 10^6           | m     | F    | E    | 1    | 1    | integer4  | 4         | var        | var    |
| ORB_CROSS_RMS             | RMS difference cross track  | 10^6           | m     | F    | E    | 1    | 1    | integer4  | 4         | var        | var    |
| ORB_RADIAL_RMS            | RMS difference radial   | 10^6           | m     | F    | E    | 1    | 1    | integer4  | 4         | var        | var    |
| NUM_PERIOD_CLOCK_QUALITY  | Number of periods that the clock quality is provided, G               |                |       | 1    | 1    | 1    | 1    | uinteger2 | 2         | 2          | var    |
| CLOCK_COMPARISON_START    | Start time of the clock comparison                                    | 10^9           | s     | G    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| CLOCK_ORB_COMPARISON_END  | End time of the clock comparison                                      | 10^9           | s     | G    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| CLOCK_REF_FILE_NAME       | Name of the reference file  |                |       | G    | 1    | 1    | 1    | string    | 88        | var        | var    |
| CLOCK_AVERAGE_RMS         | Average RMS   | 10^15          | s     | G    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| CLOCK_AVERAGE_STDEV       | Average standard deviation  | 10^15          | s     | G    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| NUM_GPS_CLOCK_QUALITY     | Number of GPS satellites that the clock quality is provided for, H    |                |       | G    | 1    | 1    | 1    | uinteger1 | 1         | var        | var    |
| CLOCK_GPS_ID              | GPS PRN number  |                |       | H    | G    | 1    | 1    | uinteger1 | 1         | var        | var    |
| CLOCK_GPS_RMS             | RMS clock difference  | 10^15          | s     | H    | G    | 1    | 1    | integer8  | 8         | var        | var    |
| CLOCK_GPS_STDEV           | Standard deviation of the clock difference                            | 10^15          | s     | H    | G    | 1    | 1    | integer8  | 8         | var        | var    |
| NUM_STATION_CLOCK_QUALITY | Number of fiducial stations that the clock quality is provided for, K |                |       | G    | 1    | 1    | 1    | uinteger1 | 1         | var        | var    |
| CLOCK_FID_GPS_ID          | Fiducial station ID   |                |       | K    | G    | 1    | 1    | string    | 4         | var        | var    |
| CLOCK_FID_RMS             | RMS clock difference  | 10^15          | s     | K    | G    | 1    | 1    | integer8  | 8         | var        | var    |
| CLOCK_FID_STDEV           | Standard deviation of the clock difference                            | 10^15          | s     | K    | G    | 1    | 1    | integer8  | 8         | var        | var    |
| Total: var                |   |                |       |      |      |      |      |           |           |            |        |

### 9.11 VIADR ( name 'viadr-1a-metop-pod', class 7, subclass 10, version 3 )

| Name                         | Description                           | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|------------------------------|---------------------------------------|-----------------|-------|------|------|------|------|------------|-----------|------------|--------|
| RECORD_HEADER                | Generic Record Header                 |                 |       | 1    | 1    | 1    | 1    | REC_HEAD   | 20        | 20         | 0      |
| Metop_NRT_orbit_arc          |                                       |                 |       |      |      |      |      |            |           |            |        |
| START_VALIDITY               | Start time of the record validity     | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 20     |
| END_VALIDITY                 | End time of the record validity       | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 28     |
| SAMPLE_INTERVAL              | Time sample interval used in solution |                 | s     | 1    | 1    | 1    | 1    | uinteger2  | 2         | 2          | 36     |
| NUMBER_SATELLITE             | Number of GPS satellites in solution  |                 |       | 1    | 1    | 1    | 1    | uinteger1  | 1         | 1          | 38     |
| <a href="#">PRODUCT_TYPE</a> | NRT or enhanced POD product           |                 |       | 1    | 1    | 1    | 1    | enumerated | 1         | 1          | 39     |
| POSITION_UNCERTAINTY_X       | Satellite position x uncertainty      | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 40     |
| POSITION_UNCERTAINTY_Y       | Satellite position y uncertainty      | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 48     |
| POSITION_UNCERTAINTY_Z       | Satellite position z uncertainty      | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 56     |
| VELOCITY_UNCERTAINTY_X       | Satellite velocity x uncertainty      | 10 <sup>6</sup> | m/s   | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 64     |
| VELOCITY_UNCERTAINTY_Y       | Satellite velocity y uncertainty      | 10 <sup>6</sup> | m/s   | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 72     |
| VELOCITY_UNCERTAINTY_Z       | Satellite velocity z uncertainty      | 10 <sup>6</sup> | m/s   | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 80     |
| NUMBER_OF_EPOCHS             | Number of solution epochs, N          |                 |       | 1    | 1    | 1    | 1    | uinteger4  | 4         | 4          | 88     |
| EPOCH_TIME                   | Time stamp in reference time          | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8  | 8         | var        | 92     |
| SATELLITE_POSITION_X         | Satellite position x at epoch time    | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| SATELLITE_POSITION_Y         | Satellite position y at epoch time    | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| SATELLITE_POSITION_Z         | Satellite position z at epoch time    | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |



| Name                 | Description                        | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|----------------------|------------------------------------|----------------|-------|------|------|------|------|----------|-----------|------------|--------|
| SATELLITE_VELOCITY_X | Satellite velocity x at epoch time | 10^6           | m/s   | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| SATELLITE_VELOCITY_Y | Satellite velocity y at epoch time | 10^6           | m/s   | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| SATELLITE_VELOCITY_Z | Satellite velocity z at epoch time | 10^6           | m/s   | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| Total: var           |                                    |                |       |      |      |      |      |          |           |            |        |

## 9.12 VIADR ( name 'viadr-1a-metop-attitude', class 7, subclass 11, version 3 )

| Name                                | Description                       | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset     |
|-------------------------------------|-----------------------------------|----------------|-------|------|------|------|------|------------|-----------|------------|------------|
| RECORD_HEADER                       | Generic Record Header             |                |       | 1    | 1    | 1    | 1    | REC_HEAD   | 20        | 20         | 0          |
| Metop_attitude                      |                                   |                |       |      |      |      |      |            |           |            |            |
| START_VALIDITY                      | Start time of the record validity | 10^9           | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 20         |
| END_VALIDITY                        | End time of the record validity   | 10^9           | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 28         |
| NUMBER_OF_EPOCHS                    | Number of attitude data epochs, N |                |       | 1    | 1    | 1    | 1    | uinteger4  | 4         | 4          | 36         |
| EPOCH_TIME                          | Time stamp in reference time      | 10^9           | s     | N    | 1    | 1    | 1    | uinteger8  | 8         | var        | 40         |
| <a href="#">METOP_STEERING_MODE</a> | Metop steering mode indicator     |                |       | N    | 1    | 1    | 1    | enumerated | 1         | var        | var        |
| METOP_MISPOINTING_ROLL              | Mispointing angle Dh              | 10^3           | deg   | N    | 1    | 1    | 1    | integer8   | 8         | var        | var        |
| METOP_MISPOINTING_PITCH             | Mispointing angles Dx             | 10^3           | deg   | N    | 1    | 1    | 1    | integer8   | 8         | var        | var        |
| METOP_MISPOINTING_YAW               | Mispointing angles Dz             | 10^3           | deg   | N    | 1    | 1    | 1    | integer8   | 8         | var        | var        |
| METOP_TRUE_LATITUDE                 | Metop true latitude angle         | 10^3           | deg   | N    | 1    | 1    | 1    | integer8   | 8         | var        | var        |
|                                     |                                   |                |       |      |      |      |      |            |           |            | Total: var |

### 9.13 VIADR ( name 'viadr-1a-metop-clock', class 7, subclass 12, version 3 )

| Name                         | Description  | Scaling factor   | Units | Dim1     | Dim2     | Dim3     | Dim4     | Type             | Type size | Field size | Offset     |
|------------------------------|--|------------------|-------|----------|----------|----------|----------|------------------|-----------|------------|------------|
| RECORD_HEADER                | Generic Record Header                                  |                  |       | 1        | 1        | 1        | 1        | REC_HEAD         | 20        | 20         | 0          |
| Metop_NRT_orbit_arc          |  |                  |       |          |          |          |          |                  |           |            |            |
| START_VALIDITY               | Start time of the record validity                      | 10 <sup>9</sup>  | s     | 1        | 1        | 1        | 1        | uinteger8        | 8         | 8          | 20         |
| END_VALIDITY                 | End time of the record validity                        | 10 <sup>9</sup>  | s     | 1        | 1        | 1        | 1        | uinteger8        | 8         | 8          | 28         |
| SAMPLE_INTERVAL              | Time sample interval used in solution                  |                  | s     | 1        | 1        | 1        | 1        | uinteger2        | 2         | 2          | 36         |
| NUMBER_SATELLITE             | Number of GPS satellites in solution                   |                  |       | 1        | 1        | 1        | 1        | uinteger1        | 1         | 1          | 38         |
| <a href="#">PRODUCT_TYPE</a> | NRT or enhanced POD product                            |                  |       | 1        | 1        | 1        | 1        | enumerated       | 1         | 1          | 39         |
| CLOCK_OFFSET_UNCERTAINTY     | Satellite transmitter clock offset uncertainty         | 10 <sup>9</sup>  | s     | 1        | 1        | 1        | 1        | integer8         | 8         | 8          | 40         |
| CLOCK_DRIFT_UNCERTAINTY      | Satellite transmitter clock rate of change uncertainty | 10 <sup>9</sup>  | s/s   | 1        | 1        | 1        | 1        | integer8         | 8         | 8          | 48         |
| <b>NUMBER_OF_EPOCHS</b>      | <b>Number of solution epochs, N</b>                    |                  |       | <b>1</b> | <b>1</b> | <b>1</b> | <b>1</b> | <b>uinteger4</b> | <b>4</b>  | <b>4</b>   | <b>56</b>  |
| EPOCH_TIME                   | Time stamp in reference time                           | 10 <sup>9</sup>  | s     | N        | 1        | 1        | 1        | uinteger8        | 8         | var        | 60         |
| CLOCK_OFFSET                 | Clock offset estimate                                  | 10 <sup>20</sup> | s     | N        | 1        | 1        | 1        | integer8         | 8         | var        | var        |
| CLOCK_DRIFT                  | Satellite transmitter clock rate of change             | 10 <sup>20</sup> | s/s   | N        | 1        | 1        | 1        | integer8         | 8         | var        | var        |
|                              |  |                  |       |          |          |          |          |                  |           |            | Total: var |

## 9.14 MDR ( name 'mdr-1a-onboard-navigation', class 8, subclass 1, version 3 )

| Name                       | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|----------------------------|--|-----------------|-------|------|------|------|------|------------|-----------|------------|--------|
| RECORD_HEADER              | Generic Record Header  |                 |       | 1    | 1    | 1    | 1    | REC_HEAD   | 20        | 20         | 0      |
| GENERIC_QUALITY_INDICATORS |  |                 |       |      |      |      |      |            |           |            |        |
| DEGRADED_INST_MDR          | Quality of MDR has been degraded from nominal due to an instrument degradation |                 |       | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 20     |
| DEGRADED_PROC_MDR          | Quality of MDR has been degraded from nominal due to a processing degradation  |                 |       | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 21     |
| MEASUREMENT_DATA           |  |                 |       |      |      |      |      |            |           |            |        |
| START_EPOCH                | Epoch of the measurement start   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 22     |
| END_EPOCH                  | Epoch of the measurement end   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 30     |
| GRAS_MODE                  | Navigation or occultation mode   |                 |       | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 38     |
| NUMBER_OF_SAMPLES          | Number of data samples, N  |                 |       | 1    | 1    | 1    | 1    | uinteger4  | 4         | 4          | 39     |
| TIME_IMT                   | IMT time stamp of the sample   | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8  | 8         | var        | 43     |
| TIME.UTC_GRAS              | UTC_GRAS time stamp of the sample  | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8  | 8         | var        | var    |
| TIME_OBT                   | OBT time stamp of the sample   | 10 <sup>6</sup> | s     | N    | 1    | 1    | 1    | longtime   | 8         | var        | var    |
| ONBOARD_NAV_SOLUTION       | Onboard navigation solution method   |                 |       | N    | 1    | 1    | 1    | enumerated | 1         | var        | var    |
| POS_X                      | Position vector x  | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| POS_Y                      | Position vector y  | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| POS_Z                      | Position vector z  | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| VEL_X                      | Velocity vector x  | 10 <sup>6</sup> | m/s   | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| VEL_Y                      | Velocity vector y  | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |

| Name       | Description       | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|------------|-------------------|----------------|-------|------|------|------|------|----------|-----------|------------|--------|
| VEL_Z      | Velocity vector z | 10^6           | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| Total: var |                   |                |       |      |      |      |      |          |           |            |        |

### 9.15 MDR ( name 'mdr-1a-gain', class 8, subclass 2, version 3 )

| Name                       | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|----------------------------|--|-----------------|-------|------|------|------|------|------------|-----------|------------|--------|
| RECORD_HEADER              | Generic Record Header  |                 |       | 1    | 1    | 1    | 1    | REC_HEAD   | 20        | 20         | 0      |
| GENERIC_QUALITY_INDICATORS |  |                 |       |      |      |      |      |            |           |            |        |
| DEGRADED_INST_MDR          | Quality of MDR has been degraded from nominal due to an instrument degradation |                 |       | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 20     |
| DEGRADED_PROC_MDR          | Quality of MDR has been degraded from nominal due to a processing degradation  |                 |       | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 21     |
| MEASUREMENT_DATA           |  |                 |       |      |      |      |      |            |           |            |        |
| START_EPOCH                | Epoch of the measurement start   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 22     |
| END_EPOCH                  | Epoch of the measurement end   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 30     |
| NUMBER_OF_SAMPLES          | Number of data samples, N  |                 |       | 1    | 1    | 1    | 1    | uinteger4  | 4         | 4          | 38     |
| TIME_IMT                   | IMT time stamp of the sample   | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8  | 8         | var        | 42     |
| <a href="#">ZALS</a>       | GZA AGC loop status  |                 |       | N    | 1    | 1    | 1    | enumerated | 1         | var        | var    |
| ZHIMT                      | GZA instrument measurement time of the histogram                               | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8  | 8         | var        | var    |
| ZHIST                      | GZA DISC histogram   |                 |       | N    | 7    | 1    | 1    | integer2   | 2         | var        | var    |
| ZGCIMT                     | GZA instrument measurement time of the last                                    | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8  | 8         | var        | var    |

| Name                  | Description   | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type           | Type size | Field size | Offset |
|-----------------------|---|----------------|-------|------|------|------|------|----------------|-----------|------------|--------|
|                       | change in gain  |                |       |      |      |      |      |                |           |            |        |
| <a href="#">ZANA</a>  | GZA receiver channel analogue gain setting                  |                |       | N    | 1    | 1    | 1    | enumerated     | 1         | var        | var    |
| <a href="#">ZDIG</a>  | GZA receiver channel digital gain setting                   |                |       | N    | 1    | 1    | 1    | bitfield ( 6 ) | 6         | var        | var    |
| <a href="#">VALS</a>  | GVA AGC loop status   |                |       | N    | 1    | 1    | 1    | enumerated     | 1         | var        | var    |
| VHIMT                 | GVA instrument measurement time of the histogram            | 10^9           | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| VHIST                 | GVA DISC histogram  |                |       | N    | 7    | 1    | 1    | integer2       | 2         | var        | var    |
| VGCIMT                | GVA instrument measurement time of the last change in gain  | 10^9           | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| <a href="#">VANA</a>  | GVA receiver channel analogue gain setting                  |                |       | N    | 1    | 1    | 1    | enumerated     | 1         | var        | var    |
| <a href="#">VDIG</a>  | GVA receiver channel digital gain setting                   |                |       | N    | 1    | 1    | 1    | bitfield ( 6 ) | 6         | var        | var    |
| <a href="#">AVALS</a> | GAVA AGC loop status  |                |       | N    | 1    | 1    | 1    | enumerated     | 1         | var        | var    |
| AVHIMT                | GAVA instrument measurement time of the histogram           | 10^9           | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| AVHIST                | GAVA DISC histogram   |                |       | N    | 7    | 1    | 1    | integer2       | 2         | var        | var    |
| AVGCIMT               | GAVA instrument measurement time of the last change in gain | 10^9           | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| <a href="#">AVANA</a> | GAVA receiver channel analogue gain setting                 |                |       | N    | 1    | 1    | 1    | enumerated     | 1         | var        | var    |
| <a href="#">AVDIG</a> | GAVA receiver channel digital gain setting                  |                |       | N    | 1    | 1    | 1    | bitfield ( 6 ) | 6         | var        | var    |
| Total: var            |   |                |       |      |      |      |      |                |           |            |        |

## 9.16 MDR ( name 'mdr-1a-temperature', class 8, subclass 3, version 3 )

| Name                       | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type           | Type size | Field size | Offset |
|----------------------------|--|-----------------|-------|------|------|------|------|----------------|-----------|------------|--------|
| RECORD_HEADER              | Generic Record Header  |                 |       | 1    | 1    | 1    | 1    | REC_HEAD       | 20        | 20         | 0      |
| GENERIC_QUALITY_INDICATORS |  |                 |       |      |      |      |      |                |           |            |        |
| DEGRADED_INST_MDR          | Quality of MDR has been degraded from nominal due to an instrument degradation |                 |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | 20     |
| DEGRADED_PROC_MDR          | Quality of MDR has been degraded from nominal due to a processing degradation  |                 |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | 21     |
| MEASUREMENT_DATA           |  |                 |       |      |      |      |      |                |           |            |        |
| START_EPOCH                | Epoch of the measurement start   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8      | 8         | 8          | 22     |
| END_EPOCH                  | Epoch of the measurement end   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8      | 8         | 8          | 30     |
| NUMBER_OF_SAMPLES          | Number of data samples, N  |                 |       | 1    | 1    | 1    | 1    | uinteger4      | 4         | 4          | 38     |
| TIME_OBT                   | OBT time stamp of the sample   |                 | s     | N    | 1    | 1    | 1    | longtime       | 8         | var        | 42     |
| <a href="#">GEU_STS</a>    | GEU status register  |                 |       | N    | 1    | 1    | 1    | bitfield ( 1 ) | 1         | var        | var    |
| USO_TIM                    | On-board time of last USO oven switch on or off                                | 10 <sup>6</sup> | s     | N    | 1    | 1    | 1    | time           | 6         | var        | var    |
| ZAT                        | Zenith antenna temperature   | 10 <sup>3</sup> | degC  | N    | 1    | 1    | 1    | integer8       | 8         | var        | var    |
| VAT                        | Velocity antenna temperature   | 10 <sup>3</sup> | degC  | N    | 1    | 1    | 1    | integer8       | 8         | var        | var    |
| AVAT                       | Anti-velocity antenna temperature  | 10 <sup>3</sup> | degC  | N    | 1    | 1    | 1    | integer8       | 8         | var        | var    |
| RZT                        | Zenith RFCU temperature  | 10 <sup>3</sup> | degC  | N    | 1    | 1    | 1    | integer8       | 8         | var        | var    |
| RVT                        | Velocity RFCU temperature  | 10 <sup>3</sup> | degC  | N    | 1    | 1    | 1    | integer8       | 8         | var        | var    |
| RAVT                       | Anti-velocity RFCU temperature   | 10 <sup>3</sup> | degC  | N    | 1    | 1    | 1    | integer8       | 8         | var        | var    |
| GEUT                       | GEU temperature  | 10 <sup>3</sup> | degC  | N    | 1    | 1    | 1    | integer8       | 8         | var        | var    |
| ISACT                      | ISAC temperature   | 10 <sup>3</sup> | degC  | N    | 1    | 1    | 1    | integer8       | 8         | var        | var    |

| Name       | Description               | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|------------|---------------------------|----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| USOIT      | USO internal temperature  | 10^3           | degC  | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| USOET      | USO external temperature  | 10^3           | degC  | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| DBUPV      | DBU power voltage         | 10^3           | V     | N    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| TSV        | Thermistor supply voltage | 10^3           | V     | N    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| FGT        | FG temperature            | 10^3           | degC  | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| USOG       | USO ground                | 10^3           | V     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| D5V        | Digital 5 V               | 10^3           | V     | N    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| Total: var |                           |                |       |      |      |      |      |           |           |            |        |

### 9.17 MDR ( name 'mdr-1a-tracking-state', class 8, subclass 4, version 3 )

| Name                       | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|----------------------------|--|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| RECORD_HEADER              | Generic Record Header  |                 |       | 1    | 1    | 1    | 1    | REC_HEAD  | 20        | 20         | 0      |
| GENERIC_QUALITY_INDICATORS |  |                 |       |      |      |      |      |           |           |            |        |
| DEGRADED_INST_MDR          | Quality of MDR has been degraded from nominal due to an instrument degradation |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 20     |
| DEGRADED_PROC_MDR          | Quality of MDR has been degraded from nominal due to a processing degradation  |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 21     |
| TRACKING_STATE_DATA        |  |                 |       |      |      |      |      |           |           |            |        |
| START_EPOCH                | Epoch of the measurement start   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 22     |
| END_EPOCH                  | Epoch of the measurement end   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 30     |
| NUMBER_OF_SAMPLES          | Number of data samples, N  |                 |       | 1    | 1    | 1    | 1    | uinteger4 | 4         | 4          | 38     |

| Name                               | Description                             | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type           | Type size | Field size | Offset |
|------------------------------------|---|-----------------|-------|------|------|------|------|----------------|-----------|------------|--------|
| TIME_IMT                           | IMT time stamp of the sample            | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | 42     |
| CODE_STATUS                        | Codeless or coded tracking mode         |                 |       | N    | 1    | 1    | 1    | boolean        | 1         | var        | var    |
| CH0_SATELLITE_IDENTIFIER           | Identifier of the tracked GPS satellite |                 |       | N    | 1    | 1    | 1    | uinteger1      | 1         | var        | var    |
| <a href="#">CH0_TRACKING_STATE</a> | Tracking state                          |                 |       | N    | 1    | 1    | 1    | bitfield ( 2 ) | 2         | var        | var    |
| CH0_IMT                            | Time of the tracking state change       | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| CH1_SATELLITE_IDENTIFIER           | Identifier of the tracked GPS satellite |                 |       | N    | 1    | 1    | 1    | uinteger1      | 1         | var        | var    |
| <a href="#">CH1_TRACKING_STATE</a> | Tracking state                          |                 |       | N    | 1    | 1    | 1    | bitfield ( 2 ) | 2         | var        | var    |
| CH1_IMT                            | Time of the tracking state change       | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| CH2_SATELLITE_IDENTIFIER           | Identifier of the tracked GPS satellite |                 |       | N    | 1    | 1    | 1    | uinteger1      | 1         | var        | var    |
| <a href="#">CH2_TRACKING_STATE</a> | Tracking state                          |                 |       | N    | 1    | 1    | 1    | bitfield ( 2 ) | 2         | var        | var    |
| CH2_IMT                            | Time of the tracking state change       | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| CH3_SATELLITE_IDENTIFIER           | Identifier of the tracked GPS satellite |                 |       | N    | 1    | 1    | 1    | uinteger1      | 1         | var        | var    |
| <a href="#">CH3_TRACKING_STATE</a> | Tracking state                          |                 |       | N    | 1    | 1    | 1    | bitfield ( 2 ) | 2         | var        | var    |
| CH3_IMT                            | Time of the tracking state change       | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| CH4_SATELLITE_IDENTIFIER           | Identifier of the tracked GPS satellite |                 |       | N    | 1    | 1    | 1    | uinteger1      | 1         | var        | var    |
| <a href="#">CH4_TRACKING_STATE</a> | Tracking state                          |                 |       | N    | 1    | 1    | 1    | bitfield ( 2 ) | 2         | var        | var    |
| CH4_IMT                            | Time of the tracking state change       | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| CH5_SATELLITE_IDENTIFIER           | Identifier of the tracked GPS satellite |                 |       | N    | 1    | 1    | 1    | uinteger1      | 1         | var        | var    |
| <a href="#">CH5_TRACKING_STATE</a> | Tracking state                          |                 |       | N    | 1    | 1    | 1    | bitfield ( 2 ) | 2         | var        | var    |
| CH5_IMT                            | Time of the tracking state change       | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| CH6_SATELLITE_IDENTIFIER           | Identifier of the tracked GPS satellite |                 |       | N    | 1    | 1    | 1    | uinteger1      | 1         | var        | var    |
| <a href="#">CH6_TRACKING_STATE</a> | Tracking state                          |                 |       | N    | 1    | 1    | 1    | bitfield ( 2 ) | 2         | var        | var    |



| Name                                | Description                             | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type           | Type size | Field size | Offset |
|-------------------------------------|---|----------------|-------|------|------|------|------|----------------|-----------|------------|--------|
| CH6_IMT                             | Time of the tracking state change       | 10^9           | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| CH7_SATELLITE_IDENTIFIER            | Identifier of the tracked GPS satellite |                |       | N    | 1    | 1    | 1    | uinteger1      | 1         | var        | var    |
| <a href="#">CH7_TRACKING_STATE</a>  | Tracking state                          |                |       | N    | 1    | 1    | 1    | bitfield ( 2 ) | 2         | var        | var    |
| CH7_IMT                             | Time of the tracking state change       | 10^9           | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| CH8_SATELLITE_IDENTIFIER            | Identifier of the tracked GPS satellite |                |       | N    | 1    | 1    | 1    | uinteger1      | 1         | var        | var    |
| <a href="#">CH8_TRACKING_STATE</a>  | Tracking state                          |                |       | N    | 1    | 1    | 1    | bitfield ( 2 ) | 2         | var        | var    |
| CH8_IMT                             | Time of the tracking state change       | 10^9           | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| CH9_SATELLITE_IDENTIFIER            | Identifier of the tracked GPS satellite |                |       | N    | 1    | 1    | 1    | uinteger1      | 1         | var        | var    |
| <a href="#">CH9_TRACKING_STATE</a>  | Tracking state                          |                |       | N    | 1    | 1    | 1    | bitfield ( 2 ) | 2         | var        | var    |
| CH9_IMT                             | Time of the tracking state change       | 10^9           | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| CH10_SATELLITE_IDENTIFIER           | Identifier of the tracked GPS satellite |                |       | N    | 1    | 1    | 1    | uinteger1      | 1         | var        | var    |
| <a href="#">CH10_TRACKING_STATE</a> | Tracking state                          |                |       | N    | 1    | 1    | 1    | bitfield ( 2 ) | 2         | var        | var    |
| CH10_IMT                            | Time of the tracking state change       | 10^9           | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| CH11_SATELLITE_IDENTIFIER           | Identifier of the tracked GPS satellite |                |       | N    | 1    | 1    | 1    | uinteger1      | 1         | var        | var    |
| <a href="#">CH11_TRACKING_STATE</a> | Tracking state                          |                |       | N    | 1    | 1    | 1    | bitfield ( 2 ) | 2         | var        | var    |
| CH11_IMT                            | Time of the tracking state change       | 10^9           | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| Total: var                          |   |                |       |      |      |      |      |                |           |            |        |

## 9.18 MDR ( name 'mdr-1a-ephemeris', class 8, subclass 5, version 3 )

| Name                       | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|----------------------------|--|-----------------|-------|------|------|------|------|------------|-----------|------------|--------|
| RECORD_HEADER              | Generic Record Header  |                 |       | 1    | 1    | 1    | 1    | REC_HEAD   | 20        | 20         | 0      |
| GENERIC_QUALITY_INDICATORS |  |                 |       |      |      |      |      |            |           |            |        |
| DEGRADED_INST_MDR          | Quality of MDR has been degraded from nominal due to an instrument degradation |                 |       | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 20     |
| DEGRADED_PROC_MDR          | Quality of MDR has been degraded from nominal due to a processing degradation  |                 |       | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 21     |
| MEASUREMENT_DATA           |  |                 |       |      |      |      |      |            |           |            |        |
| START_EPOCH                | Epoch of the measurement start   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 22     |
| END_EPOCH                  | Epoch of the measurement end   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 30     |
| NUMBER_OF_SATELLITES       | Number of GPS satellites, N  |                 |       | 1    | 1    | 1    | 1    | uinteger1  | 1         | 1          | 38     |
| GPS_ID                     | GPS satellite identification   |                 |       | N    | 1    | 1    | 1    | uinteger1  | 1         | var        | 39     |
| NUMBER_OF_SAMPLES          | Number of data samples, M  |                 |       | N    | 1    | 1    | 1    | uinteger4  | 4         | var        | var    |
| TIME_OBT                   | OBT time stamp of the sample   |                 | s     | M    | N    | 1    | 1    | longtime   | 8         | var        | var    |
| A_FLAG                     | Alert flag   |                 |       | M    | N    | 1    | 1    | boolean    | 1         | var        | var    |
| AS_FLAG                    | Anti-spoofing flag   |                 |       | M    | N    | 1    | 1    | boolean    | 1         | var        | var    |
| <a href="#">C2</a>         | Codes on L2 channel  |                 |       | M    | N    | 1    | 1    | enumerated | 1         | var        | var    |
| SVA                        | SV accuracy  |                 |       | M    | N    | 1    | 1    | uinteger1  | 1         | var        | var    |
| D2                         | Data flag for L2 on P-code   |                 |       | M    | N    | 1    | 1    | boolean    | 1         | var        | var    |
| CF                         | Curve fit interval   |                 |       | M    | N    | 1    | 1    | boolean    | 1         | var        | var    |
| WN                         | Week number  |                 |       | M    | N    | 1    | 1    | uinteger2  | 2         | var        | var    |

| Name               | Description  | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|--------------------|--|----------------|-------|------|------|------|------|------------|-----------|------------|--------|
| NH                 | GPS navigation data health summary   |                |       | M    | N    | 1    | 1    | boolean    | 1         | var        | var    |
| <a href="#">SH</a> | GPS signal health  |                |       | M    | N    | 1    | 1    | enumerated | 1         | var        | var    |
| IODC               | Issue of data (Clock)  |                |       | M    | N    | 1    | 1    | uinteger2  | 2         | var        | var    |
| A_F0               | SV clock correction polynomial constant                                      |                |       | M    | N    | 1    | 1    | integer4   | 4         | var        | var    |
| A_F1               | SV clock correction polynomial constant                                      |                |       | M    | N    | 1    | 1    | integer2   | 2         | var        | var    |
| A_F2               | SV clock correction polynomial constant                                      |                |       | M    | N    | 1    | 1    | integer2   | 2         | var        | var    |
| T_GD               | Estimated group delay differential   |                |       | M    | N    | 1    | 1    | integer2   | 2         | var        | var    |
| T_OC               | Clock data reference time  |                |       | M    | N    | 1    | 1    | integer2   | 2         | var        | var    |
| C_RS               | Amplitude of the sine harmonic correction term to the orbit radius           |                |       | M    | N    | 1    | 1    | integer2   | 2         | var        | var    |
| DELTA_N            | Mean motion diff. From computed value  |                |       | M    | N    | 1    | 1    | integer2   | 2         | var        | var    |
| M_0                | Mean anomaly at reference time   |                |       | M    | N    | 1    | 1    | integer4   | 4         | var        | var    |
| C_UC               | Amplitude of the cosine harmonic correction term to the argument of latitude |                |       | M    | N    | 1    | 1    | integer2   | 2         | var        | var    |
| E                  | Eccentricity   |                |       | M    | N    | 1    | 1    | integer4   | 4         | var        | var    |
| C_US               | Amplitude of the sine harmonic correction term to the argument of latitude   |                |       | M    | N    | 1    | 1    | integer2   | 2         | var        | var    |
| SQRT_A             | Square root of the semi-major axis   |                |       | M    | N    | 1    | 1    | uinteger4  | 4         | var        | var    |
| T_OE               | Reference time ephemeris   |                |       | M    | N    | 1    | 1    | uinteger4  | 4         | var        | var    |
| C_IC               | Amplitude of the cosine harmonic correction term to the angle of inclination |                |       | M    | N    | 1    | 1    | integer2   | 2         | var        | var    |
| OMEGA_0            | Longitude of ascending node of orbit plane at weekly epoch                   |                |       | M    | N    | 1    | 1    | integer4   | 4         | var        | var    |
| C_IS               | Amplitude of the sine harmonic correction term                               |                |       | M    | N    | 1    | 1    | integer2   | 2         | var        | var    |

| Name        | Description   | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|-------------|---|----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
|             | to the angle of inclination   |                |       |      |      |      |      |           |           |            |        |
| I_0         | Inclination angle at reference time   |                |       | M    | N    | 1    | 1    | integer4  | 4         | var        | var    |
| C_RC        | Amplitude of the cosine harmonic correction term to the orbit radius                  |                |       | M    | N    | 1    | 1    | integer2  | 2         | var        | var    |
| OMEGA       | Argument of perigee   |                |       | M    | N    | 1    | 1    | integer4  | 4         | var        | var    |
| OMEGA_DOT   | Rate of right ascension   |                |       | M    | N    | 1    | 1    | integer4  | 4         | var        | var    |
| IODE        | Issue of data (Ephemeris)   |                |       | M    | N    | 1    | 1    | uinteger1 | 1         | var        | var    |
| I_DOT       | Rate of inclination angle   |                |       | M    | N    | 1    | 1    | integer2  | 2         | var        | var    |
| ASAT        | GPS identifier of satellite from which the UTC and ionosphere parameters are acquired |                |       | M    | N    | 1    | 1    | uinteger1 | 1         | var        | var    |
| A1          | Polynomial constant   |                |       | M    | N    | 1    | 1    | integer4  | 4         | var        | var    |
| A0          | Polynomial constant   |                |       | M    | N    | 1    | 1    | integer4  | 4         | var        | var    |
| DELTA_T_LS  | Delta time due to leap seconds  |                |       | M    | N    | 1    | 1    | integer1  | 1         | var        | var    |
| T_OT        | Reference time for UTC data   |                |       | M    | N    | 1    | 1    | uinteger1 | 1         | var        | var    |
| WN_T        | UTC reference week number   |                |       | M    | N    | 1    | 1    | uinteger1 | 1         | var        | var    |
| WN_LSF      | UTC reference week number   |                |       | M    | N    | 1    | 1    | integer1  | 1         | var        | var    |
| DN          | Day number  |                |       | M    | N    | 1    | 1    | integer1  | 1         | var        | var    |
| DELTA_T_LSF | Delta time due to leap seconds  |                |       | M    | N    | 1    | 1    | integer1  | 1         | var        | var    |
| ALPHA_0     | Ionosphere parameter  |                |       | M    | N    | 1    | 1    | integer1  | 1         | var        | var    |
| ALPHA_1     | Ionosphere parameter  |                |       | M    | N    | 1    | 1    | integer1  | 1         | var        | var    |
| ALPHA_2     | Ionosphere parameter  |                |       | M    | N    | 1    | 1    | integer1  | 1         | var        | var    |
| ALPHA_3     | Ionosphere parameter  |                |       | M    | N    | 1    | 1    | integer1  | 1         | var        | var    |
| BETA_0      | Ionosphere parameter  |                |       | M    | N    | 1    | 1    | integer1  | 1         | var        | var    |

| Name       | Description          | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|------------|----------------------|----------------|-------|------|------|------|------|----------|-----------|------------|--------|
| BETA_1     | Ionosphere parameter |                |       | M    | N    | 1    | 1    | integer1 | 1         | var        | var    |
| BETA_2     | Ionosphere parameter |                |       | M    | N    | 1    | 1    | integer1 | 1         | var        | var    |
| BETA_3     | Ionosphere parameter |                |       | M    | N    | 1    | 1    | integer1 | 1         | var        | var    |
| Total: var |                      |                |       |      |      |      |      |          |           |            |        |

