Sentinel GPSR

Measurement Data Interface Specification

DRL: -
CI-No.: -

Applicable for: S1 ☒ S2 ☒ S3 ☒ EC ☒

☒ Sentinel A
☒ Sentinel B
☐ Sentinel B, Amendment to:

	NAME:	FUNCTION:	SIGNATURE:	DATE:
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Issue	Date	Modified Pages	Description
1.0	10 Jan 2009	All	Initial version
			Changes wrt [SMDIS], issue 3.4:
		§5.1	New Measurement Data Header format
		§5.3	Added a note on the needed splitting of packets.
			Table 5-5: Navigation solution is no longer for diagnostic purposes, it is now part of the customer requirements, because S-3 needs it, see S3-MN-TAF-GN-00440.
			Navigation Solution and Time Correlation Data Records are now transmitted via TM(3,25) to meet requirements stated in S3-MN-TAF-GN-00440. The SIDs are incremented by 212 compared to SWARM to meet requirements stated in “TASI Comments to S2 PUS Proposal for GPS_02.doc”.
		§5.4.1.1	Navigation Solution Data Record extended by four entities required by S-3, such as height above ellipsoid.
		§5.4.1.3	Unlike in SWARM, UTC is not provided via the CCSDS header, in Sentinel it is provided as part of the data record instead of the LOBT.
		§5.5.1.2	UTC is no longer provided via the CCSDS header
		§5.6	HK data is now described in [CHKDIS].

		Table 5-5	Now the Time Correlation Data Record is subject to qualification testing, because no other record contains UTC; consequently the IMT/GPST Correlation Data Record does no longer need to be subject to qualification testing
2	22 Apr 2009	§4.2	Update of Figure 4-1 as closeout of DESIGN-PERF-IF-135: Sentinel 1 and Sentinels 2 + 3 have the same time field length. Removal of the trailing filler bytes.
		§5.5, Table 5-5	Corrected the SID for the minimum navigation solution
		Table 5-28	I_{DOT} is contained in subframe 3 instead of 2, corrected.
		Table 5-11 Table 5-15 Table 5-17	Inconsistencies wrt mapping from single frequency tracking states -> multi-frequency tracking state (MFC_TS) resolved - Table 5-11 and Table 5-15 referred to 1st, 2nd and 3rd SFC while Table 5-17 referred to 1st, 2nd and 3rd signal (which is the correct interpretation).
		§5.4.1.7	Clarification added that the carrier phase starts at the begin of the track with 0 cycles.
		Table 5-4	Description of NSM field improved.
3	7 Oct 2009	Table 5-5	Harmonised the SIDs for Startup Mode and other modes acc. to DESIGN-PERF-IN-23. Removed the checkmark for qualification testing for the Minimum Navigation Solution Data Record.
		Table 5-6	Removed references to the Sentinel mission numbers acc. to DESIGN-PERF-IN-2.
		Table 5-2	Takeover from SWARM: Data valid conditions for navigation solution data records and time correlation records updated.
		Table 5-14	Takeover from SWARM: New table with single frequency tracking state enumerations to resolve a TBD in Table 5-13.
		Table 5-11	Takeover from SWARM: corrected the mapping of tracking states to generated data records.
4	10 Jan 2010	Various places	Renamed “SWARM Auxiliary Data Record” to “Auxiliary Data Record”
		Table 5-6	Values not supported by the SWARM Navigation Solution are no longer defined to be zero but defined as “not for reference”. Removed references to the Sentinel mission numbers acc. to DESIGN-PERF-IN-2.

		Table 5-13	Changed description to achieve unique names for database export
5	10 Jun 2010	Table 5-2	Criteria for Data Valid Flags in Navigation Solution and Time Correlation data records updated.
		Table 5-4	L2CM signal declared applicable to Sentinel B. Definition of Value ‘3’ for NSM field added.
		Table 5-5	Removed the obsolete indication that AGC status and Noise Histograms would be different for Standby and Navigate mode. Number of Code Phase data records per TM corrected from 18 to 19. Maximum number of records per TM corrected for Satellite in View status and Code Phase data records. Inconsistency for Satellite in View Status records corrected – this record type is sent via TM(212,1) service, and the number of records is not constant, in particular during a cold start. GPS CNAV Group Delay Data Record added. Column with number of TM packets per sample period added.
		Table 5-6	Resolution of LONGITUDE and LATITUDE fields corrected, VERTSPEED changed to signed type. GDOP field description corrected.
		§5.4.1.2	TBD for time span t_1- t_0 resolved.
		Table 5-7 Table 5-9	FP field added to provide information on the tracking scheme decision in Sentinel B.
		Table 5-9	Clarified that differential correction and CNAV is not supported in Sentinel.
		Table 5-37	N/U field removed.
		§5	AGC rate corrected
		Figure 5-1 Table 5-1	Serial number field declared unused, ID field added for internal purposes
		Table 5-8 Table 5-36	TDOP field description corrected.
		Table 5-12 Table 5-16	Added to reflect the situation with L2 CM processing.
		Table 5-14	Tracking states for L2CM acquisition and tracking added.
		Table 5-37	CM added as the alternative code to be tracked on the second SFC of an MFC. Clarified that NDS field is only related to C/A code processing.
		§5.4.3.1	Added to allow for L2C Inter-Signal Correction.

		Table 5-5 §5.5.1.1	Minimum Navigation Solution record type replaced with S1 Navigation Solution record type according to mail with subject “Réf. : GNSS CDR Board disposition for PCAT” on Thu, 22 Apr 2010 15:45:14 from Patrick.Nicol@thalesaleniaspace.com
		§5.5.1.1 Table 5-6	Clarifications and rewording acc. to internal document review.
6	30 Jun 2010	Table 5-4	BLOCK field description corrected, clarified that ‘other’ values are currently unknown but not invalid.
		§5.4.1.8	Clarification regarding undefined amplitude offset in Carrier Amplitude Data record.
		§5.4.3.1	Layout corrected, there is the need for a common header in all NAV or CNAV format definitions.
7	20 Nov 2010	Table 5-6	Added a note that the PV results refer to the center of mass to close action DESIGN/PERFOR-17-1 from the SW CDR. Replaced “geodetic reference frame” by “WGS-84 reference freame” acc. to action DESIGN/PERFOR-15-1.
		Table 5-2	Clarification regarding the Data Valid flag for the Time Correlation Data Record and the IMT/GPST Correlation Data Record during NSM=3 added.
8	18 Jan 2011	Table 5-2	Split the definition of the Data Valid Flag for the Time Correlation Data Record and the IMT/GPST Data Record.
		Table 5-1	Reference to [HWSWICD] added for field ‘FE_TEMP’.
		Table 5-5	Constellation Status has a variable number of records, corresponding column corrected
9	5 Apr 2011	Table 5-14	Updated Tracking State IDs to values in source code.
		Table 5-4	Added interpretation of the T_REC field for the Function Parameter reports.
		Table 5-37 Figure 5-18	Field CONS replaced with field SCHEME to provide information on the tracking scheme actually used on a certain MFC. This change is only relevant for Sentinel B, in Sentinel A only tracking scheme '0', i.e. L1 C/A + P(Y) is used. Lock flag description detailed for the specified tracking schemes.
		§5.4.3.1	Clarification on usage of ISC parameters added.
		§5.4.1.5	Notes on delay of code phase data record generation compared to the reached tracking state added.

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1. INTRODUCTION

1.1 SCOPE OF THE PROJECT

The Sentinel GPS Receiver (GPSR) is used in missions Sentinel-1, Sentinel-2, and Sentinel-3. It is a dual-frequency navigation receiver designed to be used on spacecrafts in Low Earth Orbits.

1.2 PURPOSE OF THE DOCUMENT

This document specifies the possible formats and content of the scientific measurement data generated by the Sentinel GPSR. The document is complementary to [CHKDIS] and contains

- CCSDS packet structure definitions for services TM(212,1)
- Navigation data format definitions used in services TC(211,1) and TM(211,3)

1.3 DOCUMENT EVOLUTION

- Issue 1 of this document is derived from [SMDIS] issue 3.4 and from [PUS].
- Issue 2 contains updates based on the results of the Preliminary Design Review.
- Issue 3 contains updates based on results of the Preliminary Design Review for the Enhanced Navigation Solution and contains a takeover of updates of [SMDIS] issue 3.7.
- Issue 4 includes a few small corrections.
- Issue 5 includes the extensions introduced to support Sentinel B.
- Issue 6 has been established in preparation of the Sentinel A CDR data package.
- Issue 7 includes clarifications and closeout of Sentinal A CDR RIDs.
- Issue 8 contains minor updates made in preparation of the Sentinel A QR data package.
- Issue 9 contains minor updates after the Sentinel A QR and additional information as required for the Sentinel B delta CDR data package.

1.4 ACRONYMS

AD .... Applicable Documents
AGC.......... Automatic Gain Control
AGGA....... Advanced GPS/GLONASS ASIC
AS............ Anti-Spoofing
C&DH .... Command and Data Handling
CCSDS..... Consultative Committee for Space Data Systems
CDS.......... CCSDS Day Segmented time code
CIDL .... Configuration Item Data List
CS .... GPS Control Segment
CUC.......... CCSDS Unsegmented time code
EGT.......... Estimated GPS Time
FEC .... Forward Error Correction
GNSS .... Global Navigation Satellite System
GPS.......... Global Positioning System
GPS SV .... GPS Space Vehicle
GPSR .... Global Positioning System Receiver
GPST........ Global Positioning System Time
IMT .... Instrument Measurement Time
IT .... Integration Time
LEO .... Low Earth Orbit
LOBT .... Local On-Board Time
LSB........... Least Significant Bit
LSW.......... Least Significant Word
MD............ Measurement Data
MFC.......... Multi Frequency Channel (logical channel defined in software)
MSB.......... Most Significant Bit
MSW......... Most Significant Word
N/A .... Not Applicable
N/U .... Not Used
NCO .... Numerically Controlled Oscillator
PEC.......... (CCSDS) Packet Error Control
PID .... Process ID
PIT............ Point In Time
PRN.......... Pseudo Random Noise
RSA.......... RUAG Space GmbH
RD .... Reference Document
RMS .... Root-Mean-Square
S/A............ Selective Availability
SC, S/C .... Spacecraft
SFC .... Single frequency channel (physical channel defined in the AGGA)
SID .... Structure ID
SV............. Space vehicle
TBC .... To be confirmed
TBD .... To be defined
TC............. Telecommand
TM .... Telemetry
TS............. Tracking State
URA.......... User Range Accuracy
USNO....... U.S. Naval Observatory
UTC.......... Universal Time Coordinated
WGS84..... World Geodetic System 1984

2. DOCUMENTS

The following documents form part of this document to the extent specified here-in.

In the event of a conflict between this document and the Applicable Documents (AD), the AD shall have the precedence. Any such conflict should however be brought to the attention of RSA for resolution.

This document has been established based on the issues of ADs and RDs as given below. Issue changes of ADs and RDs will lead to an update of this document only in case of impacts on its content.

This document has been established based on the ADs and RDs as given below. The valid revision numbers are reflected in the relevant Configuration Item Data List Issue. Changes of ADs and RDs will lead to an update of this document only in case of impacts on its content.

2.1 APPLICABLE DOCUMENTS

[SRD]	S1-RS-AAE-SC-0001	Sentinel GPSR Software Requirements Specification
[PUS]	GS2.STD.ASD.SY.00001	Sentinel-2 Packet Utilization Standard

2.2 REFERENCE DOCUMENTS

[ICD200]	IS-GPS-200	Navstar GPS Space Segment / Navigation User Interface
[ECSS70]	ECSS-E-70-41A	Space Engineering - Ground Systems and Operations - Telemetry and Telecommand Packet Utilization
[CCS301]	CCSDS 301.0-B-3	CCSDS Recommendations for Time Code Formats
[CHKDIS]	S1-IF-AAE-SC-0001	Sentinel GPSR Command and House-keeping Data Interface Specification
[SUM]	TBD	Software Users Manual
[WGS84]	NIMA TR 8350.2	Department of Defence World Geodetic System 1984, Its Definition and Relationships with Local Geodetic Systems
[SMDIS]	SW-IF-AAE-GP-002	SWARM GPSR Measurement Data Interface Specification
[CCP]	S1-PL-AAE-SC-0020	Calibration and Characterisation Plan

[HWSWICD]	S1-IF-AAE-SC-0005	Hardware / Software ICD

3. DEFINITIONS AND CONVENTIONS

3.1 DEFINITIONS

Antenna Zenith Direction
The antenna zenith direction is equivalent to the antenna boresight direction.

Anti-Spoofing
In the Anti-Spoofing (AS) mode of operation, the P-Code is encrypted into the Y-Code. The encryption is performed by modulating a classified W-code on the P-code. The Y-code is modulated on both the L1 and L2 carriers.

C/A-code
The coarse/acquisition code (C/A-code) has a 1.023 MHz chip rate, a period of one millisecond (ms) and is used primarily to acquire the P-code.

Carrier Phase Measurement
Carrier phase measurements for the different signal components (e.g.: L1 C/A or L2 P(Y)) correspond to the carrier phase of these signal components received through the corresponding antenna, measured at the output of the AGGA correlator.

CCSDS Packet
A CCSDS-formatted data block, see [ECSS70], [CCS301] and [PUS].

CL-code
The civil-long code (CL-code) is only transmitted by modernised GPS satellites on L2, has a 511.5 Kbps chip rate and a period of 1.5 seconds. Nominally, the CL code is transmitted in a chip-by-chip time multiplex combination with the CM code where only the CM code carries navigation data.

CM-code
The civil-moderate code (CM-code) is only transmitted by modernised GPS satellites on L2, has a 511.5 Kbps chip rate and a period of 20 ms. Nominally, the CM code is transmitted in a chip-by-chip time multiplex combination with the CL code where only the CM code carries navigation data.

Code Epoch
The length of a Code Epoch is the length of a C/A-code, CL-code, CM-code or P-code sequence.

e.g.:
The C/A-code epoch has a length of 1023 chips, corresponding to 1 ms.
The P-code epoch has a length of 1 GPS week.

Code Phase
The spreading codes of the GPS signal (C/A-code, CL, CM and P-code) are periodic codes defined in [ICD200 §3.2.1]. The code phase is defined as the number of code chips and fractions of code chips relative the latest reset of the respective code.

Code Phase Measurement
The code phase measurement is the estimated code phase of the signal received. It is estimated with an unambiguous range of 1023 chips (300 km) for the C/A code and 10230 and 767250 chips (6000 and 450000 km), respectively, for the L2 CM and CL codes. For P(Y) code the unambiguous range is about $6*10^{12}$ chips.

Dual Frequency
The term refers to the L1 and L2 GPS frequencies.

Dual-Frequency Tracking
Requires that both code and carrier for two signal components have been acquired and are tracked.

GPS CNAV Data
This is the navigation data $D_C(t)$ that is transmitted by GPS SVs starting with Block IIR-M, modulated with FEC on L2CM code at 25 bps and L5-I5 code at 50 bps. For more details see [ICD200].

GPS NAV Data
This is the navigation data D(t) that is transmitted by all GPS SVs on L1 C/A code and L1, L2 P code at 50 bps. For more details see [ICD200].

GPS Time
The GPS Time is based on the atomic clocks in the satellites and in the ground segment. GPS Time does not introduce any leap seconds. The GPS control segment keeps the GPS Time within 1 μs of the UTC_{USNO} time (modulo-1 s). The GPS UTC parameters are used to relate them more precisely, as defined in [ICD200].

L1 signal
The primary L-band signal transmitted by each GPS SV at 1572.42 MHz. The L1 broadcast is modulated with the C/A and P(Y)-codes and with the navigation message.

