Title:

PEGASUS

Interface Control Document

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Abstract

Interface Control Document for GNSS data analysis using the PEGASUS data processing and analysis system. Issue associated with V3.2 of PEGASUS

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F	12. July 2001	1, 2, 4, 5, A, B, C, E	complete review of document
G	18. December 2001	D, 2, 8	Septentrio PolaRx receiver configuration, updated chapter on GNSS measurements, added chapter on reference path
H	11. June 2002	1, 2, A, B, C, D, E	Added appendix for NovAtel OEM4 receiver configuration
			minor corrections to setup configurations
I	17. January 2003	9, F, H	Added Appendix for NovAtel MEDLL receiver
		All	Document formatting improvements and minor editorial changes
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			Addition of Septentrio PolaRx-2 Receiver
L	23. January 2004	Appendices	deleted content
			added references to the Receiver Configuration Document

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1 Introduction

1.1 Purpose

The certification process of aircraft navigation systems based on Global Navigation Satellite Systems (GNSS) requires adequate demonstration of the accuracy, integrity, availability and continuity of the positioning service provided. Simulations and theoretical analyses have provided favourable results, however, as a consequence of the complete change in technology, many factors may only be revealed through practical analysis. Therefore a project called SAPPHIRE (Satellite and Aircraft Database Project for System Integrity Research) has been set-up to analyse data collected on-board commercial transport aircraft. SAPPHIRE is intended be a core tool for the Operational Validation of GNSS-1.

Within the SAPPHIRE project a so-called DUAU (Database Update and Access Unit) has been constructed, which archives, processes and evaluates onboard recorded data. Currently, these onboard recorded data can be augmented by Differential GPS (DGPS) ground station recordings at the aircraft's home base and along its flight path.

The objective of the envisaged prototype software development described in this document is to extend the prototypes that have been developed in SAPPHIRE Phase I and II. This will allow, in the first place, the processing of data collected in-flight and on ground with the European Satellite Testbed (ESTB) and GLONASS. Secondly, this prototype shall also be used for later implementation into the SAPPHIRE DUAU. The software shall allow ranging and (wide-area)-differential ranging processing of GPS, GLONASS and SBAS and combinations thereof.

Due to the fact that the current SBAS systems do not transmit correction and integrity information for the GLONASS system, the implementation of the GLONASS option of the PEGASUS project is postponed until further notice. Thus, the chapters containing GLONASS measurement data (chapter 2) and GLONASS satellite navigation information (chapter 6) are still relevant in the context of the PEGASUS project.

1.2 Scope

This document contains the Interface Control Document for the Prototype EGNOS & GLONASS Analysis System Using SAPPHIRE (PEGASUS). The ICD describes the format and the content of the input data that is needed in order to execute the data evaluation.

This document is divided into two parts. In the main document, the format and the content of the data that is needed for the execution of the prototypes is described. There are several chapters in which the GPS data, the SBAS data, the GLONASS data and additional “aircraft” parameters are described. The last chapter contains a specification for a multipath assessment capability.

Then there are several appendices where the receiver native data format for the different GPS/GLONASS/SBAS receivers (see [9]) are described. The receiver configuration is given as well. Additionally, the data content of the SBAS framed data and multipath data is provided. In the last appendix, an example description of the files generated in the context of the PEGASUS project is provided.

1.3 Reference Documents

[1] ICAO Standards and Recommended Practices SARPS, Annex 10 Volume 1 Radionavigation Aids, including Amendment 76 and 77, Montreal, 2002

[2] ESTB SIS User Interface Description, ESA Doc.-No.: E-TN-ITF-E31-0008-ESA issue 0 revision 1, June 2000

[3] GPS Standard Positioning Service Signal Specification, 2nd edition, June 1995

[4] GPS Standard Positioning Service Signal Specification, October 2001

[5] GLONASS Interface Control Document, RTCA Paper No. 639-95 SC 159-685, 1995

[6] Minimum Operational Performance Standards for GPS/WAAS Airborne Equipment, RTCA, Do 229, June 1996, including Change 1, July 1997

[7] Minimum Operational Performance Standards for GPS/WAAS Airborne Equipment, RTCA, Do 229A, June 1998

[8] Minimum Operational Performance Standards for GPS/WAAS Airborne Equipment, RTCA, Do 229B, October 1999

[9] User Requirements Document, EEC PEGASUS, Doc.No.: PEG-URD-01 issue G, July 2001

[10] User Requirements Document, EEC PEGASUS-PLUS[1], Doc.No.: PEG+-URD-01 issue D, May 2001

[11] Interface Control Document 1, EEC SAPPHIRE DUAU, Doc.-No.: DUAU-TN-2472-003

[12] Technical Note Ephemeris and Almanac Data, EEC SAPPHIRE DUAU, Doc.-No.: DUAU-TN-2472-014

[13] MiLLenium GLONASS GPSCard User Manual, Novatel Inc., Doc.-No. OM-20000040 revision 0E,

[14] MiLLenium GPSCard Software Version 4.50, Novatel Inc., Doc.-No. OM-20000041 Revision Level 1, 1998

[15] Aquarius 5000 Series User's Manual, Dassault-Sercel Navigation Products DSNP, Doc.-No.: 0311374 Rev B, Jan 1999

[16] ConfPack Configuration Software for DSNP GNSS/GPS Receivers – Reference Manual, Dassault-Sercel Navigation Products DSNP, Doc.-No.: 0311373 Rev B, Jan 1999

[17] Septentrio PolaRx evaluation kit description V1.01, July 2001

[18] W. Gurthner: RINEX - The Receiver Independent Exchange Format, Version 2, Astronomical Institute University of Berne, September 1998,

[1] The PEGASUS*Plus project established an extension to the original PEGASUS project that decode, process and evaluate the GNSS / SBAS data. Recent developments have integrated all these modules into a PEGASUS frame and the necessary documentation has been modified accordingly – except for the URD where it has been decided not to generate a new issue.

[19] YUMA almanac format description, http://navcen.uscg.gov/gps/gpsyuma.htm

[20] NMEA Standards for Interfacing Marine Electronic Devices 2.3, National Marine Electronics Association, 1998

[21] OEM4 User Manual - Volume 2 Command and Log Reference, NovAtel Inc., Pub-No OM-20000047 Revision Level 7, 2001/06/21

[22] Portable MEDLL Receiver, Installation and Operation Manual, NovAtel Inc, Pub-No OM-20000065 Rev. 0C, 26.09.2001

[23] Multipath Assessment Tool, User Manual. NovAtel Inc., Pub-No. OM-20000054, Rev 1, 10.08.2000

[24] Septentrio PolaRx2 User Manual V2.1, March 2003

1.4 SAPPHIRE related issues

Some of the data described in this Interface Control Document is required for the PEGASUS data evaluation. However, some items of the data can be characterised as optional. These optional items might be required for data evaluation in the SAPPHIRE project. In order to better characterise the property of each data item, the following scheme is adopted:

The tables describing each data item will contain an additional column called “Property“, in which up to six different numbers are set:

1 required for loading into the existing SAPPHIRE database (this level of functionality is only of interest, if data recorded using this ICD is evaluated using the database tools of SAPPHIRE phase II).

2 required for basic SAPPHIRE processing: calculation of navigation solution, RAIM evaluation, constellation evaluations and predictive monitoring.

3 required for PEGASUS processing (PEGASUS processing is defined in the relevant URD [9]).

4 required for improved SAPPHIRE RAIM processing using the barometric altitude.

5 required for improved SAPPHIRE AAIM processing using the INS position and velocity.

6 required for additional SAPPHIRE processing: wind-triangle calculation, position-velocity filter and air data computation

The following figure illustrates the properties in their relationship. Data files stored for PEGASUS purposes do not need to be included into the SAPPHIRE DUAU II database, since the evaluation is performed using prototypes. However, the later inclusion of the PEGASUS algorithms into the SAPPHIRE DUAU requires that the PEGASUS data files can be included into the existing SAPPHIRE II database. For more information, refer to the relevant PEGASUS and SAPPHIRE documentation.

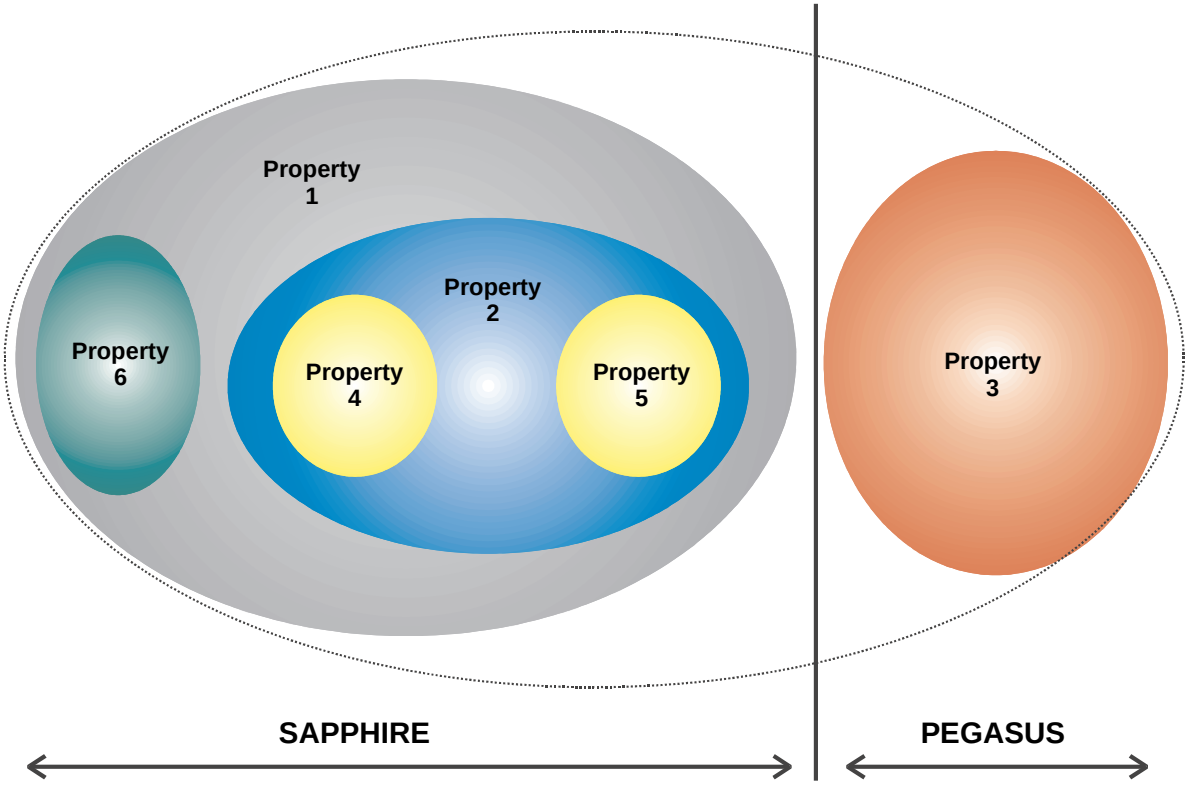

Figure 1: PEGASUS and SAPPHIRE relationship

2 GNSS measurements

The following table provides a list of GNSS data and its format. An example of how the data is organised in different files is provided in the Appendix I.