### 9.19 MDR ( name 'mdr-1a-occ-noise', class 8, subclass 6, version 3 )

| Name                       | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|----------------------------|--|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| RECORD_HEADER              | Generic Record Header  |                 |       | 1    | 1    | 1    | 1    | REC_HEAD  | 20        | 20         | 0      |
| GENERIC_QUALITY_INDICATORS |  |                 |       |      |      |      |      |           |           |            |        |
| DEGRADED_INST_MDR          | Quality of MDR has been degraded from nominal due to an instrument degradation |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 20     |
| DEGRADED_PROC_MDR          | Quality of MDR has been degraded from nominal due to a processing degradation  |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 21     |
| MEASUREMENT_DATA           |  |                 |       |      |      |      |      |           |           |            |        |
| START_EPOCH                | Epoch of the measurement start   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 22     |
| END_EPOCH                  | Epoch of the measurement end   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 30     |
| NUMBER_OF_PACKETS          | Number of measurement packets, M   |                 |       | 1    | 1    | 1    | 1    | uinteger4 | 4         | 4          | 38     |
| TIME_IMT_PACKET            | IMT time stamp of the packet   | 10 <sup>9</sup> | s     | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | 42     |
| DT                         | Integration time   | 10 <sup>9</sup> | s     | M    | 1    | 1    | 1    | uinteger4 | 4         | var        | var    |
| NUMBER_OF_SAMPLES          | Number of measurement samples, N   |                 |       | M    | 1    | 1    | 1    | uinteger4 | 4         | var        | var    |
| TIME_IMT_SAMPLE            | IMT time stamp of the sample   | 10 <sup>9</sup> | s     | N    | M    | 1    | 1    | uinteger8 | 8         | var        | var    |

| Name          | Description                            | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|---------------|--|----------------|-------|------|------|------|------|----------|-----------|------------|--------|
| GAVA_L1_I_M   | Normalised signal level detector count |                |       | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| GAVA_L1_I_S   | Normalised signal level detector count |                |       | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| GAVA_L2_I_M   | Normalised signal level detector count |                |       | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| GAVA_L2_I_S   | Normalised signal level detector count |                |       | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| GVA_L1_I_M    | Normalised signal level detector count |                |       | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| GVA_L1_I_S    | Normalised signal level detector count |                |       | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| GVA_L2_I_M    | Normalised signal level detector count |                |       | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| GVA_L2_I_S    | Normalised signal level detector count |                |       | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| GAVA_L1_Q_M   | Normalised signal level detector count |                |       | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| GAVA_L1_Q_S   | Normalised signal level detector count |                |       | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| GAVA_L2_Q_M   | Normalised signal level detector count |                |       | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| GAVA_L2_Q_S   | Normalised signal level detector count |                |       | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| GVA_L1_Q_M    | Normalised signal level detector count |                |       | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| GVA_L1_Q_S    | Normalised signal level detector count |                |       | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| GVA_L2_Q_M    | Normalised signal level detector count |                |       | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| GVA_L2_Q_S    | Normalised signal level detector count |                |       | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| L1_NOISE_GAVA | L1 noise estimate                      | 10^9           | dB    | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| L2_NOISE_GAVA | L2 noise estimate                      | 10^9           | dB    | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| L1_NOISE_GVA  | L1 noise estimate                      | 10^9           | dB    | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| L2_NOISE_GVA  | L2 noise estimate                      | 10^9           | dB    | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| Total: var    |  |                |       |      |      |      |      |          |           |            |        |

## 9.20 MDR ( name 'mdr-1a-zenith-noise', class 8, subclass 7, version 3 )

| Name                       | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|----------------------------|--|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| RECORD_HEADER              | Generic Record Header  |                 |       | 1    | 1    | 1    | 1    | REC_HEAD  | 20        | 20         | 0      |
| GENERIC_QUALITY_INDICATORS |  |                 |       |      |      |      |      |           |           |            |        |
| DEGRADED_INST_MDR          | Quality of MDR has been degraded from nominal due to an instrument degradation |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 20     |
| DEGRADED_PROC_MDR          | Quality of MDR has been degraded from nominal due to a processing degradation  |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 21     |
| MEASUREMENT_DATA           |  |                 |       |      |      |      |      |           |           |            |        |
| START_EPOCH                | Epoch of the measurement start   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 22     |
| END_EPOCH                  | Epoch of the measurement end   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 30     |
| NUMBER_OF_PACKETS          | Number of measurement packets, M   |                 |       | 1    | 1    | 1    | 1    | uinteger4 | 4         | 4          | 38     |
| TIME_IMT                   | IMT time stamp of the packet   | 10 <sup>9</sup> | s     | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | 42     |
| DT                         | Integration time   | 10 <sup>9</sup> | s     | M    | 1    | 1    | 1    | uinteger4 | 4         | var        | var    |
| NUMBER_OF_SAMPLES          | Number of measurement samples, N   |                 |       | M    | 1    | 1    | 1    | uinteger4 | 4         | var        | var    |
| TIME_IMT_SAMPLE            | IMT time stamp of the sample   | 10 <sup>9</sup> | s     | N    | M    | 1    | 1    | uinteger8 | 8         | var        | var    |
| GZA_L1_I_M                 | Normalised signal level detector count   |                 |       | N    | M    | 1    | 1    | integer8  | 8         | var        | var    |
| GZA_L1_I_S                 | Normalised signal level detector count   |                 |       | N    | M    | 1    | 1    | integer8  | 8         | var        | var    |
| GZA_L2_I_M                 | Normalised signal level detector count   |                 |       | N    | M    | 1    | 1    | integer8  | 8         | var        | var    |
| GZA_L2_I_S                 | Normalised signal level detector count   |                 |       | N    | M    | 1    | 1    | integer8  | 8         | var        | var    |
| GZA_L1_Q_M                 | Normalised signal level detector count   |                 |       | N    | M    | 1    | 1    | integer8  | 8         | var        | var    |
| GZA_L1_Q_S                 | Normalised signal level detector count   |                 |       | N    | M    | 1    | 1    | integer8  | 8         | var        | var    |
| GZA_L2_Q_M                 | Normalised signal level detector count   |                 |       | N    | M    | 1    | 1    | integer8  | 8         | var        | var    |

| Name       | Description                            | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|------------|--|----------------|-------|------|------|------|------|----------|-----------|------------|--------|
| GZA_L2_Q_S | Normalised signal level detector count |                |       | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| L1_NOISE   | L1 noise estimate                      | 10^9           | dB    | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| L2_NOISE   | L2 noise estimate                      | 10^9           | dB    | N    | M    | 1    | 1    | integer8 | 8         | var        | var    |
| Total: var |  |                |       |      |      |      |      |          |           |            |        |

## 9.21 MDR ( name 'mdr-1a-occultation-data', class 8, subclass 8, version 4 )

| Name                       | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|----------------------------|--|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| RECORD_HEADER              | Generic Record Header  |                 |       | 1    | 1    | 1    | 1    | REC_HEAD  | 20        | 20         | 0      |
| GENERIC_QUALITY_INDICATORS |  |                 |       |      |      |      |      |           |           |            |        |
| DEGRADED_INST_MDR          | Quality of MDR has been degraded from nominal due to an instrument degradation |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 20     |
| DEGRADED_PROC_MDR          | Quality of MDR has been degraded from nominal due to a processing degradation  |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 21     |
| MEASUREMENT_DATA           |  |                 |       |      |      |      |      |           |           |            |        |
| START_EPOCH                | Epoch of the measurement start   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 22     |
| END_EPOCH                  | Epoch of the measurement end   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 30     |
| PRED_START_EPOCH           | Predicted start epoch of the measurement from                                  | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 38     |



| Name                             | Description   | Scaling factor   | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|----------------------------------|---|------------------|-------|------|------|------|------|------------|-----------|------------|--------|
|                                  | occultation table   |                  |       |      |      |      |      |            |           |            |        |
| PRED_END_EPOCH                   | Predicted end epoch of the measurement from occultation table | 10 <sup>9</sup>  | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 46     |
| MEASUREMENT_ID                   | Measurement identification                                    |                  |       | 1    | 1    | 1    | 1    | string     | 32        | 32         | 54     |
| ID_FAILED                        | Measurement identification failed                             |                  |       | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 86     |
| MEASUREMENT_LENGTH               | Measurement length  |                  | s     | 1    | 1    | 1    | 1    | uinteger2  | 2         | 2          | 87     |
| GRAS_MODE                        | Navigation or occultation mode                                |                  |       | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 89     |
| <a href="#">MEASUREMENT_TYPE</a> | Rising, setting, or navigation                                |                  |       | 1    | 1    | 1    | 1    | enumerated | 1         | 1          | 90     |
| <a href="#">GRAS_CHANNEL_ID</a>  | GRAS channel identification                                   |                  |       | 1    | 1    | 1    | 1    | enumerated | 1         | 1          | 91     |
| GPS_OCC_ID                       | Occulting GPS identification                                  |                  |       | 1    | 1    | 1    | 1    | uinteger1  | 1         | 1          | 92     |
| GPS_HW_DELAY                     | Estimated GPS hardware group delay                            | 10 <sup>15</sup> | s     | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 93     |
| GPS_HW_COR_CA                    | GPS hardware delay correction for CA code phase               | 10 <sup>9</sup>  | chips | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 101    |
| GPS_HW_COR_P1                    | GPS hardware delay correction for P1 code phase               | 10 <sup>9</sup>  | chips | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 109    |
| GPS_HW_COR_P2                    | GPS hardware delay correction for P2 code phase               | 10 <sup>9</sup>  | chips | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 117    |
| USO_FREQUENCY                    | Nominal USO frequency used in the processing                  | 10 <sup>9</sup>  | Hz    | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 125    |
| ANTENNA_REF_POINT_X              | Antenna reference point position vector x in SR frame         | 10 <sup>6</sup>  | m     | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 133    |

| Name                   | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|------------------------|--|-----------------|-------|------|------|------|------|----------|-----------|------------|--------|
| ANTENNA_REF_POINT_Y    | Antenna reference point position vector y in SR frame      | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8 | 8         | 8          | 141    |
| ANTENNA_REF_POINT_Z    | Antenna reference point position vector z in SR frame      | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8 | 8         | 8          | 149    |
| METOP_COM_VECT_X       | Metop CoM position vector x in SR frame                    | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8 | 8         | 8          | 157    |
| METOP_COM_VECT_Y       | Metop CoM position vector y in SR frame                    | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8 | 8         | 8          | 165    |
| METOP_COM_VECT_Z       | Metop CoM position vector z in SR frame                    | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8 | 8         | 8          | 173    |
| CYCLE_SLIP_LIMIT       | Lower height limit for cycle slip detection and correction | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8 | 8         | 8          | 181    |
| Q_ANA                  | Analogue AGC active during measurement                     |                 |       | 1    | 1    | 1    | 1    | boolean  | 1         | 1          | 189    |
| INSTRUMENT_STABLE      | USO oven temperature has been stabilized after switch on   |                 |       | 1    | 1    | 1    | 1    | boolean  | 1         | 1          | 190    |
| USO_TEMPERATURE_START  | USO oven temperature at the beginning of the measurement   | 10 <sup>3</sup> | degC  | 1    | 1    | 1    | 1    | integer4 | 4         | 4          | 191    |
| USO_TEMPERATURE_END    | USO oven temperature at the end of the measurement         | 10 <sup>3</sup> | degC  | 1    | 1    | 1    | 1    | integer4 | 4         | 4          | 195    |
| USO_TEMPERATURE_CHANGE | USO oven temperature change during occultation             | 10 <sup>3</sup> | degC  | 1    | 1    | 1    | 1    | integer4 | 4         | 4          | 199    |
| METOP_MANOEUVRE        | This MDR is affected by a Metop manoeuvre                  |                 |       | 1    | 1    | 1    | 1    | boolean  | 1         | 1          | 203    |

| Name                                | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|-------------------------------------|--|-----------------|-------|------|------|------|------|------------|-----------|------------|--------|
| <a href="#">METOP_STEERING_MODE</a> | Metop steering mode during the measurement                                       |                 |       | 1    | 1    | 1    | 1    | enumerated | 1         | 1          | 204    |
| GPS_MANOEUVRE_FLAG                  | GPS manoeuvre flag   |                 |       | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 205    |
| GPS_MANOEUVRE_TIME                  | Time of the GPS manoeuvre  | 10 <sup>6</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 206    |
| GPS_ECLIPTING                       | GPS eclipsing  |                 |       | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 214    |
| ECLIPSE_TIME                        | Time of the eclipse  | 10 <sup>6</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 215    |
| L1_CA_AMP_LOW                       | Number of times when L1-C/A amplitude level is below the specified threshold, T1 |                 |       | 1    | 1    | 1    | 1    | uinteger2  | 2         | 2          | 223    |
| L1_CA_AMP_LOW_TIME                  | IMT time stamps corresponding to the times when the amplitude is below threshold | 10 <sup>9</sup> | s     | T1   | 1    | 1    | 1    | uinteger8  | 8         | var        | 225    |
| L1_P1_AMP_LOW                       | Number of times when L1-P1 amplitude level is below the specified threshold, T2  |                 |       | 1    | 1    | 1    | 1    | uinteger2  | 2         | 2          | var    |
| L1_P1_AMP_LOW_TIME                  | IMT time stamps corresponding to the times when the amplitude is below threshold | 10 <sup>9</sup> | s     | T2   | 1    | 1    | 1    | uinteger8  | 8         | var        | var    |
| L2_P2_AMP_LOW                       | Number of times when L2-P2 amplitude level is below the specified threshold, T3  |                 |       | 1    | 1    | 1    | 1    | uinteger2  | 2         | 2          | var    |
| L2_P2_AMP_LOW_TIME                  | IMT time stamps corresponding to the times when the amplitude is below threshold | 10 <sup>9</sup> | s     | T3   | 1    | 1    | 1    | uinteger8  | 8         | var        | var    |

| Name                                   | Description   | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type           | Type size | Field size | Offset |
|--|---|----------------|-------|------|------|------|------|----------------|-----------|------------|--------|
| L1_CA_NOISE_FLAG                       | L1-C/A noise level compared to a threshold                  |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | var    |
| L1_P1_NOISE_FLAG                       | L1-P1 noise level compared to a threshold                   |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | var    |
| L2_P2_NOISE_FLAG                       | L2-P2 noise level compared to a threshold                   |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | var    |
| L1_CA_PSEUDORANGE_FLAG                 | L1-C/A pseudorange outside the threshold                    |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | var    |
| L1_P1_PSEUDORANGE_FLAG                 | L1-P1 pseudorange outside threshold                         |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | var    |
| L2_P2_PSEUDORANGE_FLAG                 | L2-P2 pseudorange outside the threshold                     |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | var    |
| L2_NOT_TRACKED                         | Tracking state 15 was not achieved during measurement       |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | var    |
| MEASUREMENT_INCOMPLETE                 | Part of the measurement data time sequence missing          |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | var    |
| RS_DATA_MISSING                        | Raw sampling mode data missing                              |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | var    |
| ATTITUDE_MISSING                       | Metop mispointing angles data not available                 |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | var    |
| LOCAL_MULTIPATH                        | Incidence angle in the high local multipath risk directions |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | var    |
| <a href="#">LOCAL_MULTIPATH_SOURCE</a> | Possible source of local multipath based on incidence       |                |       | 1    | 1    | 1    | 1    | bitfield ( 2 ) | 2         | 2          | var    |

| Name                                    | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type           | Type size | Field size | Offset |
|---|--|-----------------|-------|------|------|------|------|----------------|-----------|------------|--------|
|   | angles   |                 |       |      |      |      |      |                |           |            |        |
| <a href="#">TELEMETRY_IN_RANGE</a>      | All telemetry data in within the specified range   |                 |       | 1    | 1    | 1    | 1    | bitfield ( 3 ) | 3         | 3          | var    |
| SA_FLAG                                 | SA flag  |                 |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | var    |
| NUMBER_OF_SAMPLES                       | Number of measurement samples, N   |                 |       | 1    | 1    | 1    | 1    | uinteger4      | 4         | 4          | var    |
| TIME_IMT                                | IMT time stamp of the sample   | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| TIME_IMT_SAMPLE                         | IMT time since the measurement start   | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| <a href="#">TRACKING_STATE</a>          | Tracking state   |                 |       | N    | 1    | 1    | 1    | bitfield ( 2 ) | 2         | var        | var    |
| <a href="#">MEASUREMENT_PACKET_TYPE</a> | Type of the measurement packet of the sample (SF,DF,RS)                                      |                 |       | N    | 1    | 1    | 1    | enumerated     | 1         | var        | var    |
| <a href="#">SECONDARY_PACKET_TYPE</a>   | Type of the measurement packet of the sample (SF,DF,RS) in case of two parallel packet types |                 |       | N    | 1    | 1    | 1    | enumerated     | 1         | var        | var    |
| POS_GPS_X                               | Position vector x of the GPS CoM   | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8       | 8         | var        | var    |
| POS_GPS_Y                               | Position vector y of the GPS CoM   | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8       | 8         | var        | var    |
| POS_GPS_Z                               | Position vector z of the GPS CoM   | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8       | 8         | var        | var    |
| VEL_GPS_X                               | Velocity vector x of the GPS CoM   | 10 <sup>6</sup> | m/s   | N    | 1    | 1    | 1    | integer8       | 8         | var        | var    |

| Name                 | Description                          | Scaling factor  | Units  | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|----------------------|--------------------------------------|-----------------|--------|------|------|------|------|----------|-----------|------------|--------|
| VEL_GPS_Y            | Velocity vector y of the GPS CoM     | 10 <sup>6</sup> | m/s    | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| VEL_GPS_Z            | Velocity vector z of the GPS CoM     | 10 <sup>6</sup> | m/s    | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| POS_METOP_OBN_X      | Position vector x of Metop from GOBS | 10 <sup>6</sup> | m      | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| POS_METOP_OBN_Y      | Position vector y of Metop from GOBS | 10 <sup>6</sup> | m      | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| POS_METOP_OBN_Z      | Position vector z of Metop from GOBS | 10 <sup>6</sup> | m      | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| VEL_METOP_OBN_X      | Velocity vector x of Metop from GOBS | 10 <sup>6</sup> | m/s    | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| VEL_METOP_OBN_Y      | Velocity vector y of Metop from GOBS | 10 <sup>6</sup> | m/s    | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| VEL_METOP_OBN_Z      | Velocity vector z of Metop from GOBS | 10 <sup>6</sup> | m/s    | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| L1_CA_PHASE_MDID     | L1-C/A carrier phase uncorrected     | 10 <sup>9</sup> | cycles | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| L1_P1_PHASE_MDID     | L1-P1 carrier phase uncorrected      | 10 <sup>9</sup> | cycles | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| L2_P2_PHASE_MDID     | L2-P2 carrier phase uncorrected      | 10 <sup>9</sup> | cycles | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| L1_CA_AMPLITUDE_MDID | L1-C/A amplitude uncorrected         | 10 <sup>9</sup> | dBV    | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| L1_P1_AMPLITUDE_MDID | L1-P1 amplitude uncorrected          | 10 <sup>9</sup> | dBV    | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| L2_P2_AMPLITUDE_MDID | L2-P2 amplitude uncorrected          | 10 <sup>9</sup> | dBV    | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |

| Name                               | Description                                       | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|------------------------------------|---|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| RAY_ZENITH_ANGLE                   | Incoming ray zenith angle from the antenna normal | 10 <sup>3</sup> | deg   | N    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| RAY_AZIMUTH_ANGLE                  | Incoming ray azimuth angle                        | 10 <sup>3</sup> | deg   | N    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| ANTENNA_PHASE_CORRECTION_L1_CA     | Antenna carrier phase correction for L1-C/A       | 10 <sup>9</sup> | m     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| ANTENNA_PHASE_CORRECTION_L1_P1     | Antenna carrier phase correction for L1-P1        | 10 <sup>9</sup> | m     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| ANTENNA_PHASE_CORRECTION_L2_P2     | Antenna carrier phase correction for L2-P2        | 10 <sup>9</sup> | m     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| RFCU_PHASE_CORRECTION_L1_CA        | RFCU carrier phase correction for L1-C/A          | 10 <sup>9</sup> | m     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| RFCU_PHASE_CORRECTION_L1_P1        | RFCU carrier phase correction for L1-P1           | 10 <sup>9</sup> | m     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| RFCU_PHASE_CORRECTION_L2_P2        | RFCU carrier phase correction for L2-P2           | 10 <sup>9</sup> | m     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| GEU_PHASE_CORRECTION_L1_CA         | GEU carrier phase correction for L1-C/A           | 10 <sup>9</sup> | m     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| GEU_PHASE_CORRECTION_L1_P1         | GEU carrier phase correction for L1-P1            | 10 <sup>9</sup> | m     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| GEU_PHASE_CORRECTION_L2_P2         | GEU carrier phase correction for L2-P2            | 10 <sup>9</sup> | m     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| ANTENNA_AMPLITUDE_CORRECTION_L1_CA | Antenna amplitude correction for L1-C/A           | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| ANTENNA_AMPLITUDE_CORRECTION_L1_P1 | Antenna amplitude correction for L1-P1            | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| ANTENNA_AMPLITUDE_CORRECTION_L2_P2 | Antenna amplitude correction                      | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |

| Name                            | Description                                      | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|---------------------------------|--|-----------------|-------|------|------|------|------|----------|-----------|------------|--------|
|                                 | for L2-P2  |                 |       |      |      |      |      |          |           |            |        |
| RFCU_AMPLITUDE_CORRECTION_L1_CA | RFCU amplitude correction for L1-C/A             | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| RFCU_AMPLITUDE_CORRECTION_L1_P1 | RFCU amplitude correction for L1-P1              | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| RFCU_AMPLITUDE_CORRECTION_L2_P2 | RFCU amplitude correction for L2-P2              | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| GEU_AMPLITUDE_CORRECTION_L1_CA  | GEU amplitude correction for L1-C/A              | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| GEU_AMPLITUDE_CORRECTION_L1_P1  | GEU amplitude correction for L1-P1               | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| GEU_AMPLITUDE_CORRECTION_L2_P2  | GEU amplitude correction for L2-P2               | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| USO_FREQUENCY_CORRECTION        | USO frequency correction                         | 10 <sup>9</sup> | Hz    | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| USO_FREQUENCY_COMP              | USO frequency after the correction               | 10 <sup>9</sup> | Hz    | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| L1_CA_PHASE                     | L1-C/A carrier phase after instrument correction | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| L1_P1_PHASE                     | L1-P1 carrier phase after instrument correction  | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| L2_P2_PHASE                     | L2-P2 carrier phase after instrument correction  | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| L1_CA_AMPLITUDE                 | L1-C/A amplitude after instrument correction     | 10 <sup>9</sup> | dBV   | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| L1_P1_AMPLITUDE                 | L1-P1 amplitude after instrument correction      | 10 <sup>9</sup> | dBV   | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |



| Name                     | Description                                 | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|--------------------------|---|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| L2_P2_AMPLITUDE          | L2-P2 amplitude after instrument correction | 10 <sup>9</sup> | dBV   | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L1_NOISE                 | L1 noise estimate                           | 10 <sup>9</sup> | dB    | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L2_NOISE                 | L2 noise estimate                           | 10 <sup>9</sup> | dB    | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| NUMBER_OF_SAMPLES_CP     | Number of code phase measurement samples, M |                 |       | 1    | 1    | 1    | 1    | uinteger4 | 4         | 4          | var    |
| TIME_IMT_CP              | IMT time stamp of the sample                | 10 <sup>9</sup> | s     | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| TIME_IMT_SAMPLE_CP       | IMT time since the measurement start        | 10 <sup>9</sup> | s     | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| ANA                      | Analogue gain setting value                 |                 | dB    | M    | 1    | 1    | 1    | integer2  | 2         | var        | var    |
| L1_CA_CODE_PHASE_MDID    | L1-C/A code phase uncorrected               | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| L1_P1_CODE_PHASE_MDID    | L1-P1 code phase uncorrected                | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| L2_P2_CODE_PHASE_MDID    | L2-P2 code phase uncorrected                | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| RFCU_CP_CORRECTION_L1_CA | RFCU code phase correction for L1-C/A       | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| RFCU_CP_CORRECTION_L1_P1 | RFCU code phase correction for L1-P1        | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| RFCU_CP_CORRECTION_L2_P2 | RFCU code phase correction for L2-P2        | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| GEU_CP_CORRECTION_L1_CA  | GEU code phase correction for L1-C/A        | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | integer8  | 8         | var        | var    |

| Name                    | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|-------------------------|--|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| GEU_CP_CORRECTION_L1_P1 | GEU code phase correction for L1-P1                                      | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| GEU_CP_CORRECTION_L2_P2 | GEU code phase correction for L2-P2                                      | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L1_CA_CODE_PHASE        | L1-C/A code phase after instrument correction                            | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| L1_P1_CODE_PHASE        | L1-P1 code phase after instrument correction                             | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| L2_P2_CODE_PHASE        | L2-P2 code phase after instrument correction                             | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| L1_CA_PSEUDORANGE       | L1-C/A pseudorange after instrument correction                           | 10 <sup>9</sup> | m     | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| L1_P1_PSEUDORANGE       | L1-P1 pseudorange after instrument correction                            | 10 <sup>9</sup> | m     | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| L2_P2_PSEUDORANGE       | L2-P2 pseudorange after instrument correction                            | 10 <sup>9</sup> | m     | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| NUMBER_OF_SAMPLES_RS    | Number of samples in a raw sampling mode, K                              |                 |       | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | var    |
| TIME_IMT_SAMPLE_RS      | IMT time stamp of the sample   | 10 <sup>9</sup> | s     | K    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| P_1_RS                  | L1 NCO phase of first sample   |                 |       | K    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| F1_1_RS                 | L1 NCO frequency setting for L1 carrier during sequence 1 in this packet |                 |       | K    | 1    | 1    | 1    | integer4  | 4         | var        | var    |
| TINT1_RS                | Total integration time from  |                 |       | K    | 1    | 1    | 1    | uinteger4 | 4         | var        | var    |

| Name            | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|-----------------|--|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
|                 | IMT when F1_1 is valid until F2_1 is set   |                 |       |      |      |      |      |           |           |            |        |
| F2_1_RS         | L1 NCO frequency setting for L1 carrier during sequence 2 in this packet                             |                 |       | K    | 1    | 1    | 1    | integer4  | 4         | var        | var    |
| TINT2_RS        | Total integration time from IMT+TINT1 when F2_1 is valid until the last measurement of the packet    |                 |       | K    | 1    | 1    | 1    | uinteger4 | 4         | var        | var    |
| IQ_CA_EXP_RS    | Exponent of I/Q samples  |                 |       | K    | 1    | 1    | 1    | uinteger2 | 2         | var        | var    |
| I_CA_RS         | I sample of L1 carrier amplitude in terms of normalised counts of the C/A punctual correlation value |                 |       | K    | 1    | 1    | 1    | integer2  | 2         | var        | var    |
| Q_CA_RS         | Q sample of L1 carrier amplitude in terms of normalised counts of the C/A punctual correlation value |                 |       | K    | 1    | 1    | 1    | integer2  | 2         | var        | var    |
| L1_PHASE_RS     | L1 carrier phase after instrument correction   | 10 <sup>9</sup> | m     | K    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L1_AMPLITUDE_RS | L1 amplitude after instrument correction   | 10 <sup>9</sup> | dBV   | K    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L1_NOISE_RS     | L1 noise estimate  | 10 <sup>9</sup> | dB    | K    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| Total: var      |  |                 |       |      |      |      |      |           |           |            |        |