L2 signal
The second L-band signal is centered at 1227.60 MHz and nominally carries the CM, CL (for modern GPS satellites) and P(Y)-code and navigation message. However, there are more options for code and navigation data transmission on L2, which are defined in [ICD200 §3.2.3].

Loss-of-Lock
The receiver software has to maintain the synchronisation to the received GPS signal, for the local replicas of both the code and the carrier phase. Loss-of-lock denotes when this synchronisation is lost.

Multi Frequency Channel (MFC)
A logical unit defined in software, to track all signals of a single GNSS satellite. It consists of a triple of adjacent single frequency channels (SFCs). The assignment is such that MFC 0 consists of SFC 0, 1, 2 and so on. In AGGA-2 based receivers the first SFC within an MFC is used to track C/A code, the second to track P(Y) on L1 and the third to track P(Y) on L2.

Packet
The data unit useful at user level, above CCSDS, transferred in one or more CCSDS Packets, contained in the DATA areas, e.g. Memory Dump Packet.

P-code
The precision code (P-code) has a 10.23 MHz chip rate and a period of one week (due to short cycling). The code sequence starts each Sunday morning at 0:00 AM, and is the principal navigation ranging code. The P-Code modulates both the L1 and L2 carriers.

Single Frequency
The term refers to the L1 GPS frequency.

Single-Frequency Tracking
Requires that both C/A-code and C/A carrier for L1 have been acquired and are tracked.

Tracking
The code phase and carrier phase synchronisation achieved during acquisition has to be maintained, which is accomplished by means of dedicated closed loops. This process is referred to as tracking.

Uncertainty
The uncertainty of a given parameter value V is specified according to point 1 or 2 below, depending on the characteristics of the parameter errors.

1. Uncertainty: (X,Y)
   where (V+X) is the minimum true value and (V+Y) is the maximum true value for a given parameter.

2. Uncertainty: Z RMS
   where Z is the root-mean-square (RMS) of the estimation errors for the given parameter.

UTC
UTC (Universal Time Coordinated) is an atomic clock time scale coordinated by the Bureau International de Poids et Mésures in Paris. UTC differs from a pure atomic clock in that it occasionally introduces leap seconds. This is done to keep this atomic time scale in approximate step with the Earth's rotation. The leap second adjustment can cause the particular minute to have 59 or 61 seconds instead of 60.

UTC_{USNO}
USNO forms its own version of the UTC, UTC_{USNO}, based on more than 20 cesium standards. UTC_{USNO} is kept within 1µs of UTC.

Y-code
In the Anti-Spoofing (AS) mode of operation, the P-Code is encrypted into the Y-Code. The encryption is performed by modulating a classified W-code on the P-code. The Y-code is modulated on both the L1 and L2 carriers.

3.2 CONVENTIONS

The following conventions are used throughout the document, unless otherwise specified.

3.2.1 Service Types and Service Subtypes

[ECSS70] defines Service types and Service subtypes. One service represents a certain part of the entire telecommand and telemetry interface, e.g. the Memory Management Service, and is divided into service subtypes. Service subtypes may correspond to either telecommand or telemetry formats. Service types and service subtypes are 8-bit numbers according to [ECSS70]. The notation used in [PUS] and in this document is defined as TC(service type, service subtype) or TM(service type, service subtype), respectively.

3.2.2 Number Representation

- Hexadecimal numbers are subscripted by 'H', e.g. 15_H = 21 decimal.
- Binary numbers are subscripted by 'B', e.g. 1011_B = 11 decimal.
- Any other number, i.e. not followed by the 'H' or 'B' subscripts, is decimal.

3.2.3 Bit, Byte, and Word

The bit number of an N-bit field is defined according to Figure 3-1. Bit number 0 is the most significant bit (MSB) of the field and bit number N-1 is the least significant bit (LSB). The MSB is always on the left side and the LSB is always on the right side.

Bit number				
0	1	…	N-2	N-1
MSB				LSB

Figure 3-1 – Bit Numbering

A byte is an 8-bit field.

A word is a 16-bit field.

A word-32 is a 32-bit field.

An array of more than one word and an N-bit field consisting of more than one word is organized according to Figure 3-2. Word number 0 is the most significant word (MSW) of the array or field and word number N-1 is the least significant word (LSW).

	Word number
MSW	0
	1
	…
	N-2
LSW	N-1

Figure 3-2 – Word Numbering

3.2.4 Field Values

The value of an N-bit field can have one of the following representations:

- An **unsigned integer** value uses the whole N-bit field to represent any number in the range from 0 to 2^N-1.
- A **signed integer** is represented using two's complement with the most significant bit indicating a positive (0) or a negative (1) number. The range of an N-bit signed integer is from -2^{N-1} to 2^{N-1}-1.
- A **range** from N to M occupying less than the full range of a field is expressed as N .. M.
- An **enumeration** type, either if the full range of the field is used or not, is expressed as discrete values with comments describing the definition of each value.
- **N/U** (Not Used) indicates that the field is not used. All bits in the field shall have the value 0. On reception N/U fields are verified.

3.3 TIME AND TIME FORMATS

See [CHKDIS].

4. CCSDS PACKET SPECIFICATION

4.1 GENERAL CCSDS PACKET STRUCTURE

See [CHKDIS].

4.2 PACKET TYPES DEFINED FOR MEASUREMENT DATA

The packets used for Measurement Data delivery are all of non-segmented, time-stamped type. Figure 4-1 below depicts how Measurement Data is embedded into telemetry packets of type (212,1).

The top row shows the number of bytes per field.

6	1	1	1	1	8	1	6	1	4*n	4*n	4*n	2

Science Data Service	16	212	1	0													
CCSDS Packet Header with time stamp etc. according to [CHKDIS]	PUS Version	Service Type	Service Subtype	Destination Identifier	Time field, see [CHKDIS]	Structure Identifier	Filler	Filler	Filler	Front-End Temperature	RSA Identifier	SN / V / Receiver Mode	Number of Records	Measurement Data Record 1	...	Measurement Data Record N	CRC

Source Packet Header	Data Field Header	SID		N	Measurement Data Set	Packet Error Control
		Measurement Data Header			N Data Records	

Figure 4-1– Packet Structure for Science Data Reports and Housekeeping Data Reports

5. MEASUREMENT DATA

This section specifies the Measurement Data generated by the GPSR. With the exception of the Navigation Solution Data Record and the Time Correlation Data Record Measurement Data is contained in a TM(212,1) Science Data Report, as shown in Figure 4-1. The other two Data Records are contained in a TM(3,25) Housekeeping Parameter Report, which has the same format as TM(212,1) but contains a different Service number and Subservice number. The telemetry packet contains a Measurement Data Header and a variable number of Measurement Data Records of the same type. Each record type has individual but constant length.

The timestamp may, depending on the Measurement Data Record type, correspond to either the sampling event or the end of a sampling period (see Table 5-5). Receiver-internal measurement sampling is performed synchronously to the PPS. Since the timestamp in the Data Field Header already corresponds to the sampling event, no additional timestamp is included in the Measurement Data Block. The high-resolution Instrument Measurement Time (IMT) and GPS Time (GPST) values and a corresponding UTC are provided via a dedicated time correlation packet – refer to section 5.4.1.3 and section 5.5.1.2 for details. Regardless of sample rate settings, sampling is always fully synchronous to the PPS, e.g. the measurements provided at a 0.1Hz rate are based on values sampled at the PPS.

Note: There are two exceptions, where timestamps are included in the Measurement Data Block:

- Navigation Solution Data Record, which includes the GPST in order to provide the complete PVT information.
- AGC Status Data Record, which is generated by the internal automatic gain control loop at 5Hz and therefore may change the applied gain setting between two PPS pulses.

The Measurement Data packet type is defined by the SID. The assignment of SIDs as well as the send type classification (periodic, on request, on event) are given in Table 5-5 on page 27.

5.1 MEASUREMENT DATA HEADER

The format details of the Measurement Data Header are shown in Figure 5-1; the meaning of the fields is described in Table 5-1. The message layout is compatible to that of TM(3,25).

<table>
<tr><td rowspan="2">Byte</td><td colspan="8">Bit number</td><td rowspan="2"></td></tr>
<tr><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr>
<tr><td>0</td><td colspan="8">SID</td><td rowspan="8">Measurement Data Header</td></tr>
<tr><td>1</td><td colspan="8">FILLER</td></tr>
<tr><td>2</td><td colspan="8">FILLER</td></tr>
<tr><td>3</td><td colspan="8">FILLER</td></tr>
<tr><td>4</td><td colspan="8">FE_TEMP</td></tr>
<tr><td>5</td><td colspan="8">ID</td></tr>
<tr><td>6</td><td colspan="4">SN</td><td>V</td><td colspan="3">R_MODE</td></tr>
<tr><td>7</td><td colspan="8">NOF_REC</td></tr>
<tr><td>…</td><td colspan="8">Data Record 1</td><td rowspan="3">Measurement Data Records</td></tr>
<tr><td></td><td colspan="8">…</td></tr>
<tr><td>…</td><td colspan="8">Data Record N (= NOF_REC)</td></tr>
</table>

Figure 5-1 – Measurement Data Header Format

Name	Definition	Field width	Value/Type	Interpretation
SID	Structure identifier	8	unsigned	The SID specifies the TM record type, see Table 5-5.
FE_TEMP	R/F front-end temperature	8	unsigned	Raw value, scaling and calibration on ground. Zero when in Startup Mode. The relation between raw values and physical temperature values is given in [HWSWICD Table 23] .
ID	Internal use only	8	unsigned	For internal use by RSA
SN	Serial Number	4	0	Not used in Sentinel
V	Data valid flag	1	0	Not all data is valid, see Table 5-2
			1	All data in the data records is valid
R_MODE	Receiver mode	3	1	Startup mode
			2	Standby mode
			3	Navigate mode
			other	Invalid
NOF_REC	Number of records in data block	8	unsigned	A data block may consist of several equally structured records

Table 5-1 – Measurement Data Header Definition

The criteria for the valid flag are listed in Table 5-2 below:

<table>
<tr><th>Record Type</th><th>Criteria for Data Valid Flag = 1</th><th>Criteria for Data Valid Flag = 0</th></tr>
<tr><td>Navigation Solution Data Record</td><td rowspan="2">All of the following criteria have to be fulfilled for a ‘data valid’ condition:

▪ The position quality index in the QUAL_INDEX field is below a threshold of 20m.

Note: The position quality index is determined by means of navigation solution mode dependent algorithms and therefore the detailed NSM field content is considered in that way.</td><td rowspan="2">▪ Navigation solution method is ‘propagated’ (NSM=1) , position uncertainty has been provided via FMT_InitialStateVector TC and is greater than position quality index threshold or the position quality index threshold has been exceeded during the ongoing propagation phase
▪ The navigation solution is based on Least Square or Kalman Filtering (NSM=3, 4 or 5), 4 or more SV available, but either a bad PDOP, URA, Pseudo-range or residual position error leads to a bad position quality index
▪ The navigation solution is based on Kalman Filtering (NSM=5) with less than 4 SV available, and PDOP degraded over time, thus leading to a bad position quality index
▪ The navigation solution is invalid (NSM=7) after a first fix has already been achieved once, because of less than 4 SV available and the position uncertainty increased over time, thus leading to a bad position quality index</td></tr>
<tr><td>S1 Navigation Solution Data Record</td></tr>
<tr><td>Time Correlation Data Record</td><td>All of the following criteria have to be fulfilled for a ‘data valid’ condition:

▪ PPS is in the synchronised state, PPS output enabled (this implicitly means that a first fix since transition from Standby mode has been achieved)
▪ UTC conversion parameter are available (either uploaded from ground or downloaded from the GPS constellation)
▪ The time quality index in the QUAL_INDEX field is below a threshold of 500ns.

Note: The time quality index is determined by means of navigation solution mode dependent algorithms and therefore the detailed NSM field content is considered in that way.</td><td rowspan="2">▪ Navigation solution method is ‘propagated’ (NSM=1), time uncertainty stemming from a FMT_LOBT TC is greater than time quality index threshold or the time quality index threshold has been exceeded during the ongoing propagation phase
▪ The navigation solution is computed in the cold start least squares mode (NSM=3), i.e. no DOP-optimised first fix has been achieved
▪ The navigation solution is based on Least Square or Kalman Filtering (NSM=4 or 5), 4 or more SV available, but either a bad TDOP, URA, Pseudo-range or residual position error leads to a bad time quality index
▪ The navigation solution is based on Kalman Filtering (NSM=5) with less than 4 SV available, and TDOP degraded over time, thus leading to a bad time quality index
▪ The navigation solution is invalid (NSM=7) after a first fix has already been achieved once, because of less than 4 SV available and the time uncertainty increased over time, thus leading to a bad time quality index
▪ A first fix has been achieved (NSM=2), but the PPS is not synchronised yet and thus the output still disabled
▪ The PPS was synchronised after the first fix (NSM=2), but the control loop detected a control deviation of more than 0.5µs
▪ Only for the Time Correlation Data Record: The UTC conversion</td></tr>
<tr><td>IMT/GPST Correlation Data Record</td><td>All of the following criteria have to be fulfilled for a ‘data valid’ condition:

▪ PPS is in the synchronised state, PPS output enabled (this implicitly means that a first fix since transition from Standby mode has been achieved)
▪ The time quality index in the QUAL_INDEX field is below a threshold of 500ns.

Note: The time quality index is determined by means of navigation solution mode dependent algorithms and therefore the detailed NSM field content is considered in that way.</td></tr>
</table>

Record Type	Criteria for Data Valid Flag = 1	Criteria for Data Valid Flag = 0
		parameters are not available, either not uploaded, not downloaded yet or outdated
Carrier Phase Data Record	Polynomial fitting algorithm succeeded, phase values computed in the normal way	Polynomial fitting algorithm failed (singular input matrix), phase values in data record set to zero
Code Phase Data Record		
Satellites In View Status Record	Data Valid Flag always 1	None
Constellation Status Record		
Tracking State Data Record		
Channel Status Record		
Carrier Amplitude Data Record		
Noise Histogram Data Record		
AGC Status Data Record		
GPS NAV Almanac Data Record		
GPS NAV Ephemeris Data Record		
GPS NAV UTC and Ionosphere Data Record		
Auxiliary Data Record		
Housekeeping Parameter Report		

Table 5-2 – Interpretation of the Data Valid Flag

5.2 COMMON DEFINITIONS FOR MEASUREMENT DATA RECORDS

Commonly used receiver-specific key features and field definitions for subsequently defined data records are listed in Table 5-3 and Table 5-4, respectively.