GNSS Data Characteristics									
Counter	Parameter	Parameter Name[2]	Units	Minimum Value	Maximum Value	Minimum Resolution	Update Rate[3]	Note	PEGASUS Property[4]
1	Satellite PRN Number	SVNx[5]	N/A	1	138	1	1 Hz	satellite PRN number	1, 2, 3, 4, 5
2	Operation Mode	OPMx[6]	N/A	see table 4	see table 4	1	1 Hz	receiver status, see table 4	1
3	Measurement Status	MSx	N/A	see table 3	see table 3	1	1 Hz	channel status, see table 3	1
4	Carrier to Noise Ratio	CNOx	dBHz	0	60	1	1 Hz	signal to noise ratio	1
5	Pseudo Range	PRCx	m	N/A[7]	N/A	256	1 Hz	code pseudorange	1, 2, 3, 4, 5
6	Pseudo Range Fine[8]	PRFx	m	0	256	0.125	1 Hz	code pseudorange	1, 2, 3, 4, 5
7	Range Rate[9]	RRx	ms^{-1}	-4096	4096	0.0039	1 Hz	instantaneous Doppler	1
8	Delta Range[10][11]	DRx	m	-40960	40960	0.0039	1 Hz	change in carrier phase	1, 2, 3, 4, 5

2 In the naming convention for the datum ABCx the small x is to be understood as a placeholder for a decimal starting with 0. Thus, it is indicated that there are several of these data items (either because these are channel related data or different issues of the same data). If the data for several channels can not be obtained, the values of these data should be set to zero.
3 The specified update rate relates to issues of the SAPPHIRE database Update and Access Unit. For PEGASUS related issues, this column is only intended as information and any other consistent update rate of a receiver will be sufficient for data evaluation purposes.
4 In the column PEGASUS property up to six numbers are shown, following the scheme defined in chapter 1.4. If the aim of the ESTB data collection is not the evaluation using the PEGASUS and SAPPHIRE tools, this column can be disregarded.
5 For clarification: SVNx represents the PRN numbers which are also used in the ephemeris data format. The following convention should be kept in mind: GPS: PRN 1 to PRN 37, GLONASS: PRN 38 to PRN 61, EGNOS: PRN 120 to PRN 138 (for more information, refer to the relevant specifications [1] and [7]).
6 The datum OPM represents a receiver status, thus having one value for the receiver (and not different values for each channel). However, the ICD of SAPPHIRE Phase I ([11]) defines the datum to be channel-related.
7 For a receiver set up using a clock control scheme, the specification of a minimum and a maximum value for the pseudorange is appropriate. However, if the receiver uses no clock control model, the pseudoranges contain a significant amount of the receiver clock error. Thus a specification of an appropriate interval for the pseudorange is not appropriate for all purposes.
8 In all cases where values are split, the full value can be restored by the sum of the coarse and the fine value. The fine value can be set to zero if the resolution for the coarse value meets the specified requirements for the complete datum.
9 Sign Convention: if the range (i.e. the sum of PRC and PRF) is increasing in magnitude, the range rate is assumed to be negative.
10 Sign Convention: if the carrier phase is increasing in magnitude, the delta range is assumed to be negative.

GNSS Data Characteristics									
Counter	Parameter	Parameter Name[2]	Units	Minimum Value	Maximum Value	Minimum Resolution	Update Rate[3]	Note	PEGASUS Property[4]
9	UTC Meas. Time	GUTCx	s	0	10	0.00000954	1 Hz	time of signal reception[12]	1
10	GPS Altitude[13]	GALT	ft	-1500	131072	0.125	1 Hz	computed altitude	1, 2, 3, 4, 5
11	HDOP	HDOP	N/A	0	1024	0.03125	1 Hz	HDOP	1
12	VDOP	VDOP	N/A	0	1024	0.03125	1 Hz	VDOP	1
13	GPS Latitude	GLAT	1°	-90	+90	$1.7166*10^{-4}$	1 Hz	computed latitude	1, 2, 3, 4, 5
14	GPS Longitude	GLON	1°	-180	+180	$1.7166*10^{-4}$	1 Hz	computed longitude	1, 2, 3, 4, 5
15	GPS Latitude Fine	GLATF	1°	-0.000172	+0.000172	$8.381903*10^{-8}$	1 Hz	computed latitude	1, 2, 3, 4, 5
16	GPS Longitude Fine	GLONF	1°	-0.000172	+0.000172	$8.381903*10^{-8}$	1 Hz	computed longitude	1, 2, 3, 4, 5
17	Horizontal Integrity Limit	HINTL	nm	0	16	$6.104*10^{-5}$	1 Hz	horizontal integrity limit	1
18	UTC Hour[14]	UTC_hrs	hr	0	23	1	1 Hz	time information	1, 2, 3, 4, 5
19	UTC Minute	UTC_mins	min	0	59	1	1 Hz	time information	1, 2, 3, 4, 5
20	UTC Second[15]	UTC	s	0	60	1	1 Hz	time information	1, 2, 3, 4, 5
21	UTC Fine	UTCF	s	0	1.0	$9.5*10^{-7}$	1 Hz	time information	1, 2, 3, 4, 5
22	UTC Fine Fraction	UTCFF	s	0	$9.5*10^{-7}$	$9.3132*10^{-10}$	1 Hz	time information	1, 2, 3, 4, 5
23	GPS Sensor Status Satellites tracked	SATT[16]	N/A	0	26	1	1 Hz	number of satellites tracked by receiver	1, 2, 3, 4, 5

11 If the carrier phase is acquired in the current epoch, a delta range (i.e. the change in the “accumulated delta range value” can not be determined. In these circumstances, the DR value is assumed to be zero. The same approach applies to re-acquisition processes and loss-of-lock effects. In order to accommodate a gap of 10 s in the data recording, the minimum and maximum values of the delta range are set to those values. It is assumed that after a gap of 10 s, the data evaluation of the delta range values has to be initialised anyway.
12 The UTC measurement time represents the time of signal reception of the receiver modulo 10 s. For receive-time receivers, it is the same for each channel, whereas for transmit-time receivers, it varies for each channel.
13 Although provided in feet, the GPS Altitude is a WGS84 altitude.
14 The time information contained in the datum UTC represents the GNSS derived time information including leap seconds. It is split up into the sublabels hour, minute, second, seconds fine and seconds fine fraction. It is not used for time synchronisation purposes between different files.
15 The maximum value is deliberately set to 60 in order to incorporate GNSS leap seconds into the data format.
16 The PEGASUS prototypes are designed to incorporate data from a 24 channel receiver.

GNSS Data Characteristics									
Counter	Parameter	Parameter Name[2]	Units	Minimum Value	Maximum Value	Minimum Resolution	Update Rate[3]	Note	PEGASUS Property[4]
24	GPS Sensor Status Satellites visible	SATV	N/A	0	26	1	1 Hz	number of satellites visible to receiver	1, 2
25	GPS Sensor Status mode	GMODE	N/A	see table 2	see table 2	1	1 Hz	receiver mode, see table 2	1
26	GPS Time[17]	GSEC	S	0	604799.99	0.01	1 Hz	time information	3
27	GPS Week	GWEEK	Weeks	0	> 1024	1	1 Hz	time information	3

Table 1: GNSS Data Characteristics

Predefined Values for the Receiver Mode[18]	Value
self test mode	0
initialisation mode	1
acquisition mode	2
navigation mode	3
altitude aiding or clock coasting mode	4
fault	7
no receiver calculated position available	99

Table 2: Predefined Values for the Datum GMODE

17 The data GPS Time and GPS Week will be used in the PEGASUS project for time synchronisation purposes. Thus, it is strongly recommended that these data items should be recorded.
18 Each receiver may have additional proprietary modes in the range of 8 to 99

Predefined Values for the Channel Status[19]	Description
bit 1 set	ephemeris data used for satellite position calculation
Bit 1 not set	Almanac data used for satellite position calculation
bit 2 set	user clock update
Bit 2 not set	no user clock update
Bit 3 set	P code measurement
Bit 3 not set	C/A code measurement
Bit 4 set	valid delta range measurement
Bit 4 not set	invalid delta range measurement
Added Values for the Channel Status[20]	Description
Bit 5 set[21]	no phase, no parity and no code
Bit 6 set	phase locked
Bit 6 not set	phase not locked
Bit 7 set	parity known
Added Values for the Channel Status	Description
Bit 7 not set	parity not known
Bit 8 set	code
Bit 8 not set	no code

Table 3: Predefined Values for the Datum MSx

19 Due to backwards compatibility purposes, the first four bits of the channel status describe the channel status as was defined in the SAPPHIRE project using 4 bits. If a measurement of a channel is diagnosed to be correct, then these 4 bits are still suitable to describe the channel status. However, each receiver used during the PEGASUS project may have additional proprietary modes.
20 During the implementation of several receivers in the PEGASUS project, it was seen as helpful to add some additional diagnosis capability for each channel measurement. These additional bits will only be used in the case where a channel measurement had been diagnosed as being incorrect.
21 By setting bit 5, the diagnosis “no code”, “no parity” and “no phase” is selected.

Predefined Values for the Receiver Status[22]	Value
normal operation	0
no computed data	1
unit in self-test mode	2
Fault	7

Table 4: Predefined Values for the Datum OPMx

22 Each receiver may have additional proprietary modes in the range of 3-6 and 8 to 99. Although this datum represents a receiver status, for backwards compatibility issues with the SAPPHIRE II DUAU, this datum is required to be a channel datum.

3 GPS satellite position data

The GPS satellite position data consists of two different types of orbital parameters: the almanac and the ephemeris. Almanac data is used for coarse satellite positioning, whereas ephemeris data is used for precise satellite positioning and ranging. The almanacs and ephemeris data shall be stored in two different files.

3.1 Almanac data

Almanac data shall be provided in the YUMA format (see [19], as well). The following table provides a list of parameters, which are contained in the YUMA format. A parameter name by which the individual parameter is accessed is not provided since the almanac file is stored in a fixed file format. Furthermore, an example of the file format is provided. A minimum value and a maximum value are defined only in those cases, where a definite bound could be established. Since the PEGASUS prototype does not perform a plausibility check on these data, the specification of maximum and minimum values is optional.

GPS YUMA Almanac							
Counter	Parameter	Units	Minimum Value[23]	Maximum Value	Minimum Resolution	Note	PEGASUS Property[24]
100	Satellite PRN Number	N/A	1	37	1	PRN number of the satellite	2, 3, 4, 5
101	Satellite Health	N/A				flag used for indicating the health of the satellite	2, 3, 4, 5
102	Eccentricity	N/A				eccentricity of the satellite orbit	2, 3, 4, 5
103	Time of Applicability	s	0	604799	1	reference time for the almanac	2, 3, 4, 5
104	Orbital Inclination	rad				inclination of the satellite above the equatorial plane	2, 3, 4, 5
105	Rate of Right Ascension	$rads^{-1}$				rate of change for the right ascension	2, 3, 4, 5
106	Square Root of Semi-Major Axis	$m^{1/2}$				semi-major axis of the satellite orbit	2, 3, 4, 5

23 A minimum value, a maximum value and the minimum resolution is not specified for all the data contained in the table. A plausibility check on the GPS almanac data is not in the purview of the PEGASUS project.
24 In the column PEGASUS property up to six numbers are shown, following the scheme defined in chapter 1.4. If the aim of the ESTB data collection is not the evaluation using the PEGASUS and SAPPHIRE tools, this column can be disregarded.

GPS YUMA Almanac							
Counter	Parameter	Units	Minimum Value[23]	Maximum Value	Minimum Resolution	Note	PEGASUS Property[24]
107	Right Ascension at the Time of Week[25]	rad				arc between the vernal equinox and the longitude of the ascending node on the equatorial plane at the begin of the reference week	2, 3, 4, 5
108	Argument of Perigee	rad	0			argument of perigee for the satellite	2, 3, 4, 5
109	Mean Anomaly	rad				mean anomaly of the satellite at the time-of-applicability	2, 3, 4, 5
110	Satellite Clock Correction Constant Polynomial Term	s				satellite clock correction in the form of a first order polynomial using the time-of-applicability and the current time in the week	2, 3, 4, 5
111	Satellite Clock Correction First Order Polynomial Term	ss^{-1}				satellite clock correction in the form of a first order polynomial using the time-of-applicability and the current time in the week	2, 3, 4, 5
112	Week Number	N/A	0	> 1024	1	GPS week number of the almanac	2, 3, 4, 5

Table 5: GPS YUMA Almanac Format

Since the GPS/GLONASS/EGNOS receiver should deliver the new almanac data at least upon start and then regularly, the almanac file contains the almanac of all GPS satellites for the relevant GPS week. It is recommended to name the file with xxxx_GPSyyyy.ALM ; where xxxx represents the file name basis selected and yyyy stands for the GPS week number (with optional leading zeros) of the data. Thus, in the example the file generated is named TUBS_GPS0001.ALM.

25 Although the YUMA specifications (see [19]) require the right ascension at the time of applicability, this parameter is always provided at the “time of week”, i.e. at second 0 on the night between Saturday and Sunday. The parameter line in a particular almanac is then labelled ‘right ascension at time of week’.