## 9.22 MDR ( name 'mdr-1a-navigation-data', class 8, subclass 9, version 4 )

| Name                       | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|----------------------------|--|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| RECORD_HEADER              | Generic Record Header  |                 |       | 1    | 1    | 1    | 1    | REC_HEAD  | 20        | 20         | 0      |
| GENERIC_QUALITY_INDICATORS |  |                 |       |      |      |      |      |           |           |            |        |
| DEGRADED_INST_MDR          | Quality of MDR has been degraded from nominal due to an instrument degradation |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 20     |
| DEGRADED_PROC_MDR          | Quality of MDR has been degraded from nominal due to a processing degradation  |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 21     |
| MEASUREMENT_DATA           |  |                 |       |      |      |      |      |           |           |            |        |
| START_EPOCH                | Epoch of the measurement start   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 22     |
| END_EPOCH                  | Epoch of the measurement end   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 30     |
| PRED_START_EPOCH           | Predicted start epoch of the measurement from occultation table                | 10 <sup>6</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 38     |
| PRED_END_EPOCH             | Predicted end epoch of the measurement from occultation table                  | 10 <sup>6</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 46     |
| MEASUREMENT_ID             | Measurement identification   |                 |       | 1    | 1    | 1    | 1    | string    | 32        | 32         | 54     |
| ID_FAILED                  | Measurement identification failed  |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 86     |
| MEASUREMENT_LENGTH         | Measurement length   |                 | s     | 1    | 1    | 1    | 1    | uinteger2 | 2         | 2          | 87     |
| GRAS_MODE                  | Navigation or occultation  |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 89     |

| Name                             | Description   | Scaling factor   | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|----------------------------------|---|------------------|-------|------|------|------|------|------------|-----------|------------|--------|
|                                  | mode  |                  |       |      |      |      |      |            |           |            |        |
| <a href="#">MEASUREMENT_TYPE</a> | Rising, setting, or navigation                        |                  |       | 1    | 1    | 1    | 1    | enumerated | 1         | 1          | 90     |
| <a href="#">GRAS_CHANNEL_ID</a>  | GRAS channel identification                           |                  |       | 1    | 1    | 1    | 1    | enumerated | 1         | 1          | 91     |
| GPS_ID                           | GPS identification                                    |                  |       | 1    | 1    | 1    | 1    | uinteger1  | 1         | 1          | 92     |
| GPS_HW_DELAY                     | Estimated GPS hardware group delay                    | 10 <sup>15</sup> | s     | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 93     |
| GPS_HW_COR_CA                    | GPS hardware delay correction for CA code phase       | 10 <sup>9</sup>  | chips | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 101    |
| GPS_HW_COR_P1                    | GPS hardware delay correction for P1 code phase       | 10 <sup>9</sup>  | chips | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 109    |
| GPS_HW_COR_P2                    | GPS hardware delay correction for P2 code phase       | 10 <sup>9</sup>  | chips | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 117    |
| USO_FREQUENCY                    | Nominal USO frequency used in the processing          | 10 <sup>9</sup>  | Hz    | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 125    |
| ANTENNA_REF_POINT_X              | Antenna reference point position vector x in SR frame | 10 <sup>6</sup>  | m     | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 133    |
| ANTENNA_REF_POINT_Y              | Antenna reference point position vector y in SR frame | 10 <sup>6</sup>  | m     | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 141    |
| ANTENNA_REF_POINT_Z              | Antenna reference point position vector z in SR frame | 10 <sup>6</sup>  | m     | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 149    |
| METOP_COM_VECT_X                 | Metop CoM position vector x in SR frame               | 10 <sup>6</sup>  | m     | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 157    |
| METOP_COM_VECT_Y                 | Metop CoM position vector y in SR frame               | 10 <sup>6</sup>  | m     | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 165    |
| METOP_COM_VECT_Z                 | Metop CoM position vector z                           | 10 <sup>6</sup>  | m     | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 173    |

| Name                                | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|-------------------------------------|--|-----------------|-------|------|------|------|------|------------|-----------|------------|--------|
|                                     | in SR frame  |                 |       |      |      |      |      |            |           |            |        |
| Q_ANA                               | Analogue AGC active during measurement   |                 |       | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 181    |
| INSTRUMENT_STABLE                   | USO oven temperature has been stabilized after switch on                         |                 |       | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 182    |
| USO_TEMPERATURE_START               | USO oven temperature at the beginning of the measurement                         | 10 <sup>3</sup> | degC  | 1    | 1    | 1    | 1    | integer4   | 4         | 4          | 183    |
| USO_TEMPERATURE_END                 | USO oven temperature at the end of the measurement                               | 10 <sup>3</sup> | degC  | 1    | 1    | 1    | 1    | integer4   | 4         | 4          | 187    |
| USO_TEMPERATURE_CHANGE              | USO oven temperature change during measurement                                   | 10 <sup>3</sup> | degC  | 1    | 1    | 1    | 1    | integer4   | 4         | 4          | 191    |
| METOP_MANOEUVRE                     | This MDR is affected by a Metop manoeuvre  |                 |       | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 195    |
| <a href="#">METOP_STEERING_MODE</a> | Metop steering mode during the measurement                                       |                 |       | 1    | 1    | 1    | 1    | enumerated | 1         | 1          | 196    |
| GPS_MANOEUVRE_FLAG                  | Measured GPS manoeuvre flag  |                 |       | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 197    |
| GPS_MANOEUVRE_TIME                  | Time of the GPS manoeuvre  | 10 <sup>6</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 198    |
| GPS_ECLIPTING                       | Measured GPS eclipsing   |                 |       | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 206    |
| ECLIPSE_TIME                        | Time of the eclipse  | 10 <sup>6</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 207    |
| L1_CA_AMP_LOW                       | Number of times when L1-C/A amplitude level is below the specified threshold, T1 |                 |       | 1    | 1    | 1    | 1    | uinteger2  | 2         | 2          | 215    |
| L1_CA_AMP_LOW_TIME                  | IMT time stamps  | 10 <sup>9</sup> | s     | T1   | 1    | 1    | 1    | uinteger8  | 8         | var        | 217    |

| Name                   | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|------------------------|--|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
|                        | corresponding to the times when the amplitude is below threshold                 |                 |       |      |      |      |      |           |           |            |        |
| L1_P1_AMP_LOW          | Number of times when L1-P1 amplitude level is below the specified threshold, T2  |                 |       | 1    | 1    | 1    | 1    | uinteger2 | 2         | 2          | var    |
| L1_P1_AMP_LOW_TIME     | IMT time stamps corresponding to the times when the amplitude is below threshold | 10 <sup>9</sup> | s     | T2   | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| L2_P2_AMP_LOW          | Number of times when L2-P2 amplitude level is below the specified threshold, T3  |                 |       | 1    | 1    | 1    | 1    | uinteger2 | 2         | 2          | var    |
| L2_P2_AMP_LOW_TIME     | IMT time stamps corresponding to the times when the amplitude is below threshold | 10 <sup>9</sup> | s     | T3   | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| L1_CA_NOISE_FLAG       | L1-C/A noise level compared to a threshold                                       |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | var    |
| L1_P1_NOISE_FLAG       | L2-P2 noise level compared to a threshold  |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | var    |
| L2_P2_NOISE_FLAG       | L2-Y noise level compared to a threshold   |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | var    |
| L1_CA_PSEUDORANGE_FLAG | L1-C/A pseudorange outside the threshold   |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | var    |
| L1_P1_PSEUDORANGE_FLAG | L2-P2 pseudorange outside threshold  |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | var    |

| Name                                    | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type           | Type size | Field size | Offset |
|---|--|-----------------|-------|------|------|------|------|----------------|-----------|------------|--------|
| L2_P2_PSEUDORANGE_FLAG                  | L2-Y pseudorange outside the threshold                       |                 |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | var    |
| L2_NOT_TRACKED                          | Tracking state 15 was not achieved during measurement        |                 |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | var    |
| MEASUREMENT_INCOMPLETE                  | Part of the measurement data time sequence missing           |                 |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | var    |
| ATTITUDE_MISSING                        | Metop mispointing angles data not available                  |                 |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | var    |
| LOCAL_MULTIPATH                         | Incidence angle in the high local multipath risk directions  |                 |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | var    |
| <a href="#">LOCAL_MULTIPATH_SOURCE</a>  | Possible source of local multipath based on incidence angles |                 |       | 1    | 1    | 1    | 1    | bitfield ( 2 ) | 2         | 2          | var    |
| <a href="#">TELEMETRY_IN_RANGE</a>      | All telemetry data in within the specified range             |                 |       | 1    | 1    | 1    | 1    | bitfield ( 3 ) | 3         | 3          | var    |
| SA_FLAG                                 | SA flag  |                 |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | var    |
| NUMBER_OF_SAMPLES                       | Number of measurement samples, N                             |                 |       | 1    | 1    | 1    | 1    | uinteger4      | 4         | 4          | var    |
| TIME_IMT                                | IMT time stamp of the sample                                 | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| TIME_IMT_SAMPLE                         | IMT time since the measurement start                         | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| <a href="#">TRACKING_STATE</a>          | Tracking state   |                 |       | N    | 1    | 1    | 1    | bitfield ( 2 ) | 2         | var        | var    |
| <a href="#">MEASUREMENT_PACKET_TYPE</a> | Type of the measurement                                      |                 |       | N    | 1    | 1    | 1    | enumerated     | 1         | var        | var    |



| Name                                  | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|---------------------------------------|--|-----------------|-------|------|------|------|------|------------|-----------|------------|--------|
|                                       | packet of the sample (SF,DF,RS)  |                 |       |      |      |      |      |            |           |            |        |
| <a href="#">SECONDARY_PACKET_TYPE</a> | Type of the measurement packet of the sample (SF,DF,RS) in case of two parallel packet types |                 |       | N    | 1    | 1    | 1    | enumerated | 1         | var        | var    |
| POS_GPS_X                             | Position vector x of the GPS CoM   | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| POS_GPS_Y                             | Position vector y of the GPS CoM   | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| POS_GPS_Z                             | Position vector z of the GPS CoM   | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| VEL_GPS_X                             | Velocity vector x of the GPS CoM   | 10 <sup>6</sup> | m/s   | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| VEL_GPS_Y                             | Velocity vector y of the GPS CoM   | 10 <sup>6</sup> | m/s   | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| VEL_GPS_Z                             | Velocity vector z of the GPS CoM   | 10 <sup>6</sup> | m/s   | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| POS_METOP_OBN_X                       | Position vector x of Metop from GOBS   | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| POS_METOP_OBN_Y                       | Position vector y of Metop from GOBS   | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| POS_METOP_OBN_Z                       | Position vector z of Metop from GOBS   | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| VEL_METOP_OBN_X                       | Velocity vector x of Metop from GOBS   | 10 <sup>6</sup> | m/s   | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |

| Name                           | Description                                       | Scaling factor  | Units  | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|--------------------------------|---|-----------------|--------|------|------|------|------|-----------|-----------|------------|--------|
| VEL_METOP_OBN_Y                | Velocity vector y of Metop from GOBS              | 10 <sup>6</sup> | m/s    | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| VEL_METOP_OBN_Z                | Velocity vector z of Metop from GOBS              | 10 <sup>6</sup> | m/s    | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L1_CA_PHASE_MDID               | L1-C/A carrier phase uncorrected                  | 10 <sup>9</sup> | cycles | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L1_P1_PHASE_MDID               | L1-P1 carrier phase uncorrected                   | 10 <sup>9</sup> | cycles | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L2_P2_PHASE_MDID               | L2-P2 carrier phase uncorrected                   | 10 <sup>9</sup> | cycles | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L1_CA_AMPLITUDE_MDID           | L1-C/A amplitude uncorrected                      | 10 <sup>9</sup> | dBV    | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L1_P1_AMPLITUDE_MDID           | L1-P1 amplitude uncorrected                       | 10 <sup>9</sup> | dBV    | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L2_P2_AMPLITUDE_MDID           | L2-P2 amplitude uncorrected                       | 10 <sup>9</sup> | dBV    | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| RAY_ZENITH_ANGLE               | Incoming ray zenith angle from the antenna normal | 10 <sup>3</sup> | deg    | N    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| RAY_AZIMUTH_ANGLE              | Incoming ray azimuth angle                        | 10 <sup>3</sup> | deg    | N    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| ANTENNA_PHASE_CORRECTION_L1_CA | Antenna carrier phase correction for L1-C/A       | 10 <sup>9</sup> | m      | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| ANTENNA_PHASE_CORRECTION_L1_P1 | Antenna carrier phase correction for L1-P1        | 10 <sup>9</sup> | m      | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| ANTENNA_PHASE_CORRECTION_L2_P2 | Antenna carrier phase correction for L2-P2        | 10 <sup>9</sup> | m      | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| RFCU_PHASE_CORRECTION_L1_CA    | RFCU carrier phase correction for L1-C/A          | 10 <sup>9</sup> | m      | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |

| Name                               | Description                             | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|------------------------------------|---|-----------------|-------|------|------|------|------|----------|-----------|------------|--------|
| RFCU_PHASE_CORRECTION_L1_P1        | RFCU carrier phase correction for L1-P1 | 10 <sup>9</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| RFCU_PHASE_CORRECTION_L2_P2        | RFCU carrier phase correction for L2-P2 | 10 <sup>9</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| GEU_PHASE_CORRECTION_L1_CA         | GEU carrier phase correction for L1-C/A | 10 <sup>9</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| GEU_PHASE_CORRECTION_L1_P1         | GEU carrier phase correction for L1-P1  | 10 <sup>9</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| GEU_PHASE_CORRECTION_L2_P2         | GEU carrier phase correction for L2-P2  | 10 <sup>9</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| ANTENNA_AMPLITUDE_CORRECTION_L1_CA | Antenna amplitude correction for L1-C/A | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| ANTENNA_AMPLITUDE_CORRECTION_L1_P1 | Antenna amplitude correction for L1-P1  | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| ANTENNA_AMPLITUDE_CORRECTION_L2_P2 | Antenna amplitude correction for L2-P2  | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| RFCU_AMPLITUDE_CORRECTION_L1_CA    | RFCU amplitude correction for L1-C/A    | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| RFCU_AMPLITUDE_CORRECTION_L1_P1    | RFCU amplitude correction for L1-P1     | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| RFCU_AMPLITUDE_CORRECTION_L2_P2    | RFCU amplitude correction for L2-P2     | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| GEU_AMPLITUDE_CORRECTION_L1_CA     | GEU amplitude correction for L1-C/A     | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| GEU_AMPLITUDE_CORRECTION_L1_P1     | GEU amplitude correction for L1-P1      | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |

| Name                           | Description                                      | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|--------------------------------|--|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| GEU_AMPLITUDE_CORRECTION_L2_P2 | GEU amplitude correction for L2-P2               | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| USO_FREQUENCY_CORRECTION       | USO frequency correction                         | 10 <sup>9</sup> | Hz    | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| USO_FREQUENCY_COMP             | USO frequency after the correction               | 10 <sup>9</sup> | Hz    | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L1_CA_PHASE                    | L1-C/A carrier phase after instrument correction | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L1_P1_PHASE                    | L1-P1 carrier phase after instrument correction  | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L2_P2_PHASE                    | L2-P2 carrier phase after instrument correction  | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L1_CA_AMPLITUDE                | L1-C/A amplitude after instrument correction     | 10 <sup>9</sup> | dBV   | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L1_P1_AMPLITUDE                | L1-P1 amplitude after instrument correction      | 10 <sup>9</sup> | dBV   | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L2_P2_AMPLITUDE                | L2-P2 amplitude after instrument correction      | 10 <sup>9</sup> | dBV   | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L1_NOISE                       | L1 noise estimate                                | 10 <sup>9</sup> | dB    | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L2_NOISE                       | L2 noise estimate                                | 10 <sup>9</sup> | dB    | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| NUMBER_OF_SAMPLES_CP           | Number of code phase measurement samples, M      |                 |       | 1    | 1    | 1    | 1    | uinteger4 | 4         | 4          | var    |
| TIME_IMT_CP                    | IMT time stamp of the sample                     | 10 <sup>9</sup> | s     | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| TIME_IMT_SAMPLE_CP             | IMT time since the measurement start             | 10 <sup>9</sup> | s     | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |

| Name                     | Description                                    | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|--------------------------|--|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| ANA                      | Analogue gain setting value                    |                 | dB    | M    | 1    | 1    | 1    | integer2  | 2         | var        | var    |
| L1_CA_CODE_PHASE         | L1-C/A code phase after instrument correction  | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| L1_P1_CODE_PHASE         | L1-P1 code phase after instrument correction   | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| L2_P2_CODE_PHASE         | L2-P2 code phase after instrument correction   | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| L1_CA_PSEUDORANGE        | L1-C/A pseudorange after instrument correction | 10 <sup>9</sup> | m     | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| L1_P1_PSEUDORANGE        | L1-P1 pseudorange after instrument correction  | 10 <sup>9</sup> | m     | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| L2_P2_PSEUDORANGE        | L2-P2 pseudorange after instrument correction  | 10 <sup>9</sup> | m     | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| RFCU_CP_CORRECTION_L1_CA | RFCU code phase correction for L1-C/A          | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| RFCU_CP_CORRECTION_L1_P1 | RFCU code phase correction for L1-P1           | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| RFCU_CP_CORRECTION_L2_P2 | RFCU code phase correction for L2-P2           | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| GEU_CP_CORRECTION_L1_CA  | GEU code phase correction for L1-C/A           | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| GEU_CP_CORRECTION_L1_P1  | GEU code phase correction for L1-P1            | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| GEU_CP_CORRECTION_L2_P2  | GEU code phase correction for L2-P2            | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L1_CA_CODE_PHASE_MDID    | L1-C/A code phase                              | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |

| Name                  | Description                  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset     |
|-----------------------|------------------------------|-----------------|-------|------|------|------|------|-----------|-----------|------------|------------|
|                       | uncorrected                  |                 |       |      |      |      |      |           |           |            |            |
| L1_P1_CODE_PHASE_MDID | L1-P1 code phase uncorrected | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var        |
| L2_P2_CODE_PHASE_MDID | L2-P2 code phase uncorrected | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var        |
|                       |                              |                 |       |      |      |      |      |           |           |            | Total: var |

### 9.23 MDR ( name 'mdr-1a-nav-frame', class 8, subclass 10, version 3 )

| Name                            | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|---------------------------------|--|-----------------|-------|------|------|------|------|------------|-----------|------------|--------|
| RECORD_HEADER                   | Generic Record Header  |                 |       | 1    | 1    | 1    | 1    | REC_HEAD   | 20        | 20         | 0      |
| GENERIC_QUALITY_INDICATORS      |  |                 |       |      |      |      |      |            |           |            |        |
| DEGRADED_INST_MDR               | Quality of MDR has been degraded from nominal due to an instrument degradation |                 |       | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 20     |
| DEGRADED_PROC_MDR               | Quality of MDR has been degraded from nominal due to a processing degradation  |                 |       | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 21     |
| MEASUREMENT_DATA                |  |                 |       |      |      |      |      |            |           |            |        |
| START_EPOCH                     | Epoch of the MDR start   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 22     |
| END_EPOCH                       | Epoch of the MDR end   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 30     |
| GPS_ID                          | GPS identification   |                 |       | 1    | 1    | 1    | 1    | uinteger1  | 1         | 1          | 38     |
| <a href="#">GRAS_CHANNEL_ID</a> | GRAS channel identification  |                 |       | 1    | 1    | 1    | 1    | enumerated | 1         | 1          | 39     |
| NUMBER_OF_SAMPLES               | Number of packets, N   |                 |       | 1    | 1    | 1    | 1    | uinteger2  | 2         | 2          | 40     |

| Name                     | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type           | Type size | Field size | Offset |
|--------------------------|--|-----------------|-------|------|------|------|------|----------------|-----------|------------|--------|
| TIME_IMT                 | IMT time stamp of the bit string                             | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8      | 8         | var        | 42     |
| UNUSED_BITS              | Number of unused bits in the last 16-bit words of the packet |                 |       | N    | 1    | 1    | 1    | uinteger1      | 1         | var        | var    |
| NUMBER_OF_BIT_STRINGS    | Number of navigation data bit strings in a packet, M         |                 |       | N    | 1    | 1    | 1    | uinteger4      | 4         | var        | var    |
| <a href="#">NDF_BITS</a> | Navigation message data bit string                           |                 |       | M    | N    | 1    | 1    | bitfield ( 8 ) | 8         | var        | var    |
| Total: var               |  |                 |       |      |      |      |      |                |           |            |        |

#### 9.24 MDR ( name 'mdr-1a-gras-monitoring', class 8, subclass 11, version 4 )

| Name                       | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|----------------------------|--|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| RECORD_HEADER              | Generic Record Header  |                 |       | 1    | 1    | 1    | 1    | REC_HEAD  | 20        | 20         | 0      |
| GENERIC_QUALITY_INDICATORS |  |                 |       |      |      |      |      |           |           |            |        |
| DEGRADED_INST_MDR          | Quality of MDR has been degraded from nominal due to an instrument degradation |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 20     |
| DEGRADED_PROC_MDR          | Quality of MDR has been degraded from nominal due to a processing degradation  |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 21     |
| GRAS_Monitoring            |  |                 |       |      |      |      |      |           |           |            |        |
| START_EPOCH                | Epoch of the measurement start   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 22     |
| END_EPOCH                  | Epoch of the measurement end   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 30     |
| NUMBER_OF_EPOCHS           | Number of monitoring data epochs, N  |                 |       | 1    | 1    | 1    | 1    | uinteger4 | 4         | 4          | 38     |
| TIME_IMT                   | IMT time stamp of the samples  | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8 | 8         | var        | 42     |

| Name                     | Description   | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|--------------------------|---|----------------|-------|------|------|------|------|----------|-----------|------------|--------|
| ENGINEERING_PARAMETER_1  | Engineering parameter for in-flight monitoring of GRAS status | 10^9           |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| ENGINEERING_PARAMETER_2  | Engineering parameter for in-flight monitoring of GRAS status | 10^9           |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| ENGINEERING_PARAMETER_3  | Engineering parameter for in-flight monitoring of GRAS status | 10^9           |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| ENGINEERING_PARAMETER_4  | Engineering parameter for in-flight monitoring of GRAS status | 10^9           |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| ENGINEERING_PARAMETER_5  | Engineering parameter for in-flight monitoring of GRAS status | 10^9           |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| ENGINEERING_PARAMETER_6  | Engineering parameter for in-flight monitoring of GRAS status | 10^9           |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| ENGINEERING_PARAMETER_7  | Engineering parameter for in-flight monitoring of GRAS status | 10^9           |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| ENGINEERING_PARAMETER_8  | Engineering parameter for in-flight monitoring of GRAS status | 10^9           |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| ENGINEERING_PARAMETER_9  | Engineering parameter for in-flight monitoring of GRAS status | 10^9           |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| ENGINEERING_PARAMETER_10 | Engineering parameter for in-flight monitoring of GRAS status | 10^9           |       | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| Total: var               |   |                |       |      |      |      |      |          |           |            |        |



**Enumeration DISPOSITION\_MODE**

| Value | Name          | Description |
|-------|---------------|-------------|
| T     | Testing       |             |
| O     | Operational   |             |
| C     | Commissioning |             |

**Enumeration EARTH\_MODEL\_ID**

| Value | Name                  | Description |
|-------|-----------------------|-------------|
| 0     | Not used              |             |
| 1     | WGS84 ellipsoid model |             |

**Enumeration GRAS\_CHANNEL\_ID**

| Value | Name             | Description |
|-------|------------------|-------------|
| 0     | Zenith chain 0   |             |
| 1     | Zenith chain 1   |             |
| 2     | Zenith chain 2   |             |
| 3     | Zenith chain 3   |             |
| 4     | Zenith chain 4   |             |
| 5     | Zenith chain 5   |             |
| 6     | Zenith chain 6   |             |
| 7     | Zenith chain 7   |             |
| 8     | Velocity chain 8 |             |

|    |                        |  |
|----|------------------------|--|
| 9  | Velocity chain 9       |  |
| 10 | Anti-velocity chain 10 |  |
| 11 | Anti-velocity chain 11 |  |

### Enumeration GRAS\_ID

| Value | Name     | Description |
|-------|----------|-------------|
| 0     | Not used |             |
| 1     | GRAS 1   |             |
| 2     | GRAS 2   |             |
| 3     | GRAS 3   |             |

### Enumeration INSTRUMENT\_ID

| Value | Name    | Description                               |
|-------|---------|---|
| AMSA  | AMSU-A  |   |
| ASCA  | ASCAT   |   |
| ATOV  | ATOVs   | instruments: AVHRR/3, HIRS/4, AMSU-A, MHS |
| AVHR  | AVHRR/3 |   |
| GOME  | GOME    |   |
| GRAS  | GRAS    |   |
| HIRS  | HIRS/4  |   |
| IASI  | IASI    |   |
| MHSx  | MHS     |   |

|      |                        |  |
|------|------------------------|--|
| NOAA | All NOAA               | instruments specific to Level 0 NOAA product |
| SEMx | SEM                    |  |
| ADCS | ADCS                   |  |
| SBUV | SBUV                   |  |
| xxxx | No specific instrument |  |
| HKTM | VCDU34                 | data specific to Level 0                     |

### Enumeration INSTRUMENT\_MODEL

| Value | Name              | Description |
|-------|-------------------|-------------|
| 0     | Reserved          |             |
| 1     | Flight Model 1    |             |
| 2     | Flight Model 2    |             |
| 3     | Engineering Model |             |
| 4     | Protoflight Model |             |

### Enumeration MEASUREMENT\_TYPE

| Value | Name       | Description            |
|-------|------------|------------------------|
| 0     | Rising     | Rising occultation     |
| 1     | Setting    | Setting occultation    |
| 2     | Navigation | Navigation measurement |
| 3     | Spare      |                        |

**Enumeration METOP\_STEERING\_MODE**

| Value | Name                    | Description |
|-------|-------------------------|-------------|
| 0     | Rate Reduction Mode     |             |
| 1     | Coarse Acquisition Mode |             |
| 2     | Fine Acquisition Mode 1 |             |
| 3     | Fine Acquisition Mode 2 |             |
| 4     | Fine Acquisition Mode 3 |             |
| 5     | Operational Mode        |             |
| 6     | Fine Pointing Mode      |             |
| 7     | Yaw Steering Mode       |             |
| 8     | Orbit Control Mode      |             |
| 9     | Fine Control Mode       |             |
| 10    | Safe Mode               |             |

**Enumeration PROCESSING\_CENTRE**

| Value | Name | Description                             |
|-------|------|---|
| CGS1  |      | First EUMETSAT EPS Core Ground Segment  |
| CGS2  |      | Second EUMETSAT EPS Core Ground Segment |
| CGS3  |      | Third EUMETSAT EPS Core Ground Segment  |
| NSSx  |      | NOAA/NESDIS                             |
| RUSx  |      | Reference User Station                  |
| DMIx  |      | DMI, Copenhagen (GRAS SAF)              |

|      |  |                              |
|------|--|------------------------------|
| DWDx |  | DWD, Offenbach (Climate SAF) |
| FMIx |  | FMI , Helsinki (Ozone SAF)   |
| IMPx |  | IMP, Lisbon (Land SAF)       |
| INMx |  | INM, Madrid (NCW SAF)        |
| MFxx |  | MF, Lannion (OSI SAF)        |
| UKMO |  | UKMO, Bracknell (NWP SAF)    |

**Enumeration PROCESSING\_LEVEL**

| Value | Name              | Description |
|-------|-------------------|-------------|
| 00    | Level 0           |             |
| 01    | Level 1           |             |
| 1A    | Level 1a          |             |
| 1B    | Level 1b          |             |
| 1C    | Level 1c          |             |
| 02    | Level 2           |             |
| 03    | Level 3           |             |
| xx    | No Specific Level |             |

**Enumeration PROCESSING\_MODE**

| Value | Name               | Description    |
|-------|--------------------|----------------|
| N     | Nominal            | NRT processing |
| B     | Backlog Processing |                |
| R     | Reprocessing       |                |
| V     | Validation         |                |

**Enumeration PRODUCT\_TYPE**

| Value | Name | Description  |
|-------|------|--|
| ENG   |      | IASI engineering data                                      |
| GAC   |      | NOAC Global Area Coverage AVHRR data                       |
| SND   |      | Sounding Data  |
| SZF   |      | ASCAT calibrated s0 data at full resolution                |
| SZO   |      | ASCAT calibrated s0 data at operational resolution (50 km) |
| SZR   |      | ASCAT calibrated s0 data at research resolution (25 km)    |
| VER   |      | IASI verification data                                     |
| xxx   |      | No specific product type specified                         |
| AIP   |      | NOAA AIP/SAIP data   |
| TIP   |      | NOAA TIP/STIP data   |
| HRP   |      | HRPT data  |
| LRP   |      | LRPT data  |

**Enumeration RECEIVING\_GROUND\_STATION**

| Value | Name | Description   |
|-------|------|---|
| SVL   |      | Svalbard  |
| WAL   |      | Wallops Island, Virginia  |
| FBK   |      | Fairbanks, Alaska   |
| SOC   |      | SOCC (NESDIS Satellite Operations Control Centre), Suitland, Maryland |
| RUS   |      | Reference User Station  |

**Enumeration SPACECRAFT\_ID**

| Value | Name | Description            |
|-------|------|------------------------|
| xxx   |      | No specific spacecraft |
| M01   |      | METOP 01               |
| M02   |      | METOP 02               |
| M02   |      | METOP 03               |
| N15   |      | NOAA-K                 |
| N16   |      | NOAA-L                 |
| N17   |      | NOAA-M                 |
| N18   |      | NOAA-N                 |
| N19   |      | NOAA-N'                |

**Enumeration AVALS**

| Value | Name                            | Description |
|-------|---------------------------------|-------------|
| 0     | Inside window                   |             |
| 1     | Above windows                   |             |
| 2     | Below window                    |             |
| 3     | Automatic gain control disabled |             |

**Enumeration AVANA**

| Value | Name | Description   |
|-------|------|---|
| 5     | 0    | Analogue Gain Setting values obtained from the AGGA |
| 9     | -5   |   |
| 6     | -10  |   |
| 10    | -15  |   |

**Enumeration C2**

| Value | Name       | Description |
|-------|------------|-------------|
| 0     | Reserved   |             |
| 1     | P code ON  |             |
| 2     | CA code ON |             |



**Enumeration MEASUREMENT\_PACKET\_TYPE**

| Value | Name       | Description      |
|-------|------------|------------------|
| 0     | Not packet |                  |
| 1     | DF         | Double Frequency |
| 2     | SF         | Single Frequency |
| 3     | RS         | Raw Sampling     |
| 4     | Spare      |                  |

**Enumeration ONBOARD\_NAV\_SOLUTION**

| Value | Name                          | Description  |
|-------|-------------------------------|--|
| 0     | Not navigation solution       |  |
| 1     | Propagated initial settings   |  |
| 2     | First-fix                     |  |
| 4     | Calculated with least square  |  |
| 5     | Calculated with Kalman filter |  |
| 7     | Invalid navigation solution   | An invalid navigation solution will be indicated if least square is used and less than 4 satellites are in the field-of-view of the zenith antenna. The reported navigation solution will be the propagated one. |

**Enumeration SECONDARY\_PACKET\_TYPE**

| Value | Name       | Description      |
|-------|------------|------------------|
| 0     | Not packet |                  |
| 1     | DF         | Double Frequency |
| 2     | SF         | Single Frequency |
| 3     | RS         | Raw Sampling     |
| 4     | Spare      |                  |

**Enumeration SH**

| Value | Name                                | Description |
|-------|-------------------------------------|-------------|
| 0     | All signals OK                      |             |
| 1     | All signals weak                    |             |
| 2     | All signals dead                    |             |
| 3     | All signals have no data modulation |             |
| 4     | L1P signal weak                     |             |
| 5     | L1P signal dead                     |             |
| 6     | L1P signal has no data modulation   |             |
| 7     | L2P signal weak                     |             |
| 8     | L2P signal dead                     |             |
| 9     | L2P signal has no data modulation   |             |
| 10    | L1C signal weak                     |             |
| 11    | L1C signal dead                     |             |

|    |   |  |
|----|---|--|
| 12 | L1C signal has no data modulation                                 |  |
| 13 | L2C signal weak   |  |
| 14 | L2C signal dead   |  |
| 15 | L2C signal has no data modulation                                 |  |
| 16 | L1 and L2P signal weak  |  |
| 17 | L1 and L2P signal dead  |  |
| 18 | L1 and L2P signal has no data modulation                          |  |
| 19 | L1 and L2C signal weak  |  |
| 20 | L1 and L2C signal dead  |  |
| 21 | L1 and L2C signal has no data modulation                          |  |
| 22 | L1 signal weak  |  |
| 23 | L1 signal dead  |  |
| 24 | L1 signal has no data modulation                                  |  |
| 25 | L2 signal weak  |  |
| 26 | L2 signal dead  |  |
| 27 | L2 signal has no data modulation                                  |  |
| 28 | SV is temporarily out   | Do not use this SV during current pass |
| 29 | SV will be temporarily out  | Use with caution                       |
| 30 | Spare   |  |
| 31 | More than one combination would be required to describe anomalies |  |

**Enumeration VALS**

| Value | Name                            | Description |
|-------|---------------------------------|-------------|
| 0     | Inside window                   |             |
| 1     | Above windows                   |             |
| 2     | Below window                    |             |
| 3     | Automatic gain control disabled |             |

**Enumeration VANA**

| Value | Name | Description   |
|-------|------|---|
| 5     | 0    | Analogue Gain Setting values obtained from the AGGA |
| 9     | -5   |   |
| 6     | -10  |   |
| 10    | -15  |   |

**Enumeration ZALS**

| Value | Name                            | Description |
|-------|---------------------------------|-------------|
| 0     | Inside window                   |             |
| 1     | Above windows                   |             |
| 2     | Below window                    |             |
| 3     | Automatic gain control disabled |             |

## Enumeration ZANA

| Value | Name | Description   |
|-------|------|---|
| 5     | 0    | Analogue Gain Setting values obtained from the AGGA |
| 9     | -5   |   |
| 6     | -10  |   |
| 10    | -15  |   |

## Bitfield LOCAL\_MULTIPATH\_SOURCE

*Length 2 bytes*

| Name                         | Description                 | Length |
|------------------------------|-----------------------------|--------|
| Spare                        |                             | 13     |
| ASCAT_ANT_RF_in_the_FOV      | 0=outside FOV, 1=inside FOV | 1      |
| ASCAT_ANT_RA_in_the_FOV      | 0=outside FOV, 1=inside FOV | 1      |
| Metop_solar_panel_in_the_FOV | 0=outside FOV, 1=inside FOV | 1      |
| Total                        |                             | 16     |

## Bitfield TELEMETRY\_IN\_RANGE

*Length 3 bytes*

| Name        | Description                        | Length |
|-------------|------------------------------------|--------|
| Spare       |                                    | 3      |
| Digital_5_V | 0 - Within range 1 - Outside range | 1      |
| USO_ground  | 0 - Within range 1 - Outside range | 1      |

|                                  |                                    |    |
|----------------------------------|------------------------------------|----|
| FG_thermistor                    | 0 - Within range 1 - Outside range | 1  |
| Thermistor_supply_voltage        | 0 - Within range 1 - Outside range | 1  |
| DBU_power_voltage                | 0 - Within range 1 - Outside range | 1  |
| USO_external_thermistor          | 0 - Within range 1 - Outside range | 1  |
| USO_internal_thermistor          | 0 - Within range 1 - Outside range | 1  |
| ISAC_thermistor                  | 0 - Within range 1 - Outside range | 1  |
| GEU_thermistor                   | 0 - Within range 1 - Outside range | 1  |
| Anti_velocity_RFCU_thermistor    | 0 - Within range 1 - Outside range | 1  |
| Velocity_RFCU_thermistor         | 0 - Within range 1 - Outside range | 1  |
| Zenith_RFCU_thermistor           | 0 - Within range 1 - Outside range | 1  |
| Anti_velocity_antenna_thermistor | 0 - Within range 1 - Outside range | 1  |
| Velocity_antenna_thermistor      | 0 - Within range 1 - Outside range | 1  |
| Zenith_antenna_thermistor        | 0 - Within range 1 - Outside range | 1  |
| ENDP_Velocity_Z                  | 0 - Within range 1 - Outside range | 1  |
| ENDP_Velocity_Y                  | 0 - Within range 1 - Outside range | 1  |
| ENDP_Velocity_X                  | 0 - Within range 1 - Outside range | 1  |
| ENDP_Position_Z                  | 0 - Within range 1 - Outside range | 1  |
| ENDP_Position_Y                  | 0 - Within range 1 - Outside range | 1  |
| ENDP_Position_X                  | 0 - Within range 1 - Outside range | 1  |
| Total                            |                                    | 24 |

## Bitfield AVDIG

*Length 6 bytes*

| Name  | Description | Length |
|-------|-------------|--------|
| CCT_5 |             | 8      |
| CCT_4 |             | 8      |
| CCT_3 |             | 8      |
| CCT_2 |             | 8      |
| CCT_1 |             | 8      |
| CCT_0 |             | 8      |
| Total |             | 48     |

## Bitfield CH0\_TRACKING\_STATE

*Length 2 bytes*

| Name  | Description | Length |
|---|-------------|--------|
| P_code_and_L2_carrier_tracking_highest_tracking_state |             | 1      |
| P_code_tracking                                       |             | 1      |
| P_code_acquisition                                    |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| Single_carrier_frequency_tracking_at_10_ms            |             | 1      |
| Single_carrier_frequency_tracking_at_1_ms             |             | 1      |

|                                |  |    |
|--------------------------------|--|----|
| undefined                      |  | 1  |
| undefined                      |  | 1  |
| undefined                      |  | 1  |
| undefined                      |  | 1  |
| L1_carrier_lock_check          |  | 1  |
| C/A_code_lock_check            |  | 1  |
| C/A_code_acquisition           |  | 1  |
| Acquisition_and_tracking_ended |  | 1  |
| Total                          |  | 16 |