Name	Definition	Value	Interpretation
NOF_SVS	Number of Space Vehicles	32	Maximum number of Space Vehicles in a GNSS Constellation
NOF_ANTS	Number of Antennas	1	Maximum number of antennas
NOF_CHAINS	Number of Processing Chains	2	Maximum number of R/F chains the received signal can be processed in
NOF_MFCS	Number of Multi Frequency Channels	8	Maximum number of logical receiver channels a single SV (multiple signal components) can be tracked in
NOF_SFCS	Number of Single Frequency Channels	24	Maximum number of physical receiver channels a signal component can be tracked in

Table 5-3 – Common Receiver Key Features

Name	Definition	Field width	Value	Interpretation
CONS	Constellation identifier	3	0	GPS Constellation
			Other	Any other value is invalid
BLOCK	GPS SV Block type	3	0	GPS Block I
			1	GPS Block II/IIA/IIR
			2	GPS Block IIR-M
			3	GPS Block IIF
			7	GPS Block information unknown due to pending download of Page 25 / Subframe 4 of the legacy navigation data message
			Other	Any other value is undefined and may be used for future GPS Block types
SV_ID	Space vehicle identifier	8	0	Not a valid GPS SV ID, used to mark a channel with no signal acquisition and tracking activities on it
			1-32	GPS SVs
			Other	Any other value is invalid
SIG	Signal type	5	0	GPS L1 C/A
			1	GPS L1 P

Name	Definition	Field width	Value	Interpretation
			2	GPS L2 C/A (N/A for Sentinel)
			3	GPS L2 P
			4	GPS L2 CM (Sentinel B only)
			5	GPS L2 CL (N/A for Sentinel)
			6	No signal processing on this channel
			Other	Any other value is invalid
ANT	Antenna identifier	4	0	First antenna
			1	Second antenna (invalid in Sentinel)
			Other	Any other value is invalid
CHAIN	Down-conversion chain identifier	4	0	Antenna 1, L1 carrier
			1	Antenna 1, L2 carrier
			Other	Any other value is invalid
SF_CHN	Single-frequency channel number	8	0 .. 23	Physical single frequency channel number (for the AGGA-2 based receiver)
			Other	Any other value is invalid
MF_CHN	Multi-frequency channel number	8	0 .. 7	Logical multi frequency channel number (for the AGGA-2 based receiver) MF_CHN 0 consists of SF_CHN 0, 1, 2 MF_CHN 1 consists of SF_CHN 3, 4, 5 etc.
			Other	Any other value is invalid
NSM	Navigation Solution Method	3	1	Navigation solution method is 'propagated' , no first fix after transition from Standby to Navigate (propagated initial values of default or uploaded state vector) or no SV available for PVT or Kalman Filter diverged and not enough SV for Least Square to re-initialise Kalman Filter.
			2	First Navigation Fix. This is the very first navigation solution accomplished after entering Navigate mode, using information from four GNSS SVs. A least square method is used.
			3	The receiver has achieved a first fix in the frame of a cold start, but has not yet enough information for a GDOP optimised selection. The reported navigation solution is estimated with a least squares method until enough Almanac data records have been collected to allow autonomous selection for a warm start and Kalman Filter pull-in.
			4	The reported navigation solution is estimated with a least squares method, using all visible and healthy satellites, limited by the number of receiver channels.
			5	The reported navigation solution is estimated with a Kalman filter. Default during nominal operation.
			7	Invalid navigation solution, last known good navigation solution is propagated. Indicated if least square is used and less than 4 satellites are in the field-of-view of the antenna after a first navigation fix has been achieved.
			Other	Any other value is invalid
T_REC	Time of reception	16	Unsigned	This entry denotes the time within the GPS week when the data in the data record was received. This timestamp is derived from the time of week count (TOW) in the navigation message, see also [ICD200]. Navigation data uploaded by the user need to set this field to $FFFF_H$ in order to indicate that it was uploaded by telecommand. Units: [12s]. In the Function Parameter Report TM(211,3) the field T_REC is set to zero to indicate that the record for this SV has not been retrieved by the GPSR and all parameters have the value zero in the record. A T_REC value of 0xFFFF indicates that the record for this SV was uploaded with TC(211,1).

Table 5-4 – Common Parameter Field Definition

5.3 RECORD TYPE DEPENDENT INFORMATION

Table 5-5 lists the record types with the according SID, their distribution category, and the possible transmission directions. Additionally, the timestamp category for each packet type is specified, which means that the timestamp can either be a specific point in time (PIT) the data was generated and is valid for (e.g. navigation solution) or a point in time marking the end of a period (EOP) the data is valid for (e.g. carrier amplitude). The two rightmost columns define the use of the packet and thus define the extent of testing applied during software development.

Record type	Section	SID (SWARM SID + 212)	Service Type	Subservice Type	Record size [octets]	Maximum number of records per sample period. If the max. size of a TM-packet is exceeded, more packets are sent.	Maximum number of records per TM	Number of TM packets per sample period	Variable number of records in TM	Periodic	On request	On event	Dataflow out of the receiver	Dataflow into the receiver	Timestamp PIT ...Point in time EOP ...End of Period	Subject to qualification testing?	For verification and diagnostic purposes only
Navigation Solution Data Record	5.4.1.1	213	3	25	96	1	1	1	-	✓	✓	-	✓	-	PIT	✓	-
Satellites In View Status Record	5.4.1.2	223	212	1	28	NOF_SVS	8	0...4	✓	✓	✓	-	✓	-	PIT	-	✓
Time Correlation Data Record	5.4.1.3	214	3	25	28	1	1	1	-	✓	✓	-	✓	-	PIT	✓	-
Constellation Status Record	5.4.1.4	229	212	1	4	NOF_SVS	NOF_SVS	1	✓	-	✓	✓	✓	-	EOP	✓	-
Tracking State Data Record	5.4.1.5	215	212	1	12	NOF_MFCS	NOF_MFCS	1	-	✓	✓	-	✓	-	PIT	-	✓
Channel Status Record	5.4.1.6	224	212	1	8	NOF_SFCS	NOF_SFCS	1	-	✓	✓	-	✓	-	PIT	-	✓
Carrier Phase Data Record	5.4.1.7	225	212	1	16	NOF_CHAINS * NOF_MFCS	14	0...2	✓	✓	✓	-	✓	-	PIT	✓	-
Carrier Amplitude Data Record	5.4.1.8	226	212	1	8	NOF_CHAINS * NOF_MFCS	NOF_CHAINS * NOF_MFCS	0...1	✓	✓	✓	-	✓	-	EOP	✓	-
Code Phase Data Record	5.4.1.9	227	212	1	12	NOF_SFCS	19	0...2	✓	✓	✓	-	✓	-	PIT	✓	-
Noise Histogram Data Record	5.4.1.10	235	212	1	36	NOF_CHAINS	NOF_CHAINS	1	-	✓	✓	-	✓	-	EOP	-	✓
AGC Status Data Record	5.4.1.11	234	212	1	12	NOF_CHAINS	NOF_CHAINS	0...1	✓	-	✓	✓	✓	-	PIT	-	✓
GPS NAV Almanac Data Record	5.4.2.1	230	212	1	36	NOF_SVS	6	0...6	✓	-	✓	✓	✓	✓	EOP	✓	-
GPS NAV Ephemeris Data Record	5.4.2.2	231	212	1	68	NOF_MFCS	3	0...3	✓	-	✓	✓	✓	✓	EOP	✓	-
GPS NAV UTC and Ionosphere Data Record	5.4.2.3	232	212	1	28	1	1	0...1	-	-	✓	✓	✓	✓	EOP	✓	-
GPS CNAV Group Delay Data Record	5.4.3.1	233	212	1	12	8	19	0	✓	-	✓	-	✓	✓	EOP	✓	-
S1 Navigation Solution Data Record	5.5.1.1	216	212	1	96	1	1	1	-	✓	✓	-	✓	-	PIT	✓	-
IMT/GPST Correlation Data Record	5.5.1.2	217	212	1	20	1	1	1	-	✓	✓	-	✓	-	PIT	-	-
Auxiliary Data Record	5.5.1.3	218	212	1	4	NOF_MFCS	NOF_MFCS	1	-	✓	✓	-	✓	-	PIT	✓	-
Housekeeping Parameter Report	[CHKDIS]	219	3	25	24	1	1	1	-	✓	✓	-	✓	-	PIT/EOP	✓	-

Table 5-5 – Record Type Dependent Information

Refer to Table 5-4 and Table 5-3 for the meaning of the constants in uppercase letters.

Note that not all Data Records will fit into a single CCSDS packet of up to 256 bytes. For example the delivery of all Code Phase Data Records will require two TM packets - one packet containing 19 records and one with 5 records. On the other hand, for Data Records with a variable number of records there might also be the case that no TM packet is generated in the sample period, e.g. immediately after entering the Navigate mode when no SV is tracked.

5.4 GENERAL DATA RECORDS

5.4.1 Constellation Independent Data Records

5.4.1.1 Navigation Solution Data Record

The purpose of this record is to give the position and velocity of the receiver at a defined point in time. Additionally, quality measures for the current navigation solution are supplied.

	Bit number															
Word	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	GPST															
1																
2																
3																
4	N/U	NSM			QUAL_INDEX											
5	GDOP															
6	MAX_URA					MAX_FIT				N/U			NOF_SV			
7	POS_X															
8																
9																
10	POS_Y															
11																
12																
13	POS_Z															
14																
15																
16	VEL_X															
17																
18	VEL_Y															
19																
20	VEL_Z															
21																
22	PDOP															
23	TDOP															
24	Δx															
25																
26	Δy															
27																
28	Δz															
29																
30	Δt															
31																
32	Δv_x															
33																
34	Δv_y															
35																
36	Δv_z															
37																
38	Δf															
39																
40	HEIGHT															
41																
42	VERTSPEED															
43																
44	LONGITUDE															
45																
46	LATITUDE															
47																

Figure 5-2 – Navigation Solution Data Record Format

Name	Definition	Field width	Type/Value	Interpretation
GPST	GPS time	64	GPS-type	GPST representation of the synchronisation time stamp. GPS type definition see [CHKDIS].
N/U	Not Used	1	0	-
NSM	Navigation Solution Method	3	Unsigned	see Table 5-4
QUAL_INDEX	Quality index	12	Unsigned	[m], position quality index, values greater than 4095m are saturated to 4095m, details see [SUM]
GDOP	Geometrical dilution of precision	16	Unsigned	1 LSB corresponds to 10^{-2}; values greater than 655.34 are saturated to 65534
			65535	This value is set in case of Kalman filtered navigation solution (NSM=5) with fewer than 4 SVs available[1] or propagated initial state vector (NSM=1).
MAX_URA	Maximum user range accuracy	5	-15 .. 15	Worst user range accuracy figure of all SVs contributing to the current navigation solution, values see URA index in [ICD200]
			-16	Propagated PVT vector (NSM equal to 1) and therefore no URA available
MAX_FIT	Maximum curve fit interval taken from all SVs used in current navigation solution	4	0	4 h
			1	6 h
			2	8 h
			3	14 h
			4	26 h
			5	50 h
			6	74 h
			7	98 h
			8	122 h
			9	146 h
			15	In case of propagated PVT vector (NSM equal to 1) and therefore no value available
			Other	Any other value is invalid
N/U	Not Used	3	0	-
NOF_SV	Number of SVs contributing to the Navigation Solution	4	0… NOF_MFCS	The number of SVs the receiver was able to use for the Navigation Solution computation, i.e. SVs for which code and carrier phase measurements and Ephemeris data were available.
POS_X	X-coordinate	48	Signed	[mm] in WGS84, see also [WGS84] Estimated position of the platform reference point (center of mass) according to the Navigation Solution Method (NSM) at the point in time of GPST.
POS_Y	Y-coordinate	48	Signed	
POS_Z	Z-coordinate	48	Signed	
VEL_X	X-velocity	32	Signed	[mm/s] in WGS84, see also [WGS84] Estimated velocity of the platform reference point (center of mass) according to the Navigation Solution Method (NSM) at the point in time of GPST.
VEL_Y	Y-velocity	32	Signed	
VEL_Z	Z-velocity	32	Signed	
PDOP	Position dilution of precision	16	Unsigned	1 LSB corresponds to 10^{-2}, values greater than 655.34 are saturated to 65534
			65535	This value is set in case of Kalman filtered navigation solution (NSM=5) with fewer than 4 SVs available[1] or propagated initial state vector (NSM=1).
TDOP	Time dilution of precision	16	Unsigned	1 LSB corresponds to 10^{-2}, values greater than 655.34 are saturated to 65534
			65535	This value is set in case of Kalman filtered navigation solution (NSM=5) with fewer than 4 SVs available[1] or propagated initial state vector (NSM=1).
Δx	Position error in x direction	32	Signed	[mm]
Δy	Position error in y direction			

[1] The dilution of precision values can only be computed with at least 4 SVs available for navigation solution computation.

Name	Definition	Field width	Type/Value	Interpretation
Δz	Position error in z direction		2147483647	This value is set in case of Kalman filtered navigation solution (NSM=5) with fewer than 4 SVs available[1] or propagated initial state vector (NSM=1).
Δt	GNSS system time error	32	Signed	[ns]
			2147483647	This value is set in case of Kalman filtered navigation solution (NSM=5) with fewer than 4 SVs available[1] or propagated initial state vector (NSM=1).
Δv_x	Velocity error in x direction	32	Signed	[mm/s]
Δv_y	Velocity error in y direction			
Δv_z	Velocity error in z direction		2147483647	This value is set in case of Kalman filtered navigation solution (NSM=5) with fewer than 4 SVs available[1] or propagated initial state vector (NSM=1).
Δf	Receiver clock frequency error	32	Signed	[mHz]
			2147483647	This value is set in case of Kalman filtered navigation solution (NSM=5) with fewer than 4 SVs available[1] or propagated initial state vector (NSM=1).
HEIGHT	Height above reference ellipsoid	32	Unsigned	Height w.r.t WGS-84 reference frame in [cm]
VERTSPEED	Vertical speed	32	Signed	Vertical speed w.r.t WGS-84 reference frame in [0.01mm/s]
LONGITUDE	Longitude	32	Signed	Longitude w.r.t WGS-84 reference frame -180 degrees to +180 degrees in [1e-7deg]
LATITUDE	Latitude	32	Signed	Latitude w.r.t WGS-84 reference frame -90 degrees to +90 degrees in [1e-7deg]

Table 5-6 – Navigation Solution Data Record Definition

Note:

The error fields in the navigation solution data record (Δx, Δy, … , Δf) are derived from pseudo-range and delta-range errors for successful least square or Kalman filtered navigation solution. In any other case they are set to a saturated value.

5.4.1.2 Satellites In View Status Record

This record reflects basic info of all GPS SVs currently in view (not only the ones being processed). All the fields in the record form the basis for the current GNSS SV selection process.

<table>
<tr><th rowspan="2">Word</th><th colspan="16">Bit number</th></tr>
<tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th></tr>
<tr><td>0</td><td colspan="3">CONS</td><td colspan="8">SV_ID</td><td colspan="3">BLOCK</td><td>E</td><td>B</td></tr>
<tr><td>1</td><td colspan="4">ANT</td><td>X</td><td>N</td><td>M</td><td>S</td><td colspan="8">MFC_TS</td></tr>
<tr><td>2</td><td colspan="5">URA</td><td>AL</td><td>FP</td><td>N/U</td><td>H1</td><td>H2</td><td colspan="6">N/U</td></tr>
<tr><td>3</td><td colspan="16" rowspan="3">PSEUDO_R</td></tr>
<tr><td>4</td></tr>
<tr><td>5</td></tr>
<tr><td>6</td><td colspan="16" rowspan="2">DELTA_R</td></tr>
<tr><td>7</td></tr>
<tr><td>8</td><td colspan="16">ZENITH t_0</td></tr>
<tr><td>9</td><td colspan="16">AZ t_0</td></tr>
<tr><td>10</td><td colspan="16">ZENITH t_1</td></tr>
<tr><td>11</td><td colspan="16">AZ t_1</td></tr>
<tr><td>12</td><td colspan="16">ATT_UNC</td></tr>
<tr><td>13</td><td colspan="16">N/U</td></tr>
</table>

Figure 5-3 – Satellites In View Status Record Format

Note: The elevation and azimuth angles the GNSS SV is seen from the receiver are given for two points in time, t_0 and t_1. t_0 is the timestamp of the current SV selection process and t_1 is a time in the future that shall also be relevant for the current selection process since the SV shall be in the field of view for at least a certain time. The time span t_1- t_0 is 180 seconds for an acquisition in the frame of a warm start and 40 seconds for an acquisition during steady state navigation.