Example of a YUMA almanac file

```
******** Week    1 almanac for PRN-01 ********
ID:                         01
Health:                     000
Eccentricity:               0.4695415497E-002
Time of Applicability(s):   405504.0000
Orbital Inclination(rad):   0.9585786022
Rate of Right Ascen(r/s):  -0.7966046104E-008
SQRT(A)  (m 1/2):           5154.298340
Right Ascen at Week(rad):   0.2548266037E+001
Argument of Perigee(rad):  -1.728664896
Mean Anom(rad):             0.7613727885E-002
Af0(s):                     0.9727478027E-004
Af1(s/s):                   0.0000000000E+000
week:                          1

******** Week    1 almanac for PRN-02 ********
ID:                         02
Health:                     000
Eccentricity:               0.1937818527E-001
Time of Applicability(s):   405504.0000
Orbital Inclination(rad):   0.9351194820
Rate of Right Ascen(r/s):  -0.8080336578E-008
SQRT(A)  (m 1/2):           5153.605469
Right Ascen at Week(rad):  -0.1725276356E+001
Argument of Perigee(rad):  -2.175051433
Mean Anom(rad):             0.2797708316E+001
Af0(s):                    -0.1058578491E-003
Af1(s/s):                  -0.3637978807E-011
week:                          1

******** Week    1 almanac for PRN-03 ********
ID:                         03
Health:                     000
Eccentricity:               0.1937818527E-001
Time of Applicability(s):   405504.0000
Orbital Inclination(rad):   0.9351194820
Rate of Right Ascen(r/s):  -0.8080336578E-008
SQRT(A)  (m 1/2):           5153.605469
Right Ascen at Week(rad):  -0.1725276356E+001

...
```

3.2 Ephemeris data

Ephemeris data shall be provided in the RINEX2 format dated September 1998 (for detailed information, refer to [18]). The following table provides a list of parameters, which are contained in the RINEX2 format. A parameter name by which the individual parameter is accessed is not provided since the ephemeris file is stored in a fixed file format. Furthermore, an example of the file format is provided. A minimum value and a maximum value are defined only in those cases, where a definite bound could be established. Since the PEGASUS prototype does not perform a plausibility check on these data, the specification of maximum and minimum values is optional.

GPS RINEX2 Ephemeris							
Counter	Parameter	Units	Minimum Value[26]	Maximum Value	Minimum Resolution	Note	PEGASUS Property[27]
200	Ionosphere Parameter Alpha 0	s				ionospheric correction parameter alpha constant term	2, 3, 4, 5
201	Ionosphere Parameter Alpha 1	s/semicircle				ionospheric correction parameter alpha first order term	2, 3, 4, 5
202	Ionosphere Parameter Alpha 2	$s/semicircle^2$				ionospheric correction parameter alpha second order term	2, 3, 4, 5
203	Ionosphere Parameter Alpha 3	$s/semicircle^3$				ionospheric correction parameter alpha third order term	2, 3, 4, 5
204	Ionosphere Parameter Beta 0	s				ionospheric correction parameter beta constant term	2, 3, 4, 5
205	Ionosphere Parameter Beta 1	s/semicircle				ionospheric correction parameter beta first order term	2, 3, 4, 5
206	Ionosphere Parameter Beta 2	$s/semicircle^2$				ionospheric correction parameter beta second order term	2, 3, 4, 5
207	Ionosphere Parameter Beta 3	$s/semicircle^3$				ionospheric correction parameter beta third order term	2, 3, 4, 5
208	UTC System Time Correction A0	s				time transformation parameter correction to system time constant term	2, 3, 4, 5

26 A minimum value, a maximum value and the minimum resolution is not specified for all the data contained in the table. A plausibility check on the GPS ephemeris data is not in the purview of the PEGASUS project.

27 In the column PEGASUS property up to six numbers are shown, following the scheme defined in chapter 1.4. If the aim of the ESTB data collection is not the evaluation using the PEGASUS tools, this column can be disregarded

GPS RINEX2 Ephemeris							
Counter	Parameter	Units	Minimum Value[26]	Maximum Value	Minimum Resolution	Note	PEGASUS Property[27]
209	UTC System Time Correction A1	s/s				time transformation parameter correction to system time first order term	2, 3, 4, 5
210	Reference Time for UTC Data	s				reference time for time correction parameters	2, 3, 4, 5
211	UTC Reference Week	N/A				reference week for time correction parameters	2, 3, 4, 5
212	Satellite PRN Number	N/A				satellite PRN number	2, 3, 4, 5
213	Epoch Time Year	yr				time information	2, 3, 4, 5
214	Epoch Time Months	months				time information	2, 3, 4, 5
215	Epoch Time Day	day				time information	2, 3, 4, 5
216	Epoch Time Hours	hr				time information	2, 3, 4, 5
217	Epoch Time Minutes	min				time information	2, 3, 4, 5
218	Epoch Time Seconds	s				time information	2, 3, 4, 5
219	Satellite Clock Bias	s				satellite clock correction polynomial constant term	2, 3, 4, 5
220	Satellite Clock Drift	s/s				satellite clock correction polynomial first order term	2, 3, 4, 5
221	Satellite Clock Drift Rate	s/s^2				satellite clock correction polynomial second order term	2, 3, 4, 5
222	Issue of Data Ephemeris IODE	N/A				issue of data ephemeris	2, 3, 4, 5
223	Correction Parameter CRS	m				correction parameter	2, 3, 4, 5
224	Correction Parameter DELTAN	rad/s				correction parameter	2, 3, 4, 5
225	Mean Anomaly	rad				mean anomaly	2, 3, 4, 5
226	Correction Parameter CUC	rad				correction parameter	2, 3, 4, 5
227	Eccentricity E	N/A				eccentricity	2, 3, 4, 5
228	Correction Parameter CUS	rad				correction parameter	2, 3, 4, 5

GPS RINEX2 Ephemeris							
Counter	Parameter	Units	Minimum Value[26]	Maximum Value	Minimum Resolution	Note	PEGASUS Property[27]
229	Square-Root of Semi-Major Axis	$m^{1/2}$				semi-major axis	2, 3, 4, 5
230	Time of Ephemeris	s				time of applicability ephemeris	2, 3, 4, 5
231	Correction Parameter CIC	rad				correction parameter	2, 3, 4, 5
232	Argument of Right Ascension OMEGA	rad				argument of right ascension	2, 3, 4, 5
233	Correction Parameter CIS	rad				correction parameter	2, 3, 4, 5
234	Inclination I0	rad				inclination	2, 3, 4, 5
235	Correction Parameter CRC	m				correction parameter	2, 3, 4, 5
236	Argument of Perigee omega	rad				argument of perigee	2, 3, 4, 5
237	Drift Rate of Argument of Right Ascension OMEGADOT	rad/s				rate of change of argument of right ascension	2, 3, 4, 5
238	Drift Rate of Inclination IDOT	rad/s				rate of change of inclination	2, 3, 4, 5
239	Codes on L2 Channel	N/A				flag for C/A data on L2 channel	2, 3, 4, 5
240	GPS Week Number	N/A				week number	2, 3, 4, 5
241	L2 P-Code Flag	N/A				flag for P data on L2 channel	2, 3, 4, 5
242	Satellite Accuracy	m				accuracy indicator	2, 3, 4, 5
243	Satellite Health	N/A				satellite health	2, 3, 4, 5
244	Correction Parameter Time Group Delay TGD	s				group delay time correction parameter	2, 3, 4, 5
245	Issue of Data Clock IODC	N/A				issue of data clock	2, 3, 4, 5
246	Transmission Time of Message	s				time of signal transmission	2, 3, 4, 5

GPS RINEX2 Ephemeris							
Counter	Parameter	Units	Minimum Value[26]	Maximum Value	Minimum Resolution	Note	PEGASUS Property[27]
247	Spare	N/A				spare value for RINEX2 format	2, 3, 4, 5
248	Spare	N/A				spare value for RINEX2 format	2, 3, 4, 5
249	Spare	N/A				spare value for RINEX2 format	2, 3, 4, 5

Table 6: GPS RINEX2 Ephemeris Format

The ephemeris file is stored in a fixed file format. The RINEX2 ephemeris file format is subdivided into a header and a body of values. It is essential that the layout of the file is observed, since the processing of the ephemeris information is performed line-driven. A structure for the header of a RINEX2 ephemeris file is given in the following templates.

After the header, the RINEX2 ephemeris file contains the body in which the values of the ephemeris information is provided. In contrast to the original RINEX2 format, only the ephemeris data of the received satellites are stored. Even though a chronological order of the ephemeris information is kept, the PEGASUS RINEX2 file need not cover the whole day. A sorting of ephemeris information by the PRN number is not done. A structure for the body of a RINEX2 ephemeris file is given in the following templates.

A structure for the RINEX2 ephemeris file containing the header and the body is provided as well.

It is recommended to name the file xxxx_BRDCttt0.zzN, where xxxx represents the common file name basis selected, ttt is the Julian day of the year of the data, and zz describes the year of recording and N stands for “GPS Navigation Data”. Alternatively, the file can be named xxxx_ttt0.zzN, with xxxx, ttta and zz as defined above.

To provide an example, the file TUBS_BRDC0350.99N contains GPS ephemeris files and was recorded by the Technical University of Braunschweig on the 35th day of 1999 (alternatively, the file could be named TUBS_035.99N).

Template of the Header of the RINEX2 ephemeris file

NAVIGATION MESSAGE FILE - **HEADER SECTION** DESCRIPTION		
HEADER LABEL (Columns 61-80)	DESCRIPTION	FORMAT
RINEX VERSION / TYPE	- Format version (2) - File type ('N' for Navigation data)	I6,14X, A1,19X
PGM / RUN BY / DATE	- Name of program creating current file - Name of agency creating current file - Date of file creation	A20, A20, A20
COMMENT	Comment line(s)	A60
ION ALPHA	Ionosphere parameters A0-A3 of almanac (page 18 of subframe 4)	2X,4D12.4
ION BETA	Ionosphere parameters B0-B3 of almanac	2X,4D12.4
DELTA-UTC: A0,A1,T,W	Almanac parameters to compute time in UTC (page 18 of subframe 4) A0,A1: terms of polynomial T : reference time for UTC data W : UTC reference week number. Continuous number, not mod(1024)!	3X,2D19.12, 2I9
LEAP SECONDS	Delta time due to leap seconds	I6
END OF HEADER	Last record in the header section.	60X

Template of the Body of the RINEX2 ephemeris file

NAVIGATION MESSAGE FILE - **DATA RECORD** DESCRIPTION		
OBS. RECORD	DESCRIPTION	FORMAT
PRN / EPOCH / SV CLK	- Satellite PRN number	I2,
	- Epoch: Toc - Time of Clock	
	year (2 digits)	5I3,
	month	
	day	
	hour	
	minute	
	second	F5.1,
	- SV clock bias (seconds)	3D19.12
	- SV clock drift (sec/sec)	
	- SV clock drift rate (sec/sec2)	
BROADCAST ORBIT - 1	- IODE Issue of Data, Ephemeris	3X,4D19.12
	- Crs (meters)	
	- Delta n (radians/sec)	
	- M0 (radians)	
BROADCAST ORBIT - 2	- Cuc (radians)	3X,4D19.12
	- e Eccentricity	
	- Cus (radians)	
	- sqrt(A) (sqrt(m))	
BROADCAST ORBIT - 3	- Toe Time of Ephemeris	3X,4D19.12
	(sec of GPS week)	
	- Cic (radians)	
	- OMEGA (radians)	
	- CIS (radians)	
BROADCAST ORBIT - 4	- i0 (radians)	3X,4D19.12
	- Crc (meters)	
	- omega (radians)	
	- OMEGA DOT (radians/sec)	
BROADCAST ORBIT - 5	- IDOT (radians/sec)	3X,4D19.12
	- Codes on L2 channel	
	- GPS Week # (to go with TOE)	
	Continuous number, not mod(1024)!	
	- L2 P data flag	
BROADCAST ORBIT - 6	- SV accuracy (meters)	3X,4D19.12

	- SV health	(MSB only)	
	- TGD	(seconds)	
	- IODC Issue of Data, Clock		
BROADCAST ORBIT - 7	- Transmission time of message (sec of GPS week, derived e.g. from Z-count in Hand Over Word (HOW)		3X,4D19.12
	- spare		
	- spare		
	- spare		

Example of a RINEX2 ephemeris file

```
                     NAVIGATION MESSAGE FILE - EXAMPLE

----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|

     2             N: GPS NAV DATA                         RINEX VERSION / TYPE
XXRINEXN V2.0       AIUB                12-SEP-90 15:22     PGM / RUN BY / DATE
EXAMPLE OF VERSION 2 FORMAT                                 COMMENT
     .1676D-07   .2235D-07  -.1192D-06  -.1192D-06          ION ALPHA
     .1208D+06   .1310D+06  -.1310D+06  -.1966D+06          ION BETA
     .133179128170D-06  .107469588780D-12   552960       39 DELTA-UTC: A0,A1,T,W
     6                                                      LEAP SECONDS
                                                            END OF HEADER
 6 90  8  2 17 51 44.0 -.839701388031D-03 -.165982783074D-10  .000000000000D+00
     .910000000000D+02  .934062500000D+02  .116040547840D-08  .162092304801D+00
     .484101474285D-05  .626740418375D-02  .652112066746D-05  .515365489006D+04
     .409904000000D+06 -.242143869400D-07  .329237003460D+00 -.596046447754D-07
     .111541663136D+01  .326593750000D+03  .206958726335D+01 -.638312302555D-08
     .307155651409D-09  .000000000000D+00  .551000000000D+03  .000000000000D+00
     .000000000000D+00  .000000000000D+00  .000000000000D+00  .910000000000D+02
     .406800000000D+06

13 90  8  2 19  0  0.0  .490025617182D-03  .204636307899D-11  .000000000000D+00
     .133000000000D+03 -.963125000000D+02  .146970407622D-08  .292961152146D+01
    -.498816370964D-05  .200239347760D-02  .928156077862D-05  .515328476143D+04
     .414000000000D+06 -.279396772385D-07  .243031939942D+01 -.558793544769D-07
     .110192796930D+01  .271187500000D+03 -.232757915425D+01 -.619632953057D-08
    -.785747015231D-11  .000000000000D+00  .551000000000D+03  .000000000000D+00
     .000000000000D+00  .000000000000D+00  .000000000000D+00  .389000000000D+03
     .410400000000D+06
.........................
```

4 SBAS messages

The following table provides a list of SBAS data and its format according to the specification found in [7]. The 0 provides an overview of the different message types and their purpose. An example of how the data is organised in different files is provided in the Appendix I.