### Bitfield CH10\_TRACKING\_STATE

*Length 2 bytes*

| Name  | Description | Length |
|---|-------------|--------|
| P_code_and_L2_carrier_tracking_highest_tracking_state |             | 1      |
| P_code_tracking                                       |             | 1      |
| P_code_acquisition                                    |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| Single_carrier_frequency_tracking_at_10_ms            |             | 1      |
| Single_carrier_frequency_tracking_at_1_ms             |             | 1      |
| undefined   |             | 1      |



|                                |  |    |
|--------------------------------|--|----|
| undefined                      |  | 1  |
| undefined                      |  | 1  |
| undefined                      |  | 1  |
| L1_carrier_lock_check          |  | 1  |
| C/A_code_lock_check            |  | 1  |
| C/A_code_acquisition           |  | 1  |
| Acquisition_and_tracking_ended |  | 1  |
| Total                          |  | 16 |

### Bitfield CH11\_TRACKING\_STATE

*Length 2 bytes*

| Name  | Description | Length |
|---|-------------|--------|
| P_code_and_L2_carrier_tracking_highest_tracking_state |             | 1      |
| P_code_tracking                                       |             | 1      |
| P_code_acquisition                                    |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| Single_carrier_frequency_tracking_at_10_ms            |             | 1      |
| Single_carrier_frequency_tracking_at_1_ms             |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |

|                                |  |    |
|--------------------------------|--|----|
| undefined                      |  | 1  |
| undefined                      |  | 1  |
| L1_carrier_lock_check          |  | 1  |
| C/A_code_lock_check            |  | 1  |
| C/A_code_acquisition           |  | 1  |
| Acquisition_and_tracking_ended |  | 1  |
| Total                          |  | 16 |

### Bitfield CH1\_TRACKING\_STATE

*Length 2 bytes*

| Name  | Description | Length |
|---|-------------|--------|
| P_code_and_L2_carrier_tracking_highest_tracking_state |             | 1      |
| P_code_tracking                                       |             | 1      |
| P_code_acquisition                                    |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| Single_carrier_frequency_tracking_at_10_ms            |             | 1      |
| Single_carrier_frequency_tracking_at_1_ms             |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |

|                                |  |    |
|--------------------------------|--|----|
| undefined                      |  | 1  |
| L1_carrier_lock_check          |  | 1  |
| C/A_code_lock_check            |  | 1  |
| C/A_code_acquisition           |  | 1  |
| Acquisition_and_tracking_ended |  | 1  |
| Total                          |  | 16 |

## Bitfield CH2\_TRACKING\_STATE

*Length 2 bytes*

| Name  | Description | Length |
|---|-------------|--------|
| P_code_and_L2_carrier_tracking_highest_tracking_state |             | 1      |
| P_code_tracking                                       |             | 1      |
| P_code_acquisition                                    |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| Single_carrier_frequency_tracking_at_10_ms            |             | 1      |
| Single_carrier_frequency_tracking_at_1_ms             |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |

|                                |  |    |
|--------------------------------|--|----|
| L1_carrier_lock_check          |  | 1  |
| C/A_code_lock_check            |  | 1  |
| C/A_code_acquisition           |  | 1  |
| Acquisition_and_tracking_ended |  | 1  |
| Total                          |  | 16 |

### Bitfield CH3\_TRACKING\_STATE

*Length 2 bytes*

| Name  | Description | Length |
|---|-------------|--------|
| P_code_and_L2_carrier_tracking_highest_tracking_state |             | 1      |
| P_code_tracking                                       |             | 1      |
| P_code_acquisition                                    |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| Single_carrier_frequency_tracking_at_10_ms            |             | 1      |
| Single_carrier_frequency_tracking_at_1_ms             |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| L1_carrier_lock_check                                 |             | 1      |

|                                |  |    |
|--------------------------------|--|----|
| C/A_code_lock_check            |  | 1  |
| C/A_code_acquisition           |  | 1  |
| Acquisition_and_tracking_ended |  | 1  |
| Total                          |  | 16 |

### Bitfield CH4\_TRACKING\_STATE

*Length 2 bytes*

| Name  | Description | Length |
|---|-------------|--------|
| P_code_and_L2_carrier_tracking_highest_tracking_state |             | 1      |
| P_code_tracking                                       |             | 1      |
| P_code_acquisition                                    |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| Single_carrier_frequency_tracking_at_10_ms            |             | 1      |
| Single_carrier_frequency_tracking_at_1_ms             |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| L1_carrier_lock_check                                 |             | 1      |
| C/A_code_lock_check                                   |             | 1      |

|                                |  |    |
|--------------------------------|--|----|
| C/A_code_acquisition           |  | 1  |
| Acquisition_and_tracking_ended |  | 1  |
| Total                          |  | 16 |

### Bitfield CH5\_TRACKING\_STATE

*Length 2 bytes*

| Name  | Description | Length |
|---|-------------|--------|
| P_code_and_L2_carrier_tracking_highest_tracking_state |             | 1      |
| P_code_tracking                                       |             | 1      |
| P_code_acquisition                                    |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| Single_carrier_frequency_tracking_at_10_ms            |             | 1      |
| Single_carrier_frequency_tracking_at_1_ms             |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| L1_carrier_lock_check                                 |             | 1      |
| C/A_code_lock_check                                   |             | 1      |
| C/A_code_acquisition                                  |             | 1      |

|                                |  |    |
|--------------------------------|--|----|
| Acquisition_and_tracking_ended |  | 1  |
| Total                          |  | 16 |

### Bitfield CH6\_TRACKING\_STATE

*Length 2 bytes*

| Name  | Description | Length |
|---|-------------|--------|
| P_code_and_L2_carrier_tracking_highest_tracking_state |             | 1      |
| P_code_tracking                                       |             | 1      |
| P_code_acquisition                                    |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| Single_carrier_frequency_tracking_at_10_ms            |             | 1      |
| Single_carrier_frequency_tracking_at_1_ms             |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| L1_carrier_lock_check                                 |             | 1      |
| C/A_code_lock_check                                   |             | 1      |
| C/A_code_acquisition                                  |             | 1      |
| Acquisition_and_tracking_ended                        |             | 1      |

|       |  |    |
|-------|--|----|
| Total |  | 16 |
|-------|--|----|

### Bitfield CH7\_TRACKING\_STATE

*Length 2 bytes*

| Name  | Description | Length |
|---|-------------|--------|
| P_code_and_L2_carrier_tracking_highest_tracking_state |             | 1      |
| P_code_tracking                                       |             | 1      |
| P_code_acquisition                                    |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| Single_carrier_frequency_tracking_at_10_ms            |             | 1      |
| Single_carrier_frequency_tracking_at_1_ms             |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| L1_carrier_lock_check                                 |             | 1      |
| C/A_code_lock_check                                   |             | 1      |
| C/A_code_acquisition                                  |             | 1      |
| Acquisition_and_tracking_ended                        |             | 1      |
| Total   |             | 16     |



## Bitfield CH8\_TRACKING\_STATE

*Length 2 bytes*

| Name  | Description | Length |
|---|-------------|--------|
| P_code_and_L2_carrier_tracking_highest_tracking_state |             | 1      |
| P_code_tracking                                       |             | 1      |
| P_code_acquisition                                    |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| Single_carrier_frequency_tracking_at_10_ms            |             | 1      |
| Single_carrier_frequency_tracking_at_1_ms             |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| L1_carrier_lock_check                                 |             | 1      |
| C/A_code_lock_check                                   |             | 1      |
| C/A_code_acquisition                                  |             | 1      |
| Acquisition_and_tracking_ended                        |             | 1      |
| Total   |             | 16     |

## Bitfield CH9\_TRACKING\_STATE

*Length 2 bytes*

| Name  | Description | Length |
|---|-------------|--------|
| P_code_and_L2_carrier_tracking_highest_tracking_state |             | 1      |
| P_code_tracking                                       |             | 1      |
| P_code_acquisition                                    |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| Single_carrier_frequency_tracking_at_10_ms            |             | 1      |
| Single_carrier_frequency_tracking_at_1_ms             |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| L1_carrier_lock_check                                 |             | 1      |
| C/A_code_lock_check                                   |             | 1      |
| C/A_code_acquisition                                  |             | 1      |
| Acquisition_and_tracking_ended                        |             | 1      |
| Total   |             | 16     |

## Bitfield GEU\_STS

*Length 1 bytes*

| Name                                   | Description | Length |
|--|-------------|--------|
| RFCU_Velocity_chain_RFCU_status        | 0=off, 1=on | 1      |
| RFCU_Zenith_chain_RFCU_status          | 0=off, 1=on | 1      |
| RFCU_Anti_velocity_chain_RFCU_status   | 0=off, 1=on | 1      |
| USO_Oven_Relay_Status                  | 0=off, 1=on | 1      |
| SC_Frequency_Generator_PLL_LOCK_status | 0=off, 1=on | 1      |
| LO_Frequency_Generator_PLL_LOCK_status | 0=off, 1=on | 1      |
| Not_used                               |             | 2      |
| Total                                  |             | 8      |

## Bitfield NDF\_BITS

*Length 8 bytes*

| Name     | Description  | Length |
|----------|--|--------|
| NDF bits | Navigation Data Frame bits as received from the GPS satellite (optional) | 64     |
| Total    |  | 64     |

## Bitfield TRACKING\_STATE

*Length 2 bytes*

| Name  | Description | Length |
|---|-------------|--------|
| P_code_and_L2_carrier_tracking_highest_tracking_state |             | 1      |
| P_code_tracking                                       |             | 1      |
| P_code_acquisition                                    |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| Single_carrier_frequency_tracking_at_10_ms            |             | 1      |
| Single_carrier_frequency_tracking_at_1_ms             |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| L1_carrier_lock_check                                 |             | 1      |
| C/A_code_lock_check                                   |             | 1      |
| C/A_code_acquisition                                  |             | 1      |
| Acquisition_and_tracking_ended                        |             | 1      |
| Total   |             | 16     |

**Bitfield VDIG***Length 6 bytes*

| Name  | Description | Length |
|-------|-------------|--------|
| CCT_5 |             | 8      |
| CCT_4 |             | 8      |
| CCT_3 |             | 8      |
| CCT_2 |             | 8      |
| CCT_1 |             | 8      |
| CCT_0 |             | 8      |
| Total |             | 48     |


**Bitfield ZDIG***Length 6 bytes*


| Name  | Description | Length |
|-------|-------------|--------|
| CCT_5 |             | 8      |
| CCT_4 |             | 8      |
| CCT_3 |             | 8      |
| CCT_2 |             | 8      |
| CCT_1 |             | 8      |
| CCT_0 |             | 8      |
| Total |             | 48     |

## 10 RECORD DESCRIPTION OF THE GRAS LEVEL 1B PRODUCTS

This GRAS 1a description corresponds to the GRAS Level 1 PFS [RD6] Issue v7B and the Generic PFS [RD3] Issue v7B.

In the tables below, coloured items have the following meanings:

 Compound data type, which consists of at least two basic or other compound data types. The name of the compound data type is shown first, followed by a list of the items contained within it.

 Dimension parameter for variable product fields.

### Summary of Product Format Version record contents history

|                         | PFV = 10.0     |
|-------------------------|----------------|
| Record name             | Record version |
| mphr                    | 2              |
| sphr                    | 3              |
| viadr-1b-gps-pod        | 3              |
| viadr-1b-gps-clock      | 3              |
| viadr-1b-tzd            | 3              |
| viadr-1b-station-clock  | 3              |
| viadr-1b-metop-pod      | 3              |
| viadr-1b-metop-clock    | 3              |
| viadr-1b-eop            | 5              |
| viadr-1b-metop-attitude | 3              |

|        |   |
|--------|---|
| mdr-1b | 4 |
|--------|---|

If more than one version of a record exists, all versions are described below.

### Contents:

- MPHR ( name 'mphr', class 1, subclass 0, version 2 )
- SPHR ( name 'sphr', class 2, subclass 1, version 3 )
- VIADR ( name 'viadr-1b-gps-pod', class 7, subclass 21, version 3 )
- VIADR ( name 'viadr-1b-gps-clock', class 7, subclass 22, version 3 )
- VIADR ( name 'viadr-1b-tzd', class 7, subclass 23, version 3 )
- VIADR ( name 'viadr-1b-station-clock', class 7, subclass 24, version 3 )
- VIADR ( name 'viadr-1b-metop-pod', class 7, subclass 25, version 3 )
- VIADR ( name 'viadr-1b-metop-clock', class 7, subclass 26, version 3 )
- VIADR ( name 'viadr-1b-eop', class 7, subclass 27, version 5 )
- VIADR ( name 'viadr-1b-metop-attitude', class 7, subclass 28, version 3 )
- MDR ( name 'mdr-1b', class 8, subclass 20, version 4 )

Certain record types with formats common to all products (IPR, DMDR, GEADR, VEADR) are not included below, since they are not relevant to the average user. If required, details of these records can be found in the Generic PFS [RD3].

Note: An entry of 'var' in the 'Field size' or 'Offset' columns below indicates that the entry cannot be specified exactly because of variable dimensions. To compute field sizes and offsets, please see the PFS [RD6] for more detailed information.

## 10.1 MPHR ( name 'mphr', class 1, subclass 0, version 2 )

| Name                  | Description   | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|-----------------------|---|----------------|-------|------|------|------|------|----------|-----------|------------|--------|
| RECORD_HEADER         | Generic Record Header   |                |       | 1    | 1    | 1    | 1    | REC_HEAD | 20        | 20         | 0      |
| Product Details       |   |                |       |      |      |      |      |          |           |            |        |
| PRODUCT_NAME          | Complete name of the product  |                |       | 1    | 1    | 1    | 1    | string   | 67        | 100        | 20     |
| PARENT_PRODUCT_NAME_1 | Name of the parent product from which this product has been produced. For Level 0 products, this field is filled with lower case x's.   |                |       | 1    | 1    | 1    | 1    | string   | 67        | 100        | 120    |
| PARENT_PRODUCT_NAME_2 | Name of the parent product from which this product has been produced. For Level 0 products or products for which this is not appropriate, this field is filled with lower case x's. |                |       | 1    | 1    | 1    | 1    | string   | 67        | 100        | 220    |
| PARENT_PRODUCT_NAME_3 | Name of the parent product from which this product has been produced. For Level 0 products or products for which this is not appropriate, this field is filled with lower case x's. |                |       | 1    | 1    | 1    | 1    | string   | 67        | 100        | 320    |
| PARENT_PRODUCT_NAME_4 | Name of the parent product from which this product has been produced. For Level 0 products or products for which this is not  |                |       | 1    | 1    | 1    | 1    | string   | 67        | 100        | 420    |



| Name                              | Description  | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|-----------------------------------|--|----------------|-------|------|------|------|------|------------|-----------|------------|--------|
|                                   | appropriate, this field is filled with lower case x's.   |                |       |      |      |      |      |            |           |            |        |
| <a href="#">INSTRUMENT_ID</a>     | Instrument identification  |                |       | 1    | 1    | 1    | 1    | enumerated | 4         | 37         | 520    |
| <a href="#">INSTRUMENT_MODEL</a>  | Instrument Model identification  |                |       | 1    | 1    | 1    | 1    | enumerated | 3         | 36         | 557    |
| <a href="#">PRODUCT_TYPE</a>      | Product Type   |                |       | 1    | 1    | 1    | 1    | enumerated | 3         | 36         | 593    |
| <a href="#">PROCESSING_LEVEL</a>  | Processing Level Identification  |                |       | 1    | 1    | 1    | 1    | enumerated | 2         | 35         | 629    |
| <a href="#">SPACECRAFT_ID</a>     | Spacecraft identification  |                |       | 1    | 1    | 1    | 1    | enumerated | 3         | 36         | 664    |
| SENSING_START                     | UTC Time of start of sensing data in this object (PDU, ROI or Full Product)  |                |       | 1    | 1    | 1    | 1    | time       | 15        | 48         | 700    |
| SENSING_END                       | UTC Time of end of sensing data in this object (PDU, ROI or Full Product)  |                |       | 1    | 1    | 1    | 1    | time       | 15        | 48         | 748    |
| SENSING_START_THEORETICAL         | Theoretical UTC Time of start of sensing data in the dump from which this object is derived. This data is the predicted start time at the MPF level. |                |       | 1    | 1    | 1    | 1    | time       | 15        | 48         | 796    |
| SENSING_END_THEORETICAL           | Theoretical UTC Time of end of sensing data in the dump from which this object is derived. This data is the predicted end time at the MPF level.     |                |       | 1    | 1    | 1    | 1    | time       | 15        | 48         | 844    |
| <a href="#">PROCESSING_CENTRE</a> | Processing Centre Identification   |                |       | 1    | 1    | 1    | 1    | enumerated | 4         | 37         | 892    |
| PROCESSOR_MAJOR_VERSION           | Processing chain major version number  |                |       | 1    | 1    | 1    | 1    | uinteger   | 5         | 38         | 929    |

| Name                                     | Description   | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|--|---|----------------|-------|------|------|------|------|------------|-----------|------------|--------|
| PROCESSOR_MINOR_VERSION                  | Processing chain minor version number                             |                |       | 1    | 1    | 1    | 1    | uinteger   | 5         | 38         | 967    |
| FORMAT_MAJOR_VERSION                     | Dataset Format Major Version number                               |                |       | 1    | 1    | 1    | 1    | uinteger   | 5         | 38         | 1005   |
| FORMAT_MINOR_VERSION                     | Dataset Format Minor Version number                               |                |       | 1    | 1    | 1    | 1    | uinteger   | 5         | 38         | 1043   |
| PROCESSING_TIME_START                    | UTC time of the processing at start of processing for the product |                |       | 1    | 1    | 1    | 1    | time       | 15        | 48         | 1081   |
| PROCESSING_TIME_END                      | UTC time of the processing at end of processing for the product   |                |       | 1    | 1    | 1    | 1    | time       | 15        | 48         | 1129   |
| <a href="#">PROCESSING_MODE</a>          | Identification of the mode of processing                          |                |       | 1    | 1    | 1    | 1    | enumerated | 1         | 34         | 1177   |
| <a href="#">DISPOSITION_MODE</a>         | Identification of the disposition mode                            |                |       | 1    | 1    | 1    | 1    | enumerated | 1         | 34         | 1211   |
| <a href="#">RECEIVING_GROUND_STATION</a> | Acquisition Station Identification                                |                |       | 1    | 1    | 1    | 1    | enumerated | 3         | 36         | 1245   |
| RECEIVE_TIME_START                       | UTC time of the reception at CDA for first Data Item              |                |       | 1    | 1    | 1    | 1    | time       | 15        | 48         | 1281   |
| RECEIVE_TIME_END                         | UTC time of the reception at CDA for last Data Item               |                |       | 1    | 1    | 1    | 1    | time       | 15        | 48         | 1329   |
| ORBIT_START                              | Start Orbit Number, counted incrementally since launch            |                |       | 1    | 1    | 1    | 1    | uinteger   | 5         | 38         | 1377   |
| ORBIT_END                                | Stop Orbit Number   |                |       | 1    | 1    | 1    | 1    | uinteger   | 5         | 38         | 1415   |
| ACTUAL_PRODUCT_SIZE                      | Size of the complete product                                      |                | bytes | 1    | 1    | 1    | 1    | uinteger   | 11        | 44         | 1453   |
| <b>ASCENDING NODE ORBIT PARAMETERS</b>   |   |                |       |      |      |      |      |            |           |            |        |
| STATE_VECTOR_TIME                        | Epoch time (in UTC) of the orbital                                |                | UTC   | 1    | 1    | 1    | 1    | longtime   | 18        | 51         | 1497   |

| Name             | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type    | Type size | Field size | Offset |
|------------------|--|-----------------|-------|------|------|------|------|---------|-----------|------------|--------|
|                  | elements and the orbit state vector. this corresponds to the time of crossing the ascending node for ORBIT_START |                 |       |      |      |      |      |         |           |            |        |
| SEMI_MAJOR_AXIS  | Semi major axis of orbit at time of the ascending node crossing.   |                 | mm    | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1548   |
| ECCENTRICITY     | Orbit eccentricity at time of the ascending node crossing  | 10 <sup>6</sup> |       | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1592   |
| INCLINATION      | Orbit inclination at time of the ascending node crossing   | 10 <sup>3</sup> | deg   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1636   |
| PERIGEE_ARGUMENT | Argument of perigee at time of the ascending node crossing   | 10 <sup>3</sup> | deg   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1680   |
| RIGHT_ASCENSION  | Right ascension at time of the ascending node crossing   | 10 <sup>3</sup> | deg   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1724   |
| MEAN_ANOMALY     | Mean anomaly at time of the ascending node crossing  | 10 <sup>3</sup> | deg   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1768   |
| X_POSITION       | X position of the orbit state vector in the orbit frame at ascending node  | 10 <sup>3</sup> | m     | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1812   |
| Y_POSITION       | Y position of the orbit state vector in the orbit frame at ascending node  | 10 <sup>3</sup> | m     | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1856   |
| Z_POSITION       | Z position of the orbit state vector in the orbit frame at ascending node  | 10 <sup>3</sup> | m     | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1900   |
| X_VELOCITY       | X velocity of the orbit state vector in the orbit frame at ascending   | 10 <sup>3</sup> | m/s   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1944   |

| Name                          | Description   | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type    | Type size | Field size | Offset |
|-------------------------------|---|-----------------|-------|------|------|------|------|---------|-----------|------------|--------|
|                               | node  |                 |       |      |      |      |      |         |           |            |        |
| Y_VELOCITY                    | Y velocity of the orbit state vector in the orbit frame at ascending node                 | 10 <sup>3</sup> | m/s   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 1988   |
| Z_VELOCITY                    | Z velocity of the orbit state vector in the orbit frame at ascending node                 | 10 <sup>3</sup> | m/s   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2032   |
| EARTH_SUN_DISTANCE_RATIO      | Earth-Sun distance ratio - ratio of current Earth-Sun distance to Mean Earth-Sun distance |                 |       | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2076   |
| LOCATION_TOLERANCE_RADIAL     | Nadir Earth location tolerance radial   |                 | m     | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2120   |
| LOCATION_TOLERANCE_CROSSTRACK | Nadir Earth location tolerance cross-track  |                 | m     | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2164   |
| LOCATION_TOLERANCE_ALONGTRACK | Nadir Earth location tolerance along-track  |                 | m     | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2208   |
| YAW_ERROR                     | Constant Yaw attitude error   | 10 <sup>3</sup> | deg   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2252   |
| ROLL_ERROR                    | Constant Roll attitude error  | 10 <sup>3</sup> | deg   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2296   |
| PITCH_ERROR                   | Constant Pitch attitude error   | 10 <sup>3</sup> | deg   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2340   |
| <b>LOCATION SUMMARY</b>       |   |                 |       |      |      |      |      |         |           |            |        |
| SUBSAT_LATITUDE_START         | Latitude of sub-satellite point at start of the data set                                  | 10 <sup>3</sup> | Deg   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2384   |
| SUBSAT_LONGITUDE_START        | Longitude of sub-satellite point at start of the data set                                 | 10 <sup>3</sup> | Deg   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2428   |
| SUBSAT_LATITUDE_END           | Latitude of sub-satellite point at end of the data set                                    | 10 <sup>3</sup> | Deg   | 1    | 1    | 1    | 1    | integer | 11        | 44         | 2472   |

| Name                    | Description   | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|-------------------------|---|-----------------|-------|------|------|------|------|----------|-----------|------------|--------|
| SUBSAT_LONGITUDE_END    | Longitude of sub-satellite point at end of the data set   | 10 <sup>3</sup> | Deg   | 1    | 1    | 1    | 1    | integer  | 11        | 44         | 2516   |
| Leap Second Information |   |                 |       |      |      |      |      |          |           |            |        |
| LEAP_SECOND             | Occurrence of Leap second within the product. Field is set to -1, 0 or +1 dependent upon occurrence of leap second and direction. |                 |       | 1    | 1    | 1    | 1    | integer  | 2         | 35         | 2560   |
| LEAP_SECOND.UTC         | UTC time of occurrence of the Leap Second (If no leap second in the product, value is null)                                       |                 |       | 1    | 1    | 1    | 1    | time     | 15        | 48         | 2595   |
| Record counts           |   |                 |       |      |      |      |      |          |           |            |        |
| TOTAL_RECORDS           | Total count of all records in the product   |                 |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 2643   |
| TOTAL_MPHR              | Total count of all MPHRS in product (should always be 1!)   |                 |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 2682   |
| TOTAL_SPHR              | Total count of all SPHRs in product (should be 0 or 1 only)   |                 |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 2721   |
| TOTAL_IPR               | Total count of all IPRs in the product  |                 |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 2760   |
| TOTAL_GEADR             | Total count of all GEADRs in the product  |                 |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 2799   |
| TOTAL_GIADR             | Total count of all GIADRs in the product  |                 |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 2838   |
| TOTAL_VEADR             | Total count of all VEADRs in the product  |                 |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 2877   |
| TOTAL_VIADR             | Total count of all VIADRs in the  |                 |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 2916   |

| Name                                      | Description  | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|---|--|----------------|-------|------|------|------|------|----------|-----------|------------|--------|
|   | product  |                |       |      |      |      |      |          |           |            |        |
| TOTAL_MDR                                 | Total count of all MDRs in the product   |                |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 2955   |
| <b>Record Based Generic Quality Flags</b> |  |                |       |      |      |      |      |          |           |            |        |
| COUNT_DEGRADED_INST_MDR                   | Count of MDRs with degradation due to instrument problems  |                |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 2994   |
| COUNT_DEGRADED_PROC_MDR                   | Count of MDRs with degradation due to processing problems  |                |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 3033   |
| COUNT_DEGRADED_INST_MDR_BLOCKS            | Count of the number of blocks of MDRs degraded due to degraded instrument  |                |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 3072   |
| COUNT_DEGRADED_PROC_MDR_BLOCKS            | Count of the number of blocks of MDRs degraded due to degraded processing  |                |       | 1    | 1    | 1    | 1    | uinteger | 6         | 39         | 3111   |
| <b>Time Based Generic Quality Flags</b>   |  |                |       |      |      |      |      |          |           |            |        |
| DURATION_OF_PRODUCT                       | The duration of the product in milliseconds  |                | ms    | 1    | 1    | 1    | 1    | uinteger | 8         | 41         | 3150   |
| MILLISECONDS_OF_DATA_PRESENT              | The total amount of data present in the product  |                | ms    | 1    | 1    | 1    | 1    | uinteger | 8         | 41         | 3191   |
| MILLISECONDS_OF_DATA_MISSING              | The total amount of data missing from the product  |                | ms    | 1    | 1    | 1    | 1    | uinteger | 8         | 41         | 3232   |
| <b>Regional Product Information</b>       |  |                |       |      |      |      |      |          |           |            |        |
| SUBSETTED_PRODUCT                         | Set when product has been subset (e.g. geographically subset using a region of interest filter). Implies the presence of one or more UMARF |                |       | 1    | 1    | 1    | 1    | boolean  | 1         | 34         | 3273   |

| Name        | Description   | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type | Type size | Field size | Offset |
|-------------|---|----------------|-------|------|------|------|------|------|-----------|------------|--------|
|             | GIADRs in GAD section for product retrieved from UMARF. |                |       |      |      |      |      |      |           |            |        |
| Total: 3307 |   |                |       |      |      |      |      |      |           |            |        |

## 10.2 SPHR ( name 'sphr', class 2, subclass 1, version 3 )

| Name                           | Description  | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|--------------------------------|--|----------------|-------|------|------|------|------|------------|-----------|------------|--------|
| RECORD_HEADER                  | Generic Record Header  |                |       | 1    | 1    | 1    | 1    | REC_HEAD   | 20        | 20         | 0      |
| GOBS_VER                       | Gras Onboard Software version number   |                |       | 1    | 1    | 1    | 1    | string     | 40        | 73         | 20     |
| <a href="#">GRAS_ID</a>        | GRAS instrument identification   |                |       | 1    | 1    | 1    | 1    | enumerated | 3         | 36         | 93     |
| <a href="#">EARTH_MODEL_ID</a> | Earth model identification   |                |       | 1    | 1    | 1    | 1    | enumerated | 3         | 36         | 129    |
| METOP_MANOEUVRE_FLAG           | Metop manoeuvre flag   |                |       | 1    | 1    | 1    | 1    | boolean    | 1         | 34         | 165    |
| METOP_MANOEUVRE_START          | Start time of the manoeuvre  |                | s     | 1    | 1    | 1    | 1    | longtime   | 18        | 51         | 199    |
| METOP_MANOEUVRE_END            | End time of the manoeuvre  |                | s     | 1    | 1    | 1    | 1    | longtime   | 18        | 51         | 250    |
| MANOEUVRE_IMP_END              | Time from the end of the manoeuvre after which the manoeuvre does not any more affect the MDRs |                | s     | 1    | 1    | 1    | 1    | integer    | 10        | 43         | 301    |
| Total: 344                     |  |                |       |      |      |      |      |            |           |            |        |

### 10.3 VIADR ( name 'viadr-1b-gps-pod', class 7, subclass 21, version 3 )

| Name                         | Description                                   | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|------------------------------|---|-----------------|-------|------|------|------|------|------------|-----------|------------|--------|
| RECORD_HEADER                | Generic Record Header                         |                 |       | 1    | 1    | 1    | 1    | REC_HEAD   | 20        | 20         | 0      |
| Occulting_GPS_NRT_orbit_arc  |   |                 |       |      |      |      |      |            |           |            |        |
| START_VALIDITY               | Start time of the record validity             | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 20     |
| END_VALIDITY                 | End time of the record validity               | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 28     |
| SAMPLE_INTERVAL              | Time interval of the state vector samples     |                 | s     | 1    | 1    | 1    | 1    | uinteger2  | 2         | 2          | 36     |
| NUMBER_SATELLITE             | Number of satellites used in the POD solution |                 |       | 1    | 1    | 1    | 1    | uinteger1  | 1         | 1          | 38     |
| <a href="#">PRODUCT_TYPE</a> | NRT or enhanced POD product                   |                 |       | 1    | 1    | 1    | 1    | enumerated | 1         | 1          | 39     |
| NUMBER_OF_SATELLITES         | Number of GPS satellites, N                   |                 |       | 1    | 1    | 1    | 1    | uinteger1  | 1         | 1          | 40     |
| GPS_ID                       | GPS satellite identification                  |                 |       | N    | 1    | 1    | 1    | uinteger1  | 1         | var        | 41     |
| X_POSITION_UNCERTAINTY       | Satellite position x coordinate uncertainty   | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| Y_POSITION_UNCERTAINTY       | Satellite position y coordinate uncertainty   | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| Z_POSITION_UNCERTAINTY       | Satellite position z coordinate uncertainty   | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| X_VELOCITY_UNCERTAINTY       | Satellite velocity x uncertainty              | 10 <sup>6</sup> | m/s   | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| Y_VELOCITY_UNCERTAINTY       | Satellite velocity y                          | 10 <sup>6</sup> | m/s   | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |



| Name                     | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type             | Type size | Field size | Offset |
|--------------------------|--|-----------------|-------|------|------|------|------|------------------|-----------|------------|--------|
|                          | uncertainty  |                 |       |      |      |      |      |                  |           |            |        |
| Z_VELOCITY_UNCERTAINTY   | Satellite velocity z uncertainty                       | 10 <sup>6</sup> | m/s   | N    | 1    | 1    | 1    | integer8         | 8         | var        | var    |
| CLOCK_OFFSET_UNCERTAINTY | Satellite transmitter clock offset uncertainty         | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | integer8         | 8         | var        | var    |
| CLOCK_DRIFT_UNCERTAINTY  | Satellite transmitter clock rate of change uncertainty | 10 <sup>9</sup> | s/s   | N    | 1    | 1    | 1    | integer8         | 8         | var        | var    |
| NUMBER_OF_EPOCHS         | Number of epochs for each GPS satellite, M             |                 |       | N    | 1    | 1    | 1    | uinteger2        | 2         | var        | var    |
| GPS_ORBIT_ARC            |  |                 |       | M    | N    | 1    | 1    | GPS_STATE_VECTOR | 72        | var        | var    |
| EPOCH_TIME               | Time stamp in reference time                           | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8        | 8         | 8          |        |
| SATELLITE_POSITION_X     | Satellite position x at epoch time                     | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8         | 8         | 8          |        |
| SATELLITE_POSITION_Y     | Satellite position y at epoch time                     | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8         | 8         | 8          |        |
| SATELLITE_POSITION_Z     | Satellite position z at epoch time                     | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8         | 8         | 8          |        |
| SATELLITE_VELOCITY_X     | Satellite velocity v <sub>x</sub> at epoch time        | 10 <sup>6</sup> | m/s   | 1    | 1    | 1    | 1    | integer8         | 8         | 8          |        |
| SATELLITE_VELOCITY_Y     | Satellite velocity v <sub>y</sub> at epoch time        | 10 <sup>6</sup> | m/s   | 1    | 1    | 1    | 1    | integer8         | 8         | 8          |        |
| SATELLITE_VELOCITY_Z     | Satellite velocity v <sub>z</sub> at epoch time        | 10 <sup>6</sup> | m/s   | 1    | 1    | 1    | 1    | integer8         | 8         | 8          |        |
| CLOCK_OFFSET             | Clock offset   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | integer8         | 8         | 8          |        |
| CLOCK_DRIFT              | Satellite transmitter clock rate                       | 10 <sup>9</sup> | s/s   | 1    | 1    | 1    | 1    | integer8         | 8         | 8          |        |

| Name | Description | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type | Type size | Field size | Offset     |
|------|-------------|----------------|-------|------|------|------|------|------|-----------|------------|------------|
|      | of change   |                |       |      |      |      |      |      |           |            |            |
|      |             |                |       |      |      |      |      |      |           |            | Total: var |