Name	Definition	Bit width	Value	Interpretation
CONS	Constellation identifier	3	Unsigned	See Table 5-4
SV_ID	Space vehicle Identifier	8	Unsigned	See Table 5-4
BLOCK	GPS SV Block type	3	Unsigned	See Table 5-4
E	Ephemeris data available	1	0	No ephemeris data available
			1	Ephemeris data available
B[1]	SV temporarily banned flag	1	0	SV is not banned
			1	SV is temporarily banned
ANT	Antenna identifier	4	Unsigned	See Table 5-4
X	SV is excluded by TC	1	0	SV is not excluded from tracking
			1	SV is excluded from tracking
N	SV is used for navigation solution	1	0	SV is not used for navigation solution
			1	SV is used for navigation solution
M	Multipath mitigation masking	1	0	SV is not excluded due to multipath mitigation mask
			1	SV is excluded due to multipath mitigation mask
S	GNSS SV antenna masking	1	0	SV is not excluded due to antenna masking
			1	SV is excluded due to antenna masking
MFC_TS	Multi frequency channel tracking state	8	Unsigned	Values see Table 5-17
URA	User range accuracy index	5	Unsigned	Values see URA index in [ICD200]
AL	Alert flag	1	0	Flag according to navigation message, see [ICD200]
			1	
FP	Force P(Y) tracking scheme flag	1	0	The BLOCK field determines if the civil signal on L2 (CM) shall be tracked instead of P(Y) (Sentinel B only)
			1	P(Y) code is tracked regardless of the BLOCK field content (always the case in Sentinel A)
N/U	Not Used	1	0	-
H1	Signal and data health of 1st band (is L1 for GPS) as indicated in subframes 4 and 5 of the navigation data message	1	0	L1 signal or data is unhealthy
			1	L1 signal and data is healthy
H2	Signal and data health of 2nd band (is L2 for GPS) as indicated in subframes 4 and 5 of the navigation data message	1	0	L2 signal or data is unhealthy
			1	L2 signal and data is healthy
N/U	Not Used	6	0	-
PSEUDO_R	Pseudo range	48	Unsigned	Pseudo range in [mm], measured value for SV being tracked, estimated value otherwise
DELTA_R	Delta range	32	Signed	Delta range in [0.01 mm/s], measured value for SV being tracked, estimated value otherwise
ZENITH t_0	Zenith angle at time t_0	16	Unsigned	[0.01 deg], measured from antenna zenith direction
AZ t_0	Azimuth angle at time t_0	16	Signed	[0.01 deg]
ZENITH t_1	Zenith angle at time t_1	16	Unsigned	[0.01 deg], measured from antenna zenith direction
AZ t_1	Azimuth angle at time t_1	16	Signed	[0.01 deg]
ATT_UNC	Attitude uncertainty	16	Unsigned	[0.001 deg] Single sided uncertainty
N/U	Not Used	16	0	-

Table 5-7 – Satellites In View Status Record Definition

[1] An SV is banned for some time in case acquisition of the SV does not succeed.

5.4.1.3 Time Correlation Data Record

The purpose of this record is to provide all different time bases for a specific point in time. The time tags of this block correspond to the leading edge of the last PPS pulse. Note that the LOBT is missing in the Data Record because the LOBT is found in the CCSDS header.

<table>
<tr><th rowspan="2">Word</th><th colspan="16">Bit number</th></tr>
<tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th></tr>
<tr><td>0</td><td>N/U</td><td colspan="3">NSM</td><td colspan="12">QUAL_INDEX</td></tr>
<tr><td>1</td><td colspan="16">TDOP</td></tr>
<tr><td>2</td><td colspan="16" rowspan="4">IMT</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td></tr>
<tr><td>5</td></tr>
<tr><td>6</td><td colspan="16" rowspan="4">GPST</td></tr>
<tr><td>7</td></tr>
<tr><td>8</td></tr>
<tr><td>9</td></tr>
<tr><td>10</td><td colspan="16" rowspan="4">UTC</td></tr>
<tr><td>11</td></tr>
<tr><td>12</td></tr>
<tr><td>13</td></tr>
</table>

Figure 5-4 – Time Correlation Data Record Format

Name	Definition	Value, Format	Interpretation
N/U	Not Used	0	-
NSM	Navigation Solution Method	Unsigned	see Table 5-4
QUAL_INDEX	Quality index	Unsigned	[ns], time quality index, values greater than 4095ns are saturated to 4095ns, details see [SUM]
TDOP	Time dilution of precision	Unsigned	1 LSB corresponds to 10^{-2}, values greater than 655.34 are saturated to 65534
		65535	This value is set in case of Kalman filtered navigation solution (NSM=5) with fewer than 4 SVs available[1] or during propagation of the state vector (NSM=1).
IMT	Instrument measurement time	IMT-type	IMT representation of the synchronisation time stamp. IMT type definition, see [CHKDIS].
GPST	GPS time	GPS-type	GPST representation of the synchronisation time stamp. GPS type definition see [CHKDIS].
UTC	UTC Time	UTC Format	UTC time representation of the synchronisation time stamp. The UTC Format is defined in [CHKDIS].

Table 5-8 – Time Correlation Data Record Definition

5.4.1.4 Constellation Status Record

This record provides an overview of all SVs in the constellation concerning their health, data availability and SV type info.

Word	Bit number 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	CONS			SV_ID								AS	X	BLOCK		
1	AN	EN	CN	DN	AC	EC	CC	DC	GC	FP	HEALTH					

Figure 5-5 – Constellation Status Record Format

Name	Definition	Value/Type	Interpretation
CONS	Constellation identifier	Unsigned	see Table 5-4
SV_ID	Space vehicle identifier	Unsigned	see Table 5-4
AS	Anti-spoof flag	0	Anti-Spoof off
		1	Anti-Spoof on
X	SV excluded by TC	0	SV is excluded
		1	SV is included
BLOCK	GPS SV Block type	Unsigned	See Table 5-4.
AN	Almanac data from NAV message available	0	Not available
		1	Available
EN	Ephemeris data from NAV message available	0	Not available
		1	Available
CN	Clock correction data from NAV message available	0	Not available
		1	Available
DN	Differential correction data for NAV message available	0	Not available (always the case in Sentinel)
		1	Available
AC	Almanac data from CNAV message available	0	Not available (always the case in Sentinel)
		1	Available
EC	Ephemeris data from CNAV message available	0	Not available (always the case in Sentinel)
		1	Available
CC	Clock correction data from CNAV message available	0	Not available (always the case in Sentinel)
		1	Available
DC	Differential correction data for CNAV message available	0	Not available (always the case in Sentinel)
		1	Available
GC	Group delay data for CNAV message available	0	Not available (always the case in Sentinel)
		1	Available
FP	Force P(Y) signal tracking	0	The BLOCK field determines if the civil signal on L2 (CM) shall be tracked instead of P(Y) (Sentinel B only)
		1	P(Y) code is tracked regardless of the BLOCK field content (always the case in Sentinel A)
HEALTH		Unsigned	SV health info according to subframe 5 page 25 in navigation message, see [ICD200].

Table 5-9 – Constellation Status Record Definition

5.4.1.5 Tracking State Data Record

The purpose of this record is to give the tracking state for each SV the receiver is tracking in a multi frequency channel (MFC) and to provide the related single frequency channel (SFC) assignment.

<table>
<tr><th rowspan="2">Word</th><th colspan="16">Bit number</th></tr>
<tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th></tr>
<tr><td>0</td><td colspan="3">CONS</td><td colspan="8">SV_ID</td><td>N/U</td><td colspan="4">ANT</td></tr>
<tr><td>1</td><td colspan="8">MFC_TS</td><td colspan="8">MF_CHN</td></tr>
<tr><td>2</td><td colspan="3">N/U</td><td colspan="5">SIG1</td><td colspan="8">CHN1</td></tr>
<tr><td>3</td><td colspan="3">N/U</td><td colspan="5">SIG2</td><td colspan="8">CHN2</td></tr>
<tr><td>4</td><td colspan="3">N/U</td><td colspan="5">SIG3</td><td colspan="8">CHN3</td></tr>
<tr><td>5</td><td colspan="16">N/U</td></tr>
</table>

Figure 5-6 – Tracking State Data Record Format

Name	Definition	Value/Type	Interpretation
CONS	Constellation identifier	Unsigned	see Table 5-4 on page 26
SV_ID	Space vehicle identifier	Unsigned	see Table 5-4 Note: Initially, i.e. if no SV has yet been selected for tracking in the MFC, the reported SV_ID is zero (invalid ID).
N/U	Not Used	0	-
ANT	Antenna identifier	Unsigned	see Table 5-4 on page 26
MFC_TS	Multi frequency channel tracking state	Unsigned	Values see Table 5-17 on page 46
MF_CHN	Multi frequency channel number	Unsigned	see Table 5-4 on page 26
SIG1	Signal type being processed on the first SFC within the MFC	Unsigned	see Table 5-4
CHN1	Channel number of the first SFC within the MFC	Unsigned	see Table 5-4
SIG2	Signal type being processed on the second SFC within the MFC	Unsigned	see Table 5-4
CHN2	Channel number of the second SFC within the MFC	Unsigned	see Table 5-4
SIG3	Signal type being processed on the third SFC within the MFC	Unsigned	see Table 5-4
CHN3	Channel number of the third SFC within the MFC	Unsigned	see Table 5-4
N/U	Not Used	0	32-bit padding

Table 5-10 – Tracking State Data Record Definition

The Tracking State Data record reports the state of the tracking loops. Table 5-11 indicates the relation between tracking state MFC_TS and the to be expected TM records for the combined L1 C/A and L1/L2 P(Y) tracking scheme. This relation is valid when each tracking state is in steady state.

Note: When a C/A track starts, the correctness of the bit edge position is checked by means of a histogram over the first 200 decoded 'true' navigation data bit edges. 'True' in this context means the inversion of the polarity of navigation data. The number of 'true' data bit edges depends on the actual content of the navigation data stream, therefore also the time for the bit edge check to complete depends on the navigation data content. Assuming a 'true' bit edge every 3rd bit, the length of 2 subframes (300 bits each) corresponding to 12s is a typical duration of that check. No code phase data record is generated for C/A before the correctness of the bit edge position has been proven.
In practice this means that after reaching MFC_TS=5 it may typcially take about 12s before the first C/A code phase data record is generated (plus one sample rate period for smoothing). Since in a normal case the code phase of a signal located on L2 is used to correct for ionospheric effects, and this signal on L2 is acquired after C/A tracking has been established, this delay does not really shorten the lenght of a dual-frequency track.

Record Type	Code Phase			Carrier Phase			Carrier Amplitude			Channel Status			NavData Download		
Signal	C/A	P2	P1	C/A	P2	P1	C/A	P2	P1	C/A	P2	P1	C/A	P2	P1
SFC	0	2	1	0	2	1	0	2	1	0	2	1	0	2	1
MFC_TS 0	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
MFC_TS 1	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
MFC_TS 2	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
MFC_TS 3	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
MFC_TS 4	-	-	-	-	-	-	-	-	-	✓	-	-	✓	-	-
MFC_TS 5	✓	-	-	✓	-	-	✓	-	-	✓	-	-	✓	-	-
MFC_TS 6	✓	-	-	✓	-	-	✓	-	-	✓	✓	✓	✓	-	-
MFC_TS 7	✓	-	-	✓	-	-	✓	-	-	✓	✓	✓	✓	-	-
MFC_TS 8	✓	✓	-	✓	✓	-	✓	✓	-	✓	✓	✓	✓	-	-
MFC_TS 9	✓	✓	-	✓	✓	-	✓	✓	-	✓	✓	✓	✓	-	-
MFC_TS 10	✓	✓	-	✓	✓	-	✓	✓	-	✓	✓	✓	✓	-	-
MFC_TS 11	✓	✓	✓	✓	✓	-	✓	✓	-	✓	✓	✓	✓	-	-

Table 5-11 – Generated TM records for each Tracking State (L1 C/A L1/L2 P/Y)

Note: Basically, the same navigation data as modulated on C/A on L1 is modulated on P(Y) on L1 and P(Y) on L2. However, the adaptive semi-codeless dual-frequency operation of the AGGA2 chip strips off the navigation data. Therefore the Navigation Data download is only possible on the first signal (C/A).

Table 5-12 indicates the relation between tracking state MFC_TS and the to be expected TM records for the combined L1 C/A and L2 CM tracking scheme. This relation is valid when each tracking state is in steady state.

Record Type	Code Phase			Carrier Phase			Carrier Amplitude			Channel Status			NavData Download		
Signal	C/A	CM	-	C/A	CM	-	C/A	CM	-	C/A	CM	-	C/A	CM	-
SFC	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
MFC_TS 0	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
MFC_TS 1	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
MFC_TS 2	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
MFC_TS 3	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
MFC_TS 4	-	-	-	-	-	-	-	-	-	✓	-	-	✓	-	-
MFC_TS 5	✓	-	-	✓	-	-	✓	-	-	✓	-	-	✓	-	-
MFC_TS 6	✓	-	-	✓	-	-	✓	-	-	✓	✓	-	✓	-	-
MFC_TS 7	✓	-	-	✓	-	-	✓	-	-	✓	✓	-	✓	-	-
MFC_TS 8	✓	✓	-	✓	✓	-	✓	✓	-	✓	✓	-	✓	-	-

Table 5-12 – Generated TM records for each Tracking State (L1 C/A L2 CM)

Note: When a CM track starts, the correctness of the symbol edge position is checked by means of a histogram over the first 200 decoded 'true' navigation symbol edges. 'True' in this context means the inversion of the polarity of navigation data. The number of 'true' symbol edges depends on the actual content of the CNAV data stream, therefore also the time for the bit edge check to complete depends on the navigation data content. Assuming a 'true' symbol edge every 3rd bit, the length of one CNAV-message (300 bits = 600 symbols) corresponding to 12s is a typical duration of that check. No code phase data record is generated for CM before the correctness of the symbol edge position has been proven.
In practice this means that after reaching MFC_TS=8 it may typcially take about 12s before the first CM code phase data record is generated (plus one sample rate period for smoothing). Because the acquisition of L2CM code is significantly faster than a P(Y) acquisition, L2CM based dual-frequency tracks are nevertheless longer than P(Y) based dual-frequency tracks.

5.4.1.6 Channel Status Record

The purpose of this record is to provide a detailed tracking status of all single-frequency channels.