SBAS Data Characteristics									
Counter	Parameter	Parameter Name[28][29]	Units	Minimum Value	Maximum Value	Minimum Resolution	Maximum Update Interval[30]	Remarks	PEGASUS Property[31]
300	GNSS Week of Message types[32]	GWEEK_SMT	weeks	0	> 1024	1	1 s	reception time all MT	3
301	GNSS Seconds of Message types	GSEC_SMT	s	0	604799.99	0.01	1 s	reception time all MT	3
302	PRN of Message types	PRN_SMT	N/A	120	138	1	1 s	PRN of MT transmission	3
303	Message type	MT_SMT	N/A	0	63	1	1 s	Message Type ID	3
304	GNSS Week of MT 0	GWEEK_S0	weeks	0	> 1024	1	6 s	reception time MT 0	3
305	GNSS Seconds of MT 0	GSEC_S0	s	0	604799.99	0.01	6 s	reception time MT 0	3
306	PRN of MT 0	PRN_S0	N/A	120	138	1	6 s	PRN of MT 0 transmission	3

28 In the naming convention for the datum ABCx the small x is to be understood as a placeholder for a decimal starting with 0. Thus, it is indicated that there are several of these data items (either because these are channel related data or different issues of the same data)
29 The suffix starting with "_" indicates that the parameter is derived from a SBAS message. Additionally, it contains the message identity or (in the case of the fast and slow corrections, an FC or an SC).
30 In contrast to the GPS measurements, the SBAS messages do not have a fixed update rate. However, a maximum update interval is specified in the relevant documentation ([1] and [7]).
31 In the column PEGASUS property up to six numbers are shown, following the scheme defined in chapter 1.4. If the aim of the ESTB data collection is not the evaluation using the PEGASUS and SAPPHIRE tools, this column can be disregarded
32 A time stamp of the arrival of each SBAS message type is needed for the data evaluation, since the maximum time-out interval has to be considered (for more information, see the relevant specifications [7] and [1]). Additionally, this time information will be used in the PEGASUS project for time synchronisation purposes. Thus, it is strongly recommended that these data items should be recorded.

SBAS Data Characteristics									
Counter	Parameter	Parameter Name[28][29]	Units	Minimum Value	Maximum Value	Minimum Resolution	Maximum Update Interval[30]	Remarks	PEGASUS Property[31]
307	GPS Week of MT 1	GWEEK_S1	weeks	0	> 1024	1	120 s	reception time MT 1	3
308	GPS Seconds of MT 1	GSEC_S1	s	0	604799.99	0.01	120 s	reception time MT 1	3
309	PRN of MT 1	PRN_S1	N/A	120	138	1	120 s	PRN of MT 1 transmission	3
310	Satellite Mask	SVMASK_S1	N/A	0	N/A[33]	1	120 s	MT 1	3
311	Issue Of Data PRN Mask	IODP_S1	N/A	0	3	1	120 s	MT 1	3
312	GPS Week of MT Fast Corrections	GWEEK_SFC	weeks	0	> 1024	1	6 s	reception time MT fast correction	3
313	GPS Seconds of MT Fast Corrections	GSEC_SFC	s	0	604799.99	0.01	6 s	reception time MT fast correction	3
314	PRN of MT FC	PRN_SFC	N/A	120	138	1	6 s	PRN of fast correction transmission	3
315	Issue Of Data Fast Corrections	IODF_SFC	N/A	0	3	1	6 s	MT fast correction	3
316	Issue Of Data PRN Fast Corrections	IODP_SFC	N/A	0	3	1	6 s	MT fast correction	3

33 The satellite Mask is provided as a string using hexadecimal coding.

SBAS Data Characteristics									
Counter	Parameter	Parameter Name[2829]	Units	Minimum Value	Maximum Value	Minimum Resolution	Maximum Update Interval[30]	Remarks	PEGASUS Property[31]
317	Fast Corrections Block Identifies	TYPE_SFC	N/A	2	5	1	60 s	necessary for identifying the fast correction MT[34]	3
318	Pseudorange Correction Fast	PRCx_SFC[35]	m	-256.0	255.875	0.125	60 s	MT fast correction	3
319	User Differential Range Error Indicator Fast Corrections	UDREIx_SFC	N/A	0	15	1	6 s	MT fast correction	3
320	GPS Week of MT 6	GWEEK_S6	weeks	0	> 1024	1	6 s	reception time MT 6	3
321	GPS Seconds of MT 6	GSEC_S6	s	0	604799.99	0.01	6 s	reception time MT 6	3
322	PRN of MT 6	PRN_S6	N/A	120	138	1	6 s	PRN of MT 6 transmission	3
323	Issue of Data Fast Corrections Integrity	IODFx_S6[36]	N/A	0	3	1	6 s	MT 6	3
324	User Differential Range Error Indicator Integrity	UDREIx_S6[37]	N/A	0	15	1	6 s	MT 6	3

34 In the PEGASUS implementation, the fast correction message types are contained in one data file. In order to identify the correct message type, the parameter TYPE_FC contains the information of the original message type ID (e.g. 2,3, 4 or 5).

35 The small letter x associated with the Pseudorange Corrections PRCx_FC and the User Differential Range Error Indicator UDREIx_FC is numbered through 1 to 13, indicating that this is the x^{th} data item inside this message type. The individual pseudorange correction and user differential range error indicator is always to be evaluated in combination with the datum TYPE_FC. Using the PRN mask in message type 1 and the scheme proposed in [7], the relevant PRN number of the correction information can be determined.

36 The small letter x associated with the parameter IODFx_6 is numbered through 2 to 5, indicating the message type of the associated fast corrections. Using the PRN mask in message type 1 and the scheme proposed in [7], the relevant PRN number of the correction information can be determined.

37 The small letter x associated with the parameter UDREIx_6 is numbered through 1 to 51, indicating that this is the x^{th} data item inside this message type. The individual user differential range error indicator is always to be evaluated in combination with the PRN mask in message type 1 and the scheme proposed in [7].

SBAS Data Characteristics									
Counter	Parameter	Parameter Name[2829]	Units	Minimum Value	Maximum Value	Minimum Resolution	Maximum Update Interval[30]	Remarks	PEGASUS Property[31]
325	GPS Week of MT 7	GWEEK_S7	weeks	0	> 1024	1	120 s	reception time MT 7	3
326	GPS Seconds of MT 7	GSEC_S7	s	0	604799.99	0.01	120 s	reception time MT 7	3
327	PRN of MT 7	PRN_S7	N/A	120	138	1	120 s	PRN of MT 7 transmission	3
328	System Latency Fast Correction Degradation	TLAT_S7	s	0	15	1	120 s	MT 7	3
329	Issue of Data PRN Fast Correction Degradation	IODP_S7	N/A	0	3	1	120 s	MT 7	3
330	Degradation Factor Indicator Fast Correction Degradation	AIx_S7[38]	N/A	0	15	1	120 s	MT 7	3
331	GPS Week of MT 10	GWEEK_S10	weeks	0	> 1024	1	120 s	reception time MT 10	3
332	GPS Seconds of MT 10	GSEC_S10	s	0	604799.99	0.01	120 s	reception time MT 10	3
333	PRN of MT 10	PRN_S10	N/A	120	138	1	120 s	PRN of MT 10 transmission	3
334	Estimation Noise and Round-Off Error MT 10	BRRC_S10	m	0	2.046	0.002	120 s	MT 10	3
335	Round-Off Error due to LSB Resolution MT 10	CLTCLSB_S10	m	0	2.046	0.002	120 s	MT 10	3
336	Error Bound Slow Corrections VelocityCode 1 MT 10	CLTCV1_S10	ms^{-1}	0	0.05115	0.00005	120 s	MT 10	3

38 The small letter x associated with the parameter AIx_7 is numbered through 1 to 51, indicating that this is the xth data item inside this message type. The fast correction degradation indicator is always to be evaluated in combination with the PRN mask in message type 1 and the scheme proposed in [7].

SBAS Data Characteristics									
Counter	Parameter	Parameter Name[2829]	Units	Minimum Value	Maximum Value	Minimum Resolution	Maximum Update Interval[30]	Remarks	PEGASUS Property[31]
337	Update Interval for slow Corrections VelocityCode 1 MT 10	ILTCV1_S10	s	0	511	1	120 s	MT 10	3
338	Error Bound Slow Corrections VelocityCode 0 MT 10	CLTCV0_S10	m	0	2.046	0.002	120 s	MT 10	3
339	Update Interval for Slow Corrections VelocityCode 0 MT 10	ILTCV0_S10	s	0	511	1	120 s	MT 10	3
340	Round-Off Error due to LSB Resolution MT 10	CGEOLSB_S10	m	0	0.5115	0.0005	120 s	MT 10	3
341	Error Bound Slow Corrections Geo Navigation Message MT 10	CGEOV_S10	ms^{-1}	0	0.05115	0.00005	120 s	MT 10	3
342	Update Interval Geo Navigation Message MT 10	IGEO_S10	s	0	511	1	120 s	MT 10	3
343	Extra Degradation Factor MT 10	CER_S10	m	0	31.5	0.5	120 s	MT 10	3
344	Bound on difference between successive iono grid delay values MT 10	CIONOSTEP_S10	m	0	1.023	0.001	120 s	MT 10	3
345	Minimum Update Interval Ionospheric Correction MT 10	IIONO_S10	s	0	511	1	120 s	MT 10	3
346	Rate of Change of the Ionospheric Corrections MT 10	CIONORAMP_S10	ms^{-1}	0	0.005115	0.000005	120 s	MT 10	3
347	Root-Sum-Square Flag UDRE MT 10	RSSUDRE_S10	N/A	0	1	1	120 s	MT 10	3
348	Root-Sum-Square Flag IONO MT 10	RSSIONO_S10	N/A	0	1	1	120 s	MT 10	3

SBAS Data Characteristics									
Counter	Parameter	Parameter Name[2829]	Units	Minimum Value	Maximum Value	Minimum Resolution	Maximum Update Interval[30]	Remarks	PEGASUS Property[31]
349	GPS Week of MT 12	GWEEK_S12	weeks	0	> 1024	1	300 s	reception time MT 12	3
350	GPS Seconds of MT 12	GSEC_S12	s	0	604799.99	0.01	300 s	reception time MT 12	3
351	PRN of MT 12	PRN_S12	N/A	120	138	1	300 s	PRN of MT 12 transmission	3
352	Constant Term Correction Polynomial MT 12	A1WNT_S12	ss^{-1}	$-7.45\ 10^{-9}$	$7.45\ 10^{-9}$	2^{-50}	300 s	MT 12	3
353	First Order Term Correction Polynomial MT 12	A0WNT_S12	s	-1	1	2^{-30}	300 s	MT 12	3
354	Reference Time for UTC data MT 12	T0T_S12	s	0	602112	2^{12}	300 s	MT 12	3
355	UTC Reference Week Number MT 12	WNT_S12	weeks	0	255	1	300 s	MT 12	3
356	Time Difference due to Leap Seconds MT 12	DTLS_S12	s	-127	127	1	300 s	MT 12	3
357	Week Number of Leap Second MT 12	WNLSF_S12	weeks	0	255	1	300 s	MT 12	3
358	Day Number of Leap Second MT 12	DN_S12	days	1	7	1	300 s	MT 12	3
359	Time Difference due to Leap Seconds MT 12	DTLSF_S12	s	-127	127	1	300 s	MT 12	3
360	UTC Standard Identifier MT 12	UTCID_S12	N/A	0	7	1	300 s	MT 12	3
361	GPS Time of Week MT 12	GPSTOW_S12	s	0	604799	1	300 s	MT 12	3
362	GPS Week Number MT 12	GPSWN_S12	weeks	0	> 1024	1	300 s	MT 12	3
363	GLONASS Indicator MT 12	GLONASSIND_S12	N/A	0	1	1	300 s	MT 12	3