#### 10.4 VIADR ( name 'viadr-1b-gps-clock', class 7, subclass 22, version 3 )

| Name                         | Description                               | Scaling factor   | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|------------------------------|---|------------------|-------|------|------|------|------|------------|-----------|------------|--------|
| RECORD_HEADER                | Generic Record Header                     |                  |       | 1    | 1    | 1    | 1    | REC_HEAD   | 20        | 20         | 0      |
| GPS_clock_bias_estimates     |   |                  |       |      |      |      |      |            |           |            |        |
| START_VALIDITY               | Start time of the record validity         | 10 <sup>9</sup>  | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 20     |
| END_VALIDITY                 | End time of the record validity           | 10 <sup>9</sup>  | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 28     |
| SAMPLE_INTERVAL              | Time interval of the clock offset samples |                  | s     | 1    | 1    | 1    | 1    | uinteger2  | 2         | 2          | 36     |
| GPS_NUMBER                   | Number of satellites in solution          |                  |       | 1    | 1    | 1    | 1    | uinteger1  | 1         | 1          | 38     |
| <a href="#">PRODUCT_TYPE</a> | NRT or enhanced POD product               |                  |       | 1    | 1    | 1    | 1    | enumerated | 1         | 1          | 39     |
| NUMBER_OF_SATELLITES         | Number of GPS satellites, M               |                  |       | 1    | 1    | 1    | 1    | uinteger1  | 1         | 1          | 40     |
| GPS_ID                       | GPS satellite identification              |                  |       | M    | 1    | 1    | 1    | uinteger1  | 1         | var        | 41     |
| CLOCK_QUALITY                | Quality indicator for each GPS satellite  |                  |       | M    | 1    | 1    | 1    | uinteger8  | 8         | var        | var    |
| NUM_EPOCHS                   | Number of clock solution epochs, N        |                  |       | M    | 1    | 1    | 1    | integer2   | 2         | var        | var    |
| GPS_CLOCK_OFFSETS            |   |                  |       | N    | M    | 1    | 1    | GPS_CLOCKS | 16        | var        | var    |
| EPOCH_TIME                   | Time stamp in reference time              | 10 <sup>9</sup>  | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          |        |
| GPS_CLOCK_OFFSET             | Clock offset estimate                     | 10 <sup>20</sup> | s     | 1    | 1    | 1    | 1    | integer8   | 8         | 8          |        |

| Name       | Description | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type | Type size | Field size | Offset |
|------------|-------------|----------------|-------|------|------|------|------|------|-----------|------------|--------|
| Total: var |             |                |       |      |      |      |      |      |           |            |        |

## 10.5 VIADR ( name 'viadr-1b-tzd', class 7, subclass 23, version 3 )

| Name                         | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|------------------------------|--|-----------------|-------|------|------|------|------|------------|-----------|------------|--------|
| RECORD_HEADER                | Generic Record Header                              |                 |       | 1    | 1    | 1    | 1    | REC_HEAD   | 20        | 20         | 0      |
| Tropospheric_delay_product   |  |                 |       |      |      |      |      |            |           |            |        |
| START_VALIDITY               | Start time of the record validity                  | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 20     |
| END_VALIDITY                 | End time of the record validity                    | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 28     |
| STATION_NUMBER               | Number of stations in interval                     |                 |       | 1    | 1    | 1    | 1    | uinteger2  | 2         | 2          | 36     |
| <a href="#">PRODUCT_TYPE</a> | NRT or enhanced POD product                        |                 |       | 1    | 1    | 1    | 1    | enumerated | 1         | 1          | 38     |
| TROPOS_NUMBER_PARAMETERS     | Number of tropospheric parameters for the stations |                 |       | 1    | 1    | 1    | 1    | uinteger2  | 2         | 2          | 39     |
| TROPOS_ESTIMATE_INTERVAL     | Estimation interval                                | 10 <sup>6</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 41     |
| NUMBER_OF_STATIONS           | Number of fiducial stations, M                     |                 |       | 1    | 1    | 1    | 1    | uinteger2  | 2         | 2          | 49     |
| STATION_ID                   | Ground station identification                      |                 |       | M    | 1    | 1    | 1    | string     | 4         | var        | 51     |
| NUM_EPOCHS                   | Number of epochs, T                                |                 |       | M    | 1    | 1    | 1    | uinteger2  | 2         | var        | var    |
| STATION_TZD_ESTIMATES        |  |                 |       | T    | M    | 1    | 1    | TROP_DELAY | 72        | var        | var    |
| EPOCH_TIME                   | Time stamp in reference time                       | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          |        |
| MEASURED_SURFACE_PRESSURE    | Measured surface pressure at                       | 10 <sup>3</sup> | mbar  | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          |        |

| Name                            | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|---------------------------------|--|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
|                                 | the station location   |                 |       |      |      |      |      |           |           |            |        |
| MEASURED_SURFACE_TEMPERATURE    | Measured surface temperature at the station location                             | 10 <sup>3</sup> | K     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          |        |
| MEASURED_PARTIAL_WV_PRESSURE    | Measured partial pressure of the water vapour at surface at the station location | 10 <sup>3</sup> | mbar  | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          |        |
| NWP_SURFACE_PRESSURE            | NWP surface pressure at the station location                                     | 10 <sup>3</sup> | mbar  | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          |        |
| NWP_SURFACE_TEMPERATURE         | NWP surface temperature at the station location                                  | 10 <sup>3</sup> | K     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          |        |
| NWP_PARTIAL_WV_PRESSURE         | Partial pressure of the water vapour at surface at the station location          | 10 <sup>3</sup> | mbar  | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          |        |
| TROP0S_ZENITH_DELAY             | Zenith tropospheric delay estimate from the GSN                                  | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          |        |
| TROPOS_ZENITH_DELAY_UNCERTAINTY | Uncertainty in zenith tropospheric delay estimate                                | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8  | 8         | 8          |        |
| Total: var                      |  |                 |       |      |      |      |      |           |           |            |        |

## 10.6 VIADR ( name 'viadr-1b-station-clock', class 7, subclass 24, version 3 )

| Name          | Description           | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|---------------|-----------------------|----------------|-------|------|------|------|------|----------|-----------|------------|--------|
| RECORD_HEADER | Generic Record Header |                |       | 1    | 1    | 1    | 1    | REC_HEAD | 20        | 20         | 0      |

| Name                                | Description                           | Scaling factor   | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type           | Type size | Field size | Offset |
|-------------------------------------|---------------------------------------|------------------|-------|------|------|------|------|----------------|-----------|------------|--------|
| Ground_station_clock_bias_estimates |                                       |                  |       |      |      |      |      |                |           |            |        |
| START_VALIDITY                      | Start time of the record validity     | 10 <sup>9</sup>  | s     | 1    | 1    | 1    | 1    | uinteger8      | 8         | 8          | 20     |
| END_VALIDITY                        | End time of the record validity       | 10 <sup>9</sup>  | s     | 1    | 1    | 1    | 1    | uinteger8      | 8         | 8          | 28     |
| ESTIMATE_INTERVAL                   | Estimation interval for clock bias    |                  | s     | 1    | 1    | 1    | 1    | uinteger2      | 2         | 2          | 36     |
| STATION_NUMBER                      | Number of stations in solution        |                  |       | 1    | 1    | 1    | 1    | uinteger1      | 1         | 1          | 38     |
| <a href="#">PRODUCT_TYPE</a>        | NRT or enhanced POD product           |                  |       | 1    | 1    | 1    | 1    | enumerated     | 1         | 1          | 39     |
| NUMBER_OF_STATIONS                  | Number of fiducial stations, M        |                  |       | 1    | 1    | 1    | 1    | uinteger1      | 1         | 1          | 40     |
| STATION_ID                          | Ground station identification         |                  |       | M    | 1    | 1    | 1    | string         | 4         | var        | 41     |
| CLOCK_QUALITY                       | Quality indicator for each station    |                  |       | M    | 1    | 1    | 1    | uinteger8      | 8         | var        | var    |
| NUM_EPOCHS                          | Number of epochs, E                   |                  |       | M    | 1    | 1    | 1    | uinteger2      | 2         | var        | var    |
| STATION_CLOCK_OFFSETS               |                                       |                  |       | E    | M    | 1    | 1    | STATION_CLOCKS | 72        | var        | var    |
| EPOCH_TIME                          | Time stamp in reference time          | 10 <sup>9</sup>  | s     | 1    | 1    | 1    | 1    | uinteger8      | 8         | 8          |        |
| STATION_CLOCK_OFFSET                | Clock offset                          | 10 <sup>20</sup> | s     | 1    | 1    | 1    | 1    | integer8       | 8         | 8          |        |
| STATION_CLOCK_DRIFT                 | Clock drift                           | 10 <sup>9</sup>  | s/s   | 1    | 1    | 1    | 1    | integer8       | 8         | 8          |        |
| STATION_POSITION_MEASUREMENT_X      | Position of measurement point x (ECI) | 10 <sup>6</sup>  | m     | 1    | 1    | 1    | 1    | integer8       | 8         | 8          |        |

| Name                           | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|--------------------------------|--|-----------------|-------|------|------|------|------|----------|-----------|------------|--------|
| STATION_POSITION_MEASUREMENT_Y | Position of measurement point y (ECI)                  | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8 | 8         | 8          |        |
| STATION_POSITION_MEASUREMENT_Z | Position of measurement point z (ECI)                  | 10 <sup>6</sup> | m     | 1    | 1    | 1    | 1    | integer8 | 8         | 8          |        |
| STATION_VELOCITY_X             | Velocity v <sub>x</sub> of the measurement point (ECI) | 10 <sup>6</sup> | m/s   | 1    | 1    | 1    | 1    | integer8 | 8         | 8          |        |
| STATION_VELOCITY_Y             | Velocity v <sub>y</sub> of the measurement point (ECI) | 10 <sup>6</sup> | m/s   | 1    | 1    | 1    | 1    | integer8 | 8         | 8          |        |
| STATION_VELOCITY_Z             | Velocity v <sub>z</sub> of the measurement point (ECI) | 10 <sup>6</sup> | m/s   | 1    | 1    | 1    | 1    | integer8 | 8         | 8          |        |
| Total: var                     |  |                 |       |      |      |      |      |          |           |            |        |

## 10.7 VIADR ( name 'viadr-1b-metop-pod', class 7, subclass 25, version 3 )

| Name                | Description                                   | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|---------------------|---|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| RECORD_HEADER       | Generic Record Header                         |                 |       | 1    | 1    | 1    | 1    | REC_HEAD  | 20        | 20         | 0      |
| Metop_NRT_orbit_arc |   |                 |       |      |      |      |      |           |           |            |        |
| START_VALIDITY      | Start time of the record validity             | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 20     |
| END_VALIDITY        | End time of the record validity               | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 28     |
| SAMPLE_INTERVAL     | Time interval of the state vector samples     |                 | s     | 1    | 1    | 1    | 1    | uinteger2 | 2         | 2          | 36     |
| NUMBER_SATELLITE    | Number of GPS satellites used in POD solution |                 |       | 1    | 1    | 1    | 1    | uinteger1 | 1         | 1          | 38     |

| Name                         | Description                                 | Scaling factor | Units | Dim1     | Dim2     | Dim3     | Dim4     | Type             | Type size | Field size | Offset    |
|------------------------------|---|----------------|-------|----------|----------|----------|----------|------------------|-----------|------------|-----------|
| <a href="#">PRODUCT_TYPE</a> | NRT or enhanced POD product                 |                |       | 1        | 1        | 1        | 1        | enumerated       | 1         | 1          | 39        |
| X_POSITION_UNCERTAINTY       | Satellite position x coordinate uncertainty | 10^6           | m     | 1        | 1        | 1        | 1        | integer8         | 8         | 8          | 40        |
| Y_POSITION_UNCERTAINTY       | Satellite position y coordinate uncertainty | 10^6           | m     | 1        | 1        | 1        | 1        | integer8         | 8         | 8          | 48        |
| Z_POSITION_UNCERTAINTY       | Satellite position z coordinate uncertainty | 10^6           | m     | 1        | 1        | 1        | 1        | integer8         | 8         | 8          | 56        |
| X_VELOCITY_UNCERTAINTY       | Satellite velocity x uncertainty            | 10^6           | m/s   | 1        | 1        | 1        | 1        | integer8         | 8         | 8          | 64        |
| Y_VELOCITY_UNCERTAINTY       | Satellite velocity y uncertainty            | 10^6           | m/s   | 1        | 1        | 1        | 1        | integer8         | 8         | 8          | 72        |
| Z_VELOCITY_UNCERTAINTY       | Satellite velocity z uncertainty            | 10^6           | m/s   | 1        | 1        | 1        | 1        | integer8         | 8         | 8          | 80        |
| <b>NUMBER_OF_EPOCHS</b>      | <b>Number of solution epochs, N</b>         |                |       | <b>1</b> | <b>1</b> | <b>1</b> | <b>1</b> | <b>uinteger4</b> | <b>4</b>  | <b>4</b>   | <b>88</b> |
| EPOCH_TIME                   | Time stamp in reference time                | 10^9           | s     | N        | 1        | 1        | 1        | uinteger8        | 8         | var        | 92        |
| METOP_POSITION_X             | Satellite position x vector                 | 10^6           | m     | N        | 1        | 1        | 1        | integer8         | 8         | var        | var       |
| METOP_POSITION_Y             | Satellite position y vector                 | 10^6           | m     | N        | 1        | 1        | 1        | integer8         | 8         | var        | var       |
| METOP_POSITION_Z             | Satellite position z vector                 | 10^6           | m     | N        | 1        | 1        | 1        | integer8         | 8         | var        | var       |
| METOP_VELOCITY_X             | Satellite velocity x at epoch time          | 10^6           | m/s   | N        | 1        | 1        | 1        | integer8         | 8         | var        | var       |
| METOP_VELOCITY_Y             | Satellite velocity y at epoch time          | 10^6           | m/s   | N        | 1        | 1        | 1        | integer8         | 8         | var        | var       |
| METOP_VELOCITY_Z             | Satellite velocity z at epoch time          | 10^6           | m/s   | N        | 1        | 1        | 1        | integer8         | 8         | var        | var       |
| Total: var                   |   |                |       |          |          |          |          |                  |           |            |           |

## 10.8 VIADR ( name 'viadr-1b-metop-clock', class 7, subclass 26, version 3 )

| Name                         | Description  | Scaling factor   | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset     |
|------------------------------|--|------------------|-------|------|------|------|------|------------|-----------|------------|------------|
| RECORD_HEADER                | Generic Record Header                                  |                  |       | 1    | 1    | 1    | 1    | REC_HEAD   | 20        | 20         | 0          |
| Metop_NRT_orbit_arc          |  |                  |       |      |      |      |      |            |           |            |            |
| START_VALIDITY               | Start time of the record validity                      | 10 <sup>9</sup>  | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 20         |
| END_VALIDITY                 | End time of the record validity                        | 10 <sup>9</sup>  | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 28         |
| SAMPLE_INTERVAL              | Time interval of the clock offset samples              |                  | s     | 1    | 1    | 1    | 1    | uinteger2  | 2         | 2          | 36         |
| NUMBER_SATELLITE             | Number of GPS satellites in solution                   |                  |       | 1    | 1    | 1    | 1    | uinteger1  | 1         | 1          | 38         |
| <a href="#">PRODUCT_TYPE</a> | NRT or enhanced POD product                            |                  |       | 1    | 1    | 1    | 1    | enumerated | 1         | 1          | 39         |
| CLOCK_OFFSET_UNCERTAINTY     | Satellite transmitter clock offset uncertainty         | 10 <sup>9</sup>  | s     | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 40         |
| CLOCK_DRIFT_UNCERTAINTY      | Satellite transmitter clock rate of change uncertainty | 10 <sup>9</sup>  | s/s   | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 48         |
| NUMBER_OF_EPOCHS             | Number of solution epochs, N                           |                  |       | 1    | 1    | 1    | 1    | uinteger4  | 4         | 4          | 56         |
| EPOCH_TIME                   | Time stamp in reference time                           | 10 <sup>9</sup>  | s     | N    | 1    | 1    | 1    | uinteger8  | 8         | var        | 60         |
| CLOCK_OFFSET                 | Clock offset estimate                                  | 10 <sup>20</sup> | s     | N    | 1    | 1    | 1    | integer8   | 8         | var        | var        |
| CLOCK_DRIFT                  | Satellite transmitter clock rate of change             | 10 <sup>20</sup> | s/s   | N    | 1    | 1    | 1    | integer8   | 8         | var        | var        |
|                              |  |                  |       |      |      |      |      |            |           |            | Total: var |



## 10.9 VIADR ( name 'viadr-1b-eop', class 7, subclass 27, version 5 )

| Name                         | Description                        | Scaling factor  | Units  | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset     |
|------------------------------|------------------------------------|-----------------|--------|------|------|------|------|-----------|-----------|------------|------------|
| RECORD_HEADER                | Generic Record Header              |                 |        | 1    | 1    | 1    | 1    | REC_HEAD  | 20        | 20         | 0          |
| NUM_EPOCHS                   | Number of EOP epochs, N            |                 |        | 1    | 1    | 1    | 1    | integer2  | 2         | 2          | 20         |
| Earth_Orientation_Parameters |                                    |                 |        |      |      |      |      |           |           |            |            |
| EPOCH                        | Start time of the record validity  | 10 <sup>9</sup> | s      | N    | 1    | 1    | 1    | uinteger8 | 8         | var        | 22         |
| X_POLE                       | x-pole                             | 10 <sup>6</sup> | arcsec | N    | 1    | 1    | 1    | integer8  | 8         | var        | var        |
| Y_POLE                       | y-pole                             | 10 <sup>6</sup> | arcsec | N    | 1    | 1    | 1    | integer8  | 8         | var        | var        |
| DUT1                         | UT1-UTC                            | 10 <sup>6</sup> | s      | N    | 1    | 1    | 1    | integer8  | 8         | var        | var        |
| EOP_STATUS                   | Final or predicted EOP products    |                 |        | N    | 1    | 1    | 1    | boolean   | 1         | var        | var        |
| D_psi                        | Celestial pole offset in longitude | 10 <sup>6</sup> | arcsec | N    | 1    | 1    | 1    | integer8  | 8         | var        | var        |
| D_eps                        | Celestial pole offset in obliquity | 10 <sup>6</sup> | arcsec | N    | 1    | 1    | 1    | integer8  | 8         | var        | var        |
| DX_POLE                      | Uncertainty in X-Pole              | 10 <sup>6</sup> | arcsec | N    | 1    | 1    | 1    | integer8  | 8         | var        | var        |
| DY_POLE                      | Uncertainty in Y-Pole              | 10 <sup>6</sup> | arcsec | N    | 1    | 1    | 1    | integer8  | 8         | var        | var        |
| DLOD                         | Uncertainty in Length of day (LOD) | 10 <sup>6</sup> | s      | N    | 1    | 1    | 1    | integer8  | 8         | var        | var        |
|                              |                                    |                 |        |      |      |      |      |           |           |            | Total: var |

## 10.10 VIADR ( name 'viadr-1b-metop-attitude', class 7, subclass 28, version 3 )

| Name           | Description                       | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|----------------|-----------------------------------|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| RECORD_HEADER  | Generic Record Header             |                 |       | 1    | 1    | 1    | 1    | REC_HEAD  | 20        | 20         | 0      |
| Metop_attitude |                                   |                 |       |      |      |      |      |           |           |            |        |
| START_VALIDITY | Start time of the record validity | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 20     |

| Name                                | Description                       | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|-------------------------------------|-----------------------------------|-----------------|-------|------|------|------|------|------------|-----------|------------|--------|
| END_VALIDITY                        | End time of the record validity   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 28     |
| NUMBER_OF_EPOCHS                    | Number of attitude data epochs, N |                 |       | 1    | 1    | 1    | 1    | uinteger4  | 4         | 4          | 36     |
| EPOCH_TIME                          | Time stamp in reference time      | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8  | 8         | var        | 40     |
| <a href="#">METOP_STEERING_MODE</a> | Metop steering mode indicator     |                 |       | N    | 1    | 1    | 1    | enumerated | 1         | var        | var    |
| METOP_MISPOINTING_ROLL              | Mispointing angle Dh              | 10 <sup>3</sup> | deg   | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| METOP_MISPOINTING_PITCH             | Mispointing angles Dx             | 10 <sup>3</sup> | deg   | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| METOP_MISPOINTING_YAW               | Mispointing angles Dz             | 10 <sup>3</sup> | deg   | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| METOP_TRUE_LATITUDE                 | Metop true latitude angle         | 10 <sup>3</sup> | deg   | N    | 1    | 1    | 1    | integer8   | 8         | var        | var    |
| Total: var                          |                                   |                 |       |      |      |      |      |            |           |            |        |

### 10.11 MDR ( name 'mdr-1b', class 8, subclass 20, version 4 )

| Name                       | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|----------------------------|--|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| RECORD_HEADER              | Generic Record Header  |                 |       | 1    | 1    | 1    | 1    | REC_HEAD  | 20        | 20         | 0      |
| GENERIC_QUALITY_INDICATORS |  |                 |       |      |      |      |      |           |           |            |        |
| DEGRADED_INST_MDR          | Quality of MDR has been degraded from nominal due to an instrument degradation |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 20     |
| DEGRADED_PROC_MDR          | Quality of MDR has been degraded from nominal due to a processing degradation  |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 21     |
| MEASUREMENT_DATA           |  |                 |       |      |      |      |      |           |           |            |        |
| START_EPOCH                | Epoch of the measurement start   | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 22     |

| Name                             | Description   | Scaling factor   | Units  | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|----------------------------------|---|------------------|--------|------|------|------|------|------------|-----------|------------|--------|
| END_EPOCH                        | Epoch of the measurement end                                    | 10 <sup>9</sup>  | s      | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 30     |
| PRED_START_EPOCH                 | Predicted start epoch of the measurement from occultation table | 10 <sup>6</sup>  | s      | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 38     |
| PRED_END_EPOCH                   | Predicted end epoch of the measurement from occultation table   | 10 <sup>6</sup>  | s      | 1    | 1    | 1    | 1    | uinteger8  | 8         | 8          | 46     |
| PRED_START_LAT                   | Predicted start latitude of the measurement                     | 10 <sup>3</sup>  | degree | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 54     |
| PRED_START_LONG                  | Predicted start longitude of the measurement                    | 10 <sup>3</sup>  | degree | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 62     |
| PRED_END_LAT                     | Predicted end latitude of the measurement                       | 10 <sup>3</sup>  | degree | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 70     |
| PRED_END_LONG                    | Predicted end longitude of the measurement                      | 10 <sup>3</sup>  | degree | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 78     |
| MEASUREMENT_ID                   | Measurement identification                                      |                  |        | 1    | 1    | 1    | 1    | string     | 32        | 32         | 86     |
| ID_FAILED                        | Measurement identification failed                               |                  |        | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 118    |
| MEASUREMENT_LENGTH               | Measurement length  |                  | s      | 1    | 1    | 1    | 1    | uinteger2  | 2         | 2          | 119    |
| GRAS_MODE                        | Navigation or occultation mode                                  |                  |        | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 121    |
| <a href="#">MEASUREMENT_TYPE</a> | Rising, setting, or navigation                                  |                  |        | 1    | 1    | 1    | 1    | enumerated | 1         | 1          | 122    |
| <a href="#">GRAS_CHANNEL_ID</a>  | GRAS channel identification                                     |                  |        | 1    | 1    | 1    | 1    | enumerated | 1         | 1          | 123    |
| GPS_OCC_ID                       | Occulting GPS identification                                    |                  |        | 1    | 1    | 1    | 1    | uinteger1  | 1         | 1          | 124    |
| OCC_GPS_HW_DELAY                 | Estimated GPS hardware group delay                              | 10 <sup>15</sup> | s      | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 125    |
| OCC_GPS_HW_COR_CA                | GPS hardware delay correction for CA code phase                 | 10 <sup>9</sup>  | chips  | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 133    |
| OCC_GPS_HW_COR_P1                | GPS hardware delay correction for P1 code phase                 | 10 <sup>9</sup>  | chips  | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 141    |

| Name              | Description  | Scaling factor   | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|-------------------|--|------------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| OCC_GPS_HW_COR_P2 | GPS hardware delay correction for P2 code phase  | 10 <sup>9</sup>  | chips | 1    | 1    | 1    | 1    | integer8  | 8         | 8          | 149    |
| GPS_PIV_ID        | Pivot GPS identification   |                  |       | 1    | 1    | 1    | 1    | uinteger1 | 1         | 1          | 157    |
| PIV_GPS_HW_DELAY  | Estimated GPS hardware group delay   | 10 <sup>15</sup> | s     | 1    | 1    | 1    | 1    | integer8  | 8         | 8          | 158    |
| PIV_GPS_HW_COR_CA | GPS hardware delay correction for CA code phase  | 10 <sup>9</sup>  | chips | 1    | 1    | 1    | 1    | integer8  | 8         | 8          | 166    |
| PIV_GPS_HW_COR_P1 | GPS hardware delay correction for P1 code phase  | 10 <sup>9</sup>  | chips | 1    | 1    | 1    | 1    | integer8  | 8         | 8          | 174    |
| PIV_GPS_HW_COR_P2 | GPS hardware delay correction for P2 code phase  | 10 <sup>9</sup>  | chips | 1    | 1    | 1    | 1    | integer8  | 8         | 8          | 182    |
| FID_ID_DD1        | Reference fiducial station identification for DD1  |                  |       | 1    | 1    | 1    | 1    | string    | 4         | 4          | 190    |
| FID_ID_DD2        | Second reference fiducial station identification for DD2                                     |                  |       | 1    | 1    | 1    | 1    | string    | 4         | 4          | 194    |
| LOW_PIV_GZA_SD1   | Pivot satellite elevation from GZA is below threshold in SD1 processing                      |                  |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 198    |
| LOW_OCC_FID_SD2   | Occulting GPS satellite elevation from fiducial station is below threshold in SD2 processing |                  |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 199    |
| LOW_PIV_GZA_DD1   | Pivot satellite elevation from GZA is below threshold in DD1 processing                      |                  |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 200    |
| LOW_PIV_FID_DD1   | Pivot satellite elevation from fiducial station is below threshold in DD1 processing         |                  |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 201    |
| LOW_OCC_FID_DD1   | Occulting GPS satellite elevation from fiducial station is below                             |                  |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 202    |

| Name                              | Description  | Scaling factor  | Units  | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|-----------------------------------|--|-----------------|--------|------|------|------|------|-----------|-----------|------------|--------|
|                                   | threshold in DD1 processing  |                 |        |      |      |      |      |           |           |            |        |
| LOW_PIV_GZA_DD2                   | Pivot satellite elevation from GZA is below threshold in DD2 processing                      |                 |        | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 203    |
| LOW_PIV_FID_DD2                   | Pivot satellite elevation from fiducial station is below threshold in DD2 processing         |                 |        | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 204    |
| LOW_OCC_FID_DD2                   | Occulting GPS satellite elevation from fiducial station is below threshold in DD2 processing |                 |        | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 205    |
| MEAN_OCCULTATION_RAY_TANGENT_LAT  | Mean latitude of the ray tangent point   | 10 <sup>3</sup> | degree | 1    | 1    | 1    | 1    | integer8  | 8         | 8          | 206    |
| MEAN_OCCULTATION_RAY_TANGENT_LONG | Mean longitude of the ray tangent point  | 10 <sup>3</sup> | degree | 1    | 1    | 1    | 1    | integer8  | 8         | 8          | 214    |
| USO_FREQUENCY                     | Nominal USO frequency used in the processing   | 10 <sup>9</sup> | Hz     | 1    | 1    | 1    | 1    | uinteger8 | 8         | 8          | 222    |
| ANTENNA_REF_POINT_X               | Antenna reference point position vector x in SR frame  | 10 <sup>6</sup> | m      | 1    | 1    | 1    | 1    | integer8  | 8         | 8          | 230    |
| ANTENNA_REF_POINT_Y               | Antenna reference point position vector y in SR frame  | 10 <sup>6</sup> | m      | 1    | 1    | 1    | 1    | integer8  | 8         | 8          | 238    |
| ANTENNA_REF_POINT_Z               | Antenna reference point position vector z in SR frame  | 10 <sup>6</sup> | m      | 1    | 1    | 1    | 1    | integer8  | 8         | 8          | 246    |
| METOP_COM_VECT_X                  | Metop CoM position vector x in SR frame  | 10 <sup>6</sup> | m      | 1    | 1    | 1    | 1    | integer8  | 8         | 8          | 254    |
| METOP_COM_VECT_Y                  | Metop CoM position vector y in SR frame  | 10 <sup>6</sup> | m      | 1    | 1    | 1    | 1    | integer8  | 8         | 8          | 262    |
| METOP_COM_VECT_Z                  | Metop CoM position vector z in SR frame  | 10 <sup>6</sup> | m      | 1    | 1    | 1    | 1    | integer8  | 8         | 8          | 270    |

| Name                                | Description   | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type       | Type size | Field size | Offset |
|-------------------------------------|---|-----------------|-------|------|------|------|------|------------|-----------|------------|--------|
|                                     | frame   |                 |       |      |      |      |      |            |           |            |        |
| Q_ANA                               | Analogue AGC active during measurement  |                 |       | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 278    |
| INSTRUMENT_STABLE                   | USO oven temperature has been stabilized after switch on  |                 |       | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 279    |
| USO_TEMPERATURE_START               | USO oven temperature at the beginning of the measurement  | 10 <sup>3</sup> | degC  | 1    | 1    | 1    | 1    | integer4   | 4         | 4          | 280    |
| USO_TEMPERATURE_END                 | USO oven temperature at the end of the measurement  | 10 <sup>3</sup> | degC  | 1    | 1    | 1    | 1    | integer4   | 4         | 4          | 284    |
| USO_TEMPERATURE_CHANGE              | USO oven temperature change during occultation  | 10 <sup>3</sup> | degC  | 1    | 1    | 1    | 1    | integer4   | 4         | 4          | 288    |
| METOP_MANOEUVRE                     | This MDR is affected by a Metop manoeuvre   |                 |       | 1    | 1    | 1    | 1    | boolean    | 1         | 1          | 292    |
| <a href="#">METOP_STEERING_MODE</a> | Metop steering mode during the measurement  |                 |       | 1    | 1    | 1    | 1    | enumerated | 1         | 1          | 293    |
| L1_CA_AMP_LOW                       | Number of times when L1-C/A amplitude level is below the specified threshold  |                 |       | 1    | 1    | 1    | 1    | uinteger2  | 2         | 2          | 294    |
| L1_CA_AMP_TIME                      | Epoch corresponding to the maximum impact parameter height before the amplitude has been below threshold (from the top of the atmosphere) | 10 <sup>6</sup> | s     | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 296    |
| L1_CA_IMPACT_LIMIT                  | Maximum impact parameter height before the amplitude has been below threshold (from the top of the atmosphere)                            | 10 <sup>9</sup> | m     | 1    | 1    | 1    | 1    | integer8   | 8         | 8          | 304    |

| Name               | Description   | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|--------------------|---|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| L1_P1_AMP_LOW      | Number of times when L1-P1 amplitude level is below the specified threshold   |                 |       | 1    | 1    | 1    | 1    | uinteger2 | 2         | 2          | 312    |
| L1_P1_AMP_TIME     | Epoch corresponding to the maximum impact parameter height before the amplitude has been below threshold (from the top of the atmosphere) | 10 <sup>6</sup> | s     | 1    | 1    | 1    | 1    | integer8  | 8         | 8          | 314    |
| L1_P1_IMPACT_LIMIT | Maximum impact parameter height before the amplitude has been below threshold (from the top of the atmosphere)                            | 10 <sup>9</sup> | m     | 1    | 1    | 1    | 1    | integer8  | 8         | 8          | 322    |
| L2_P2_AMP_LOW      | Number of times when L2-P2 amplitude level is below the specified threshold   |                 |       | 1    | 1    | 1    | 1    | uinteger2 | 2         | 2          | 330    |
| L2_P2_AMP_TIME     | Epoch corresponding to the maximum impact parameter height before the amplitude has been below threshold (from the top of the atmosphere) | 10 <sup>6</sup> | s     | 1    | 1    | 1    | 1    | integer8  | 8         | 8          | 332    |
| L2_P2_IMPACT_LIMIT | Maximum impact parameter height before the amplitude has been below threshold (from the top of the atmosphere)                            | 10 <sup>9</sup> | m     | 1    | 1    | 1    | 1    | integer8  | 8         | 8          | 340    |
| L1_CA_NOISE_FLAG   | L1-C/A noise level compared to a threshold  |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 348    |
| L1_P1_NOISE_FLAG   | L1-P1 noise level compared to a threshold   |                 |       | 1    | 1    | 1    | 1    | boolean   | 1         | 1          | 349    |

| Name                                   | Description  | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type           | Type size | Field size | Offset |
|--|--|----------------|-------|------|------|------|------|----------------|-----------|------------|--------|
| L2_P2_NOISE_FLAG                       | L2-P2 noise level compared to a threshold                    |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | 350    |
| L1_CA_PSEUDORANGE_FLAG                 | L1-C/A pseudorange outside the threshold                     |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | 351    |
| L1_P1_PSEUDORANGE_FLAG                 | L1-P1 pseudorange outside threshold                          |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | 352    |
| L2_P2_PSEUDORANGE_FLAG                 | L2-P2 pseudorange outside the threshold                      |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | 353    |
| USO_TEMP_NOMINAL                       | USO temperature outside threshold                            |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | 354    |
| USO_TEMP_DRIFT_NOMINAL                 | USO temperature drift outside threshold                      |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | 355    |
| L2_NOT_TRACKED                         | Tracking state 15 was not achieved during measurement        |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | 356    |
| MEASUREMENT_INCOMPLETE                 | Part of the measurement data time sequence missing           |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | 357    |
| ATTITUDE_MISSING                       | Metop mispointing angles data not available                  |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | 358    |
| RS_DATA_MISSING                        | Raw sampling mode data missing                               |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | 359    |
| LOCAL_MULTIPATH                        | Incidence angle in the high local multipath risk directions  |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | 360    |
| <a href="#">LOCAL_MULTIPATH_SOURCE</a> | Possible source of local multipath based on incidence angles |                |       | 1    | 1    | 1    | 1    | bitfield ( 2 ) | 2         | 2          | 361    |
| <a href="#">TELEMETRY_IN_RANGE</a>     | All telemetry data is within the specified range             |                |       | 1    | 1    | 1    | 1    | bitfield ( 3 ) | 3         | 3          | 363    |
| SA_FLAG                                | Selective Availability flag                                  |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | 366    |
| A_FLAG                                 | Alert flag   |                |       | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | 367    |