<table>
<tr><th rowspan="2">Word</th><th colspan="16">Bit number</th></tr>
<tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th></tr>
<tr><td>0</td><td colspan="3">CONS</td><td colspan="8">SV_ID</td><td colspan="5">SIG</td></tr>
<tr><td>1</td><td colspan="4">ANT</td><td colspan="4">NDS</td><td colspan="8">SF_CHN</td></tr>
<tr><td>2</td><td colspan="2">CRIT</td><td colspan="2">CRBW</td><td>CRD</td><td>CRL</td><td colspan="2">CRM</td><td colspan="2">CDIT</td><td colspan="2">CDBW</td><td>CDD</td><td>CDL</td><td colspan="2">CDM</td></tr>
<tr><td>3</td><td colspan="8">TS</td><td>FRIT</td><td>FRBW</td><td>FRDS</td><td>FRTH</td><td>FDIT</td><td>FDBW</td><td>FDSP</td><td>FDTH</td></tr>
</table>

Figure 5-7 – Channel Status Record Format

Name	Definition	Value	Interpretation
CONS	Constellation identifier	Unsigned	see Table 5-4 on page 26
SV_ID	Space vehicle identifier	Unsigned	see Table 5-4
SIG	Signal type	Unsigned	see Table 5-4
ANT	Antenna identifier	Unsigned	see Table 5-4
NDS	Navigation Data Synchronisation status	0	Navigation Data stream not synchronised
		1	Navigation Data synchronisation achieved, data stream not inverted
		3	Navigation Data synchronisation achieved, data stream inverted
		Other	Any other value is invalid
SF_CHN	Channel number	Unsigned	see Table 5-4
CRIT	Carrier loop integration time	Unsigned	Index of actual carrier loop integration time setting. See SET_IND parameter of FMT_LoopIntPeriods in [CHKDIS].
CRBW	Carrier loop bandwidth	Unsigned	Index of actual carrier loop bandwidth setting. See SET_IND parameter of FMT_LoopFilterPar in [CHKDIS].
CRD	Carrier phase deterioration	0	no deterioration
		1	measurement quality deterioration
CRL	Carrier loop lock	0	not locked
		1	locked
CRM	Carrier loop mode	0	No carrier loop activities
		1	Carrier acquisition ongoing
		2	Carrier tracking ongoing
		3	Carrier acquisition error
CDIT	Code loop integration time	Unsigned	Index of actual code loop integration time setting. See SET_IND parameter of FMT_LoopIntPeriods in [CHKDIS].
CDBW	Code loop bandwidth	Unsigned	Index of actual carrier loop bandwidth setting. See SET_IND parameter of FMT_LoopFilterPar in [CHKDIS].
CDD	Code phase deterioration	0	no deterioration
		1	measurement quality deterioration
CDL	Code loop lock	0	not locked
		1	locked
CDM	Code loop mode	0	No code loop activities
		1	Code acquisition ongoing
		2	Code tracking ongoing
		3	Code acquisition error
TS	Logical tracking state	Unsigned	See Table 5-14
FRIT	Carrier loop integration time final flag	0	Carrier loop integration time not final
		1	Final carrier loop integration time applied
FRBW	Carrier loop bandwidth final flag	0	Carrier loop bandwidth not final
		1	Final carrier loop bandwidth applied
FRDS	Carrier loop discriminator final flag	0	Carrier loop discriminator not final
		1	Final carrier loop discriminator applied
FRTH	Carrier loop threshold final flag	0	Carrier loop threshold not final
		1	Final carrier loop threshold applied
FDIT	Code loop integration time final flag	0	Code loop integration time not final
		1	Final code loop integration time applied
FDBW	Code loop bandwidth final flag	0	Code loop bandwidth not final

		1	Final code loop bandwidth applied
FDSP	Code loop correlator spacing final flag	0	Code loop correlator spacing not final
		1	Final code loop correlator spacing applied
FDTH	Code loop threshold final flag	0	Code loop threshold not final
		1	Final code loop threshold applied

Table 5-13 – Channel Status Record Definition

The following table gives an overview about the possible single frequency tracking states. The entire numerical range can be divided into 4 parts. The first part deals with states applicable for C/A code acquisition and tracking while the second part covers states for P(Y) acquisition and tracking on L1. It is followed by the third part that lists the states for P(Y) acquisition and tracking on L2 and the fourth part with states for CM acquisition and tracking on L2.

Note: Not all states are used in the Sentinel missions, i.e. states 48 to 56, 67 to 75, 102 to 110 and 138 to 146 are not used.

Tracking State	Short description
0	AT_STATE__CA_INIT
1	AT_STATE__CA_WAIT_PPS
2	AT_STATE__CA_DISPATCH
3	AT_STATE__CA_COLD_INIT
4	AT_STATE__CA_COLD_WAIT_IE
5	AT_STATE__CA_COLD_WAIT_ME_1
6	AT_STATE__CA_COLD_MFC_SYNC
7	AT_STATE__CA_COLD_WAIT_ME_2
8	AT_STATE__CA_COLD_START_SHIFT
9	AT_STATE__CA_COLD_1ST_DWELL
10	AT_STATE__CA_FIRST_WARM_INIT
11	AT_STATE__CA_WARM_WAIT_IE
12	AT_STATE__CA_WARM_WAIT_ME
13	AT_STATE__CA_WARM_MFC_SYNC
14	AT_STATE__CA_WARM_START_SHIFT
15	AT_STATE__CA_WARM_1ST_DWELL
16	AT_STATE__CA_2ND_RUN_WAIT_ME
17	AT_STATE__CA_2ND_RUN_WAIT_IE_IMT
18	AT_STATE__CA_2ND_RUN_START_SHIFT
19	AT_STATE__CA_COLD_ACQ_FB
20	AT_STATE__CA_FIRST_WARM_ACQ_FB
21	AT_STATE__CA_WARM_ACQ_FB
22	AT_STATE__CA_DEFAULT_ACQ_FB
23	AT_STATE__CA_CODE_TRACKING_FB
24	AT_STATE__CA_WARM_INIT
25	AT_STATE__CA_DEFAULT_INIT
26	AT_STATE__CA_DEFAULT_WAIT_IE
27	AT_STATE__CA_DEFAULT_WAIT_ME
28	AT_STATE__CA_DEFAULT_WAIT_IE_IMT
29	AT_STATE__CA_DEFAULT_START_SHIFT
30	AT_STATE__CA_DEFAULT_1ST_DWELL
31	AT_STATE__CA_DEFAULT_1ST_DWELL_WAIT
32	AT_STATE__CA_CHANGE_DELAY_LINE_MODE
33	AT_STATE__CA_WAIT_CODE_LOCK_CHECK

Tracking State	Short description
34	AT_STATE__CA_CODE_LOCK_CHECK
35	AT_STATE__CA_CODE_BW_REDUCTION
36	AT_STATE__CA_PREP_FFT_SAMPLING
37	AT_STATE__CA_COLL_FFT_SAMPLES
38	AT_STATE__CA_WAIT_CARR_LOCK_CHECK
39	AT_STATE__CA_CARR_LOCK_CHECK
40	AT_STATE__CA_CARR_BW_REDUCTION
41	AT_STATE__CA_CORR_SPACING_6CC_4CC
42	AT_STATE__CA_CORR_SPACING_4CC_2CC
43	AT_STATE__CA_PREP_1ST_TINT_CHANGE
44	AT_STATE__CA_INIT_1ST_TINT_CHANGE
45	AT_STATE__CA_EXEC_1ST_TINT_CHANGE
46	AT_STATE__CA_TRACKING_STABILISE
47	AT_STATE__CA_EXEC_1ST_PAR_CHANGE
48	AT_STATE__CA_PREP_2ND_TINT_CHANGE
49	AT_STATE__CA_INIT_2ND_TINT_CHANGE
50	AT_STATE__CA_EXEC_2ND_TINT_CHANGE
51	AT_STATE__CA_EXEC_2ND_PAR_CHANGE
52	AT_STATE__CA_PREP_3RD_TINT_CHANGE
53	AT_STATE__CA_INIT_3RD_TINT_CHANGE
54	AT_STATE__CA_EXEC_3RD_TINT_CHANGE
55	AT_STATE__CA_EXEC_3RD_PAR_CHANGE
56	AT_STATE__CA_STEADY
57	AT_STATE__P1_INIT
58	AT_STATE__P1_WAIT_IE
59	AT_STATE__P1_PREP_TINT_CHANGE
60	AT_STATE__P1_INIT_TINT_CHANGE
61	AT_STATE__P1_EXEC_TINT_CHANGE
62	AT_STATE__P1_WAIT_CODE_LOCK_CHECK
63	AT_STATE__P1_CODE_LOCK_CHECK
64	AT_STATE__P1_CODE_BW_REDUCTION
65	AT_STATE__P1_TRACKING_STABILISE
66	AT_STATE__P1_EXEC_1ST_PAR_CHANGE
67	AT_STATE__P1_PREP_2ND_TINT_CHANGE

Tracking State	Short description
68	AT_STATE__P1_INIT_2ND_TINT_CHANGE
69	AT_STATE__P1_EXEC_2ND_TINT_CHANGE
70	AT_STATE__P1_EXEC_2ND_PAR_CHANGE
71	AT_STATE__P1_PREP_3RD_TINT_CHANGE
72	AT_STATE__P1_INIT_3RD_TINT_CHANGE
73	AT_STATE__P1_EXEC_3RD_TINT_CHANGE
74	AT_STATE__P1_EXEC_3RD_PAR_CHANGE
75	AT_STATE__P1_STEADY
76	AT_STATE__P2_INIT
77	AT_STATE__P2_WAIT_IE
78	AT_STATE__P2_PREP_TINT_CHANGE
79	AT_STATE__P2_INIT_TINT_CHANGE
80	AT_STATE__P2_EXEC_TINT_CHANGE
81	AT_STATE__P2_WAIT_RETRY_TIMESLOT
82	AT_STATE__P2_INIT_CCC
83	AT_STATE__P2_WRITE_P_CODE_SETTING
84	AT_STATE__P2_RECOVER_P1_CODE_FREQ
85	AT_STATE__P2_RECOVER_P2_CODE_FREQ
86	AT_STATE__P2_START_CODE_GEN
87	AT_STATE__P2_WRITE_CYCLE_DIFF
88	AT_STATE__P2_WAIT_ME
89	AT_STATE__P2_START_SHIFT
90	AT_STATE__P2_1ST_DWELL
91	AT_STATE__P2_1ST_DWELL_WAIT
92	AT_STATE__P2_WAIT_CODE_LOCK_CHECK
93	AT_STATE__P2_CODE_LOCK_CHECK
94	AT_STATE__P2_CODE_BW_REDUCTION
95	AT_STATE__P2_PREP_FFT_SAMPLING
96	AT_STATE__P2_COLL_FFT_SAMPLES
97	AT_STATE__P2_WAIT_CARR_LOCK_CHECK
98	AT_STATE__P2_CARR_LOCK_CHECK
99	AT_STATE__P2_CARR_BW_REDUCTION
100	AT_STATE__P2_TRACKING_STABILISE
101	AT_STATE__P2_EXEC_1ST_PAR_CHANGE

Tracking State	Short description
102	AT_STATE__P2_PREP_2ND_TINT_CHANGE
103	AT_STATE__P2_INIT_2ND_TINT_CHANGE
104	AT_STATE__P2_EXEC_2ND_TINT_CHANGE
105	AT_STATE__P2_EXEC_2ND_PAR_CHANGE
106	AT_STATE__P2_PREP_3RD_TINT_CHANGE
107	AT_STATE__P2_INIT_3RD_TINT_CHANGE
108	AT_STATE__P2_EXEC_3RD_TINT_CHANGE
109	AT_STATE__P2_EXEC_3RD_PAR_CHANGE
110	AT_STATE__P2_STEADY
111	AT_STATE__SLAVE_INIT
112	AT_STATE__SLAVE_WAIT_ME
113	AT_STATE__SLAVE_START_SHIFT
114	AT_STATE__SLAVE_WAIT_IE_IMT
115	AT_STATE__SLAVE_WAIT_IE
116	AT_STATE__SLAVE_PREP_1ST_TINT_CHANGE
117	AT_STATE__SLAVE_INIT_1ST_TINT_CHANGE
118	AT_STATE__SLAVE_EXEC_1ST_TINT_CHANGE
119	AT_STATE__SLAVE_TIMESLOT_WAIT
120	AT_STATE__SLAVE_START_CODE_GEN
121	AT_STATE__SLAVE_ACQ_FB
122	AT_STATE__SLAVE_CODE_TRACKING_FB
123	AT_STATE__SLAVE_1ST_DWELL
124	AT_STATE__SLAVE_1ST_DWELL_WAIT
125	AT_STATE__SLAVE_CHANGE_DELAY_LINE_MODE
126	AT_STATE__SLAVE_WAIT_CODE_LOCK_CHECK
127	AT_STATE__SLAVE_CODE_LOCK_CHECK
128	AT_STATE__SLAVE_CODE_BW_REDUCTION
129	AT_STATE__SLAVE_PREP_FFT_SAMPLING
130	AT_STATE__SLAVE_COLL_FFT_SAMPLES
131	AT_STATE__SLAVE_WAIT_CARR_LOCK_CHECK
132	AT_STATE__SLAVE_CARR_LOCK_CHECK
133	AT_STATE__SLAVE_CARR_BW_REDUCTION
134	AT_STATE__SLAVE_CORR_SPACING_6CC_4CC
135	AT_STATE__SLAVE_CORR_SPACING_4CC_2CC

Tracking State	Short description
136	AT_STATE__SLAVE_TRACKING_STABILISE
137	AT_STATE__SLAVE_EXEC_1ST_PAR_CHANGE
138	AT_STATE__SLAVE_PREP_2ND_TINT_CHANGE
139	AT_STATE__SLAVE_INIT_2ND_TINT_CHANGE
140	AT_STATE__SLAVE_EXEC_2ND_TINT_CHANGE
141	AT_STATE__SLAVE_EXEC_2ND_PAR_CHANGE
142	AT_STATE__SLAVE_PREP_3RD_TINT_CHANGE
143	AT_STATE__SLAVE_INIT_3RD_TINT_CHANGE
144	AT_STATE__SLAVE_EXEC_3RD_TINT_CHANGE
145	AT_STATE__SLAVE_EXEC_3RD_PAR_CHANGE
146	AT_STATE__SLAVE_STEADY
147	AT_STATE__CODE_ACQ_ERROR
148	AT_STATE__CODE_ACQ_ERROR_REPORTED
149	AT_STATE__CARR_ACQ_ERROR
150	AT_STATE__CARR_ACQ_ERROR_REPORTED
151	AT_STATE__STOPPED
152	AT_STATE__STOPPED_REPORTED

Table 5-14 – Single Frequency Tracking States

Table 5-15 shows the mapping between the high-level multi-frequency channel tracking state MFC_TS (Tracking State Data Record) and the low-level single-frequency channel status information (Channel Status Record) for the combined L1 C/A and L1/L2 P(Y) tracking scheme.

MFC_TS	C/A SFC Status	CDM	CDL	FDIT	FDBW	FDSP	FDTH	CRM	CRL	FRIT	FRBW	FRDS	FRTH
0		0	x	x	x	x	x	x	x	x	x	x	x
1		3	x	x	x	x	x	x	x	x	x	x	x
2		1	x	x	x	x	x	x	x	x	x	x	x
3		2	1	x	x	x	x	<2	x	x	x	x	x
4		2	1	x	x	x	x	2	1	x	x	x	x
5		2	1	1	1	1	1	2	1	1	1	1	1
MFC_TS	P2 SFC Status	CDM	CDL	CDIT	FDBW	FDSP	FDTH	CRM	CRL	FRIT	FRBW	FRDS	FRTH
6	C/A SFC Status same as for MFC_TS 5	2	1	x	x	x	x	<2	x	x	x	x	x
7		2	1	x	x	x	x	2	1	x	x	x	x
8		2	1	1	1	1	1	2	1	1	1	1	1
MFC_TS	P1 SFC Status	CDM	CDL	CDIT	FDBW	FDSP	FDTH	CRM	CRL	FRIT	FRBW	FRDS	FRTH
9	P2 SFC Status same as for MFC_TS 8	2	1	x	x	x	x	<2	1	x	x	x	x
10		2	1	x	x	x	x	2	1	x	x	x	x
11		2	1	1	1	1	1	2	1	1	1	1	1

Table 5-15 – Relation Tracking State vs. Channel Status (L1 C/A L1/L2 P/Y)

Table 5-16 shows the mapping between the high-level multi-frequency channel tracking state MFC_TS (Tracking State Data Record) and the low-level single-frequency channel status information (Channel Status Record) for the combined L1 C/A and L2 CM tracking scheme.