SBAS Data Characteristics									
Counter	Parameter	Parameter Name[2829]	Units	Minimum Value	Maximum Value	Minimum Resolution	Maximum Update Interval[30]	Remarks	PEGASUS Property[31]
364	GLONASS Time Offset MT 12	GLONASSOFF_S12	TBD	TBD	TBD	TBD	300 s	MT 12	3
365	GPS Week of MT 18	GWEEK_S18	weeks	0	> 1024	1	300 s	reception time MT 18	3
366	GPS Seconds of MT 18	GSEC_S18	s	0	604799.99	0.01	300 s	reception time MT 18	3
367	PRN of MT 18	PRN_S18	N/A	120	138	1	300 s	PRN of MT 18 transmission	3
368	Number of Bands Broadcast Ionosphere	NB_S18	N/A	0	9	1	300 s	MT 18	3
369	Band Number Broadcast Ionosphere	BN_S18	N/A	0	8	1	300 s	MT 18	3
370	Issue of Data Ionosphere	IODI_S18	N/A	0	3	1	300 s	MT 18	3
371	Ionospheric Grid Point Mask[39]	IGP_S18	N/A	0	N/A	1	300 s	MT 18	3
372	GPS Week of MT slow correction	GWEEK_SSC	weeks	0	> 1024	1	120 s	reception time MT slow correction	3
373	GPS Seconds of MT slow correction	GSEC_SSC	s	0	604799.99	0.01	120 s	reception time MT slow correction	3
374	PRN of MT slow correction	PRN_SSC	N/A	120	138	1	120 s	PRN of MT slow correction transmission	3
375	Velocity Code Slow Corrections	VCx_SSC[40]	N/A	0	1	1	120 s	MT slow correction	3

39 The IGP mask is provided as a string using hexadecimal coding.

40 The small letter x associated with the parameters VCx_SSC, PRNx_SSC, IODSx_SSC, DXx_SSC, DYx_SSC, DZx_SSC, DAF0x_SSC, DXROCx_SSC, DYROCx_SSC, DZROCx_SSC, DAF1x_SSC, TOAx_SSC and IODPx_SSC is numbered through 0 to 3, indicating the position of the particular parameter inside the message type 24 or 25. Although the parameters VCx_SSC and IODPx_SSC are contained in the broadcast of the SBAS Signal-In-Space only once (twice, respectively), the implementation chosen for the PEGASUS development needs to have these two parameters present for each of the slow correction data sets transmitted in one message type MT 24 or 25 (i.e. maximum four times). If the message type MT 24 or 25 contains only one, two (or three) slow correction data sets, the other parameters should contain zero values.

SBAS Data Characteristics									
Counter	Parameter	Parameter Name[2829]	Units	Minimum Value	Maximum Value	Minimum Resolution	Maximum Update Interval[30]	Remarks	PEGASUS Property[31]
376	PRN Mask Number Slow Corrections	PRNx_SSC	N/A	0	51	1	120 s	MT slow correction	3
377	Issue of Data Slow Corrections	IODSx_SSC	N/A	0	255	1	120 s	MT slow correction	3
378	Delta X Slow Corrections	DXx_SSC	m	-128	128	0.125	120 s	MT slow correction	3
379	Delta Y Slow Corrections	DYx_SSC	m	-128	128	0.125	120 s	MT slow correction	3
380	Delta Z Slow Corrections	DZx_SSC	m	-128	128	0.125	120 s	MT slow correction	3
381	Delta AF0 Slow Corrections	DAF0x_SSC	s	-2^{-21}	2^{-21}	2^{-31}	120 s	MT slow correction	3
382	Delta X Rate of Change Slow Corrections	DXROCx_SSC	ms^{-1}	-0.0625	0.0625	2^{-11}	120 s	MT slow correction	3
383	Delta X Rate of Change Slow Corrections	DYROCx_SSC	ms^{-1}	-0.0625	0.0625	2^{-11}	120 s	MT slow correction	3
384	Delta X Rate of Change Slow Corrections	DZROCx_SSC	ms^{-1}	-0.0625	0.0625	2^{-11}	120 s	MT slow correction	3
385	Delta AF1 Slow Corrections	DAF1x_SSC	ss^{-1}	-2^{-32}	2^{-32}	2^{-39}	120 s	MT slow correction	3
386	Time of Applicability Slow Corrections	TOAx_SSC	s	0	86384	16	120 s	MT slow correction	3
387	Issue of Data PRN of MT 25	IODPx_SSC	N/A	0	3	1	120 s	MT slow correction	3
388	GPS Week of MT 26	GWEEK_S26	weeks	0	> 1024	1	300 s	reception time MT 26	3
389	GPS Second of MT 26	GSEC_S26	s	0	604799.99	0.01	300 s	reception time MT 26	3

SBAS Data Characteristics									
Counter	Parameter	Parameter Name[28][29]	Units	Minimum Value	Maximum Value	Minimum Resolution	Maximum Update Interval[30]	Remarks	PEGASUS Property[31]
390	PRN of MT 26	PRN_S26	N/A	120	138	1	300 s	PRN of MT 26 transmission	3
391	Band Number Iono-spheric Delay	BN_S26	N/A	0	8	1	300 s	MT 26	3
392	Block Identifier - Ionospheric Delay	BI_S26	N/A	0	13	1	300 s	MT 26	3
393	IGP Vertical Delay Estimate	DELAYx_S26[41]	m	0	63.875	0.125	300 s	MT 26	3
394	Grid Ionospheric Vertical Error Indicator	GIVEIx_S26	N/A	0	15	1	300 s	MT 26	3
395	Issue of Data Ionosphere	IODI_S26	N/A	0	3	1	300 s	MT 26	3
396	GPS Week of MT 27	GWEEK_S27	weeks	0	> 1024	1	300 s	reception time MT 27	3
397	GPS Seconds of MT 27	GSEC_S27	s	0	604799.99	0.01	300 s	reception time MT 27	3
398	PRN of MT 27	PRN_S27	N/A	120	138	1	300 s	PRN of MT 27 transmission	3
399	Region Latitude	LATx_S27[42]	1°	-90	90	0.25	300 s	MT 27	3
400	Region Longitude	LONx_S27	1°	-180	180	0.25	300 s	MT 27	3
401	Region Radius Indicator	RADx_S27	N/A	0	7	1	300 s	MT 27	3
402	SBAS Service Indicator	SIDx_S27	N/A	0	15	1	300 s	MT 27	3
403	Number of Service Messages	NS_S27	N/A	1	15	1	300 s	MT 27	3
404	Issue of Data Service	IODS_S27	N/A	0	7	1	300 s	MT 27	3

Table 7: SBAS Data Characteristics

[41] The small letter x associated with the parameters DELAYx_26 and GIVEIx_26 is numbered through 1 to 15, indicating the position of the particular parameter inside the message type 26.
[42] The small letter x associated with the parameters LATx_27, LONx_27, RADx_27 and SIDx_27 is numbered through 1 to 7, indicating the number of the service region message

5 SBAS satellite position data

The SBAS satellite position data consists of two different types of orbital parameters: the almanac and the ephemeris. Almanac data in message type 17 is used for coarse satellite positioning, whereas ephemeris data in message type 9 is used for precise satellite positioning and ranging. The almanacs and ephemeris data shall be stored in two different files.

5.1 Almanac data

Almanac data for the SBAS shall be provided in a format specified in the relevant documentation ([1] and [7]). The following table provides a list of parameters, which are contained in the format. A parameter name by which the individual parameter is accessed is not provided since the almanac file is stored in a fixed file format. Furthermore, an example of the file format is provided. A minimum value and a maximum value are defined only in those cases, where a definite bound could be established. Since the PEGASUS prototype does not perform a plausibility check on these data, the specification of maximum and minimum values is optional.

SBAS Almanac							
Counter	Parameter	Units	Minimum Value	Maximum Value	Minimum Resolution	Note	PEGASUS Property[43]
400	GPS Week of MT 17	weeks	0	> 1024	1	time stamp for MT 17	3
401	GPS Seconds of MT 17	s	0	604799.99	0.01	time stamp for MT 17	3
402	Satellite PRN	N/A	120	138	1	satellite PRN number of SBAS satellite for MT 17	3
403	Service Provider ID	N/A	0	3	1	service provider of SBAS service for MT 17	3
404	Health and Status	N/A	0	N/A	1	health and status of the SBAS satellite for MT 17	3
405	Daytime of Applicability	s	0	86336	1	time-of-applicability in seconds since the beginning of the day in the SBAS network time frame for MT 17	3
406	Day of Week of Applicability	N/A	1	7	1	day number in week for MT 17	3

43 In the column PEGASUS functionality up to six numbers are shown, following the scheme defined in chapter 1.4. If the aim of the ESTB data collection is not the evaluation using the PEGASUS and SAPPHIRE tools, this column can be disregarded

SBAS Almanac							
Counter	Parameter	Units	Minimum Value	Maximum Value	Minimum Resolution	Note	PEGASUS Property[43]
407	Week Number of Applicability	week	0	> 1024	1	week number for MT 17	3
408	X Position of SBAS satellite	m	-42 595 800	42 595 800	2600	ECEF position co-ordinate of the SBAS satellite for MT 17	3
409	Y Position of SBAS satellite	m	-42 595 800	42 595 800	2600	ECEF position co-ordinate of the SBAS satellite for MT 17	3
410	Z Position of SBAS satellite	m	-6 630 000	6 630 000	26000	ECEF position co-ordinate of the SBAS satellite for MT 17	3
411	X Velocity of SBAS satellite	ms^{-1}	-40	40	10	ECEF velocity of the SBAS satellite for MT 17	3
412	Y Velocity of SBAS satellite	ms^{-1}	-40	40	10	ECEF velocity of the SBAS satellite for MT 17	3
413	Z Velocity of SBAS satellite	ms^{-1}	-480	480	10	ECEF velocity of the SBAS satellite for MT 17	3

Table 8: SBAS Almanac Format

Since the GPS/GLONASS/EGNOS receiver should deliver the new almanac data regularly in the framed raw data, the almanac file contains the almanac of all SBAS satellites for the relevant week.

It is recommended to name the file with xxx_GEOyyyy.ALM, where xxxx represents the common file name basis and yyyy (optional with leading zeros) stands for the week number. Thus, in the example the file generated is named TUBS_GEO1044.ALM.

Example of a SBAS almanac file

```
SBAS*** Week 1044 almanac for PRN-120 *******
Week of MT 17        : 1044
Seconds of MT 17     : 13000.00
PRN number           : 120
Data ID              : 1
Health and Status    : 0
Daytime of Appl. (s) : 13229
Day of week (days)   : 2
week number          :   1044
XGeo (m)             :   4.2234400000E+007
YGeo (m)             :  -1.1770210000E+007
ZGeo (m)             :  -1.3100000000E+002
XGeo rate (m/s)      :   2.2451430500E+000
YGeo rate (m/s)      :  -1.1771020000E+001
ZGeo rate (m/s)      :  -1.3020000000E-001

SBAS*** Week 1044 almanac for PRN-122 *******
Week of MT 17        : 1044
Seconds of MT 17     : 18000.00
PRN number           : 122
Data ID              : 0
Health and Status    : 1
Daytime of Appl. (s) : 18229.8125
Day of week (days)   : 2
week number          :  1044
XGeo (m)             :   3.1255460000E+007
YGeo (m)             :  -3.5456665000E+007
ZGeo (m)             :  -3.3430000000E+001
XGeo rate (m/s)      :   1.5745475400E+000
YGeo rate (m/s)      :   2.3454340000E+001
ZGeo rate (m/s)      :   1.1021100000E-001

SBAS*** Week 1044 almanac for PRN-123 *******
Week of MT 17        : 1044
Seconds of MT 17     : 13000.00
PRN number           : 123
Data ID              : 1
Health and Status    : 0
Daytime of Appl. (s) : 13229
```

5.2 Ephemeris data

With the Navigation Message (Type 9) the SBAS broadcasts data needed for precise positioning of the SBAS satellites. It should be noted that the data format is not identical to the format proposed by [18], although it is very similar to it. Several small changes had to be made in order to accommodate the functionality of the development. The following format is proposed.