| Name            | Description                                | Scaling factor | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type    | Type size | Field size | Offset |
|-----------------|--|----------------|-------|------|------|------|------|---------|-----------|------------|--------|
| AS_FLAG         | Anti-spoofing flag                         |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 368    |
| PHASE_L1        | Phase residual L1 quality                  |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 369    |
| PHASE_L2        | Phase residual L2 quality                  |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 370    |
| DOPPLER_L1      | Doppler residual L1 quality                |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 371    |
| DOPPLER_L2      | Doppler residual L2 quality                |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 372    |
| DOPPLER_RATE_L1 | Doppler rate L1 quality                    |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 373    |
| DOPPLER_RATE_L2 | Doppler rate L2 quality                    |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 374    |
| DOPPLER_ACC_L1  | Doppler acceleration L1 quality            |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 375    |
| DOPPLER_ACC_L2  | Doppler acceleration L2 quality            |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 376    |
| TEC_QUALITY     | TEC quality                                |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 377    |
| TEC_DRIFT       | TEC drift quality                          |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 378    |
| TEC_ACC         | TEC acceleration quality                   |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 379    |
| BENDING_L1      | Bending angle L1 quality                   |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 380    |
| BENDING_L2      | Bending angle L2 quality                   |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 381    |
| NEUTRAL_BENDING | Ionosphere corrected bending angle quality |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 382    |
| IMPACT_L1       | Impact parameter L1 quality                |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 383    |
| IMPACT_L2       | Impact parameter L2 quality                |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 384    |
| L1_CA_STRAT     | L1-CA noise level in stratosphere          |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 385    |
| L1_P1_STR       | L1-P1 noise level in stratosphere          |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 386    |
| L2_P2_STRAT     | L2-P2 noise level in stratosphere          |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 387    |
| L1_CA_TROP      | L1-CA noise level in troposphere           |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 388    |
| L1_P1_TROP      | L1-P1 noise level in troposphere           |                |       | 1    | 1    | 1    | 1    | boolean | 1         | 1          | 389    |

| Name   | Description   | Scaling factor  | Units      | Dim1 | Dim2 | Dim3 | Dim4 | Type           | Type size | Field size | Offset |
|--|---|-----------------|------------|------|------|------|------|----------------|-----------|------------|--------|
| L2_P2_TROP                                       | L2-P2 noise level in troposphere  |                 |            | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | 390    |
| PGE  | Probability of Gross Error  | 10 <sup>2</sup> |            | 1    | 1    | 1    | 1    | uinteger2      | 2         | 2          | 391    |
| <a href="#">ONBOARD_NAV_SOLUTION</a>             | Onboard navigation solution method  |                 |            | 1    | 1    | 1    | 1    | enumerated     | 1         | 1          | 393    |
| <a href="#">SELECTED_CLOCK_CORRECTION_METHOD</a> | Selected clock correction differencing method (ND/SD1/SD2/DD1/DD2)            |                 |            | 1    | 1    | 1    | 1    | enumerated     | 1         | 1          | 394    |
| <a href="#">CLOCK_CORRECTION_FALLBACK_MODE</a>   | Selected clock correction not possible and a fallback mode has been activated |                 |            | 1    | 1    | 1    | 1    | bitfield ( 1 ) | 1         | 1          | 395    |
| <a href="#">SSD_AVAILABILITY</a>                 | Availability of the SSD data  |                 |            | 1    | 1    | 1    | 1    | bitfield ( 2 ) | 2         | 2          | 396    |
| BE_FLAG  | Bias estimation on/off  |                 |            | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | 398    |
| BE_TYPE  | BBE or FBE  |                 |            | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | 399    |
| <a href="#">BE_MODEL</a>                         | Atmospheric model used in bias estimation                                     |                 |            | 1    | 1    | 1    | 1    | enumerated     | 1         | 1          | 400    |
| BE_HEIGHT  | Bias estimation height  | 10 <sup>6</sup> | m          | 1    | 1    | 1    | 1    | integer8       | 8         | 8          | 401    |
| BE_WINDOW  | Bias estimation window half aperture  | 10 <sup>6</sup> | m          | 1    | 1    | 1    | 1    | integer8       | 8         | 8          | 409    |
| BE_BIAS_ESTIMATE                                 | Bias error estimate (note: unit depends on the BE type)                       | 10 <sup>9</sup> | rad or m/s | 1    | 1    | 1    | 1    | integer8       | 8         | 8          | 417    |
| LOCAL_CURVATURE_X                                | Local radius vector of curvature x  | 10 <sup>6</sup> | m          | 1    | 1    | 1    | 1    | integer8       | 8         | 8          | 425    |
| LOCAL_CURVATURE_Y                                | Local radius vector of curvature y  | 10 <sup>6</sup> | m          | 1    | 1    | 1    | 1    | integer8       | 8         | 8          | 433    |
| LOCAL_CURVATURE_Z                                | Local radius vector of curvature z  | 10 <sup>6</sup> | m          | 1    | 1    | 1    | 1    | integer8       | 8         | 8          | 441    |
| COORDINATES_OF_CENTRE_REFRACTION_X               | Coordinate x of the local centre of refraction                                | 10 <sup>6</sup> | m          | 1    | 1    | 1    | 1    | integer8       | 8         | 8          | 449    |
| COORDINATES_OF_CENTRE_REFRACTION_Y               | Coordinate y of the local centre of refraction                                | 10 <sup>6</sup> | m          | 1    | 1    | 1    | 1    | integer8       | 8         | 8          | 457    |

| Name                                  | Description                                      | Scaling factor  | Units  | Dim1 | Dim2 | Dim3 | Dim4 | Type           | Type size | Field size | Offset |
|---------------------------------------|--|-----------------|--------|------|------|------|------|----------------|-----------|------------|--------|
| COORDINATES_OF_CENTRE_REFRACTION_Z    | Coordinate z of the local centre of refraction   | 10 <sup>6</sup> | m      | 1    | 1    | 1    | 1    | integer8       | 8         | 8          | 465    |
| OCCULTING_GPS_MANOEUVRE               | Occluding GPS manoeuvre flag                     |                 |        | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | 473    |
| GPS_MANOEUVRE_TIME                    | Time of the occulting GPS manoeuvre              | 10 <sup>6</sup> | s      | 1    | 1    | 1    | 1    | uinteger8      | 8         | 8          | 474    |
| GPS_ECLIPTING                         | Occluding GPS eclipsing                          |                 |        | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | 482    |
| ECLIPSE_TIME                          | Time of the eclipse                              | 10 <sup>6</sup> | s      | 1    | 1    | 1    | 1    | uinteger8      | 8         | 8          | 483    |
| GPS_NAV_HEALTH                        | GPS navigation data health summary               |                 |        | 1    | 1    | 1    | 1    | boolean        | 1         | 1          | 491    |
| <a href="#">GPS_SH</a>                | GPS signal health information                    |                 |        | 1    | 1    | 1    | 1    | enumerated     | 1         | 1          | 492    |
| MEAN_AZIMUTH_INCOMING_RAY             | Mean azimuth of the incoming ray to GRAS         | 10 <sup>3</sup> | degree | 1    | 1    | 1    | 1    | integer8       | 8         | 8          | 493    |
| MEAN_AZIMUTH_OUTGOING_RAY             | Mean azimuth of the outgoing ray from GPS        | 10 <sup>3</sup> | degree | 1    | 1    | 1    | 1    | integer8       | 8         | 8          | 501    |
| <a href="#">RECEIVER_ANALOG_GAIN</a>  | receiver channel analogue gain setting           |                 |        | 1    | 1    | 1    | 1    | enumerated     | 1         | 1          | 509    |
| <a href="#">RECEIVER_DIGITAL_GAIN</a> | receiver channel digital gain setting            |                 |        | 1    | 1    | 1    | 1    | bitfield ( 6 ) | 6         | 6          | 510    |
| <a href="#">TEC_METHOD</a>            | TEC determination method                         |                 |        | 1    | 1    | 1    | 1    | enumerated     | 1         | 1          | 516    |
| ERROR_COVARIANCE_ID                   | Error covariance matrix reference identification |                 |        | 1    | 1    | 1    | 1    | integer2       | 2         | 2          | 517    |
| MAX_SLTH                              | Maximum straight line tangent height             | 10 <sup>6</sup> | m      | 1    | 1    | 1    | 1    | integer8       | 8         | 8          | 519    |
| MIN_SLTH                              | Minimum straight line tangent height             | 10 <sup>6</sup> | m      | 1    | 1    | 1    | 1    | integer8       | 8         | 8          | 527    |
| LAT_STRAIGHT_PATH_HIGH                | Latitude of the straight path at 80 km           | 10 <sup>3</sup> | degree | 1    | 1    | 1    | 1    | integer4       | 4         | 4          | 535    |
| LONG_STRAIGHT_PATH_HIGH               | Longitude of the straight path at 80 km          | 10 <sup>3</sup> | degree | 1    | 1    | 1    | 1    | integer4       | 4         | 4          | 539    |

| Name                                | Description  | Scaling factor  | Units  | Dim1 | Dim2 | Dim3 | Dim4 | Type           | Type size | Field size | Offset |
|-------------------------------------|--|-----------------|--------|------|------|------|------|----------------|-----------|------------|--------|
| LAT_STRAIGHT_PATH_LOW               | Latitude of the straight path at lowest height                                       | 10 <sup>3</sup> | degree | 1    | 1    | 1    | 1    | integer4       | 4         | 4          | 543    |
| LONG_STRAIGHT_PATH_LOW              | Longitude of the straight path at lowest height                                      | 10 <sup>3</sup> | degree | 1    | 1    | 1    | 1    | integer4       | 4         | 4          | 547    |
| LAT_STRAIGHT_PATH_MID               | Latitude of the straight path at user definable impact parameter value               | 10 <sup>3</sup> | degree | 1    | 1    | 1    | 1    | integer4       | 4         | 4          | 551    |
| LONG_STRAIGHT_PATH_MID              | Longitude of the straight path at user definable impact parameter value              | 10 <sup>3</sup> | degree | 1    | 1    | 1    | 1    | integer4       | 4         | 4          | 555    |
| CYCLE_SLIP_LIMIT                    | Lower height limit for cycle slip detection and correction                           | 10 <sup>6</sup> | m      | 1    | 1    | 1    | 1    | integer8       | 8         | 8          | 559    |
| CYCLE_SLIP_FLAG_CL_OCC              | Number of detected and corrected cycle slips in closed loop mode in occultation data |                 |        | 1    | 1    | 1    | 1    | integer2       | 2         | 2          | 567    |
| CYCLE_SLIP_FLAG_RS                  | Number of detected and corrected cycle slips in raw sampling mode                    |                 |        | 1    | 1    | 1    | 1    | integer2       | 2         | 2          | 569    |
| CYCLE_SLIP_FLAG_CL_PIV              | Number of detected and corrected cycle slips in closed loop mode in pivot GPS data   |                 |        | 1    | 1    | 1    | 1    | integer2       | 2         | 2          | 571    |
| <a href="#">WO_CHARACTERISATION</a> | Characterisation of the WO method  |                 |        | 1    | 1    | 1    | 1    | bitfield ( 4 ) | 4         | 4          | 573    |
| <a href="#">ATM_MULTIPATH</a>       | Atmospheric muttipath flag   |                 |        | 1    | 1    | 1    | 1    | bitfield ( 4 ) | 4         | 4          | 577    |
| WO_START                            | Starting height of WO processing   | 10 <sup>6</sup> | m      | 1    | 1    | 1    | 1    | integer8       | 8         | 8          | 581    |
| WO_END                              | Ending height of WO processing   | 10 <sup>6</sup> | m      | 1    | 1    | 1    | 1    | integer8       | 8         | 8          | 589    |
| WO_HEIGHT_STEP                      | WO height step   | 10 <sup>6</sup> | m      | 1    | 1    | 1    | 1    | integer8       | 8         | 8          | 597    |
| BP_PLANES                           | Number of BP planes considered   |                 |        | 1    | 1    | 1    | 1    | integer2       | 2         | 2          | 605    |
| BP_LOCATION                         | Location of the BP plane   | 10 <sup>6</sup> | m      | 1    | 1    | 1    | 1    | integer8       | 8         | 8          | 607    |

| Name                    | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|-------------------------|--|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| DELTA.UTC_REF           | Time difference between UTC time and GSN reference time at the reference time of the first GO measurement sample | 10 <sup>9</sup> | s     | 1    | 1    | 1    | 1    | integer8  | 8         | 8          | 615    |
| NUMBER_OF_SAMPLES       | Number of observation samples, N   |                 |       | 1    | 1    | 1    | 1    | uinteger4 | 4         | 4          | 623    |
| TIME_REF                | Reference time of the sample   | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8 | 8         | var        | 627    |
| TIME.UTC                | UTC time of the sample   | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| TIME_START_OCCULTATION  | Time from the beginning of the occultation   | 10 <sup>9</sup> | s     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| ENGINEERING_PARAMETER_1 | Engineering parameter for in-flight monitoring of GRAS status  | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| ENGINEERING_PARAMETER_2 | Engineering parameter for in-flight monitoring of GRAS status  | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| ENGINEERING_PARAMETER_3 | Engineering parameter for in-flight monitoring of GRAS status  | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| ENGINEERING_PARAMETER_4 | Engineering parameter for in-flight monitoring of GRAS status  | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| ENGINEERING_PARAMETER_5 | Engineering parameter for in-flight monitoring of GRAS status  | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| ENGINEERING_PARAMETER_6 | Engineering parameter for in-flight monitoring of GRAS status  | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| ENGINEERING_PARAMETER_7 | Engineering parameter for in-flight monitoring of GRAS status  | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| ENGINEERING_PARAMETER_8 | Engineering parameter for in-flight monitoring of GRAS status  | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| ENGINEERING_PARAMETER_9 | Engineering parameter for in-flight  | 10 <sup>9</sup> |       | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |

| Name                           | Description   | Scaling factor  | Units  | Dim1 | Dim2 | Dim3 | Dim4 | Type           | Type size | Field size | Offset |
|--------------------------------|---|-----------------|--------|------|------|------|------|----------------|-----------|------------|--------|
|                                | monitoring of GRAS status                                     |                 |        |      |      |      |      |                |           |            |        |
| ENGINEERING_PARAMETER_10       | Engineering parameter for in-flight monitoring of GRAS status | 10 <sup>9</sup> |        | N    | 1    | 1    | 1    | integer8       | 8         | var        | var    |
| <a href="#">TRACKING_STATE</a> | Tracking state  |                 |        | N    | 1    | 1    | 1    | bitfield ( 2 ) | 2         | var        | var    |
| SLTH                           | Straight line tangent height                                  | 10 <sup>3</sup> | m      | N    | 1    | 1    | 1    | integer4       | 4         | var        | var    |
| LAT_RAY_TANGENT_L1             | Latitude of the ray tangent point for L1                      | 10 <sup>3</sup> | degree | N    | 1    | 1    | 1    | integer4       | 4         | var        | var    |
| LAT_RAY_TANGENT_L2             | Latitude of the ray tangent point for L2                      | 10 <sup>3</sup> | degree | N    | 1    | 1    | 1    | integer4       | 4         | var        | var    |
| LAT_RAY_TANGENT_LC             | Latitude of the ray tangent point for LC                      | 10 <sup>3</sup> | degree | N    | 1    | 1    | 1    | integer4       | 4         | var        | var    |
| LONG_RAY_TANGENT_L1            | Longitude of the ray tangent point for L1                     | 10 <sup>3</sup> | degree | N    | 1    | 1    | 1    | integer4       | 4         | var        | var    |
| LONG_RAY_TANGENT_L2            | Longitude of the ray tangent point for L2                     | 10 <sup>3</sup> | degree | N    | 1    | 1    | 1    | integer4       | 4         | var        | var    |
| LONG_RAY_TANGENT_LC            | Longitude of the ray tangent point for LC                     | 10 <sup>3</sup> | degree | N    | 1    | 1    | 1    | integer4       | 4         | var        | var    |
| OCCULTING_GPS_POSITION_X       | Occulting GPS position vector x                               | 10 <sup>6</sup> | m      | N    | 1    | 1    | 1    | integer8       | 8         | var        | var    |
| OCCULTING_GPS_POSITION_Y       | Occulting GPS position vector y                               | 10 <sup>6</sup> | m      | N    | 1    | 1    | 1    | integer8       | 8         | var        | var    |
| OCCULTING_GPS_POSITION_Z       | Occulting GPS position vector z                               | 10 <sup>6</sup> | m      | N    | 1    | 1    | 1    | integer8       | 8         | var        | var    |
| OCCULTING_GPS_VELOCITY_X       | Occulting GPS velocity vector x                               | 10 <sup>6</sup> | m/s    | N    | 1    | 1    | 1    | integer8       | 8         | var        | var    |
| OCCULTING_GPS_VELOCITY_Y       | Occulting GPS velocity vector y                               | 10 <sup>6</sup> | m/s    | N    | 1    | 1    | 1    | integer8       | 8         | var        | var    |
| OCCULTING_GPS_VELOCITY_Z       | Occulting GPS velocity vector z                               | 10 <sup>6</sup> | m/s    | N    | 1    | 1    | 1    | integer8       | 8         | var        | var    |
| METOP_POSITION_X               | Satellite position x vector                                   | 10 <sup>6</sup> | m      | N    | 1    | 1    | 1    | integer8       | 8         | var        | var    |

| Name                      | Description                          | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|---------------------------|--------------------------------------|-----------------|-------|------|------|------|------|----------|-----------|------------|--------|
| METOP_POSITION_Y          | Satellite position y vector          | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| METOP_POSITION_Z          | Satellite position z vector          | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| METOP_VELOCITY_X          | Satellite velocity x at epoch time   | 10 <sup>6</sup> | m/s   | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| METOP_VELOCITY_Y          | Satellite velocity y at epoch time   | 10 <sup>6</sup> | m/s   | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| METOP_VELOCITY_Z          | Satellite velocity z at epoch time   | 10 <sup>6</sup> | m/s   | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| PIVOT_GPS_POSITION_X      | Pivot GPS position vector x          | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| PIVOT_GPS_POSITION_Y      | Pivot GPS position vector y          | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| PIVOT_GPS_POSITION_Z      | Pivot GPS position vector z          | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| PIVOT_GPS_VELOCITY_X      | Pivot GPS velocity vector x          | 10 <sup>6</sup> | m/s   | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| PIVOT_GPS_VELOCITY_Y      | Pivot GPS velocity vector y          | 10 <sup>6</sup> | m/s   | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| PIVOT_GPS_VELOCITY_Z      | Pivot GPS velocity vector z          | 10 <sup>6</sup> | m/s   | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| FIDUCIAL_STAT1_POSITION_X | Fiducial station 1 position vector x | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| FIDUCIAL_STAT1_POSITION_Y | Fiducial station 1 position vector y | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| FIDUCIAL_STAT1_POSITION_Z | Fiducial station 1 position vector z | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| FIDUCIAL_STAT1_VELOCITY_X | Fiducial station 1 velocity vector x | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| FIDUCIAL_STAT1_VELOCITY_Y | Fiducial station 1 velocity vector y | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| FIDUCIAL_STAT1_VELOCITY_Z | Fiducial station 1 velocity vector z | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| FIDUCIAL_STAT2_POSITION_X | Fiducial station 2 position vector x | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| FIDUCIAL_STAT2_POSITION_Y | Fiducial station 2 position vector y | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| FIDUCIAL_STAT2_POSITION_Z | Fiducial station 2 position vector z | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| FIDUCIAL_STAT2_VELOCITY_X | Fiducial station 2 velocity vector x | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| FIDUCIAL_STAT2_VELOCITY_Y | Fiducial station 2 velocity vector y | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8 | 8         | var        | var    |

| Name                      | Description                                      | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|---------------------------|--|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| FIDUCIAL_STAT2_VELOCITY_Z | Fiducial station 2 velocity vector z             | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| METOP_MISPOINTING_ROLL    | Mispointing angle Dh                             | 10 <sup>3</sup> | deg   | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| METOP_MISPOINTING_PITCH   | Mispointing angles Dx                            | 10 <sup>3</sup> | deg   | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| METOP_MISPOINTING_YAW     | Mispointing angles Dz                            | 10 <sup>3</sup> | deg   | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| METOP_TRUE_LATITUDE       | Metop true latitude angle                        | 10 <sup>3</sup> | deg   | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| USO_FREQUENCY_CORRECTION  | USO frequency correction                         | 10 <sup>9</sup> | Hz    | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| USO_FREQUENCY_COMP        | USO frequency after the correction               | 10 <sup>9</sup> | Hz    | N    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| L1_CA_PHASE               | L1-C/A carrier phase after instrument correction | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L1_P1_PHASE               | L1-P1 carrier phase after instrument correction  | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L2_P2_PHASE               | L2-P2 carrier phase after instrument correction  | 10 <sup>6</sup> | m     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L1_CA_AMPLITUDE           | L1-C/A amplitude after instrument correction     | 10 <sup>9</sup> | dBV   | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L1_P1_AMPLITUDE           | L1-P1 amplitude after instrument correction      | 10 <sup>9</sup> | dBV   | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L2_P2_AMPLITUDE           | L2-P2 amplitude after instrument correction      | 10 <sup>9</sup> | dBV   | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L1_NOISE                  | L1 noise estimate                                | 10 <sup>9</sup> | dB    | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L2_NOISE                  | L2 noise estimate                                | 10 <sup>9</sup> | dB    | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| RESIDUAL_PHASE_DELAY_L1   | Residual phase delay L1                          | 10 <sup>9</sup> | m     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| RESIDUAL_PHASE_DELAY_L2   | Residual phase delay L2                          | 10 <sup>9</sup> | m     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| RESIDUAL_DOPPLER_SHIFT_L1 | Residual Doppler shift L1                        | 10 <sup>9</sup> | m/s   | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |



| Name                             | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|----------------------------------|--|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| RESIDUAL_DOPPLER_SHIFT_L2        | Residual Doppler shift L2                              | 10 <sup>9</sup> | m/s   | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| GO_BENDING_ANGLE_L1              | GO Bending angle L1                                    | 10 <sup>9</sup> | rad   | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| GO_BENDING_ANGLE_L2              | GO Bending angle L2                                    | 10 <sup>9</sup> | rad   | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| GO_IMPACT_PARAMETE_L1            | GO Impact parameter L1                                 | 10 <sup>9</sup> | m     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| GO_IMPACT_PARAMETE_L2            | GO Impact parameter L2                                 | 10 <sup>9</sup> | m     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| IONOSPHERIC_CORRECTED_GO_BENDING | GO Ionospheric corrected bending angle                 | 10 <sup>9</sup> | rad   | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| TEC                              | Total electron content along the ray path              | 10 <sup>9</sup> | TECU  | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| GO_APPROXIMATE_L1_RAY_HEIGHT     | GO Impact parameter L1 - local radius of the curvature | 10 <sup>9</sup> | m     | N    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| NUMBER_OF_SAMPLES_CP             | Number of code phase measurement samples, M            |                 |       | 1    | 1    | 1    | 1    | uinteger4 | 4         | 4          | var    |
| TIME_REF_CP                      | Reference time of the sample                           | 10 <sup>9</sup> | s     | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| TIME_UTC_CP                      | UTC time of the sample                                 | 10 <sup>9</sup> | s     | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| TIME_START_OCCULTATION_CP        | Time from the beginning of the occultation             | 10 <sup>9</sup> | s     | M    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| L1_CA_CODE_PHASE                 | L1-C/A code phase after instrument correction          | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| L1_P1_CODE_PHASE                 | L1-P1 code phase after instrument correction           | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| L2_P2_CODE_PHASE                 | L2-P2 code phase after instrument correction           | 10 <sup>9</sup> | chips | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| L1_CA_PSEUDORANGE                | L1-C/A pseudorange after instrument correction         | 10 <sup>9</sup> | m     | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |

| Name                             | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|----------------------------------|--|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| L1_P1_PSEUDORANGE                | L1-P1 pseudorange after instrument correction      | 10 <sup>9</sup> | m     | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| L2_P2_PSEUDORANGE                | L2-P2 pseudorange after instrument correction      | 10 <sup>9</sup> | m     | M    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| NUMBER_OF_SAMPLES_WO             | Number of samples in the Wave Optics processing, W |                 |       | 1    | 1    | 1    | 1    | uinteger4 | 4         | 4          | var    |
| TIME_REF_WO                      | Reference time of the WO sample                    | 10 <sup>9</sup> | s     | W    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| TIME_UTC_WO                      | UTC time of the WO sample                          | 10 <sup>9</sup> | s     | W    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| BP_HEIGHT                        | Height in BP plane                                 | 10 <sup>6</sup> | m     | W    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| WO_L1_CA_AMPLITUDE               | L1 C/A amplitude in BP plane                       | 10 <sup>9</sup> | dBV   | W    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| WO_L1_P_AMPLITUDE                | L1 P amplitude in BP plane                         | 10 <sup>9</sup> | dBV   | W    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| WO_L2_P_AMPLITUDE                | L2 P amplitude in BP plane                         | 10 <sup>9</sup> | dBV   | W    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| WO_RESIDUAL_PHASE_DELAY_L1       | Residual phase delay L1 in BP plane                | 10 <sup>9</sup> | m     | W    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| WO_RESIDUAL_PHASE_DELAY_L2       | Residual phase delay L2 in BP plane                | 10 <sup>9</sup> | m     | W    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| WO_RESIDUAL_DOPPLER_SHIFT_L1     | Residual Doppler shift L1 in BP plane              | 10 <sup>9</sup> | m/s   | W    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| WO_RESIDUAL_DOPPLER_SHIFT_L2     | Residual Doppler shift L2 in BP plane              | 10 <sup>9</sup> | m/s   | W    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| WO_BENDING_ANGLE_L1              | WO Bending angle L1                                | 10 <sup>9</sup> | rad   | W    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| WO_BENDING_ANGLE_L2              | WO Bending angle L2                                | 10 <sup>9</sup> | rad   | W    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| WO_IMPACT_PARAMETE_L1            | WO Impact parameter L1                             | 10 <sup>9</sup> | m     | W    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| WO_IMPACT_PARAMETE_L2            | WO Impact parameter L2                             | 10 <sup>9</sup> | m     | W    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| IONOSPHERIC_CORRECTED_WO_BENDING | WO Ionosphere corrected bending angle              | 10 <sup>9</sup> | rad   | W    | 1    | 1    | 1    | integer8  | 8         | var        | var    |

| Name                         | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type      | Type size | Field size | Offset |
|------------------------------|--|-----------------|-------|------|------|------|------|-----------|-----------|------------|--------|
| WO_APPROXIMATE_L1_RAY_HEIGHT | WO Impact parameter L1 - local radius of the curvature   | 10 <sup>9</sup> | m     | W    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| NUMBER_OF_SAMPLES_RS         | Number of samples in a raw sampling mode, K  |                 |       | 1    | 1    | 1    | 1    | uinteger4 | 4         | 4          | var    |
| TIME_IMT_RS                  | IMT time stamp of the sample   | 10 <sup>9</sup> | s     | K    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| TIME_UTC_GRAS_RS             | UTC_GRAS time stamp of the sample  | 10 <sup>9</sup> | s     | K    | 1    | 1    | 1    | uinteger8 | 8         | var        | var    |
| TIME_OBT_RS                  | OBT time stamp of the sample   |                 | s     | K    | 1    | 1    | 1    | longtime  | 8         | var        | var    |
| TIME_REF_RS                  | Reference time of the sample   | 10 <sup>9</sup> | s     | K    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| P_1_RS                       | L1 NCO phase of first sample   |                 |       | K    | 1    | 1    | 1    | integer8  | 8         | var        | var    |
| F1_1_RS                      | L1 NCO frequency setting for L1 carrier during sequence 1 in this packet                             |                 |       | K    | 1    | 1    | 1    | integer4  | 4         | var        | var    |
| TINT1_RS                     | Total integration time from IMT when F1_1 is valid until F2_1 is set                                 |                 |       | K    | 1    | 1    | 1    | uinteger4 | 4         | var        | var    |
| F2_1_RS                      | L1 NCO frequency setting for L1 carrier during sequence 2 in this packet                             |                 |       | K    | 1    | 1    | 1    | integer4  | 4         | var        | var    |
| TINT2_RS                     | Total integration time from IMT+TINT1 when F2_1 is valid until the last measurement of the packet    |                 |       | K    | 1    | 1    | 1    | uinteger4 | 4         | var        | var    |
| IQ_CA_EXP_RS                 | Exponent of I/Q samples  |                 |       | K    | 1    | 1    | 1    | uinteger2 | 2         | var        | var    |
| I_CA_RS                      | I sample of L1 carrier amplitude in terms of normalised counts of the C/A punctual correlation value |                 |       | K    | 1    | 1    | 1    | integer2  | 2         | var        | var    |

| Name            | Description  | Scaling factor  | Units | Dim1 | Dim2 | Dim3 | Dim4 | Type     | Type size | Field size | Offset |
|-----------------|--|-----------------|-------|------|------|------|------|----------|-----------|------------|--------|
| Q_CA_RS         | Q sample of L1 carrier amplitude in terms of normalised counts of the C/A punctual correlation value |                 |       | K    | 1    | 1    | 1    | integer2 | 2         | var        | var    |
| L1_PHASE_RS     | L1 carrier phase after instrument correction   | 10 <sup>9</sup> | deg   | K    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| L1_AMPLITUDE_RS | L1 amplitude after instrument correction   | 10 <sup>9</sup> | dBV   | K    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| L1_NOISE_RS     | L1 noise estimate  | 10 <sup>9</sup> | dB    | K    | 1    | 1    | 1    | integer8 | 8         | var        | var    |
| Total: var      |  |                 |       |      |      |      |      |          |           |            |        |

**Enumeration BE\_MODEL**

| Value | Name       | Description                |
|-------|------------|----------------------------|
| 0     | MSISE90    | Baseline                   |
| 1     | NRLMSISE00 | Updated model from MSISE90 |
| 2     | Spare      |                            |

**Enumeration DISPOSITION\_MODE**

| Value | Name          | Description |
|-------|---------------|-------------|
| T     | Testing       |             |
| O     | Operational   |             |
| C     | Commissioning |             |

**Enumeration EARTH\_MODEL\_ID**

| Value | Name                  | Description |
|-------|-----------------------|-------------|
| 0     | Not used              |             |
| 1     | WGS84 ellipsoid model |             |

**Enumeration GPS\_SH**

| Value | Name             | Description |
|-------|------------------|-------------|
| 0     | All signals OK   |             |
| 1     | All signals weak |             |

|    |  |  |
|----|--|--|
| 2  | All signals dead                         |  |
| 3  | All signals have no data modulation      |  |
| 4  | L1P signal weak                          |  |
| 5  | L1P signal dead                          |  |
| 6  | L1P signal has no data modulation        |  |
| 7  | L2P signal weak                          |  |
| 8  | L2P signal dead                          |  |
| 9  | L2P signal has no data modulation        |  |
| 10 | L1C signal weak                          |  |
| 11 | L1C signal dead                          |  |
| 12 | L1C signal has no data modulation        |  |
| 13 | L2C signal weak                          |  |
| 14 | L2C signal dead                          |  |
| 15 | L2C signal has no data modulation        |  |
| 16 | L1 and L2P signal weak                   |  |
| 17 | L1 and L2P signal dead                   |  |
| 18 | L1 and L2P signal has no data modulation |  |
| 19 | L1 and L2C signal weak                   |  |
| 20 | L1 and L2C signal dead                   |  |
| 21 | L1 and L2C signal has no data modulation |  |
| 22 | L1 signal weak                           |  |
| 23 | L1 signal dead                           |  |
| 24 | L1 signal has no data modulation         |  |

|    |   |  |
|----|---|--|
| 25 | L2 signal weak  |  |
| 26 | L2 signal dead  |  |
| 27 | L2 signal has no data modulation                                  |  |
| 28 | SV is temporarily out   | Do not use this SV during current pass |
| 29 | SV will be temporarily out  | Use with caution                       |
| 30 | Spare   |  |
| 31 | More than one combination would be required to describe anomalies |  |

### Enumeration GRAS\_CHANNEL\_ID

| Value | Name                   | Description |
|-------|------------------------|-------------|
| 0     | Zenith chain 0         |             |
| 1     | Zenith chain 1         |             |
| 2     | Zenith chain 2         |             |
| 3     | Zenith chain 3         |             |
| 4     | Zenith chain 4         |             |
| 5     | Zenith chain 5         |             |
| 6     | Zenith chain 6         |             |
| 7     | Zenith chain 7         |             |
| 8     | Velocity chain 8       |             |
| 9     | Velocity chain 9       |             |
| 10    | Anti-velocity chain 10 |             |
| 11    | Anti-velocity chain 11 |             |

**Enumeration GRAS\_ID**

| Value | Name     | Description |
|-------|----------|-------------|
| 0     | Not used |             |
| 1     | GRAS 1   |             |
| 2     | GRAS 2   |             |
| 3     | GRAS 3   |             |