MFC_TS	C/A SFC Status	CDM	CDL	FDIT	FDBW	FDSP	FDTH	CRM	CRL	FRIT	FRBW	FRDS	FRTH
0		0	x	x	x	x	x	x	x	x	x	x	x
1		3	x	x	x	x	x	x	x	x	x	x	x
2		1	x	x	x	x	x	x	x	x	x	x	x
3		2	1	x	x	x	x	<2	x	x	x	x	x
4		2	1	x	x	x	x	2	1	x	x	x	x
5		2	1	1	1	1	1	2	1	1	1	1	1
MFC_TS	CM SFC Status	CDM	CDL	CDIT	FDBW	FDSP	FDTH	CRM	CRL	FRIT	FRBW	FRDS	FRTH
6	C/A SFC Status same as for MFC_TS 5	2	1	x	x	x	x	<2	x	x	x	x	x
7		2	1	x	x	x	x	2	1	x	x	x	x
8		2	1	1	1	1	1	2	1	1	1	1	1

Table 5-16 – Relation Tracking State vs. Channel Status (L1 C/A L2 CM)

For the utilisation of the measurements of a certain satellite in a navigation solution, some kind of high-level information regarding the measurement acquisition circumstances is required, i.e. a certain tracking state has to be reached.

The Channel Status Record (refer to §5.4.1.6) contains a lot of detailed information about the tracking state of a SFC, but for the navigation solution a summary of the MFC status is better suited. Therefore the MFC_TS in the Tracking State Data Record is composed of a number of logical information of up to three SFCs.

As it can be seen from Table 5-15, the MFC_TS has a range from 0 to 11. An interpretation of the MFC_TS values is given in Table 5-17.

The following bullet list provides some additional information regarding the fallback strategy in acquisition and tracking:

- MFC_TS is set to 2 as soon as the SV is selected (code acquisition is started).
- If carrier tracking is lost, MFC_TS falls back from e.g. 5 or 4 to 3, and an attempt to re-acquire the carrier is made.
- If the carrier re-acquisition fails, a fallback to code acquisition is performed.
- If code tracking is lost on the first (=master) SFC, MFC_TS falls back from 5 or 4 to 2, and a configurable number of re-acquisition attempts is made.
- If the code re-acquisition does not succeed, MFC_TS is set to 1 and remains, until the SV selection on the MFC is changed.
- For slave SFCs (2nd and 3rd) a code re-acquisition failure leads temporary to inactivity on the corresponding SFC, with no explicit MFC_TS value assigned.
- If the SV is deselected MFC_TS is set to 0.

MFC_TS	Interpretation	Detailed description
0	No Measurement Data available	The Code Loop Mode (CDM) of the first signal component is 0, therefore there is no activity at all.
1	Code acquisition on the first SFC failed	The code loop dedicated for acquisition of the first signal component is in the mode 'Code acquisition error'.
2	Code acquisition on the first SFC in progress	The code loop dedicated for acquisition of the first signal component is in the mode 'Code acquisition ongoing'.
3	Code tracking of the first signal component	The code loop dedicated for tracking of the first signal component is in the tracking mode (CDM = 2) and the code threshold criteria (CDL = 1) is satisfied. The final flags for loop integration period (FDIT), bandwidth (FDBW), correlator spacing (FDSP) and code loss of lock threshold (FDTH) are not of interest for reaching this MFC tracking state. No carrier phase measurements are available since the Carrier Loop Mode (CRM) is below 2.
4	Code and Carrier tracking of the first signal component	The code loop and the carrier loop dedicated for tracking of the first signal component are in the tracking mode (CDM = 2, CRM = 2) and both code and carrier lock criteria (CDL = 1, CRL = 1) are satisfied. The final flags for loop integration period (FRIT), bandwidth (FRBW), carrier discriminator (FRDS) and carrier loss-of-lock threshold (FRTH) are not of interest for reaching this MFC tracking state.
5	Code and Carrier tracking of the first signal component with final loop parameters	The code loop and the carrier loop dedicated for tracking of the first signal component are in the tracking mode (CDM = 2, CRM = 2) and both code and carrier lock criteria (CDL = 1, CRL = 1) are satisfied. All final flags (FDIT, FDBW, FDSP, FDTH, FRIT, FRBW, FRDS, FRTH) are set to indicate the final tracking state.
6	Final tracking of the first signal component, Code tracking of the second signal component	Same as for MFC_TS 3, but for the second signal component instead of the first one.
7	Final tracking of the first signal component, Code and Carrier tracking of the second signal component	Same as for MFC_TS 4, but for the second signal component instead of the first one.
8	Final tracking of the first signal component, Code and Carrier tracking of the second signal component with final loop parameters	Same as for MFC_TS 5, but for the second signal component instead of the first one.
9	Final tracking of the first and second signal component, Code tracking of the third signal component	Same as for MFC_TS 3, but for the third signal component instead of the first one.
10	Final tracking of the first and second signal component, Code and Carrier tracking of the third signal component	Same as for MFC_TS 4, but for the third signal component instead of the first one.
11	Final tracking of the first and second signal component, Code and Carrier tracking of the third signal component with final loop parameters	Same as for MFC_TS 5, but for the third signal component instead of the first one.

Table 5-17 – Interpretation of the MFC_TS values

5.4.1.7 Carrier Phase Data Record

The purpose of this record is to provide carrier-phase measurements suitable for computation of a navigation solution external to the receiver. This type of measurements is delivered for each single-frequency channel being in a tracking state high enough to generate reliable data (see Table 5-11). Two measurements are provided in parallel for flexibility reasons.

<table>
<tr><th rowspan="2">Word</th><th colspan="16">Bit number</th></tr>
<tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th></tr>
<tr><td>0</td><td colspan="3">CONS</td><td colspan="8">SV_ID</td><td colspan="5">SIG</td></tr>
<tr><td>1</td><td colspan="4">ANT</td><td>D</td><td colspan="3">N/U</td><td colspan="8">SF_CHN</td></tr>
<tr><td>2</td><td colspan="16" rowspan="4">NCO_PHASE</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td></tr>
<tr><td>5</td></tr>
<tr><td>6</td><td colspan="16" rowspan="2">DELTA_RNG</td></tr>
<tr><td>7</td></tr>
</table>

Figure 5-8 – Carrier Phase Data Record Format

Name	Definition	Value/Type	Interpretation
CONS	Constellation identifier	Unsigned	see Table 5-4 on page 26
SV_ID	Space vehicle identifier	Unsigned	see Table 5-4
SIG	Signal type	Unsigned	see Table 5-4
ANT	Antenna identifier	Unsigned	see Table 5-4
D	Deterioration flag	0	Carrier loop lock steady
		1	Measurement Data may be deteriorated, carrier loop lock unsteady
N/U	Not Used	0	-
SF_CHN	Channel number	Unsigned	see Table 5-4
NCO_PHASE	Carrier Cycle count and Carrier NCO phase	Signed	Carrier cycle count [2^{-12} Carrier cycles] Note: At the begin of each track the integer carrier cycle count starts with 0.
DELTA_RNG	Delta Range	Signed	[0.01 mm/s]

Table 5-18 – Carrier Phase Data Record Definition

The Doppler frequency shift is calculated using the following formula:

$f_{Doppler,SIG} = \frac{DELTA\_RANGE_{SIG}}{c_0} * f_{SIG}$, c_0 refers to the speed of light. The equivalent resolution for L1, L2 is given below:

Carrier	Resolution $f_{Doppler}$ in [Hz]
L1	5.251E-5
L2	4.092E-5

Table 5-19 – Equivalent Resolution for Doppler Frequency in [Hz]

Word	Bit number 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	Integer NCO Cycle Count MSBs															
1																
2																
3	LSBs				NCO Cycle fraction											

Table 5-20 – NCO_PHASE field divided into integer and fractional part

The NCO_PHASE field shown in Table 5-18 and more in detail in Table 5-20 can be divided into

- A 52-bit Integer Cycle Counter with a range of +/-2.252E+15 NCO cycles
- A 12-bit Cycle Fraction with a range of -2048 to +2047 corresponding to 360º divided by 4096

NCO (and carrier) cycle resolution is thus

Carrier	Resolution in [deg]	Resolution in [µm]
L1	0.088	46.49
L2	0.088	59.66

Table 5-21 – Cycle count resolution

5.4.1.8 Carrier Amplitude Data Record

The purpose of this record is to provide absolute and relative carrier amplitude figures to allow an assessment of the reception conditions external to the receiver. This type of measurements is delivered for each single frequency channel being in a tracking state high enough to generate reliable data (see Table 5-11). The amplitude values are directly derived from the 1ms correlation results.

Note that the reported carrier amplitude values AMPL have an undefined offset. An AGC change is also visible as a jump of the AMPL value. Thus, AMPL should only be used to see the carrier amplitude difference between two channels. If one is interested in the absolute value of the carrier amplitude, then the characterization/calibration approach as described in [CCP] should be followed.

Word	Bit number 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	CONS			SV_ID								SIG				
1	ANT				N/U				SF_CHN							
2	C/N_0															
3	AMPL															

Figure 5-9 – Carrier Amplitude Data Record Format

Name	Definition	Value/Type	Interpretation
CONS	Constellation identifier	Unsigned	see Table 5-4 on page 26
SV_ID	Space vehicle identifier	Unsigned	see Table 5-4
SIG	Signal type	Unsigned	see Table 5-4
ANT	Antenna identifier	Unsigned	see Table 5-4
N/U	Not Used	0	-
SF_CHN	Channel number	Unsigned	see Table 5-4
C/N_0	Carrier to noise power density ratio	Signed	[0.01 dBHz]
AMPL	Carrier amplitude	Signed	[0.01 dB]

Table 5-22 – Carrier Amplitude Data Record Definition

5.4.1.9 Code Phase Data Record

The purpose of this record is to provide code-phase measurements suitable for computation of a navigation solution external to the receiver. This type of measurements is delivered for each single-frequency channel being in a tracking state high enough to generate reliable data (see Table 5-11).

<table>
<tr><th rowspan="2">Word</th><th colspan="16">Bit number</th></tr>
<tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th></tr>
<tr><td>0</td><td colspan="3">CONS</td><td colspan="8">SV_ID</td><td colspan="5">SIG</td></tr>
<tr><td>1</td><td colspan="4">ANT</td><td>D</td><td>S</td><td colspan="2">N/U</td><td colspan="8">SF_CHN</td></tr>
<tr><td>2</td><td colspan="16" rowspan="3">CC</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td></tr>
<tr><td>5</td><td colspan="16">FP</td></tr>
</table>

Figure 5-10 – Code Phase Data Record Format

Name	Definition	Value/Type	Interpretation
CONS	Constellation identifier	Unsigned	see Table 5-4
SV_ID	Space vehicle identifier	Unsigned	see Table 5-4
SIG	Signal type	Unsigned	see Table 5-4
ANT	Antenna identifier	Unsigned	see Table 5-4
D	Deterioration flag	0	Code loop lock steady
		1	Measurement Data may be deteriorated, code loop lock unsteady
S	Smoothing flag	0	Smoothing not applied
		1	Carrier phase-based smoothing applied for the reported code phase
N/U	Not Used	0	-
SF_CHN	Channel number	Unsigned	see Table 5-4
CC	Chip count	Unsigned	Number of code chips since start of GPS week
FP	Code phase fractional part	Unsigned	[2^{-16} code chips]

Table 5-23 – Code Phase Data Record Definition

5.4.1.10 Noise Histogram Data Record

The noise histogram provides a means to estimate the received power from measurements of the signal and noise power after the gain-adjustment.

Word	Bit number 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	CHAIN				N/U											
1	N_POWER															
2	0															
3	0															
4	LVL_I_P3															
5	LVL_I_P1															
6	LVL_I_M1															
7	LVL_I_M3															
8	0															
9	0															
10	0															
11	0															
12	LVL_Q_P3															
13	LVL_Q_P1															
14	LVL_Q_M1															
15	LVL_Q_M3															
16	0															
17	0															

Figure 5-11 – Noise Histogram Data Record Format

Name	Definition	Type	Interpretation
CHAIN	Chain index	Unsigned	see Table 5-4 on page 26
N/U	Not Used	-	Always 0
N_POWER	Noise power as seen at the input of the variable gain IF amplifier	Signed	Average value over the selected sample rate period in [0.01 dB]
LVL_I_P3 LVL_I_P1	Normalised signal level detector counts of the positive In-phase samples	Unsigned	The acquisition period for a single count value is two Measurement Epochs (compare to SWARM, single antenna case). However, the counts are always normalised to the number of samples within one nominal Measurement Epoch (20ms, 560000 samples). Normalised level detector counts are further down-scaled by 2^3. In case of an overflow values are saturated to 65535.
LVL_I_M1 LVL_I_M3	Normalised signal level detector counts of the negative In-phase samples	Unsigned	
LVL_Q_P3 LVL_Q_P1	Normalised signal level detector counts of the positive Quadrature-phase samples	Unsigned	
LVL_Q_M1 LVL_Q_M3	Normalised signal level detector counts of the negative Quadrature-phase samples	Unsigned	

Table 5-24 – Noise Histogram Data Record Definition

5.4.1.11 AGC Status Data Record

The purpose of this block is to provide information about the gain setting of the signal chain.

<table>
<tr><th rowspan="2">Word</th><th colspan="16">Bit number</th></tr>
<tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th></tr>
<tr><td>0</td><td colspan="16" rowspan="4">GCTS</td></tr>
<tr><td>1</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td><td colspan="4">CHAIN</td><td>N/U</td><td>L</td><td>U</td><td>E</td><td colspan="8">GAIN</td></tr>
<tr><td>5</td><td colspan="16">N/U</td></tr>
</table>

Figure 5-12 – AGC Status Data Record Format

<table>
<tr><th>Name</th><th>Definition</th><th>Type/Value</th><th>Interpretation</th></tr>
<tr><td>GCTS</td><td>Gain control change timestamp</td><td>IMT-type</td><td>Timestamp of the most recent gain change.
For the IMT type definition see [CHKDIS].</td></tr>
<tr><td>CHAIN</td><td>Chain index</td><td>Unsigned</td><td>see Table 5-4 on page 26</td></tr>
<tr><td>N/U</td><td>Not Used</td><td>0</td><td>-</td></tr>
<tr><td rowspan="2">L</td><td rowspan="2">Lower settling threshold</td><td>0</td><td>Not below lower settling threshold</td></tr>
<tr><td>1</td><td>Lower settling threshold exceeded,
i.e. gain too low</td></tr>
<tr><td rowspan="2">U</td><td rowspan="2">Upper settling threshold</td><td>0</td><td>Not above upper settling threshold</td></tr>
<tr><td>1</td><td>Upper settling threshold exceeded,
i.e. gain too high</td></tr>
<tr><td rowspan="2">E</td><td rowspan="2">Enabled</td><td>0</td><td>AGC disabled</td></tr>
<tr><td>1</td><td>AGC enabled</td></tr>
<tr><td>GAIN</td><td>Analogue Gain Setting</td><td>Unsigned</td><td>Gain DAC steps (typically 0.65dB per step)</td></tr>
<tr><td>N/U</td><td>Not Used</td><td>0</td><td>32-bit padding</td></tr>
</table>

Table 5-25 – AGC Status Data Record Definition

5.4.2 GPS NAV Data Message Records

5.4.2.1 GPS NAV Almanac Data Record

This data record describes the almanac data for a single GPS SV extracted from the legacy GPS NAV data message.

<table>
<tr><th rowspan="2">Word</th><th colspan="16">Bit number</th></tr>
<tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th></tr>
<tr><td>0</td><td colspan="3">CONS</td><td colspan="8">SV_ID</td><td colspan="5">N/U</td></tr>
<tr><td>1</td><td colspan="16">T_REC</td></tr>
<tr><td>2</td><td colspan="8">ACQ_SV_ID</td><td colspan="8">N/U</td></tr>
<tr><td>3</td><td colspan="8">WN_a</td><td colspan="3">NDH</td><td colspan="5">SH</td></tr>
<tr><td>4</td><td colspan="16">a_{f0}</td></tr>
<tr><td>5</td><td colspan="16">a_{f1}</td></tr>
<tr><td>6</td><td colspan="8">N/U</td><td colspan="8">t_{oa}</td></tr>
<tr><td>7</td><td colspan="16">e</td></tr>
<tr><td>8</td><td colspan="16">δ_I</td></tr>
<tr><td>9</td><td colspan="16">Ω_{DOT}</td></tr>
<tr><td>10</td><td colspan="16" rowspan="2">$\sqrt{A}$</td></tr>
<tr><td>11</td></tr>
<tr><td>12</td><td colspan="16" rowspan="2">Ω_0</td></tr>
<tr><td>13</td></tr>
<tr><td>14</td><td colspan="16" rowspan="2">ω</td></tr>
<tr><td>15</td></tr>
<tr><td>16</td><td colspan="16" rowspan="2">M_0</td></tr>
<tr><td>17</td></tr>
</table>

Figure 5-13 – GPS NAV Almanac Data Record Format

Note:
The almanac data as specified in [ICD200] is extended with constellation data acquired from pages 25 of subframe 4 and 5 and the ID of the SV the data has been acquired from.