The following table provides a list of parameters, which are contained in the proposed “RINEX2” format. A parameter name by which the individual parameter is accessed is not provided since the ephemeris file is stored in a fixed file format. Furthermore, an example of the file format is provided. A minimum value and a maximum value are defined only in those cases, where a definite bound could be established. Since the PEGASUS prototype does not perform a plausibility check on these data, the specification of maximum and minimum values is optional.

SBAS Ephemeris							
Counter	Parameter	Units	Minimum Value	Maximum Value	Minimum Resolution	Note	PEGASUS Property[44]
500	Satellite PRN Number	N/A	120	138	1	satellite PRN number for MT 9	3
501	Epoch of Ephemeris Data Year	year	1970	2069	1	time of applicability, year for MT 9	3
502	Epoch of Ephemeris Data Months	month	1	12	1	time of applicability, month for MT 9	3
503	Epoch of Ephemeris Data Days	day	1	31	1	time of applicability, day for MT 9	3
504	Epoch of Ephemeris Data Hours	hr	0	23	1	time of applicability, hour for MT 9	3
505	Epoch of Ephemeris Data Minutes	min	0	59	1	time of applicability, minute for MT 9	3
506	Epoch of Ephemeris Data Seconds	s	0	59	1	time of applicability, second for MT 9	3
507	Satellite Clock Bias AGF0	s	$-9.537*10^{-6}$	$9.537*10^{-6}$	2^{-32}	satellite clock correction polynomial constant term for MT 9	3

44 In the column PEGASUS functionality up to five numbers are shown, following the scheme defined in chapter 1.4. If the aim of the ESTB data collection is not the evaluation using the PEGASUS tools, this column can be disregarded

SBAS Ephemeris							
Counter	Parameter	Units	Minimum Value	Maximum Value	Minimum Resolution	Note	PEGASUS Property[44]
508	Satellite Clock Drift AGF1	ss^{-1}	$-1.1642*10^{-10}$	$1.1642*10^{-10}$	2^{-40}	satellite clock correction polynomial first order term for MT 9	3
509	Message Frame Time	s	0		1	time of message reception for MT 9	3
510	Satellite Position X	m	-42 949 673	-42 949 673	0.08	satellite position, ECEF co-ordinate for MT 9	3
511	Satellite Velocity X	ms^{-1}	-40.96	-40.96	0.000625	satellite velocity, ECEF co-ordinate for MT 9	3
512	Satellite Acceleration X	ms^{-2}	-0.0064	0.0064	0.0000125	satellite acceleration, ECEF co-ordinate for MT 9	3
513	Satellite Accuracy	N/A	N/A	N/A	N/A	accuracy indicator for MT 9	3
514	Satellite Position Y	m	-42 949 673	-42 949 673	0.08	satellite position, ECEF co-ordinate for MT 9	3
515	Satellite Velocity Y	ms^{-1}	-40.96	-40.96	0.000625	satellite velocity, ECEF co-ordinate for MT 9	3
516	Satellite Acceleration Y	ms^{-2}	-0.0064	0.0064	0.0000125	satellite acceleration, ECEF co-ordinate for MT 9	3
517	Time of Applicability T0	s	0	86384	1	time of applicability for MT 9	3
518	Satellite Position Z	m	-6 710 886.4	6 710 886.4	0.4	satellite position, ECEF co- ordinate for MT 9	3
519	Satellite Velocity Z	ms^{-1}	-524.288	524.288	0.004	satellite position, ECEF co- ordinate for MT 9	3
520	Satellite Acceleration Z	ms^{-2}	-0.032	0.032	0.0000625	satellite position, ECEF co- ordinate for MT 9	3
521	Issue of Data Ephemeris	N/A	0	255	1	issue of data ephemeris for MT 9	3

Table 9: SBAS Ephemeris Format

The ephemeris file is stored in a fixed file format. The SBAS ephemeris file format is subdivided into a header and a body of values. It is essential that the layout of the file is observed, since the processing of the ephemeris information is performed line-driven. A structure for the header of a SBAS ephemeris file is given in the following template.

After the header, the SBAS ephemeris file contains the body in which the values of the ephemeris information is provided. only the ephemeris data of the received satellites are stored. Even though a chronological order of the ephemeris information is kept, the PEGASUS SBAS ephemeris file need not cover the whole day. A sorting of ephemeris information by the PRN number is not done. A structure for the body of a SBAS ephemeris file is given in the following template.

A structure file for the SBAS ephemeris file containing the header and the body is provided as well.

It is recommended to name the file with xxxx_BRDCttt0.zzE, where xxxx represents the common file name basis, ttt is the Julian day of the year of the recording, zz describes the year of recording and E stands for “SBAS Navigation Data”. Alternatively, the file can be named xxxx_ttt.zzE with xxxx, ttt and zz as defined above.

To provide an example, the file TUBS_BRDC0350.00E contains SBAS ephemeris files and was recorded by the Technical University of Braunschweig on the 35th day of 2000. The alternate file name is TUBS_035.00E.

Template of the Header of the SBAS ephemeris file

SBAS NAVIGATION MESSAGE FILE - HEADER SECTION DESCRIPTION		
HEADER LABEL (Columns 61-80)	DESCRIPTION	FORMAT
RINEX VERSION / TYPE	- Format version (2.01) - File type ('S' = SBAS nav mess data)	F9.2,11X, A1,39X
PGM / RUN BY / DATE	- Name of program creating current file - Name of agency creating current file - Date of file creation (dd-mmm-yy hh:mm)	A20, A20, A20
COMMENT	Comment line(s)	A60
END OF HEADER	Last record in the header section.	60X

Template of the Body of the SBAS ephemeris file

SBAS NAVIGATION MESSAGE FILE - DATA RECORD DESCRIPTION		
OBS. RECORD	DESCRIPTION	FORMAT
PRN / EPOCH / SV CLK	- Satellite number,	I3,
	- Epoch of ephemeris (UTC)	
	- year (2 digits)	5I3,
	- month	
	- day	
	- hour	
	- minute	
	- second	F5.1,
	- SV clock bias (sec) (aGf0)	D19.12,
	- SV clock drift (sec/sec) (aGf1)	D19.12,
	- message frame time (sec of day UTC)	D18.11
BROADCAST ORBIT - 1	- Satellite position X (m)	3X,4D19.12
	- velocity X dot (m/sec)	
	- X acceleration (m/sec2)	
	- Accuracy (acc.URA) (meters)	
BROADCAST ORBIT - 2	- Satellite position Y (m)	3X,4D19.12
	- velocity Y dot (m/sec)	
	- Y acceleration (m/sec2)	
	- Time of day applicability t0 (sec)	
BROADCAST ORBIT - 3	- Satellite position Z (m)	3X,3D19.12,
	- velocity Z dot (m/sec)	16X,3I
	- Z acceleration (m/sec2)	
	- Issue of Data (-)	

Example of a SBAS ephemeris file

```
+-----------------------------------------------------------------------------+
|                                TABLE A12                                    |
|                SBAS    NAVIGATION MESSAGE FILE - EXAMPLE                    |
+-----------------------------------------------------------------------------+

----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|

     2.01           SBAS    NAV DATA                         RINEX VERSION / TYPE
CONVERTG V1.1.0 VM  AIUB                20-JAN-00 10:42     PGM / RUN BY / DATE
STATION IFF                                                 COMMENT
                                                            END OF HEADER
120 98  2 15  0 15  0.0 0.163525342941D-03 0.363797880709D-11 0.108000000000D+05
    0.422344000000D+08-0.177120000000D+01-0.6545600000000-09 0.480000000000D+02
   -0.117702000000D+08 0.288163375854D+01 0.931322574615D-09 0.213000000000D+03
   -0.130000000000D+05 0.454599342346D+00-0.186264514923D-08                132
121 98  2 15  0 15  0.0 0.163525342941D-03 0.363797880709D-11 0.108000000000D+05
    0.242344000000D+08 0.234440000000D+01-0.1121200000000-09 0.480000000000D+02
   -0.456365500000D+08 0.112312100000D+01 0.234233000000D-09 0.210000000000D+03
    0.112433000000D+05-0.454599342346D+01-0.421220000000D-08                  3


----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
```

6 GLONASS satellite position data

As with GPS, the GLONASS almanacs and ephemeris data shall be stored in two different files. Again the format of the almanacs should be kept close to the YUMA format while there already exists an standard for the ephemeris (for detailed information, refer to the relevant documentation [18]). The description of the GLONASS signal can be found with the GLONASS interface control document ([5]).

6.1 Almanac data

The almanac for GLONASS satellites shall be formed as the GPS almanac in YUMA Format but with GLONASS specific parameters. The broadcast data contains Keplerian elements. However, there are some differences in the message content. Thus, an own format is defined here to contain the specific data which are broadcast from the GLONASS satellites.

The following table provides a list of parameters, which are contained in the GLONASS almanac format. A parameter name by which the individual parameter is accessed is not provided since the almanac file is stored in a fixed file format. Furthermore, an example of the file format is provided. A minimum value and a maximum value are defined only in those cases, where a definite bound could be established. Since the PEGASUS prototype does not perform a plausibility check on these data, the specification of maximum and minimum values is optional.

GLONASS Almanac							
Counter	Parameter	Units	Minimum Value[45]	Maximum Value	Minimum Resolution	Note	PEGASUS Property[46]
600	Slot Number	N/A				identification parameter comparable to the GPS PRN number	3
601	Frequency Number	N/A				additional identification parameter for antipodal GLONASS satellites on the same frequency	3
602	Health	N/A				health status of the satellite	3

45 A minimum value, a maximum value and the minimum resolution is not specified for all the data contained in the table. A plausibility check on the GLONASS almanac data is not in the purview of the PEGASUS project.

46 In the column PEGASUS property up to six numbers are shown, following the scheme defined in chapter 1.4. If the aim of the ESTB data collection is not the evaluation using the PEGASUS tools, this column can be disregarded

GLONASS Almanac							
Counter	Parameter	Units	Minimum Value[45]	Maximum Value	Minimum Resolution	Note	PEGASUS Property[46]
603	GLONASS Days N	days				days in the four year GLONASS period, which starts at the beginning of each leap year	3
604	Eccentricity	N/A				eccentricity of the satellite orbit	3
605	Omega	rad				argument of the perigee	3
606	Delta Inclination	rad				difference of inclination to the nominal value of 63°	3
607	Lambda	rad				longitude of first pass of the ascending node within the day N in the PZ90 co-ordinate system	3
608	Time of Lambda Pass	s	0	86399	1	time of first passage of the ascending node expressed in seconds of the day, comparable to the time-of-applicability of the GPS almanac	3
609	Delta T Dracon	$s(rev)^{-1}$				correction to the mean value of the draconian period[47] of the satellite at the time of lambda pass	3
610	Delta T Drift	$s(rev)^{-2}$				time derivative of Delta T Dracon	3
611	Tau nA Satellite	s				constant correction for the satellite clock in order to synchronise the satellite clock with the GLONASS system time at the time of lambda pass	3
612	Tau C System	s				constant correction for the GLONASS system time in order to synchronise the GLONASS system time to the UTC(SU) at the time of lambda pass	3

Table 10: GLONASS Almanac Format

Since the GPS/GLONASS/EGNOS receiver should deliver the new almanac data at least upon start and then regularly, the almanac file contains the almanac of all GLONASS satellites for the relevant GPS week.