**Enumeration INSTRUMENT\_ID**

| Value | Name     | Description                                  |
|-------|----------|--|
| AMSA  | AMSU-A   |  |
| ASCA  | ASCAT    |  |
| ATOV  | ATOVs    | instruments: AVHRR/3, HIRS/4, AMSU-A, MHS    |
| AVHR  | AVHRR/3  |  |
| GOME  | GOME     |  |
| GRAS  | GRAS     |  |
| HIRS  | HIRS/4   |  |
| IASI  | IASI     |  |
| MHSx  | MHS      |  |
| NOAA  | All NOAA | instruments specific to Level 0 NOAA product |
| SEMx  | SEM      |  |
| ADCS  | ADCS     |  |



|      |                        |                          |
|------|------------------------|--------------------------|
| SBUV | SBUV                   |                          |
| xxxx | No specific instrument |                          |
| HKTM | VCDU34                 | data specific to Level 0 |

### Enumeration INSTRUMENT\_MODEL

| Value | Name              | Description |
|-------|-------------------|-------------|
| 0     | Reserved          |             |
| 1     | Flight Model 1    |             |
| 2     | Flight Model 2    |             |
| 3     | Engineering Model |             |
| 4     | Protoflight Model |             |

### Enumeration MEASUREMENT\_TYPE

| Value | Name       | Description            |
|-------|------------|------------------------|
| 0     | Rising     | Rising occultation     |
| 1     | Setting    | Setting occultation    |
| 2     | Navigation | Navigation measurement |
| 3     | Spare      |                        |

**Enumeration METOP\_STEERING\_MODE**

| Value | Name                    | Description |
|-------|-------------------------|-------------|
| 0     | Rate Reduction Mode     |             |
| 1     | Coarse Acquisition Mode |             |
| 2     | Fine Acquisition Mode 1 |             |
| 3     | Fine Acquisition Mode 2 |             |
| 4     | Fine Acquisition Mode 3 |             |
| 5     | Operational Mode        |             |
| 6     | Fine Pointing Mode      |             |
| 7     | Yaw Steering Mode       |             |
| 8     | Orbit Control Mode      |             |
| 9     | Fine Control Mode       |             |
| 10    | Safe Mode               |             |

**Enumeration ONBOARD\_NAV\_SOLUTION**

| Value | Name                          | Description  |
|-------|-------------------------------|--|
| 0     | Not navigation solution       |  |
| 1     | Propagated initial settings   |  |
| 2     | First-fix                     |  |
| 4     | Calculated with least square  |  |
| 5     | Calculated with Kalman filter |  |
| 7     | Invalid navigation solution   | An invalid navigation solution will be indicated if least square is used |

|  |  |  |
|--|--|--|
|  |  | and less than 4 satellites are in the field-of-view of the zenith antenna.<br>The reported navigation solution will be the propagated one. |
|--|--|--|

### Enumeration PROCESSING\_CENTRE

| Value | Name | Description                             |
|-------|------|---|
| CGS1  |      | First EUMETSAT EPS Core Ground Segment  |
| CGS2  |      | Second EUMETSAT EPS Core Ground Segment |
| CGS3  |      | Third EUMETSAT EPS Core Ground Segment  |
| NSSx  |      | NOAA/NESDIS                             |
| RUSx  |      | Reference User Station                  |
| DMIx  |      | DMI, Copenhagen (GRAS SAF)              |
| DWDx  |      | DWD, Offenbach (Climate SAF)            |
| FMIx  |      | FMI , Helsinki (Ozone SAF)              |
| IMPx  |      | IMP, Lisbon (Land SAF)                  |
| INMx  |      | INM, Madrid (NCW SAF)                   |
| MFxx  |      | MF, Lannion (OSI SAF)                   |
| UKMO  |      | UKMO, Bracknell (NWP SAF)               |

### Enumeration PROCESSING\_LEVEL

| Value | Name    | Description |
|-------|---------|-------------|
| 00    | Level 0 |             |
| 01    | Level 1 |             |

|    |                   |  |
|----|-------------------|--|
| 1A | Level 1a          |  |
| 1B | Level 1b          |  |
| 1C | Level 1c          |  |
| 02 | Level 2           |  |
| 03 | Level 3           |  |
| xx | No Specific Level |  |

### Enumeration PROCESSING\_MODE

| Value | Name               | Description    |
|-------|--------------------|----------------|
| N     | Nominal            | NRT processing |
| B     | Backlog Processing |                |
| R     | Reprocessing       |                |
| V     | Validation         |                |

### Enumeration PRODUCT\_TYPE

| Value | Name | Description  |
|-------|------|--|
| ENG   |      | IASI engineering data                                      |
| GAC   |      | NOAC Global Area Coverage AVHRR data                       |
| SND   |      | Sounding Data  |
| SZF   |      | ASCAT calibrated s0 data at full resolution                |
| SZO   |      | ASCAT calibrated s0 data at operational resolution (50 km) |
| SZR   |      | ASCAT calibrated s0 data at research resolution (25 km)    |

|     |  |                                    |
|-----|--|------------------------------------|
| VER |  | IASI verification data             |
| xxx |  | No specific product type specified |
| AIP |  | NOAA AIP/SAIP data                 |
| TIP |  | NOAA TIP/STIP data                 |
| HRP |  | HRPT data                          |
| LRP |  | LRPT data                          |

### Enumeration RECEIVER\_ANALOG\_GAIN

| Value | Name | Description   |
|-------|------|---|
| 5     | 0    | Analogue Gain Setting values obtained from the AGGA |
| 9     | -5   |   |
| 6     | -10  |   |
| 10    | -15  |   |

### Enumeration RECEIVING\_GROUND\_STATION

| Value | Name | Description   |
|-------|------|---|
| SVL   |      | Svalbard  |
| WAL   |      | Wallops Island, Virginia  |
| FBK   |      | Fairbanks, Alaska   |
| SOC   |      | SOCC (NESDIS Satellite Operations Control Centre), Suitland, Maryland |
| RUS   |      | Reference User Station  |

**Enumeration SELECTED\_CLOCK\_CORRECTION\_METHOD**

| Value | Name | Description           |
|-------|------|-----------------------|
| 0     | ND   | No differencing       |
| 1     | SD1  | Single differencing 1 |
| 2     | SD2  | Single differencing 2 |
| 3     | DD1  | Double differencing 1 |
| 4     | DD2  | Double differencing 2 |

**Enumeration SPACECRAFT\_ID**

| Value | Name | Description            |
|-------|------|------------------------|
| xxx   |      | No specific spacecraft |
| M01   |      | METOP 01               |
| M02   |      | METOP 02               |
| M02   |      | METOP 03               |
| N15   |      | NOAA-K                 |
| N16   |      | NOAA-L                 |
| N17   |      | NOAA-M                 |
| N18   |      | NOAA-N                 |
| N19   |      | NOAA-N'                |

### Enumeration TEC\_METHOD

| Value | Name            | Description |
|-------|-----------------|-------------|
| 0     | TEC at level 1a |             |
| 1     | TEC at level 1b |             |
| 2     | Spare           |             |

### Bitfield ATM\_MULTIPATH

*Length 4 bytes*

| Name                                  | Description   | Length |
|---------------------------------------|---|--------|
| unused                                |   | 30     |
| Atmospheric_multipath_in_troposphere  | 0 = Atmospheric multipath has not been detected<br>1 = Atmospheric multipath detected | 1      |
| Atmospheric_multipath_in_stratosphere | 0 = Atmospheric multipath has not been detected<br>1 = Atmospheric multipath detected | 1      |
| Total                                 |   | 32     |

### Bitfield CLOCK\_CORRECTION\_FALLBACK\_MODE

*Length 1 bytes*

| Name      | Description                   | Length |
|-----------|-------------------------------|--------|
| Spare     |                               | 2      |
| ND_failed | No clock correction           | 1      |
| SD1__ND   | 0=no, 1=mode change performed | 1      |

|               |                               |   |
|---------------|-------------------------------|---|
| SD2__SD1      | 0=no, 1=mode change performed | 1 |
| DD1__SD2      | 0=no, 1=mode change performed | 1 |
| DD2__DD1      | 0=no, 1=mode change performed | 1 |
| Fallback_mode | 0=not activated, 1=activated  | 1 |
| Total         |                               | 8 |

### Bitfield LOCAL\_MULTIPATH\_SOURCE

*Length 2 bytes*

| Name                         | Description                 | Length |
|------------------------------|-----------------------------|--------|
| Spare                        |                             | 13     |
| ASCAT_ANT_RF_in_the_FOV      | 0=outside FOV, 1=inside FOV | 1      |
| ASCAT_ANT_RA_in_the_FOV      | 0=outside FOV, 1=inside FOV | 1      |
| Metop_solar_panel_in_the_FOV | 0=outside FOV, 1=inside FOV | 1      |
| Total                        |                             | 16     |

### Bitfield RECEIVER\_DIGITAL\_GAIN

*Length 6 bytes*

| Name  | Description | Length |
|-------|-------------|--------|
| CCT_5 |             | 8      |
| CCT_4 |             | 8      |
| CCT_3 |             | 8      |
| CCT_2 |             | 8      |



|       |  |    |
|-------|--|----|
| CCT_1 |  | 8  |
| CCT_0 |  | 8  |
| Total |  | 48 |

### Bitfield SSD\_AVAILABILITY

*Length 2 bytes*

| Name  | Description   | Length |
|---|---|--------|
| Spare                                       |   | 10     |
| Station 2 TZD estimate                      | 0 = available, 1 = not available or error too large | 1      |
| Station 1 TZD estimate                      | 0 = available, 1 = not available or error too large | 1      |
| Station_characterisation_data_for_station_2 | 0 = available, 1 = not available                    | 1      |
| Station_characterisation_data_for_station_1 | 0 = available, 1 = not available                    | 1      |
| SSD_fiducial_station_2                      | 0 = available, 1 = not available                    | 1      |
| SSD_fiducial_station_1                      | 0 = available, 1 = not available                    | 1      |
| Total                                       |   | 16     |

### Bitfield TELEMETRY\_IN\_RANGE

*Length 3 bytes*

| Name        | Description                        | Length |
|-------------|------------------------------------|--------|
| Spare       |                                    | 3      |
| Digital_5_V | 0 - Within range 1 - Outside range | 1      |
| USO_ground  | 0 - Within range 1 - Outside range | 1      |

|                                  |                                    |    |
|----------------------------------|------------------------------------|----|
| FG_thermistor                    | 0 - Within range 1 - Outside range | 1  |
| Thermistor_supply_voltage        | 0 - Within range 1 - Outside range | 1  |
| DBU_power_voltage                | 0 - Within range 1 - Outside range | 1  |
| USO_external_thermistor          | 0 - Within range 1 - Outside range | 1  |
| USO_internal_thermistor          | 0 - Within range 1 - Outside range | 1  |
| ISAC_thermistor                  | 0 - Within range 1 - Outside range | 1  |
| GEU_thermistor                   | 0 - Within range 1 - Outside range | 1  |
| Anti_velocity_RFCU_thermistor    | 0 - Within range 1 - Outside range | 1  |
| Velocity_RFCU_thermistor         | 0 - Within range 1 - Outside range | 1  |
| Zenith_RFCU_thermistor           | 0 - Within range 1 - Outside range | 1  |
| Anti_velocity_antenna_thermistor | 0 - Within range 1 - Outside range | 1  |
| Velocity_antenna_thermistor      | 0 - Within range 1 - Outside range | 1  |
| Zenith_antenna_thermistor        | 0 - Within range 1 - Outside range | 1  |
| ENDP_Velocity_Z                  | 0 - Within range 1 - Outside range | 1  |
| ENDP_Velocity_Y                  | 0 - Within range 1 - Outside range | 1  |
| ENDP_Velocity_X                  | 0 - Within range 1 - Outside range | 1  |
| ENDP_Position_Z                  | 0 - Within range 1 - Outside range | 1  |
| ENDP_Position_Y                  | 0 - Within range 1 - Outside range | 1  |
| ENDP_Position_X                  | 0 - Within range 1 - Outside range | 1  |
| Total                            |                                    | 24 |

## Bitfield WO\_CHARACTERISATION

*Length 4 bytes*

| Name                    | Description  | Length |
|-------------------------|--|--------|
| Spare                   |  | 27     |
| Phase_Matching          | 0=GOPM method has not been applied, 1=GOPM method has been applied | 1      |
| Full_Spectrum_Inversion | 0=FSI method has not been applied, 1=FSI method has been applied   | 1      |
| Canonical_Transform_2   | 0 =CT2 method has not been applied, 1=CT2 method has been applied  | 1      |
| Canonical_Transform     | 0=CT method has not been applied, 1=CT method has been applied     | 1      |
| Back_Propagation        | 0=BP method has not been applied, 1=BP method has been applied     | 1      |
| Total                   |  | 32     |

## Bitfield TRACKING\_STATE

*Length 2 bytes*

| Name  | Description | Length |
|---|-------------|--------|
| P_code_and_L2_carrier_tracking_highest_tracking_state |             | 1      |
| P_code_tracking                                       |             | 1      |
| P_code_acquisition                                    |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| undefined   |             | 1      |
| Single_carrier_frequency_tracking_at_10_ms            |             | 1      |
| Single_carrier_frequency_tracking_at_1_ms             |             | 1      |

|                                |  |    |
|--------------------------------|--|----|
| undefined                      |  | 1  |
| undefined                      |  | 1  |
| undefined                      |  | 1  |
| undefined                      |  | 1  |
| L1_carrier_lock_check          |  | 1  |
| C/A_code_lock_check            |  | 1  |
| C/A_code_acquisition           |  | 1  |
| Acquisition_and_tracking_ended |  | 1  |
| Total                          |  | 16 |

## Supplement of Product Guide Common Appendices

The following sections comprise appendices containing information that is relevant for all the EPS Product Guides.

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## APPENDIX A SUMMARY OF ALL EPS PRODUCTS

In this annex, we summarise all EPS products generated at EUMETSAT or the SAFs up to Level 2.

The following is a definition of the different product levels, as understood in the EPS context:

Level 0: Raw data after restoration of the chronological data sequence for each instrument, i.e. after demultiplexing of the data by instrument, removal of any data overlap due to the data dump procedure and relevant quality checks. Raw instrument data information (telemetry packets) is maintained during this process.

Level 1a: Instrument data in full resolution with radiometric and geometric (i.e. Earth location) calibration computed and appended but not applied.

Level 1b: Calibrated, Earth-located and quality-controlled product, expressed as radiance or brightness temperature, in the original pixel location, and packaged with needed ancillary, engineering and auxiliary data.

Level 1c: In the case of the IASI spectra, Level 1b data after application of the apodisation function and addition of co-registered AVHRR radiance analysis.

Level 2: Earth-located values converted to geophysical parameters, at the same spatial and temporal sampling as the Level 1b or Level 1c data.

Level 3: Gridded point geophysical products on a multi-pass basis.

It is understood that the average user is interested in products of Level 1b and higher. Details on Level 0 and Level 1a products will thus not be provided in this summary.

Concerning Level 3 and higher, the SAFs generate a variety of both products and software, based not only on Metop or NOAA data, but on many other satellite data and conventional observations. For a complete and updated list of these high-level products, it is best to check the EUMETSAT SAF page from [www.eumetsat.int](http://www.eumetsat.int) or the specific SAF pages which are linked from there.

In the following table, NRT and ARC stand for Near Real Time and Archive respectively. When the archive is specifically the EUMETSAT archive, ARC is replaced in the table by UMARF.

*Note that the following table is not complete for all products.*

| SATELLITE | PRODUCT NAME    | LEVEL | MAIN<br>GEOPHYSICAL<br>/ENG<br>PARAMETER | PRODUCER | COVERAGE | DISSEMINATION | NRT<br>TIMELINESS | ACCURACY   | SWATH<br>WIDTH                     | H-<br>RESOLUTION  | V-<br>RESOLUTION | H-samp  | V-samp |
|-----------|-----------------|-------|--|----------|----------|---------------|-------------------|--|------------------------------------|---|------------------|---|--------|
| Metop     | AVHR_xxx_1B_Mnn | 1b    | Radiances                                | EPS CGS  | Global   | NRT&UMARF     | 2 h 15 m          | 1 K ( $\mu$ wave & IR channels)<br><br>Geolocation: <1 km<br><br>Channel to Channel Misregistration: $\leq 0.1$ mrad | 1447 km (2048 Earth view samples)  | Square IFOV: 0.0745 deg, equivalent to 1.08x1.08 km at nadir                    | N/A              | 1.08 km across track at nadir, 1.1 km along track                             | N/A    |
| Metop     | HIRS_xxx_1B_Mnn | 1b    | Radiances                                | EPS CGS  | Global   | NRT&UMARF     | 2 h 15 m          | 1 K (IR channels)<br><br>Albedo: $10^{-2}$ digits not affected by rounding   | 1080.35 km (56 Earth view samples) | Circular IFOV: 0.69 deg, equivalent to 10.0 km at nadir                         | N/A              | 10.0 km across track at nadir, 42.15 km along track                           | N/A    |
| Metop     | AMSA_xxx_1B_Mnn | 1b    | Radiances                                | EPS CGS  | Global   | NRT&UMARF     | 2 h 15 m          | 1 K  | 1026 km (30 Earth view samples)    | Circular IFOV: 3.3 deg, equivalent to 47.63 km at nadir                         | N/A              | 47.63 km across track at nadir, 52.69 km along track                          | N/A    |
| Metop     | MHSx_xxx_1B_Mnn | 1b    | Radiances                                | EPS CGS  | Global   | NRT&UMARF     | 2 h 15 m          | 1 K  | 1077.68 km (90 Earth view samples) | Circular IFOV: 1.1 deg, equivalent to 15.88 km at nadir                         | N/A              | 15.88 km across track at nadir, 17.56 km along track                          | N/A    |
| NOAA      | AVHR_GAC_1B_Nnn | 1b    | Radiances                                | EPS CGS  | Global   | NRT&UMARF     | 2 h 15 m          | 1 K ( $\mu$ wave & IR channels)<br><br>Geolocation: <1 km<br><br>Channel to Channel Misregistration: $\leq 0.1$ mrad | 1447 km (409 Earth view samples)   | 1.1 (along-track) x 4.4 (across-track) km at nadir<br><br>(NOAA/GAC resolution) | N/A              | 3.3 (along-track) x 4.4 (across-track) km at nadir<br><br>(NOAA/GAC sampling) | N/A    |

| SATELLITE | PRODUCT NAME    | LEVEL | MAIN<br>GEOPHYSICAL<br>/ENG<br>PARAMETER | PRODUCER | COVERAGE | DISSEMINATION | NRT<br>TIMELINESS | ACCURACY  | SWATH<br>WIDTH                     | H-<br>RESOLUTION  | V-<br>RESOLUTION | H-samp  | V-samp           |
|-----------|-----------------|-------|--|----------|----------|---------------|-------------------|---|------------------------------------|---|------------------|---|------------------|
| NOAA      | HIRS_xxx_1B_Nnn | 1b    | Radiances                                | EPS CGS  | Global   | NRT&UMARF     | 2 h 15 m          | 1 K (IR channels)<br><br>Albedo: 10 <sup>-2</sup> digits not affected by rounding   | 1080.35 km (56 Earth view samples) | Circular IFOV: 0.69 deg, equivalent to 10.0 km at nadir | N/A              | 10.0 km across track at nadir, 42.15 km along track                         | N/A              |
| NOAA      | AMSA_xxx_1B_Nnn | 1b    | Radiances                                | EPS CGS  | Global   | NRT&UMARF     | 2 h 15 m          | 1 K   | 1026 km (30 Earth view samples)    | Circular IFOV: 3.3 deg, equivalent to 47.63 km at nadir | N/A              | 47.63 km across track at nadir, 52.69 km along track                        | N/A              |
| NOAA      | MHSx_xxx_1B_Nnn | 1b    | Radiances                                | EPS CGS  | Global   | NRT&UMARF     | 2 h 15 m          | 1 K   | 1077.68 km (90 Earth view samples) | Circular IFOV: 1.1 deg, equivalent to 15.88 km at nadir | N/A              | 15.88 km across track at nadir, 17.56 km along track                        | N/A              |
| Metop     | IASI_xxx_1B_Nnn | 1b    | Radiances                                | EPS CGS  | Global   | NRT&UMARF     | 2 h 15 m          |   |                                    |   |                  |   |                  |
| Metop     | GRAS_xxx_1B_Mnn | 1b    | Bending angle                            | EPS CGS  | Global   | NRT&UMARF     | 2 h 15 m          | 1 µrad or 0.4% (whichever is larger)  |                                    |   |                  | <1000 km (mean distance between individual soundings over 12 h time window) | Surface to 80 km |
| Metop     | GOME_xxx_1B_Mnn | 1b    |  | EPS CGS  | Global   | NRT&UMARF     | 2 h 15 m          | Geolocation: Barycentres of each FOV shall be positioned no worse than 0.06° of the scan mirror<br><br>TBD (46.435° scan angle) |                                    |   |                  | Instrument Footprint  | N/A              |
| Metop     | ASCA_SZO_1B_Mnn | 1b    | ASCAT σ <sub>0</sub> (normalised)        | EPS CGS  | Global   | NRT&UMARF     | 2 h 15 m          | Radiometric accuracy:   | Double swath of                    | 50x50 km  | N/A              | 25 km (21 nodes)  | N/A              |



| SATELLITE | PRODUCT NAME    | LEVEL | MAIN<br>GEOPHYSICAL<br>/ENG<br>PARAMETER                    | PRODUCER | COVERAGE | DISSEMINATION | NRT<br>TIMELINESS | ACCURACY  | SWATH<br>WIDTH   | H-<br>RESOLUTION                        | V-<br>RESOLUTION | H-samp  | V-samp                       |
|-----------|-----------------|-------|---|----------|----------|---------------|-------------------|---|--|---|------------------|---|------------------------------|
|           |                 |       | backscatter) triplets                                       |          |          |               |                   | 0.5 db peak-to-peak<br><br>Radiometric resolution: 2 - 5%<br><br>Geolocation: 4 km                        | 550 km with a gap around satellite track of 700 km                 |   |                  |   |                              |
| Metop     | ASCA_SZR_1B_Mnn | 1b    | ASCAT $\sigma_0$ (normalised backscatter) triplets          | EPS CGS  | Global   | NRT&UMARF     | 2 h 15 m          | Radiometric accuracy: 0.5 db peak-to-peak<br><br>Radiometric resolution: 4 - 11%<br><br>Geolocation: 4 km | Double swath of 550 km with a gap around satellite track of 700 km | (25-34)x(25-34) km                      | N/A              | 12.5 km (41 nodes)  | N/A                          |
| Metop     | ASCA_FUL_1B_Mnn | 1b    | ASCAT $\sigma_0$ (normalised backscatter) individual values | EPS CGS  | Global   | UMARF         | 2 h 15 m          | Radiometric accuracy: 0.5 db peak-to-peak<br><br>Geolocation: 4 km  | Double swath of 550 km with a gap around satellite track of 700 km | Instrument resolution (approx 20x10 km) | N/A              | Instrument sampling (256 values along each antenna footprint)               | N/A                          |
| Metop     | IASI_XXX_1C_Mnn | 1c    | Radiances   | EPS CGS  | Global   | NRT&UMARF     | 2 h 15 m          | 1 K (IR channels)   |  | Instrument FOV                          | N/A              | Instrument FOV  | N/A                          |
| Metop     | ATOV_SND_02_Mnn | 2     | Atmospheric temperature                                     | EPS CGS  | Global   | NRT&UMARF     | 3 h               | 1.7 K Troposphere   | 1080.35 km   | N/A                                     | N/A              | HIRS/4 instrument horizontal sampling grid: 56 pixels per scan and 42.15 km | Typically 40 Pressure levels |
|           |                 |       | Atmospheric water vapour                                    |          |          |               |                   | 2 K Stratosphere<br><br>20%   |  |   |                  |   | Typically 15 Pressure levels |

| SATELLITE | PRODUCT NAME    | LEVEL | MAIN<br>GEOPHYSICAL<br>/ENG<br>PARAMETER | PRODUCER | COVERAGE | DISSEMINATION | NRT<br>TIMELINESS | ACCURACY                              | SWATH<br>WIDTH | H-<br>RESOLUTION | V-<br>RESOLUTION | H-samp  | V-samp                       |
|-----------|-----------------|-------|--|----------|----------|---------------|-------------------|---------------------------------------|----------------|------------------|------------------|---|------------------------------|
|           |                 |       | Surface emissivity                       |          |          |               |                   | n/a (not a retrieved parameter)       |                |                  |                  | scan separation   | N/A                          |
|           |                 |       | Surface Temperature                      |          |          |               |                   | 0.6 K                                 |                |                  |                  |   | N/A                          |
|           |                 |       | Fractional cloud cover                   |          |          |               |                   | 5-10%                                 |                |                  |                  |   | N/A                          |
|           |                 |       | Cloud Top Temperature                    |          |          |               |                   | 1-2 K                                 |                |                  |                  |   | N/A                          |
|           |                 |       | Cloud Top Pressure                       |          |          |               |                   | 50 hPa                                |                |                  |                  |   | N/A                          |
|           |                 |       | Tropopause height                        |          |          |               |                   | 50 hPa                                |                |                  |                  |   | N/A                          |
|           |                 |       | Cloud Liquid Water Content               |          |          |               |                   | 0.04 mm                               |                |                  |                  |   | N/A                          |
|           |                 |       | Total Column Precipitable Water          |          |          |               |                   | 5%                                    |                |                  |                  |   | N/A                          |
| NOAA      | ATOV_SND_02_Nnn | 2     | Atmospheric temperature                  | EPS CGS  | Global   | NRT&UMARF     | 3 h               | 1.7 K Troposphere<br>2 K Stratosphere | 1080.35 km     | N/A              | N/A              | HIRS/4 instrument horizontal sampling grid: 56 pixels per scan and 42.15 km scan separation | Typically 40 Pressure levels |
|           |                 |       | Atmospheric water vapour                 |          |          |               |                   | 20%                                   |                |                  |                  |   | Typically 15 Pressure levels |
|           |                 |       | Surface emissivity                       |          |          |               |                   | n/a (not a retrieved parameter)       |                |                  |                  |   | N/A                          |
|           |                 |       | Surface Temperature                      |          |          |               |                   | 0.6 K                                 |                |                  |                  |   | N/A                          |
|           |                 |       | Fractional cloud cover                   |          |          |               |                   | 5-10%                                 |                |                  |                  |   | N/A                          |

| SATELLITE | PRODUCT NAME  | LEVEL | MAIN<br>GEOPHYSICAL<br>/ENG<br>PARAMETER | PRODUCER | COVERAGE | DISSEMINATION | NRT<br>TIMELINESS | ACCURACY                                  | SWATH<br>WIDTH | H-<br>RESOLUTION | V-<br>RESOLUTION | H-samp  | V-samp   |
|-----------|---|-------|--|----------|----------|---------------|-------------------|---|----------------|------------------|------------------|---|--|
|           |   |       | Cloud Top Temperature                    |          |          |               |                   | 1-2 K                                     |                |                  |                  |   | N/A  |
|           |   |       | Cloud Top Pressure                       |          |          |               |                   | 50 hPa                                    |                |                  |                  |   | N/A  |
|           |   |       | Tropopause height                        |          |          |               |                   | 50 hPa                                    |                |                  |                  |   | N/A  |
|           |   |       | Cloud Liquid Water Content               |          |          |               |                   | 0.04 mm                                   |                |                  |                  |   | N/A  |
|           |   |       | Total Column Precipitable Water          |          |          |               |                   | 5%  |                |                  |                  |   | N/A  |
| Metop     | Reduced ATOVS Level 2 product from Metop (TBD name) | 2     | Atmospheric temperature                  | EPS CGS  | Global   | NRT&UMARF     | 3 h               | 1.7 K Troposphere<br><br>2 K Stratosphere |                |                  |                  | Every 4th HIRS/4 FOV and every 2nd HIRS/4 scan line | Pressure levels for atmospheric temperature and water vapour profiles: every 4th level of the full product |
|           |   |       | Atmospheric water vapour                 |          |          |               |                   | 20%                                       |                |                  |                  |   |  |
|           |   |       | Surface Temperature                      |          |          |               |                   | 0.6 K                                     |                |                  |                  |   | N/A  |
| NOAA      | Reduced ATOVS Level 2 product from Metop (TBD name) | 2     | Atmospheric temperature                  | EPS CGS  | Global   | NRT&UMARF     | 3 h               | 1.7 K Troposphere<br><br>2 K Stratosphere |                |                  |                  | Every 4th HIRS/4 FOV and every 2nd HIRS/4 scan line | Pressure levels for atmospheric temperature and water vapour profiles: every 4th level of the full product |
|           |   |       | Atmospheric                              |          |          |               |                   | 20%                                       |                |                  |                  |   |  |

| SATELLITE      | PRODUCT NAME                  | LEVEL | MAIN<br>GEOPHYSICAL<br>/ENG<br>PARAMETER | PRODUCER                   | COVERAGE | DISSEMINATION | NRT<br>TIMELINESS | ACCURACY  | SWATH<br>WIDTH | H-<br>RESOLUTION | V-<br>RESOLUTION | H-samp                                      | V-samp                             |
|----------------|-------------------------------|-------|--|----------------------------|----------|---------------|-------------------|---|----------------|------------------|------------------|---|------------------------------------|
|                |                               |       | water vapour                             |                            |          |               |                   |   |                |                  |                  |   |                                    |
|                |                               |       | Surface<br>Temperature                   |                            |          |               |                   | 0.6 K   |                |                  |                  |   | N/A                                |
| Metop          | IASI_SND_02_Mnn               | 2     | Atmospheric<br>temperature               | EPS CGS                    | Global   | NRT&UMARF     | 3 h               | 1 K<br>Troposphere<br><br>2 K<br>Stratosphere   |                |                  |                  | IASI FOV                                    | 40 Pressure<br>levels to<br>1 hPa  |
|                |                               |       | Rel Humidity:<br>10%                     |                            |          |               |                   | Rel Humidity:<br>10%                            |                |                  |                  | IASI FOV                                    | 20 Pressure<br>levels to<br>10 hPa |
|                |                               |       | Cloud Cover:<br>10%<10%<br>(climate)     |                            |          |               |                   | Cloud Cover:<br>10%<br><br><10% (climate)       |                |                  |                  | IASI FOV                                    | N/A                                |
|                |                               |       | Cloud Top<br>Temperature: 2K             |                            |          |               |                   | Cloud Top<br>Temperature:<br>2 K                |                |                  |                  | IASI FOV                                    | N/A                                |
|                |                               |       | Cloud Top<br>Height: 300m                |                            |          |               |                   | Cloud Top<br>Height: 300m                       |                |                  |                  | IASI FOV                                    | N/A                                |
|                |                               |       | Trace gases                              |                            |          |               |                   | Trace gases:<br>CH4 <20%<br>N2O <20%<br>CO <10% |                |                  |                  | 250 km                                      | N/A                                |
| Metop          | Near Surface Wind<br>Vector   | 2     |  | Ocean & Sea<br>Ice SAF     | Global   | NRT           | 3 h               | 2 m/s<br>(vector<br>components)                 |                |                  |                  | nominal:<br>50 km<br><br>research:<br>25 km | N/A                                |
| Metop/<br>NOAA | Cloud Type<br>(including Fog) | 2     |  | Nowcasting<br>SAF          | Regional | Software      | 15 min            | N/A   |                |                  |                  | Full AVHRR<br>Resolution                    | N/A                                |
| Metop          | Total Ozone from<br>GOME      | 2     |  | Ozone<br>Monitoring<br>SAF | Global   | NRT           | 3 h               | <5%   |                |                  |                  | 250 km                                      | N/A                                |
| Metop/         | Total Ozone from              | 2     |  | Ozone                      | Global   | NRT           | 3 h               |   |                |                  |                  | HIRS/4 FOV                                  | N/A                                |

| SATELLITE | PRODUCT NAME                                      | LEVEL | MAIN<br>GEOPHYSICAL<br>/ENG<br>PARAMETER | PRODUCER                   | COVERAGE | DISSEMINATION | NRT<br>TIMELINESS | ACCURACY   | SWATH<br>WIDTH | H-<br>RESOLUTION | V-<br>RESOLUTION | H-samp   | V-samp   |
|-----------|---|-------|--|----------------------------|----------|---------------|-------------------|--|----------------|------------------|------------------|--|--|
| NOAA      | HIRS  |       |  | Monitoring<br>SAF          |          |               |                   |  |                |                  |                  |  |  |
| Metop     | Ozone Profiles                                    | 2     |  | Ozone<br>Monitoring<br>SAF | Global   | NRT           | 3 h               | <15% at<br>pressures<br><30 hPa<br><br><50% at<br>pressure<br>>30 hPa                  |                |                  |                  | 250 km   | 7 km at<br>pressures<br><30 hPa<br><br><10 km at<br>pressures<br>>30 hPa |
| Metop     | Aerosol Index                                     | 2     |  | Ozone<br>Monitoring<br>SAF | Global   | NRT           | 3 h               |  |                |                  |                  | 250 km   |  |
| Metop     | Trace Gases (note use<br>of IASI not planned)     | 2     |  | Ozone<br>Monitoring<br>SAF | Global   | Offline       | 3 h               | <50%<br><br>trace gases<br>include ClO,<br>BrO, SO <sub>2</sub> and<br>NO <sub>2</sub> |                |                  |                  | 250 km   | N/A  |
| Metop     | Ozone Profiles                                    | 2     |  | Ozone<br>Monitoring<br>SAF | Global   | Offline       | 3 h               | <15% at<br>pressures<br><30 hPa<br><br><50% at<br>pressure<br>>30 hPa                  |                |                  |                  | 250 km   | 7 km at<br>pressures<br><30 hPa<br><br><10 km at<br>pressures<br>>30 hPa |
| Metop     | Temperature,<br>Humidity and<br>Pressure Profiles | 2     |  | GRAS<br>Meteorology<br>SAF | Global   | NRT           | 3 h               | Temperature:<br><br>2 K<br>Troposphere<br><br>1 K<br>Stratosphere                      |                |                  |                  | <1000 km<br>(mean<br>distance<br>between<br>individual<br>soundings<br>over 12 h<br>time window) | 30 Pressure<br>levels<br>500 hPa to<br>10 hPa                            |
|           |   |       |  |                            |          |               |                   | Rel Humidity:<br>10% or<br>0.2 g/kg<br>(whichever is<br>larger)                        |                |                  |                  | <1000 km<br>(mean<br>distance<br>between<br>individual   | 20 Pressure<br>levels to<br>300 hPa                                      |

| SATELLITE              | PRODUCT NAME                                      | LEVEL | MAIN<br>GEOPHYSICAL<br>/ENG<br>PARAMETER | PRODUCER                     | COVERAGE | DISSEMINATION | NRT<br>TIMELINESS | ACCURACY  | SWATH<br>WIDTH | H-<br>RESOLUTION | V-<br>RESOLUTION | H-samp   | V-samp                                 |
|------------------------|---|-------|--|------------------------------|----------|---------------|-------------------|---|----------------|------------------|------------------|--|--|
|                        |   |       |  |                              |          |               |                   |   |                |                  |                  | soundings<br>over 12 h<br>time window)   |  |
| Metop                  | Temperature,<br>Humidity and<br>Pressure Profiles | 2     |  | GRAS<br>Meteorology<br>SAF   | Global   | Offline       | 3 h               | Temperature:<br><br>2 K<br>Troposphere<br><br>1 K<br>Stratosphere |                |                  |                  | <1000 km<br>(mean<br>distance<br>between<br>individual<br>soundings<br>over 12 h<br>time window) | 30 Pressure<br>levels 500<br>to 10 hPa |
|                        |   |       |  |                              |          |               |                   | Rel Humidity:<br>10% or<br>0.2 g/kg<br>(whichever is<br>larger)   |                |                  |                  | <1000 km<br>(mean<br>distance<br>between<br>individual<br>soundings<br>over 12 h<br>time window) | 20 Pressure<br>levels to<br>300 hPa    |
| Metop/<br>NOAA         | Aerosol   | 2     |  | Land Surface<br>Analysis SAF | Global   | NRT           | 12 h              | <50%  |                |                  |                  | 1 km   |  |
| Metop/<br>NOAA         | Land Surface<br>Temperature                       | 2     |  | Land Surface<br>Analysis SAF | Global   | NRT           | 6 h               | 4 K   |                |                  |                  | 1 km   | N/A                                    |
| Metop/<br>MSG/<br>NOAA | Land Surface<br>Temperature                       | 2     |  | Land Surface<br>Analysis SAF | Global   | NRT           | 6 h               | 4 K   |                |                  |                  | 3 km   | N/A                                    |
| Metop/<br>NOAA         | N. Europe Snow<br>Cover                           | 2     |  | Land Surface<br>Analysis SAF | Regional | NRT           | 1 d               | 5%  |                |                  |                  | 1 km   | N/A                                    |
| Metop/<br>MSG/<br>NOAA | Vegetation Index                                  | 2     |  | Land Surface<br>Analysis SAF | Regional | Offline       | 1 d               | N/A   |                |                  |                  | 1 km   | N/A                                    |

## APPENDIX B METOP OPERATIONAL ORBIT

### B.1 Metop orbit basic parameters

The orbit parameters for the operational baseline mean orbit, with respect to the inertial Mean-of-Date System J2000.0, are given below. The orbit propagation is carried out with a geopotential model GEM10B of order 36 and degree 36, with lunisolar perturbations and a medium air drag model MSIS 77.