Name	Definition	Bit Width	Type, Value	Interpretation	Initial	Ver.
CONS	Constellation identifier	3	Unsigned	See Table 5-4, page 26	0	Y
SV_ID	Space Vehicle identifier	8	Unsigned	See Table 5-4	0	Y
N/U	Not Used	5	0	-	0	Y
T_REC	Time of reception	16	Unsigned	See Table 5-4	0	Y
ACQ_SV_ID	Acquisition GPS SV Identifier. Indicates from which GPS SV the Almanac parameters were acquired.	8	0	No Almanac parameters available or they were uploaded by TC	0	Y
			Unsigned 1 … 32	The SV where Almanac parameters were acquired from, see also Table 5-4.		
N/U	Not Used	8	0	-	0	Y
WN_a	Week number (almanac)	8	Unsigned	-	0	N
NDH	Navigation Data Health	3	0	All data OK	0	N
			1	Parity failure		
			2	TLM HOW problem		
			3	Z count is bad		
			4	Sub-frames 1, 2, 3 are bad		
			5	Sub-frames 4, 5 are bad		
			6	All uploaded is bad		
			7	All data is bad		
SH	Signal Health	5	Unsigned value of the Health Code in Table 5-31	-	0	N
a_{f0}	SV clock correction polynomial constants	16[1]	Signed	[2^{-20} s]	0	Y
a_{f1}		16[1]	Signed	[2^{-38} s/s]	0	Y
N/U	Not Used	8	0	-	0	Y
t_{oa}	SV Clock Correlation Reference Time	8	Unsigned	[2^{12} s]	0	N
e	Eccentricity	16	Unsigned	2^{-21}	0	N
δ_i	Derivation (correction) of inclination	16	Signed	[2^{-19} semi-circles]	0	N
Ω_{DOT}	Rate of Right Ascension	16	Signed	[2^{-38} semi-circles/s]	0	N
$\sqrt{A}$	Square Root of the Semi-Major Axis	32[1]	Unsigned	[2^{-11} $\sqrt{m}$]	0	Y
Ω_0	Longitude of Ascending Node of Orbit Plane at Weekly Epoch	32[1]	Signed	[2^{-23} semi-circles]	0	Y
ω	Argument of Perigee	32[1]	Signed	[2^{-23} semi-circles]	0	Y
M_0	Mean Anomaly at Reference Time	32[1]	Signed	[2^{-23} semi-circles]	0	Y

Table 5-26 – GPS NAV Almanac Data Record Definition

[1] Field width as given in [ICD200] is smaller than the width given here. For signed values sign extension is applied.

Name	Subframe (page)	Bit(s)
SV_ID	5(1)	63-68
AS	4(25)	69-226
BLOCK	4(25)	69-226
WN_a	5(25)	77-84
NDH	5(1)	137-139
SH	5(1)	140-144
a_{f0}	5(1)	271-278 and 290-292
a_{f1}	5(1)	279-289
t_{oa}	5(1)	91-98
e	5(1)	69-84
δ_i	5(1)	99-114
Ω_{DOT}	5(1)	121-136
$\sqrt{A}$	5(1)	151-174
Ω_0	5(1)	181-204
ω	5(1)	211-234
M_0	5(1)	241-264

Table 5-27 – GPS Navigation Message References for Almanac Data

5.4.2.2 GPS NAV Ephemeris Data Record

The GPS NAV Ephemeris Data Record contains the current ephemeris and clock correction data from the on-board database for a single specific GPS SV. This data is extracted from the legacy GPS NAV data message. Field descriptions are extracted from [ICD200].

Table 5-28 contains the subframe and bit references in the GPS navigation message for each parameter.

Name	Subframe	Bit(s)	Name	Subframe (page)	Bit(s)
A	1	48	C_{uc}	2	151-166
AS	1	49	C_{us}	2	211-226
C2	1	71-72	C_{rc}	3	181-196
URA	1	73-76	C_{rs}	2	69-84
D2	1	91	C_{ic}	3	61-76
WN	1	61-70	C_{is}	3	121-136
NH	1	77	t_{oe}	2	271-286
SH	1	78-82	CF	2	287
IODC	1	83-84 and 211-218	A_1	4 (18)	151-174
a_{f0}	1	271-292	A_0	4 (18)	181-204 and 211-217
a_{f1}	1	249-264	Δt_{LS}	4 (18)	241-248
a_{f2}	1	241-248	t_{ot}	4 (18)	219-226
T_{GD}	1	197-204	WN_t	4 (18)	227-234
t_{oc}	1	219-234	WN_{LSF}	4 (18)	249-256
IODE	2	61-68	DN	4 (18)	257-264
M_0	2	107-114 and 121-144	Δt_{LSF}	4 (18)	271-278
Δn	2	91-106	α_0	4 (18)	69-76
e	2	167-174 and 181-204	α_1	4 (18)	77-84
$\sqrt{A}$	2	227-234 and 241-264	α_2	4 (18)	91-98
Ω_0	3	77-84 and 91-114	α_3	4 (18)	99-106
i_0	3	137-144 and 151-174	β_0	4 (18)	107-114
ω	3	197-204 and 211-234	β_1	4 (18)	121-128
Ω_{DOT}	3	241-264	β_2	4 (18)	129-136
I_{DOT}	3	279-292	β_3	4 (18)	137-144

Table 5-28 – GPS Navigation Message References

<table>
<tr><th>Word</th><th>Bit number
0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th><th colspan="2"></th></tr>
<tr><td>0</td><td colspan="3">CONS</td><td colspan="8">SV_ID</td><td colspan="5">N/U</td><td rowspan="4">SV Status</td><td rowspan="34">GPS SV Specific Parameters</td></tr>
<tr><td>1</td><td colspan="16">T_REC</td></tr>
<tr><td>2</td><td>AS</td><td>D2</td><td>CF</td><td colspan="2">C2</td><td>A</td><td>NH</td><td colspan="5">SH</td><td colspan="4">URA</td></tr>
<tr><td>3</td><td colspan="6">N/U</td><td colspan="10">WN</td></tr>
<tr><td>4</td><td colspan="16">IODC</td><td rowspan="6">Clock Correction</td></tr>
<tr><td>5</td><td colspan="16">a_{f1}</td></tr>
<tr><td>6</td><td colspan="16" rowspan="2">a_{f0}</td></tr>
<tr><td>7</td></tr>
<tr><td>8</td><td colspan="8">a_{f2}</td><td colspan="8">T_{GD}</td></tr>
<tr><td>9</td><td colspan="16">t_{oc}</td></tr>
<tr><td>10</td><td colspan="16">IODE</td><td rowspan="24">Ephemeris</td></tr>
<tr><td>11</td><td colspan="16">C_{rs}</td></tr>
<tr><td>12</td><td colspan="16">C_{rc}</td></tr>
<tr><td>13</td><td colspan="16">C_{us}</td></tr>
<tr><td>14</td><td colspan="16">C_{uc}</td></tr>
<tr><td>15</td><td colspan="16">C_{is}</td></tr>
<tr><td>16</td><td colspan="16">C_{ic}</td></tr>
<tr><td>17</td><td colspan="16">Δn</td></tr>
<tr><td>18</td><td colspan="16" rowspan="2">M_0</td></tr>
<tr><td>19</td></tr>
<tr><td>20</td><td colspan="16" rowspan="2">E</td></tr>
<tr><td>21</td></tr>
<tr><td>22</td><td colspan="16" rowspan="2">$\sqrt{A}$</td></tr>
<tr><td>23</td></tr>
<tr><td>24</td><td colspan="16" rowspan="2">Ω_0</td></tr>
<tr><td>25</td></tr>
<tr><td>26</td><td colspan="16" rowspan="2">i_0</td></tr>
<tr><td>27</td></tr>
<tr><td>28</td><td colspan="16" rowspan="2">ω</td></tr>
<tr><td>29</td></tr>
<tr><td>30</td><td colspan="16" rowspan="2">Ω_{DOT}</td></tr>
<tr><td>31</td></tr>
<tr><td>32</td><td colspan="16">t_{oe}</td></tr>
<tr><td>33</td><td colspan="16">I_{DOT}</td></tr>
</table>

Figure 5-14 – GPS NAV Ephemeris Data Record Format

To clarify the numerous definitions in this block, the definitions are separated in the different parts of the block, see the right part of the Figure 5-14:

- Table 5-29 – GPS SV Status
  The GPS SV Status parameters include information about the health of the GPS SV.
- Table 5-32 – GPS NAV Clock Correction
  The Clock Correction parameters are used to correct the GPS SV clock.
- Table 5-33 – GPS NAV Ephemeris
  The Ephemeris parameters describe the orbit of the GPS SV during the curve fit interval.

Note:
The parameter CF, which is included in the GPS SV status part of the block is an ephemeris parameter and is described in Table 5-33.

Name	Definition	Bits	Value/Type	Interpretation	Initial	Ver.
CONS	Constellation identifier	3	Unsigned	See Table 5-4	0	Y
SV_ID	Space vehicle identifier	8	Unsigned	See Table 5-4	0	Y
N/U	Not Used	5	0	-	0	Y
T_REC	Time of reception	16	Unsigned	See Table 5-4	0	Y
AS	Anti-Spoof Flag	1	0	Anti-Spoof Off	1	N
			1	Anti-Spoof On		
D2	Data Flag for L2 P-code. Indicates if the navigation data stream is commanded on or off on the P-code of the L2 channel.	1	0	On	0	N
			1	Off		
C2	Codes on L2 Channel. Indicates which code(s) is (are) commanded on for the L2 channel.	2	00_B	Reserved	0	Y
			01_B	P-code ON		
			10_B	C/A-code ON		
			Other	Any other value is invalid		
A	Alert flag. Indicates to the unauthorized user that the GPS SV URA may be worse than indicated in the URA field.	1	0	Nominal	0	N
			1	Unauthorized use at own risk		
NH	Navigation Data Health Summary	1	0	All navigation data OK	1	N
			1	Some or all navigation data are bad		
SH	Signal Health. Indicates the health of the signal.	5	Unsigned value of the Health Code in Table 5-31	Indicates the health of the signal components relative to the “as designed” capabilities of each GPS SV. Accordingly, any GPS SV which does not have a certain capability will be indicated as “healthy” if the lack of this capability is inherent in its design or if it has been configures into a mode which is normal from a user standpoint and does not require that capability.	2	N
URA	GPS SV Accuracy. Gives the URA index of the GPS SV for the unauthorized user.	4	URA Index in Table 5-30	Indicates the maximum estimated user errors in the navigation data, in meters.	0	N
N/U	Not Used	6	0	-	0	Y
WN	Week Number	10	Unsigned	Represents the number of the current GPS week at the start of the data set transmission interval.	0	N

Table 5-29 – GPS SV Status Definition

URA Index	URA (meters) min	max
0	0.00	2.40
1	2.40	3.40
2	3.40	4.85
3	4.85	6.85
4	6.85	9.65
5	9.65	13.65
6	13.65	24.00
7	24.00	48.00
8	48.00	96.00
9	96.00	192.00
10	192.00	384.00
11	384.00	768.00
12	768.00	1536.00
13	1536.00	3072.00
14	3072.00	6144.00
15	6144.00	

Table 5-30 – URA Index

Note:
URA Index 15 indicates the absence of an accuracy prediction and shall advise the unauthorised user to use that GPS SV at his own risk.

Health Code	Definition
0	All signals OK
1	All signals weak
2	All signals dead
3	All signals have no data modulation
4	L1 P signal weak
5	L1 P signal dead
6	L1 P signal has no data modulation
7	L2 P signal weak
8	L2 P signal dead
9	L2 P signal has no data modulation
10	L1 C signal weak
11	L1 C signal dead
12	L1 C signal has no data modulation
13	L2 C signal weak
14	L2 C signal dead
15	L2 C signal has no data modulation
16	L1 and L2 P signal weak
17	L1 and L2 P signal dead
18	L1 and L2 P signal has no data modulation
19	L1 and L2 C signal weak
20	L1 and L2 C signal dead
21	L1 and L2 C 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	GPS SV Is temporarily out (do not use this GPS SV during current pass)
29	GPS SV will be temporarily out (use with caution)
30	Spare
31	More than one combination would be required to describe anomalies

Table 5-31 – Signal Health Codes

Name	Definition	Field width	Value	Interpretation	Initial	Ver.
IODC	Issue of Data, Clock	16[1]	Unsigned	Indicates the issues number of the data set and thereby provides the user with a convenient means of detecting any change in the correction parameters.	0	Y
a_{f0}	GPS SV Clock Correction Polynomial Coefficients	32[1]	Signed	[2^{-31} s]	0	Y
a_{f1}		16	Signed	[2^{-43} s/s]	0	N
a_{f2}		8	Signed	[2^{-55} s/s^2]	0	N
t_{oc}	GPS SV Clock Correction Clock data reference time	16	Unsigned	[2^4 s] (effective range 604,784 s).	0	N
T_{GD}	Estimated Group Delay Differential time between L1 and L2.	8	Signed	[2^{-31} s] Shall be used for the benefit of “single frequency” (L1 or L2) users.	0	N

Table 5-32 – GPS NAV Clock Correction Data Definition

[1] Field width as given in [ICD200] is smaller than the width given here. For signed values sign extension is applied.

Name	Definition	Field width	Value	Interpretation	Initial	Ver.
IODE	Issue of Data, Ephemeris	16[1]	Unsigned	Indicates the issues number of the data set and thereby provides the user with a convenient means of detecting any change in the ephemeris representation parameters.	0	N
M_0	Mean Anomaly at Reference Time	32	Signed	[2^{-31} semi-circles]	0	N
Δn	Mean Motion Difference from Computed Value	16	Signed	[2^{-43} semi-circles/s]	0	N
E	Eccentricity	32	Unsigned	[2^{-33}] (effective range 0.03)	0	N
$\sqrt{A}$	Square Root of the Semi-Major Axis	32	Unsigned	[2^{-19} $\sqrt{m}$]	0	N
Ω_0	Longitude of Ascending Node of Orbit Plane at Weekly Epoch	32	Signed	[2^{-31} semi-circles]	0	N
i_0	Inclination Angle at Reference Time	32	Signed	[2^{-31} semi-circles]	0	N
ω	Argument of Perigee	32	Signed	[2^{-31} semi-circles]	0	N
Ω_{DOT}	Rate of Right Ascension	32[1]	Signed	[2^{-43} semi-circles/s]	0	Y
I_{DOT}	Rate of Inclination Angle	16[1]	Signed	[2^{-43} semi-circles/s]	0	Y
C_{uc}	Amplitude of the Cosine Harmonic Correction Term to the Argument of Latitude	16	Signed	[2^{-29} rad]	0	N
C_{us}	Amplitude of the Sine Harmonic Correction Term to the Argument of Latitude	16	Signed	[2^{-29} rad]	0	N
C_{rc}	Amplitude of the Cosine Harmonic Correction Term to the Orbit Radius	16	Signed	[2^{-5} m]	0	N
C_{rs}	Amplitude of the Sine Harmonic Correction Term to the Orbit Radius	16	Signed	[2^{-5} m]	0	N
C_{ic}	Amplitude of the Cosine Harmonic Correction Term to the Angle of Inclination	16	Signed	[2^{-29} rad]	0	N
C_{is}	Amplitude of the Sine Harmonic Correction Term to the Angle of Inclination	16	Signed	[2^{-29} rad]	0	N
t_{oe}	Reference Time Ephemeris	16	Unsigned	[2^4 s] (effective range 604,784 s)	0	N
CF	Curve Fit Interval. Indicates the curve-fit interval used by	1	0	4 hours	0	N
			1	> 4 hours		

Table 5-33 – GPS NAV Ephemeris Data Definition

[1] Field width as given in [ICD200] is smaller than the width given here. For signed values sign extension is applied.