It is recommended to name the file with xxxx_GLOyyyy.ALM with xxxx as the common file name basis and yyyy as the week number (with optional zeros). Thus, in the example the file generated is named TUBS_GLO0001.ALM

47 The draconian period for GLONASS is defined to last 43200 seconds.

Example of a GLONASS almanac file

```
GLO**** Week 1044 almanac for Slot-22 ********
Number of Slot nA       :   22
Frequency Number        :   10
Health                  :    1
GLONASS Days NA         :   3270
Eccentricity            :   1.4944565425E+000
omega (rad)             :   1.0456842245E-001
Delta Inclination(rad)  :   1.0013365554E-002
Lamda (rad)             :   0.5098999856E+001
Time of Lambda pass (s) :   114259.234634
Delta T dracon (s/rev)  :   3.0090903000E+003
Delta T Drift (s/rev2)  :  -2.4565456000E-004
Tau nA - satellite (s)  :   3.2331322000E-008
Tau C – system (s)      :   2.1255087000E-004

GLO**** Week 1044 almanac for Slot-22 ********
Number of Slot nA       :   22
Frequency Number        :   10
Health                  :    1
GLONASS Days NA         :   3270
Eccentricity            :   1.4944565425E+000
omega (rad)             :   1.0456842245E-001
Delta Inclination(rad)  :   1.0013365554E-002
Lamda (rad)             :   0.5098999856E+001
Time of Lambda pass (s) :   114259.234634
Delta T dracon (s/rev)  :   3.0090903000E+003
Delta T Drift (s/rev2)  :  -2.4565456000E-004
Tau nA - satellite (s)  :   3.2331322000E-008
Tau C – system (s)      :   2.1255087000E-004

.....
```

6.2 Ephemeris data

Ephemeris data shall be provided in the RINEX2 format (for detailed information, refer to [18]). The following table provides a list of parameters, which are contained in the RINEX2 format. A parameter name by which the individual parameter is accessed is not provided since the ephemeris file is stored in a fixed file format. Furthermore, an example of the file format is provided. A minimum value and a maximum value are defined only in those cases, where a definite bound could be established. Since the PEGASUS prototype does not perform a plausibility check on these data, the specification of maximum and minimum values is optional.

GLONASS RINEX2 Ephemeris							
Counter	Parameter	Units	Minimum Value[48]	Maximum Value	Minimum Resolution	Note	PEGASUS Property[49]
700	Time of Reference for System Time Correction Year	year				time of reference for system time correction, year	2, 3
701	Time of Reference for System Time Correction Month	month				time of reference for system time correction, month	2, 3
702	Time of Reference for System Time Correction Day	day				time of reference for system time correction, day	2, 3
703	Correction to System Time Scale	s				correction to system time scale	2, 3
704	Number of Leap Seconds	N/A				number of leap seconds	2, 3
705	Satellite Almanac Number	N/A				satellite almanac number	2, 3
706	Epoch of Ephemeris Year	year				epoch of ephemeris, year	2, 3
707	Epoch of Ephemeris Month	month				epoch of ephemeris, month	2, 3
708	Epoch of Ephemeris Day	day				epoch of ephemeris, day	2, 3
709	Epoch of Ephemeris Hour	hr				epoch of ephemeris, hour	2, 3
710	Epoch of Ephemeris Minute	min				epoch of ephemeris, minute	2, 3
711	Epoch of Ephemeris Seconds	s				epoch of ephemeris, second	2, 3
712	Satellite Clock Bias	s				satellite clock correction polynomial constant term	2, 3
713	Satellite Clock Drift	s/s				satellite clock correction polynomial first order term	2, 3

48 A minimum value, a maximum value and the minimum resolution is not specified for all the data contained in the table. A plausibility check on the GLONASS almanac data is not in the purview of the PEGASUS project.

49 In the column PEGASUS functionality up to five numbers are shown, following the scheme defined in chapter 1.4. If the aim of the ESTB data collection is not the evaluation using the PEGASUS and SAPPHIRE tools, this column can be disregarded

GLONASS RINEX2 Ephemeris							
Counter	Parameter	Units	Minimum Value[48]	Maximum Value	Minimum Resolution	Note	PEGASUS Property[49]
714	Message Frame Time	s				time of signal reception	2, 3
715	Satellite Position X	m				satellite position, ECEF co-ordinate	2, 3
716	Satellite Velocity X	m/s				satellite velocity, ECEF co-ordinate	2, 3
717	Satellite Acceleration X	m/s^2				satellite acceleration, ECEF co-ordinate	2, 3
718	Satellite Health	N/A				health of satellite	2, 3
719	Satellite Position Y	m				satellite position, ECEF co-ordinate	2, 3
720	Satellite Velocity Y	m/s				satellite velocity, ECEF co-ordinate	2, 3
721	Satellite Acceleration Y	m/s^2				satellite acceleration, ECEF co-ordinate	2, 3
722	Satellite Frequency Number	N/A				GLONASS frequency slot	2, 3
723	Satellite Position Z	m				satellite position, ECEF co-ordinate	2, 3
724	Satellite Velocity Z	m/s				satellite velocity, ECEF co-ordinate	2, 3
725	Satellite Acceleration Z	m/s^2				satellite acceleration, ECEF co-ordinate	2, 3
726	Age of Operations	day				age of operation	2, 3

Table 11: GLONASS RINEX2 Ephemeris Format

The ephemeris file is stored in a fixed file format. The RINEX2 ephemeris file format is subdivided into a header and a body of values. It is essential that the layout of the file is observed, since the processing of the ephemeris information is performed line-driven. A structure for the header of a RINEX2 ephemeris file is given in the following template.

After the header, the RINEX2 ephemeris file contains the body in which the values of the ephemeris information is provided. In contrast to the original RINEX2 format, only the ephemeris data of the received satellites are stored. Even though a chronological order of the ephemeris information is kept, the PEGASUS RINEX2 file need not cover the whole day. A sorting of ephemeris information by the PRN number is not done. A structure for the body of a RINEX2 ephemeris file is given in the following template.

An structure file for the RINEX2 ephemeris file containing the header and the body is provided as well.

It is recommended to name the file with xxxx_BRDCttt0.zzG, where xxxx represents the common file name basis, ttt is the Julian day of the year of the recording, zz describes the year of recording and G stands for “GLONASS Navigation Data”. Alternatively, the file can be named xxxx_ttt.zzG with xxxx, ttt and zz as defined above.

To provide an example, the file TUBS_BRDC0350.00G contains GLONASS ephemeris files and was recorded by the Technical University of Braunschweig on the 35th day of 2000. The alternative file name is TUBS_035.00G.

Template of the Header of the RINEX2 ephemeris file

GLONASS NAVIGATION MESSAGE FILE - HEADER SECTION DESCRIPTION		
HEADER LABEL (Columns 61-80)	DESCRIPTION	FORMAT
RINEX VERSION / TYPE	- Format version (2.01) - File type ('G' = GLONASS nav mess data)	F9.2,11X, A1,39X
PGM / RUN BY / DATE	- Name of program creating current file - Name of agency creating current file - Date of file creation (dd-mmm-yy hh:mm)	A20, A20, A20
COMMENT	Comment line(s)	A60
CORR TO SYSTEM TIME	- Time of reference for system time corr (year, month, day) - Correction to system time scale (sec) to correct GLONASS system time to UTC(SU) (-TauC)	 3I6, 3X,D19.12
LEAP SECONDS	Number of leap seconds since 6-Jan-1980	I6
END OF HEADER	Last record in the header section.	60X

Template of the Body of the RINEX2 ephemeris file

GLONASS NAVIGATION MESSAGE FILE - DATA RECORD DESCRIPTION		
OBS. RECORD	DESCRIPTION	FORMAT
PRN / EPOCH / SV CLK	- Satellite almanac number	I2,
	- Epoch of ephemeris (UTC)	
	- year (2 digits)	5I3,
	- month	
	- day	
	- hour	
	- minute	
	- second	F5.1,
	- SV clock bias (sec) (-TauN)	D19.12,
	- SV relative frequency bias (+GammaN)	D19.12,
	- message frame time (sec of day UTC)	D19.12
BROADCAST ORBIT - 1	- Satellite position X (km)	3X,4D19.12
	- velocity X dot (km/sec)	
	- X acceleration (km/sec2)	
	- health (0=OK) (Bn)	
BROADCAST ORBIT - 2	- Satellite position Y (km)	3X,4D19.12
	- velocity Y dot (km/sec)	
	- Y acceleration (km/sec2)	
	- frequency number (1-24)	
BROADCAST ORBIT - 3	- Satellite position Z (km)	3X,4D19.12
	- velocity Z dot (km/sec)	
	- Z acceleration (km/sec2)	
	- Age of oper. information (days) (E)	

Example of a RINEX2 ephemeris file

```
+-----------------------------------------------------------------------------+
|                  GLONASS NAVIGATION MESSAGE FILE - EXAMPLE                  |
+-----------------------------------------------------------------------------+

----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|

     2.01           GLONASS NAV DATA                         RINEX VERSION / TYPE
ASRINEXG V1.1.0 VM  AIUB                19-FEB-98 10:42     PGM / RUN BY / DATE
STATION ZIMMERWALD                                          COMMENT
  1998     2    16    0.379979610443D-06                    CORR TO SYSTEM TIME
                                                            END OF HEADER
 3 98  2 15  0 15  0.0 0.163525342941D-03 0.363797880709D-11 0.108000000000D+05
    0.106275903320D+05-0.348924636841D+00 0.931322574615D-09 0.000000000000D+00
   -0.944422070313D+04 0.288163375854D+01 0.931322574615D-09 0.210000000000D+02
    0.212257280273D+05 0.144599342346D+01-0.186264514923D-08 0.300000000000D+01
 4 98  2 15  0 15  0.0 0.179599039257D-03 0.636646291241D-11 0.122400000000D+05
    0.562136621094D+04-0.289074897766D+00-0.931322574615D-09 0.000000000000D+00
   -0.236819248047D+05 0.102263259888D+01 0.931322574615D-09 0.120000000000D+02
    0.762532910156D+04 0.339257907867D+01 0.000000000000D+00 0.300000000000D+01
11 98  2 15  0 15  0.0-0.559808686376D-04-0.272848410532D-11 0.108600000000D+05
   -0.350348437500D+04-0.255325126648D+01 0.931322574615D-09 0.000000000000D+00
    0.106803754883D+05-0.182923507690D+01 0.000000000000D+00 0.400000000000D+01
    0.228762856445D+05 0.447064399719D+00-0.186264514923D-08 0.300000000000D+01
12 98  2 15  0 15  0.0 0.199414789677D-04-0.181898940355D-11 0.108900000000D+05
    0.131731816406D+05-0.143945598602D+01 0.372529029846D-08 0.000000000000D+00
    0.171148715820D+05-0.118937969208D+01 0.931322574615D-09 0.220000000000D+02
    0.135737919922D+05 0.288976097107D+01-0.931322574615D-09 0.300000000000D+01

...
```

7 Aircraft parameters

The following table provides a list of additional aircraft data and their format. If these parameters can not be provided at the time of data collection, the values of these parameters should be set to the minimum value specified in this table (optionally they can be set to zero). An example of how the data is organised in different files is provided in the Appendix I.

Counter	Parameter	Parameter Name	Units	Minimum Value	Maximum Value	Minimum Resolution	Update Rate[50]	Note	PEGASUS Property[51]
800	Aircraft UTC Year[52]	ACUTC_year	year	1970	2069	1	1 Hz	time information	1, 2, 4, 5
801	Aircraft UTC Month	ACUTC_month	month	1	12	1	1 Hz	time information	1, 2, 4, 5
802	Aircraft UTC Day	ACUTC_day	day	1	31	1	1 Hz	time information	1, 2, 4, 5
803	Aircraft UTC Hour	ACUTC_hrs	hr	0	23	1	1 Hz	time information	1, 2, 4, 5
804	Aircraft UTC Minute	ACUTC_mins	min	0	59	1	1 Hz	time information	1, 2, 4, 5
805	Aircraft UTC Second	ACUTC_secs	s	0	59	1	1 Hz	time information	1, 2, 4, 5
806	Present Position Latitude	LATP	1°	-90	90	$1.7166*10^{-4}$	1 Hz	inertial position	1, 5
807	Present Position Longitude	LONP	1°	-180	180	$1.7166*10^{-4}$	1 Hz	inertial position	1, 5
808	Ground Speed	GS	kn	-4096	4096	0.125-	16 Hz	inertial ground speed	1, 2, 4, 5, 6
809	Track Angle True	TRK	1°	-180	180	0.00549316	16 Hz	aircraft heading	1, 2, 5, 6
810	True Heading	THDG	1°	-180	180	0.00549316	1 Hz	true heading	1, 2, 6
811	Wind Speed	WS	kn	-256	180	0.0078125	1 Hz	wind speed	1, 6
812	Wind Direct True	WD	1°	-180	180	0.00549316	1 Hz	wind direction	1, 6

50 The specified update rate relates to issues of the SAPPHIRE database Update and Access Unit. For PEGASUS related issues, this column is only intended as information and any other consistent update rate of a receiver will be sufficient for data evaluation purposes.
51 In the column PEGASUS property up to six numbers are shown, following the scheme defined in chapter 1.4. If the aim of the ESTB data collection is not the evaluation using the PEGASUS and SAPPHIRE tools, this column can be disregarded
52 Analogous to the GPS UTC specified in the table 1, the aircraft UTC does contain information about leap seconds introduced by the GPS system provider. Thus, the aircraft UTC and the GPS UTC are usually identical. However, this datum is used in the existing SAPPHIRE DUAU for synchronisation purposes. In order to keep a backwards compatibility, this datum must be required in the data collection.