The repeatability cycle is 29 days/412 orbits and the Mean Local Solar Time at ascending node is 21 h 30 min. As the right column in the table shows, this orbit is almost equivalent to a 5 days/71 orbits repeat cycle.

| Mean Element                      |          | Baseline 29 days/412 revs orbit   | Value for a 5 days/71 revs orbit  |
|-----------------------------------|----------|---|---|
| Semi-Major Axis                   | a        | 7,195,605.347 m   | 7,197,939.000 m   |
| Eccentricity                      | e        | 0.001165  | 0.001165  |
| Inclination                       | i        | 98.702198°  | 98.704663°  |
| Right Ascension of Ascending Node | $\Omega$ | 62.4731° + 0.98564735° * N<br>where:<br>N = number of Julian days from 1 Jan 2000 | 62.4731° + 0.98564735° * N<br>where:<br>N = number of Julian days from 1 Jan 2000 |
| Argument of Perigee               | $\omega$ | 90.0°   | 90.0°   |
| Mean Anomaly                      | M        | 270.133359°   | 270.133359°   |

### B.2 Metop attitude law

The Metop nominal attitude is the **Local Normal Pointing** (LNP) law augmented by the **Yaw Steering Mode** (YSM).

LNP forces the satellite to point to the local normal direction (which for an oblate planet like the Earth is generally different from the direction towards the Earth centre).

Additionally to LNP, the satellite platform slowly moves about its centre of mass with a slow rocking motion about all three axes (X or pitch, Y or roll, Z or yaw) with the largest oscillation amplitude being on the yaw axis. This is the concept of **yaw steering**.

#### B.2.1 Metop yaw steering law

Yaw steering angles are modulated on board to compensate for the apparent drift of the sub-satellite point due to Earth rotation. Use of the yaw steering law is beneficial to those instruments with swaths significantly extending sideways (e.g. ASCAT). The amplitude of the rotation about each angle is effected on board (and modelled on-ground), first computing the angle amplitude and then applying the three rotations as follows:

### Angular Coefficients:

In the reference frame selected for the Metop CFI Software (positive X pointing away from solar panel, positive Y towards the flight direction, positive Z towards outer space) the signs in front of  $C_X$  and  $C_Y$  in the following equations are negative.

$$C_X = -e_e^2 \left( \frac{a_e}{a} \right) \frac{\sin^2(i)}{2} \quad \text{Pitch}$$

$$C_Y = -e_e^2 \left( \frac{a_e}{a} \right) \sin(i) \cos(i) \quad \text{Roll}$$

$$C_Z = \frac{k \cos(i - 90)}{1 + k \sin(i - 90)} \quad \text{Yaw}$$

where:

- $a_e$  = semi-major axis of the Earth reference ellipsoid (km)
- $a$  = mean semi-major axis of the Metop reference orbit (km)
- $e_e$  = eccentricity of the Earth reference ellipsoid
- $i$  = mean inclination of the Metop orbit (radians)
- $k = (\omega_e / \omega_n)$  with  $\omega_e$  Earth angular velocity (radians/s) and  $\omega_n$  Metop angular velocity along its reference orbit (radians/s)

In the spacecraft reference frame (positive X pointing from spacecraft centre of mass to solar panel, positive Y opposite to flight direction, positive Z towards outer space) the signs of  $C_X$  and  $C_Y$  are positive. In this case the numerical value for  $C_X$  is positive for Metop and the value for  $C_Y$  is negative:

$$C_X = +e_e^2 \left( \frac{a_e}{a} \right) \frac{\sin^2(i)}{2} \quad \text{Pitch}$$

$$C_Y = +e_e^2 \left( \frac{a_e}{a} \right) \sin(i) \cos(i) \quad \text{Roll}$$

$$C_Z = \frac{k \cos(i - 90)}{1 + k \sin(i - 90)} \quad \text{Yaw}$$

In the spacecraft reference frame and with the Metop mission reference orbit data, the maximum amplitudes are:

- $C_X$  Pitch maximum amplitude:  $+0.1661^\circ$
- $C_Y$  Roll maximum amplitude:  $-0.0508^\circ$
- $C_Z$  Yaw maximum amplitude:  $+3.9400^\circ$

In the Metop CFI Software reference frame the signs of  $C_X$  and  $C_Y$  are swapped with respect to the signs of the numerical values obtained in the Metop spacecraft reference frame. The  $C_Z$  sign is unaffected by the choice of attitude reference frame.



**Steering Angles:**

$$\eta = C_x \sin(2PSO)$$

 $\eta$ : pitch steering angle

$$\xi = C_y \sin(PSO)$$

 $\xi$ : roll steering angle

$$\zeta = C_z \cos(PSO) \left( 1 - \frac{(C_z \cos(PSO))^2}{3} \right)$$

 $\zeta$ : yaw steering angle

where:

PSO (“Position sur l’Orbite”, in radians) is the angle measured in the satellite orbital plane from the latest ascending node to the current satellite position along the orbit.

**B.3 Metop orbit and attitude propagation****B.3.1 Orbit propagation**

The main concepts are already explained above in B.1.

The average operational values for maximum propagation error (in metres) after 48 hours are:

|                           |         |
|---------------------------|---------|
| in radial direction:      | 6-7 m   |
| in along-track direction: | 50-60 m |
| in cross-track direction: | 8-10 m  |

which are well below (i.e. better than) the required values.

**B.3.2 Metop attitude propagation**

The Metop attitude control system is a closed-loop one, therefore no attitude prediction is performed on ground. Our reference attitude is the LNP+YSM law (see above, B.2). Telemetry from sun sensors, earth sensors and gyros is processed on ground to check that attitude deviations from the LNP+YSM reference values stay within certain mission-defined thresholds. Deviations of less than 0.02° in pitch, roll and yaw are routinely observed.

## APPENDIX C DATA TYPES USED BY THE GENERIC EPS FORMAT

### C.1 Basic data types

| Type ID         | Type                    | Size    | Range                    | Comments  |
|-----------------|-------------------------|---------|--------------------------|---|
| <b>Integers</b> |                         |         |                          |   |
| byte            | Signed Byte             | 1 byte  | -128...127               | <p>“Two’s Complement” coding convention for negative values</p> <p>Range calculated: <math>-2^{n-1}</math> to <math>+2^{n-1}-1</math>, where n is the length of the integer in bits</p>   |
| u-byte          | Unsigned Byte           | 1 byte  | 0...255                  | Range calculated: 0 to $+2^n-1$ where n is the length of the integer in bits  |
| enumerated      | Enumerated Byte         | 1 byte  | 256 flag states          | May only contain a value from a set of specified integer values, each of which is associated with a named concept, e.g. a set of error codes. When this field type is defined, the possible integer values and associated names are completely specified. |
| boolean         | Boolean Byte            | 1 byte  | False/True               | Specific enumerated integer type which takes only 2 possible values: when all bits are zeroed, it denotes ‘FALSE’, otherwise, if any bit is set (i.e. its value is different from zero), it denotes ‘TRUE’.   |
| integer2        | Signed 2-byte Integer   | 2 bytes | -32768...32767           | <p>“Two’s Complement” coding convention for negative values</p> <p>Range calculated: <math>-2^{n-1}</math> to <math>+2^{n-1}-1</math>, where n is the length of the integer in bits</p>   |
| u-integer2      | Unsigned 2-byte Integer | 2 bytes | 0...65535                | Range calculated: 0 to $+2^n-1$ where n is the length of the integer in bits  |
| integer4        | Signed 4-byte Integer   | 4 bytes | -2147483648...2147483647 | “Two’s Complement” coding convention for negative values  |

| Type ID                     | Type                    | Size                 | Range  | Comments  |
|-----------------------------|-------------------------|----------------------|--|---|
|                             |                         |                      |  | Range calculated: $-2^{n-1}$ to $+2^{n-1} - 1$ , where n is the length of the integer in bits   |
| u-integer4                  | Unsigned 4-byte Integer | 4 bytes              | 0...4294967295                                 | Range calculated: 0 to $+2^n - 1$ where n is the length of the integer in bits  |
| integer8                    | Signed 8-byte Integer   | 8 bytes              | -9223372036854775808<br>...9223372036854775807 | “Two’s Complement” coding convention for negative values<br><br>Range calculated: $-2^{n-1}$ to $+2^{n-1} - 1$ , where n is the length of the integer in bits   |
| u-integer8                  | Unsigned 8-byte Integer | 8 bytes              | 0...18446744073709551615                       | Range calculated: 0 to $+2^n - 1$ where n is the length of the integer in bits  |
| <b>Bit Strings</b>          |                         |                      |  |   |
| Bit String                  | bitst(n)                | 1 bit per element    | n/a  | A bit string is encoded as follows: $b_{n-1} \dots b_0$ , where $b_i$ is the $i$ th bit in the string and n is the length in bits of the bit string, with $b_{n-1}$ being the most significant bit. The value of n shall always be a multiple of 8 ensuring that a bit string is always a full number of bytes in size. |
| <b>Character Strings</b>    |                         |                      |  |   |
| Standard Character String   | char(length)            | 1 byte per character | n/a  | Can only contain upper case letters [A...Z], numbers [0...9] and the underscore character (_).<br><br>The number of characters in a character string is determined by the <b>length</b> parameter e.g. CHAR(8) is an 8 character string.  |
| Enumerated Character String | e-char(length)          | 1 byte per character | n/a  | Same properties as standard character string except that it can only contain one of a set of specified string values, and may also include the lower case “x” character (used as whitespace padding).   |
| Extended Character          | x-char(length)          | 1 byte per           | n/a  | Same properties as standard character string except that it may also contain space character, the newline character (\n), the equals sign (=)   |

| Type ID               | Type              | Size      | Range | Comments   |
|-----------------------|-------------------|-----------|-------|--|
| String                |                   | character |       | and the plus (+) and minus (-) signs.<br><br>Only found in ASCII records.  |
| <b>Time formats</b>   |                   |           |       |  |
| Generalised Time      | general time      | 15 bytes  | n/a   | This is a char(15) data type with a specific format <b>YYMMDDHHMMSSZ</b> , Z indicates Zulu or UTC time.<br><br>If a field has a type of general time but no time is applicable, then the field should be filled with the string for “no applicable time”, which is a string of 14 lower case ‘x’ characters terminated by the ASCII character ‘Z’, e.g., <b>xxxxxxxxxxxxxxZ</b>             |
| Long Generalised Time | long general time | 18 bytes  | n/a   | This is a char(18) data type with a specific format <b>YYMMDDHHMMSSmmmZ</b> , Z indicates Zulu or UTC time.<br><br>If a field has a type of long general time but no time is applicable, then the field should be filled with the string for “no applicable time”, which is a string of 17 lower case ‘x’ characters terminated by the ASCII character ‘Z’, e.g., <b>xxxxxxxxxxxxxxxxxxZ</b> |

## C.2 Compound data types

| Type ID  | Type        | Size (bytes) | Components        |
|--|-------------|--------------|-------------------|
| <b>Integers - Variable Scale Factors</b><br>The EPS product format specification does not allow “real” data types to be present in a product. Instead, real values are encoded into integer format using a fixed scaling factor that is specified in the format specification tables. However, there may be some values that vary too much to be efficiently encoded into an integer value with a fixed scaling factor. If these are single values, they may be encoded into a compound that includes a scaling factor and the integer value as described in this section. If these values are an array of values, they are more easily presented by an array of bytes containing the variable scale factors followed by an array of integer data types. |             |              |                   |
| Variable Scale Factor Byte   | V-BYTE      | 2            | byte + byte       |
| Variable Scale Factor Unsigned Byte  | VU-BYTE     | 2            | byte + u-byte     |
| Variable Scale Factor Integer-2  | V-INTEGER2  | 3            | byte + integer2   |
| Variable Scale Factor Unsigned Integer-2   | VU-INTEGER2 | 3            | byte + u-integer2 |
| Variable Scale Factor Integer-4  | V-INTEGER4  | 5            | byte + integer4   |
| Variable Scale Factor Unsigned Integer-4   | VU-INTEGER4 | 5            | byte + u-integer4 |
| Variable Scale Factor Integer-8  | V-INTEGER8  | 9            | byte + integer8   |
| Variable Scale Factor Unsigned Integer-8   | VU-INTEGER8 | 9            | byte + u-integer8 |
| <b>Time formats</b><br>CCSDS Day Segmented (CDS) time represents the day since epoch (1 January 2000 starting with 0). The CDS time is UTC-based and takes into account leap second corrections.   |             |              |                   |

| Type ID        | Type           | Size (bytes) | Components   |
|----------------|----------------|--------------|--|
| Short CDS Time | short cds time | 6            | u-integer2 + u-integer4<br><br>(Encodes the day since epoch in the first 2 bytes and the number of milliseconds since the beginning of the day in the day in its last 4 bytes)   |
| Long CDS Time  | long cds time  | 8            | u-integer2 + u-integer4 + u-integer2<br><br>(Encodes the day since epoch in the first 2 bytes, the number of milliseconds since the beginning of the day in its next 4 bytes, and the number of microseconds since the last millisecond in its last 2 bytes) |

## APPENDIX D FORMAT AND CONTENTS OF THE GRH AND IPR

### D.1 Generic Record Header

| Field                   | Description  | Type           | Size (bytes) | Offset (bytes) |
|-------------------------|--|----------------|--------------|----------------|
| RECORD_CLASS            | Class of Record  | enumerated     | 1            | 0              |
| INSTRUMENT_GROUP        | Defining group for record subclasses                             | enumerated     | 1            | 1              |
| RECORD_SUBCLASS         | Subclass of this record class                                    | enumerated     | 1            | 2              |
| RECORD_SUBCLASS_VERSION | Version of this particular format of the record case             | enumerated     | 1            | 3              |
| RECORD_SIZE             | Total size of the record case (including this header)            | u-integer4     | 4            | 4              |
| RECORD_START_TIME       | Start Time for this record - context will depend on record class | short cds time | 6            | 8              |
| RECORD_STOP_TIME        | Stop Time for this record - context will depend on record class  | short cds time | 6            | 14             |
|                         |  |                | Total        | 20             |

#### D.1.1 RECORD\_CLASS enumerated values

| Index | Record Class                    | Acronym |
|-------|---------------------------------|---------|
| 0     | Reserved                        |         |
| 1     | Main Product Header Record      | MPHR    |
| 2     | Secondary Product Header Record | SPHR    |

|   |   |       |
|---|---|-------|
| 3 | Internal Pointer Record                 | IPR   |
| 4 | Global External Auxiliary Data Record   | GEADR |
| 5 | Global Internal Auxiliary Data Record   | GIADR |
| 6 | Variable External Auxiliary Data Record | VEADR |
| 7 | Variable Internal Auxiliary Data Record | VIADR |
| 8 | Measurement Data Record                 | MDR   |

#### D.1.2 INSTRUMENT\_GROUP enumerated values

| Index | Defining Group                                   |
|-------|--|
| 0     | GENERIC (no specific instrument)                 |
| 1     | AMSU-A   |
| 2     | ASCAT  |
| 3     | ATOVS instruments (AVHRR/3, HIRS/4, AMSU-A, MHS) |
| 4     | AVHRR/3  |
| 5     | GOME   |
| 6     | GRAS   |
| 7     | HIRS/4   |
| 8     | IASI (except IASI L2 products)                   |
| 9     | MHS  |



|    |   |
|----|---|
| 10 | SEM   |
| 11 | ADCS  |
| 12 | SBUV  |
| 13 | DUMMY   |
| 14 | ARCHIVE (Note: Only used in GIADRs. A GIADR with INSTRUMENT_GROUP of archive contains only descriptive information and is not processed.) |
| 15 | IASI_L2 (used for IASI L2 products only)  |

#### **D.1.3 RECORD\_SUBCLASS values**

This is determined by the Instrument Group and shall vary from instrument to instrument and also, if necessary, from processing level to processing level. The record subclasses are defined in the instrument-specific sections of this document.

#### **D.1.4 RECORD\_SUBCLASS\_VERSION values**

This is the version number of the record subclass. Any update to the format of the record subclass will result in the increment of the subclass version number.

#### **D.1.5 RECORD\_SIZE values**

This field contains the total size of the record subclass (including the GRH) in bytes.

### D.1.6 Definitions of RECORD\_START\_TIME and RECORD\_STOP\_TIME values

| Record Class                            | Record Start Time  | Record Stop Time  |
|---|--|---|
| Main Product Header Record              | RECORD_START_TIME of the first MDR in the product  | RECORD_STOP_TIME of the last MDR in the product   |
| Secondary Product Header Record         | RECORD_START_TIME of the first MDR in the product  | RECORD_STOP_TIME of the last MDR in the product   |
| Internal Pointer Record                 | RECORD_START_TIME of the first MDR in the product  | RECORD_STOP_TIME of the last MDR in the product   |
| Global External Auxiliary Data Record   | RECORD_START_TIME of the first MDR in the product  | RECORD_STOP_TIME of the last MDR in the product   |
| Global Internal Auxiliary Data Record   | RECORD_START_TIME of the first MDR in the product  | RECORD_STOP_TIME of the last MDR in the product   |
| Variable External Auxiliary Data Record | The RECORD_START_TIME of the first MDR for which this data applies.  | The RECORD_STOP_TIME of the last MDR for which this data was applied.   |
| Variable Internal Auxiliary Data Record | The RECORD_START_TIME of the first MDR for which this data applies.  | The RECORD_STOP_TIME of the last MDR for which this data was applied.   |
| Measurement Data Record                 | Usually the “sensing time” of the first measurement in the record, but see individual PFSs for local definitions | Usually the “sensing time” of the last measurement in the record, but see individual PFSs for local definitions |

## D.2 Generic Internal Pointer Record

| Field                   | Description  | Type       | Size (bytes) | Offset (bytes) |
|-------------------------|--|------------|--------------|----------------|
| TARGET_RECORD_CLASS     | Class of target record as derived from the GRH of the target record                    | enumerated | 1            | 0              |
| TARGET_INSTRUMENT_GROUP | Defining group for target record subclass as derived from the GRH of the target record | enumerated | 1            | 1              |
| TARGET_RECORD_SUBCLASS  | Subclass of target record class as derived from the GRH of the target record           | enumerated | 1            | 2              |
| TARGET_RECORD_OFFSET    | Offset of target record from start of product  | u-integer4 | 4            | 3              |
|                         |  |            | Total        | 7              |

The meaning of the TARGET\_RECORD\_CLASS, TARGET\_INSTRUMENT\_GROUP and TARGET\_RECORD\_SUBCLASS values correspond to those of the RECORD\_CLASS, INSTRUMENT\_GROUP and RECORD\_SUBCLASS in the GRH above, respectively.

The TARGET\_RECORD\_OFFSET is given in bytes.

**APPENDIX E                      ACRONYMS AND ABBREVIATIONS**

|        |   |
|--------|---|
| 1DVar  | One dimensional variational assimilation  |
| AAI    | Absorbing Aerosol Index   |
| AAPP   | ATOVS and AVHRR Pre-processing Package  |
| ADC    | Analogue Digital Converter  |
| AMSU   | Advanced Microwave Sounding Unit  |
| ANX    | Ascending Node Crossing   |
| AOD    | Aerosol Optical Depth   |
| ASCAT  | Advanced SCATterometer  |
| ASCII  | American Standard Code for Information Interchange                                |
| ATOVS  | Advanced TIROS-N Operational Vertical Sounder                                     |
| AU     | Astronomical Unit   |
| AVHRR  | Advanced Very High Resolution Radiometer  |
| BEAT   | Basic Envisat Atmospheric Toolbox   |
| BSDF   | Bi-directional Scattering Distribution Function                                   |
| BU     | Binary Unit   |
| BUFR   | Binary Universal Form for the Representation of meteorological data               |
| C/A    | Coarse Acquisition  |
| CAL    | Calibration function of EPS   |
| CATGAS | Calibration Apparatus for Trace Gas Absorption Spectroscopy                       |
| CCSDS  | Consultative Committee for Space Data Systems [recommends data standards]         |
| CDA    | Command and Data Acquisition (station)  |
| CFI    | Customer Furnished Item   |
| CGS    | Core Ground Segment   |
| CGSRD  | Core Ground Segment Requirements Document   |
| CIE    | Commission Internationale de L'Eclairage/International Commission on Illumination |
| CM SAF | Climate Monitoring Satellite Application Facility                                 |
| CMDL   | Climate Monitoring and Diagnostics Laboratory                                     |
| CU     | Calibration Unit of the GOME-2 instrument   |
| CVF    | Cal/Val Facility at EUMETSAT  |
| DBS    | Direct Broadcast Service  |
| DIAL   | Differential Absorption Lidar   |

|          |  |
|----------|--|
| DISORT   | Discrete Ordinate Radiative Transfer model   |
| DLR      | Deutsches Zentrum für Luft- und Raumfahrt e.V.   |
| DMDR     | Dummy Main Data Record   |
| DMI      | Danmarks Meteorologiske Institut   |
| DOAS     | Differential Optical Absorption Spectroscopy   |
| DVB      | Digital Video Broadcast  |
| DWD      | Deutscher Wetterdienst   |
|          |  |
| EARS     | EUMETSAT Advanced Retransmission Service   |
| EASOE    | European Arctic Stratospheric Ozone Experiment   |
| ECMWF    | European Centre for Medium-Range Weather Forecasts   |
| ENVISAT  | ENVironmental SATellite  |
| EOS      | Earth Observing System   |
| EPS      | EUMETSAT Polar System  |
| EPTOMS   | Earth Probe TOMS   |
| ERS      | European Remote Sensing (satellite)  |
| ESA      | European Space Agency  |
| ESOC     | European Space Operations Centre (Darmstadt, Germany)  |
| ESTEC    | European Space Technology Centre (Noordwijk, NL)   |
| EUMETSAT | European Organisation for the Exploitation of Meteorological Satellites (Darmstadt, Germany) |
| EURD     | End User Requirements Document   |
|          |  |
| FIR      | Finite Impulse Response  |
| FM       | Flight Model.  |
| FMI      | Finnish Meteorological Institute or Ilmatieteen Laitos                                       |
| FOV      | Field Of View  |
| FPA      | Focal Plane Assembly   |
| FRTM     | Fast Radiative Transfer Model  |
| FTIR     | Fourier Transform InfraRed   |
| FWHM     | Full Width at Half Maximum   |
|          |  |
| GAC      | Global Area Coverage (data)  |
| GAW      | Global Atmosphere Watch (WMO programme)  |
| GDP      | GOME Data Processor (ERS-2)  |
| GEADR    | Global External Auxiliary Data Record  |
| GEU      | GRAS Electronics Unit  |
| GIADR    | Global Internal Auxiliary Data Record  |
| GMF      | Geophysical Model Function   |
| GNSS     | Global Navigation Satellite System   |

|        |   |
|--------|---|
| GOME   | Global Ozone Monitoring Experiment  |
| GPS    | Global Positioning System   |
| GRH    | Generic Record Header   |
| GRIB   | Numerical weather prediction data in grid point form, expressed in binary                     |
| G/S    | Ground Segment  |
| GSN    | Ground Support Network  |
| GTL    | GOME TimeLine   |
| GTS    | Global Telecommunication System   |
| GTT    | GOME Timeline Table   |
| GZA    | GRAS Zenith Antenna   |
|        |   |
| HCL    | Hollow Cathode Lamp   |
| HDF    | Hierarchical Data Format  |
| HIRS   | High Resolution Infrared Radiation Sounder  |
| HK     | Housekeeping  |
| HNMS   | Hellenic National Meteorological Service, Greece  |
| HRPT   | High Resolution Picture Transmission  |
|        |   |
| IASI   | Infrared Atmospheric Sounding Interferometer  |
| ICU    | Instrument Control Unit   |
| ID     | Identification  |
| IFE    | Institut für Fernerkundung der Universität Bremen (D)   |
| IFOV   | Instantaneous Field Of View   |
| IIS    | Integrated Imaging Subsystem  |
| IPR    | Internal Pointer Record   |
| IR     | InfraRed  |
| ISCCP  | International Satellite Cloud Climatology Project   |
| IT     | Integration Time  |
| ITSC   | International TOVS Study Conference   |
|        |   |
| KMI    | Koninklijk Meteorologisch Instituut van België / Institut Royal<br>Météorologique de Belgique |
| KNMI   | Koninklijk Nederlands Meteorologisch Instituut (De Bilt, NL)                                  |
|        |   |
| LAP    | Laboratory of Atmospheric Physics, Aristotle University of Thessaloniki                       |
| LED    | Light Emitting Diode  |
| LIDORT | Linearised Discrete Ordinate Radiative Transfer Model   |
| LNB    | Low-Noise Block Converter   |
| LNP    | Local Normal Pointing   |
| LRPT   | Low Resolution Picture Transmission   |

|         |  |
|---------|--|
| LSA SAF | Land Surface Analysis Satellite Application Facility                                     |
| LUT     | Look-Up Table  |
| M&C     | Monitoring and Control   |
| MDR     | Main Data Record   |
| MDR     | Measurement Data Record  |
| Metop   | METeorological OPerational (satellite)   |
| MF      | Météo-France   |
| MHS     | Microwave Humidity Sounder   |
| MIPAS   | Michelson Interferometer for Passive Atmospheric Sounding                                |
| MIRP    | Manipulated Information Rate Processor (for high data rate AVHRR)                        |
| MLER    | Minimum Lambert Equivalent Reflectivity  |
| MLST    | Mean Local Solar Time  |
| MME     | Müller Matrix Element  |
| MPF     | Mission Planning Facility  |
| MPHR    | Main Product Header Record   |
| NASA    | National Aeronautics and Space Administration  |
| NDSC    | Network for the Detection of Stratospheric Change  |
| NDVI    | Normalised Difference Vegetation Index   |
| NIR     | Near InfraRed  |
| NOAA    | National Oceanic and Atmospheric Administration  |
| NPOESS  | National Polar-orbiting Operational Environmental Satellite System                       |
| NRT     | Near Real Time   |
| NWC SAF | Satellite Application Facility on support to Nowcasting and Very Short-Range Forecasting |
| NWP     | Numerical Weather Prediction   |
| NWP SAF | Numerical Weather Prediction Satellite Application Facility                              |
| O3M SAF | Ozone & Atmospheric Chemistry Monitoring Satellite Application Facility                  |
| OBCT    | On-Board Clock Time  |
| OMI     | Ozone Monitoring Instrument  |
| OMPS    | Ozone Mapping and Profiler Suite   |
| OSI SAF | Ocean and Sea Ice Satellite Application Facility   |
| PCD     | Product Confidence Data  |
| PDU     | Product Dissemination Unit   |
| PFS     | Product Format Specification   |
| PFV     | Product Format Version   |
| PG      | Power Gain   |

|           |  |
|-----------|--|
| PGE       | Product Generation Environment                                       |
| PGF       | Product Generation Facility  |
| PGS       | Product Generation (function) Specification                          |
| PLLO      | Phase-Locked Loop Oscillator   |
| PLM       | PayLoad Module   |
| PMC       | Payload Module Control   |
| PMD       | Polarisation Measurement Device                                      |
| POD       | Precise Orbit Determination  |
| PPF       | Product Processing Facility of the EPS CGS                           |
| PPG       | Pixel-to-Pixel Gain  |
| PQE       | Product Quality Evaluation   |
| PRN       | Pseudo Random Noise code [of GPS satellite]                          |
| PRT       | Platinum Resistance Thermometer                                      |
| PSF       | Points Spread Function   |
| PSO       | Position sur l'Orbite  |
| PU        | Polarisation Unit  |
|           |  |
| RAO       | Research Announcement of Opportunity                                 |
| RD        | Reference Document   |
| RFCU      | Radio Frequency Conditioning Unit                                    |
| RMDCN     | Regional Meteorological Data Communication Network                   |
| RMS       | Root Mean Square   |
| ROPP      | Radio Occultation Processing Package                                 |
| RTM       | Radiative Transfer Model   |
|           |  |
| SAA       | Southern Atlantic Anomaly  |
| SAF       | Satellite Application Facility                                       |
| SAO       | Smithsonian Astrophysical Observatory (Cambridge, USA)               |
| SBT       | Satellite Binary Time  |
| SBUV      | Solar Backscatter Ultra-Violet Experiment                            |
| SCIAMACHY | Scanning Imaging Absorption Spectrometer for Atmospheric Cartography |
| SEM       | Space Environment Monitor  |
| SESAME    | Second European Stratospheric Arctic and Mid-latitude Experiment     |
| SLS       | Spectral Light Source  |
| SMR       | Sun Mean Reference   |
| SOT       | SOLar calibration Timeline   |
| SPA       | Sensor Performance Assessment  |
| SPHR      | Secondary Product Header Record                                      |
| SRON      | Space Research Organisation of the Netherlands (Utrecht, NL)         |



|       |   |
|-------|---|
| SSD   | Sounding Support Data                                 |
| SSST  | Single Space Segment Team                             |
| SST   | Sea Surface Temperature                               |
| SVM   | SerVice Module  |
| SZA   | Solar Zenith Angle                                    |
|       |   |
| TBC   | To Be Confirmed                                       |
| TBD   | To Be Defined   |
| TIROS | Television and InfraRed Operational Satellites        |
| TOMS  | Total Ozone Mapping Spectrometer                      |
| TOVS  | TIROS Operational Vertical Sounder                    |
| TPD   | Technisch Physische Dienst (Delft, NL)                |
| TZD   | Tropospheric Zenith Delay                             |
|       |   |
| UMARF | Unified Meteorological Archive and Retrieval Facility |
| UTC   | Universal Time Coordinated                            |
| UTC   | Universal Time Clock                                  |
| UV    | UltraViolet   |
|       |   |
| VEADR | Variable External Auxiliary Data Record               |
| VERA  | Versatile Retrieval Algorithm                         |
| VIADR | Variable Internal Auxiliary Data Record               |
| VIS   | Visible   |
|       |   |
| WLS   | White Light Source                                    |
| WMO   | World Meteorological Organization                     |
| WOUDC | World Ozone and Ultraviolet Data Centre               |
|       |   |
| YSM   | Yaw Steering Mode                                     |