5.4.2.3 GPS NAV UTC and Ionosphere Data Record

This record provides the constellation specific parameter for UTC and ionosphere correction. This data is extracted from the legacy GPS NAV data message.

<table>
<tr><th rowspan="2">Word</th><th colspan="16">Bit number</th></tr>
<tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th></tr>
<tr><td>0</td><td colspan="3">CONS</td><td colspan="8">ACQ_SV_ID</td><td colspan="5">N/U</td></tr>
<tr><td>1</td><td colspan="16">T_REC</td></tr>
<tr><td>2</td><td colspan="16">N/U</td></tr>
<tr><td>3</td><td colspan="8">Δt_{LS}</td><td colspan="8">t_{ot}</td></tr>
<tr><td>4</td><td colspan="8">WN_t</td><td colspan="8">WN_{LSF}</td></tr>
<tr><td>5</td><td colspan="8">DN</td><td colspan="8">Δt_{LSF}</td></tr>
<tr><td>6</td><td colspan="16" rowspan="2">A_0</td></tr>
<tr><td>7</td></tr>
<tr><td>8</td><td colspan="16" rowspan="2">A_1</td></tr>
<tr><td>9</td></tr>
<tr><td>10</td><td colspan="8">α_0</td><td colspan="8">α_1</td></tr>
<tr><td>11</td><td colspan="8">α_2</td><td colspan="8">α_3</td></tr>
<tr><td>12</td><td colspan="8">β_0</td><td colspan="8">β_1</td></tr>
<tr><td>13</td><td colspan="8">β_2</td><td colspan="8">β_3</td></tr>
</table>

Figure 5-15 – GPS NAV UTC and Ionosphere Data Record Format

Name	Definition	Field width	Value	Interpretation	Initial	Ver.
CONS	Constellation identifier	3		See Table 5-4	0	Y
ACQ_SV_ID	Acquisition GPS SV Identifier. Indicates from which GPS SV the UTC and Ionosphere parameters were acquired.	8	0	No UTC and Ionosphere parameters available or they were uploaded by TC	0	Y
			Unsigned 1 … 32	The SV where UTC and Ionosphere parameters were acquired from, see also Table 5-4.		
N/U	Not Used	5	0	-	0	Y
T_REC	Time of reception	16	Unsigned	See Table 5-4	0	Y
N/U	Not Used	16	0	32-bit padding	0	Y
A_0	Polynomial constants	32	Signed	[2^{-30} s]	0	N
A_1		32[1]	Signed	[2^{-50} s/s]	0	Y
Δt_{LS}	Delta time due to leap seconds. Applicability see [ICD200]	8	Signed	[s]	0	N
t_{ot}	Reference time for UTC data	8	Unsigned	[2^{12} s] (effective range 602,112 s)	0	Y
WN_t	UTC reference week number	8	Unsigned	[1 week]	0	N
WN_{LSF}	UTC reference week number due to leap seconds	8	Unsigned	[1 week]	0	N
DN	Day Number	8	Unsigned 1 … 7	The current number of the day in the week according to WN (Week Number).	0	Y
			Other	Any other value is invalid		
Δt_{LSF}	Delta time due to leap seconds, index "Future". Applicability see [ICD200]	8	Signed	[s]	0	N

[1] Field width as given in [ICD200] is smaller than the width given here. For signed values sign extension is applied.

Name	Definition	Field width	Value	Interpretation	Initial	Ver.
α_0	Ionosphere Parameter	8	Signed	[2^{-30} s]	0	N
α_1		8	Signed	[2^{-27} s/semi-circle]	0	N
α_2		8	Signed	[2^{-24} s/(semi-circle)^2]	0	N
α_3		8	Signed	[2^{-24} s/(semi-circle)^3]	0	N
β_0		8	Signed	[2^{11} s]	0	N
β_1		8	Signed	[2^{14} s/semi-circle]	0	N
β_2		8	Signed	[2^{16} s/(semi-circle)^2]	0	N
β_3		8	Signed	[2^{16} s/(semi-circle)^3]	0	N

Table 5-34 – GPS NAV UTC and Ionosphere Data Definition

5.4.3 GPS CNAV Data Message Records

5.4.3.1 GPS CNAV Group Delay Data Record

This data record contains the current group delay and inter-signal correction data from the on-board database for a single specific GPS SV.

Note: This data is not extracted from Message Type 30 of the GPS CNAV data message. It may only be uploaded by ground, and stored in NVM2 to become new boot defaults.

Field descriptions are extracted from Table 30-IV of [ICD200], group differential delay figures are considered in the way described in §30.3.3.3.1.1.1 and §30.3.3.3.1.1.2 of [ICD200].

Note: The usage of this format is only relevant for Sentinel B.
As long as only legacy GPS signals are used, i.e. L1 C/A and P(Y), these parameters do not need to be updated and shall remain all zero.
Only for SV for which the civilian L2C signal is actually tracked (the corresponding P(Y) force flag according to [CHKDIS FMT_SatelliteMask] is cleared and the corresponding GPS satellite is a modernised one of block type IIR-M or IIF), the parameters $ISC_{L1C/A}$, ISC_{L2C} and T_{GD} might need to be updated. The remaining parameters in this format, i.e. ISC_{L5I5} and ISC_{L5Q5} are not used by any correction algorithm in the GPSR and should always hold zero.

Note: At time of preparing issue 9 of this document the modernised GPS satellites already part of the GPS constellation, i.e. SV PRN 1, 5, 7, 12, 15, 17, 29, 31 (block type IIR-M) and SV PRN 25 (block type IIF) do not send Message Type 30 in the GPS CNAV data message. Therefore the relevance and required frequency of parameter updates per telecommand is unknown for the time being.

	Bit number															
Word	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	CONS			SV_ID								N/U				
1	T_REC															
2	$ISC_{L1C/A}$															
3	ISC_{L2C}															
4	ISC_{L5I5}															
5	ISC_{L5Q5}															
6	N/U															
7	T_{GD}															

Figure 5-16 – GPS CNAV Group Delay Data Record Format

Name	Definition	Field width	Value	Interpretation	Initial	Ver.
CONS	Constellation identifier	3	Unsigned	See Table 5-4	0	Y
SV_ID	Space vehicle identifier	8	Unsigned	See Table 5-4	0	Y
N/U	Not Used	5	0	-	0	Y
T_REC	Time of reception	16	Unsigned	See Table 5-4	0	Y
$ISC_{L1C/A}$	Inter-signal GD Correction	16[1]	Signed	[2^{-35} s]	0	Y
ISC_{L2C}	Inter-signal GD Correction	16[1]	Signed	[2^{-35} s]	0	Y
ISC_{L5I5}	Inter-signal GD Correction	16[1]	Signed	[2^{-35} s]	0	Y
ISC_{L5Q5}	Inter-signal GD Correction	16[1]	Signed	[2^{-35} s]	0	Y
N/U	Not Used	16	0	-	0	Y
T_{GD}	Estimated Group Delay Differential time between L1 and L2.	16[1]	Signed	[2^{-35} s]	0	Y

Table 5-35 – GPS CNAV Group Delay Data Definition

[1] Field width as given in [ICD200] is smaller than the width given here (all fields marked here have a width of 13 bits in [ICD200], which corresponds to the allowed range). For signed values sign extension is applied.

5.5 DERIVED DATA RECORDS

The data records presented in this section are derived from the general data records specified in chapter 5.4. They deliver a subset of the information of larger data records and can be used in systems with limited bandwidth.

5.5.1 Constellation Independent Data Records

5.5.1.1 S1 Navigation Solution Data Record

This record has the same format and definition as the Navigation Solution Data Record, refer to §5.4.1.1 for detailed information. The background for the existence of this additional record is its transmission as a TM(212,1) rather than TM(3,25).

5.5.1.2 IMT/GPST Correlation Data Record

The purpose of this block is to provide all different time bases for a specific point in time. This specific point in time is the leading edge of the last PPS pulse.

Word	Bit number 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	N/U	NSM			QUAL_INDEX											
1	TDOP															
2	IMT															
3																
4																
5																
6	GPST															
7																
8																
9																

Figure 5-17 – IMT/GPST Correlation Data Record Format

Name	Definition	Value/Type	Interpretation
N/U	Not Used	0	-
NSM	Navigation Solution Method	Unsigned	see Table 5-4
QUAL_INDEX	Quality index	Unsigned	[ns], time quality index, values greater than 4095ns are saturated to 4095ns, details see [SUM]
TDOP	Time dilution of precision	Unsigned	1 LSB corresponds to 10^{-2}, values greater than 655.34 are saturated to 65534
		65535	This value is set in case of Kalman filtered navigation solution (NSM=5) with fewer than 4 SVs available[1] or propagated initial state vector (NSM=1).
IMT	Instrument measurement time	IMT -type	IMT representation of the synchronisation time stamp. The IMT type definition is given in [CHKDIS].
GPST	GPS time	GPS-type	GPST representation of the synchronisation time stamp. The GPS type definition is found in [CHKDIS].

Table 5-36 – IMT/GPST Correlation Data Record Definition

5.5.1.3 Auxiliary Data Record

This data record describes the auxiliary data record for a single GPS SV being tracked in one of the multi frequency channels (MF_CHN).

Word	Bit number 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	SCHEME			SV_ID								AS	MF_CHN			
1	MFC_TS								NDS		C3	C2	C1	A3	A2	A1

Figure 5-18 –Auxiliary Data Record Format

Name	Definition	Field width	Type/Value	Interpretation
SCHEME	Tracking Scheme (signal allocation for single frequency channels within a multi-frequency channel)	3	0	L1 C/A - L1 P(Y) - L2 P(Y)
			1	L1 C/A - L1 C/A [1] (Sentinel B only)
			2	L1 C/A - L2 CM (Sentinel B only)
			3	L1 C/A - L2 CL (N/A to Sentinel)
			4	L1 C/A - L2 CL - L2 CM (N/A to Sentinel)
			5	L1 C/A - L2 C/A (N/A to Sentinel)
			6	L1 C/A - L2 CM - L2 C/A (N/A to Sentinel)
			7	Invalid, not a valid tracking scheme
SV_ID	Space vehicle identifier	8	Unsigned	see Table 5-4
AS	Anti-Spoof flag as indicated in page 25 of subframe 4 of the navigation data message	1	0	Anti-Spoofing off
			1	Anti-Spoofing on
MF_CHN	Multi frequency channel number	4	Unsigned	see Table 5-4
MFC_TS	Multi frequency channel tracking state	8	Unsigned	Values see Table 5-17
NDS	Navigation Data Synchronisation status	2	0	C/A Navigation Data stream not synchronised
			1	C/A Navigation Data synchronisation achieved, data stream not inverted
			2	invalid
			3	C/A Navigation Data synchronisation achieved, data stream inverted
C3	Code lock flag for 3rd single frequency channel in the given multi frequency channel, meaning depends on the reported tracking scheme in field SCHEME	1	0	No code lock achieved
			1	Code lock achieved: ▪ SCHEME 0: L2 P(Y) locked ▪ SCHEME 1: N/A ▪ SCHEME 2: N/A ▪ SCHEME 3: N/A ▪ SCHEME 4: L2 CM locked ▪ SCHEME 5: N/A ▪ SCHEME 6: L2 C/A locked
C2	Code lock flag for 2nd single frequency channel in the given multi frequency channel, meaning depends on the	1	0	No code lock achieved
			1	Code lock achieved: ▪ SCHEME 0: L1 P(Y) locked ▪ SCHEME 1: N/A

[1] This tracking scheme is used for acquisitions during a Cold start in the frame of the Sentinel B mission. The background is that during a Cold start the block type of GPS satellites is typically unknown (as long as pages 25 of subframe 4 and 5 of the navigation data message have not been downloaded). Therefore it is not clear if CM code will be available for a dedicated SV.
Due to this information deficit only the L1 C/A code is acquired. In order to allow cross-correlation track detection, though the signal components on L2 are not available for that purpose, an L1 C/A re-scan with small code spacing and long integration time is performed on the 2nd SFC while L1 C/A is already tracked on the 1st SFC. This concurrent peak verification supports early detection of cross-correlation tracks, i.e. significantly before the Almanac/Ephemeris plausibility check can be performed. However, L1 C/A code and carrier will never get tracked on the 2nd SFC, activity is stopped on that SFC after a passed or failed peak verification has been performed.

Name	Definition	Field width	Type/Value	Interpretation
	reported tracking scheme in field SCHEME			▪ SCHEME 2: L2 CM locked ▪ SCHEME 3: L2 CL locked ▪ SCHEME 4: L2 CL locked ▪ SCHEME 5: L2 C/A locked ▪ SCHEME 6: L2 CM locked
C1	Code lock flag for 1st single frequency channel in the given multi frequency channel, meaning depends on the reported tracking scheme in field SCHEME	1	0	No code lock achieved
			1	Code lock achieved: ▪ SCHEME 0-6: L1 C/A locked
A3	Carrier lock flag for 3rd single frequency channel in the given multi frequency channel, meaning depends on the reported tracking scheme in field SCHEME	1	0	No carrier lock achieved
			1	Carrier lock achieved: ▪ SCHEME 0: L2 locked ▪ SCHEME 1: N/A ▪ SCHEME 2: N/A ▪ SCHEME 3: N/A ▪ SCHEME 4: L2 locked ▪ SCHEME 5: N/A ▪ SCHEME 6: L2 locked
A2	Carrier lock flag for 2nd single frequency channel in the given multi frequency channel, meaning depends on the reported tracking scheme in field SCHEME	1	0	No carrier lock achieved
			1	Carrier lock achieved: ▪ SCHEME 0: L1 locked[2] ▪ SCHEME 1: N/A ▪ SCHEME 2-6: L2 locked
A1	Carrier lock flag for 1st single frequency channel in the given multi frequency channel, meaning depends on the reported tracking scheme in field SCHEME	1	0	No carrier lock achieved
			1	Carrier lock achieved: ▪ SCHEME 0-6: L1 locked

Table 5-37 – Auxiliary Data Record Definition

[2] In the case of the L1 C/A - L1 P(Y) - L2 P(Y) tracking scheme the L1 carrier is tracked by means of correlated C/A code, and the L2 carrier is tracked by means of correlated L2 P(Y) code. No dedicated carrier tracking is performed based on the L1 P(Y) code, the carrier tracked by means of C/A code is slaved from the 1st single frequency channel to the 2nd single frequency channel in HW. Therefore the carrier lock information on the 2nd channel is the same as on the 1st channel.

5.6 HOUSEKEEPING DATA RECORDS

The Housekeeping Parameter Report is defined in [CHKDIS]. With the exception of the Service Type and Subservice Type, the format of this TM is identical to that of the Science Data Reports.

In addition to the Housekeeping Parameter Report defined in [CHKDIS], in the Sentinel program two Science Data Records are transferred via TM(3,25) instead of TM(212,1). Table 5-5 on page 27 has the details.