Counter	Parameter	Parameter Name	Units	Minimum Value	Maximum Value	Minimum Resolution	Update Rate[50]	Note	PEGASUS Property[51]
813	Pitch Angle	PTCH	1°	-180	180	0.00549316	1 Hz	aircraft attitude	1, 2
814	Roll Angle	ROLL	1°	-180	180	0.00549316	1 Hz	aircraft attitude	1, 2
815	Body Pitch Rate	PTCR	$1°s^{-1}$	-128	128	0.00390625	16 Hz	aircraft attitude rate of change	1
816	Body Roll Rate	ROLR	$1°s^{-1}$	-128	128	0.00390625	16 Hz	aircraft attitude rate of change	1
817	Body Yaw Rate	YAW	$1°s^{-1}$	-128	128	0.00390625	16 Hz	aircraft attitude rate of change	1
818	Body Longitudinal Acceleration	LONG	g	-4	4	0.00012207	16 Hz	aircraft acceleration – aircraft fixed coo-ordinates	1
819	Body Lateral Acceleration	LATG	g	-4	4	0.00012207	16 Hz	aircraft acceleration – aircraft fixed coo-ordinates	1
820	Body Normal Acceleration	VRTG	g	-4	4	0.00012207	16 Hz	aircraft acceleration – aircraft fixed coo-ordinates	1
821	Inertial Altitude	IALT	ft	-131072	131072	0.125	1 Hz	inertial altitude using barometric measurements	1, 5
822	Inertial Vertical Speed	IVV	$ft\ min^{-1}$	-32768	32768	1	16 Hz	inertial vertical speed using barometric measurements	1, 5
823	Altitude	ALT	ft	0	131071	1	1 Hz	barometric altitude referenced to 1013.25 mb	1, 4
824	Mach	MN	M	0	4.096	0.0000625	1 Hz	Mach number	1, 6
825	Computed Airspeed	CAS	kn	0	1023.75	0.0625	1 Hz	computed airspeed	1, 6
826	True Airspeed	TAS	kn	0	2048	0.0625	1 Hz	true airspeed	1, 6

Counter	Parameter	Parameter Name	Units	Minimum Value	Maximum Value	Minimum Resolution	Update Rate[50]	Note	PEGASUS Property[51]
827	Total Air Temperature	TAT	°C	-273.15	511.75	0.125	1 Hz	total air temperature	1, 6
828	Static Air Temperature	SAT	°C	-273.15	511.97	0.125	1 Hz	static air temperature	1, 6
829	Corrected Angle of Attack	AOA	1°	-180	180	0.0439453	1 Hz	angle of attack	1
830	Total Pressure	PT	mb	0	2047.97	.0078125	1 Hz	total pressure	1, 6
831	Corrected Average Static Pressure	PSTAT	mb	0	2047.97	.0078125	1 Hz	static pressure	1, 6
832	Hybrid Integrity Limit	HYIL	nm	0	16	$6.104*10^{-5}$	1 Hz	position solution of hybrid GPS/INS navigation system	1, 6
833	Hybrid Position Latitude	HYLA	1°	-90	90	$1.7166*10^{-4}$	1 Hz	position solution of hybrid GPS/INS navigation system	1, 6
834	Hybrid Position Longitude	HYLO	1°	-180	180	$1.7166*10^{-4}$	1 Hz	position solution of hybrid GPS/INS navigation system	1, 6
835	Hybrid Position Latitude Fraction	HYAF	1°	-0.000172	0.000172	$8.381903*10^{-8}$	1 Hz	position solution of hybrid GPS/INS navigation system	1, 6
836	Hybrid Position Longitude Fraction	HYOF	1°	-.000172	0.000172	$8.381903*10^{-8}$	1 Hz	position solution of hybrid GPS/INS navigation system	1, 6
837	Hybrid Altitude	HYAL	ft	-131072	131072	0.125	1 Hz	position solution of hybrid GPS/INS navigation system	1, 6
838	Azimuth[53]	AZIM	1°	-80	+179.8	1/0.0175781	1 Hz	azimuth	1, 2
839	Elevation[54]	ELEV	1°	-90	89.9	1/0.01757813	1 Hz	elevation	1, 2

[53] The parameter Azimuth provides the azimuth of a tracked geostationary satellite. This datum has been used in SAPPHIRE. For PEGASUS related matters, this datum can be neglected.
[54] The parameter Elevation provides the elevation of a tracked geostationary satellite. This datum has been used in SAPPHIRE. For PEGASUS related matters, this datum can be neglected.

Counter	Parameter	Parameter Name	Units	Minimum Value	Maximum Value	Minimum Resolution	Update Rate[50]	Note	PEGASUS Property[51]
840	Signal Quality	SQUAL	(S+N) $N^{-1}*10^4$	0	600	-	1 Hz	signal quality	1
841	ILS/DME Distance	ILSD	nm	0	512	0.0078125	1 Hz	DME distance	1
842	Radio Height	RALT	ft	0	8192	0.125	8 Hz	radio altimeter height	1
843	PFD Loc Deviation	LOCD	DDM	-0.4	0.4	0.00009766	8 Hz	localiser deviation	1
844	PFD G/S Deviation	GLS	DDM	-0.8	0.8	0.00019531	8 Hz	glideslope deviation	1

Table 12: Additional Aircraft Data Characteristics

8 MEDLL Parameters

The Multipath Estimation Delay Locked Loop (MEDLL) provides a way of estimating GNSS multipath error estimation, as multiple signal correlators provide the user with information about the deformation of the received signal. This information allows to reconstruct the strength of secondary received signals and estimate the range error incurred in a typical receiver. Only one implementation of this receiver is currently known; this section is therefore adapted to this specific receiver, described in more detail in Appendix F.

In order to analyse multipath, the following data fields are required. The interested reader should be aware that additional data are utilised by third-party tools, as specified in Appendix F.

- multipath data: specific to the receiver utilised
- satellite data: azimuth, elevation, satellite status / reject code and signal strength (CNO).

The following tables provide all the parameters that are needed for the multipath investigation except for the signal strength data, which is are already described in Section 2. The PEGASUS Converter shall decode these logs, and output the necessary data in a pre-determined file structure, discussed in Section I.18.

8.1 Multipath parameters

Multipath Data									
Counter	Parameter	Parameter Name	Units	Minimum Value	Maximum Value	Minimum Resolution	Maximum Update Interval	Remarks	PEGASUS Property
1000	Week Number	medll_WeekNo	n/a	0	>1024	1	1		3
1001	Seconds of Week	medll_Seconds	S	0	604800	0.01	1		3
1002	Satellite Number	SVNx	n/a	1	138	1	1	See Note 1	3
1003	Channel Status	medll_ChStatus	n/a	1	2^{32}	1	1	See Note 2	3
1004	MEDLL Status	medll_Status	n/a	1	2^{32}	1	1	See Note 3	3
1005	Delay	medll_MPDelay	C/A chips	0	3	0.001	1	See Note 4	3

Multipath Data									
Counter	Parameter	Parameter Name	Units	Minimum Value	Maximum Value	Minimum Resolution	Maximum Update Interval	Remarks	PEGASUS Property
1006	Amplitude	medll_MPAmp	n/a	0	2	0.001	1	See Note 5	3
1007	Phase	medll_MPPhase	rad	-π	+π	0.001	1	Float	3
1008	in-phase residual	medll_IresX[55]	n/a	-[float]	+[float]	[float]	1	Float	3
1009	out-of-phase residual	medll_QresX	n/a	-[float]	+[float]	[float]	1	Float	3

Table 13: Multipath Data format

The following notes apply to the contents of Table 13:

1. At this moment, MEDLL tracks only GPS satellites. However, in order to allow for future implementations of its hardware, the following convention for PRN number applies:

PRN no	SV type
1 – 37	GPS
38 – 61	GLONASS
120 – 138	SBAS

Table 14: PRN Number convention

2. The specifications for MEDLL Channel Tracking status are given in [22], Table 4 (Page 53).
3. The MEDLL Status field consists of a series of bits giving information specific to MEDLL receiver, as explained in [23] (page 32). At this moment, only the first bit of this field ('Sync Bit') is important to the user. As it can be seen from the table below, even values in this field mean bad sync, i.e., do not use the multipath estimates. Odd values mean good sync, i.e., use the multipath estimates.

[55] The X associated with the parameters medll_IresX and medll_QresX denotes the residual number, from 0 to 11, as output by the MEDLL receiver in the MPMB log

Sync Bit	Status	Interpretation
0	MEDLL Channel not in sync	MP measurements from this channel are **not** valid
1	MEDLL Channel in sync	MP measurements from this channel are valid

Table 15: MEDLL Sync Bit in MEDLL Status field

4. According the manufacturer, the multipath delay estimate output by MEDLL is only valid between 0.1 and 1.2 chips.
5. The MP amplitude output by MEDLL is calculated considering normalised direct signal amplitude (i.e. value of 1). Therefore, the multipath D/U (Desired to Undesired signal power ratio, in dB) can be obtained from the MP amplitude using the following expression:

$$D/U = -20\log_{10}(MPamplitude)$$

8.2 Satellite Specific Data

Satellite Specific Data									
Counter	Parameter	Parameter Name[56]	Units	Minimum Value	Maximum Value	Minimum Resolution	Maximum Update Interval	Remarks	PEGASUS Property
1010	GPS Week	GWEEK	weeks	0	>1024	1	1		3
1011	GPS Time of the Week	GSEC	s	0	604800	0.01	1		3
1012	Solution Status	SolStat	n/a	0	2^{32}	1	1	See Note 1	3
1013	Number of Observations	nObs	n/a	0	26	1	1		3
1014	Satellite PRN number	SVNx	n/a	1	138	1	1	See Note 2	3
1015	Azimuth	SV_AZx	rad	0	2π	0.001	1	See Note 3	3
1016	Elevation	SV_Elx	rad	$-\pi/2$	$\pi/2$	0.001	1	See Note 4	3
1017	Range Reject code	SV_RjCx	n/a	0	12	1	1	See Note 5	3

56 In the naming convention for the datum ABCx the small x is to be understood as a placeholder for a decimal starting with 0. Thus, it is indicated that there are several of these data items (either because these are channel related data or different issues of the same data)

Satellite Specific Data									
Counter	Parameter	Parameter Name[56]	Units	Minimum Value	Maximum Value	Minimum Resolution	Maximum Update Interval	Remarks	PEGASUS Property
1018	SV Health	SV_HLTHx	n/a	0	16	1	1	See Note 1	3

Table 16: Satellite-specific data

The following notes apply to Table 16:

1. The Solution Status field indicates whether the position solution has been computed or not. Any value bigger than zero indicates that the solution position is not correct (and, therefore, that the output Azimuth and Elevation values are not correct either).
2. The following convention for Satellite Number applies:

SVNx	SV type
1 – 37	GPS
38 – 61	GLONASS
120 – 138	SBAS

Table 17: PRN Number convention

3. The correct Azimuth interval goes from 0 to π radians, and Converter shall treat negative azimuths in the following way:

$$truAz = 2\pi - Az$$

4. Negative Elevation values must be allowed (e.g., antennas mounted in aircraft, or on high poles).
5. The Range Reject Code indicates whether a satellite's pseudorange is used in the receiver position solution. The following table specifies the encoding:

Reject Code	Meaning
0	Observations are good
1	Satellite's Ephemeris indicate bad health (see following note)
>1	TBD

Table 18: Reject Code Values

1. The satellite health is given by the ephemeris. Pending a more general definition in a future issue, the encoding used at the current time is receiver-specific and its encoding can be found in [3] – Table 2-9 and 2-10.

Sat. Health	Meaning
-1	Information not available from receiver
0	Satellite healthy (all signals ok)
>0	Error code according to [3]

Table 19: Satellite Health Code Values

Appendix A NovAtel Millenium GPS/SBAS Receiver

The receiver configuration , the setup recommended for processing the logged data with the PEGASUS tool and the decoding of the logged data is now described in the Receiver Configuration Document PEG-REC-01 (issue 0B) which is included as a draft version in this delivery.

Appendix B NovAtel GPS/GLONASS/SBAS receiver

The receiver configuration , the setup recommended for processing the logged data with the PEGASUS tool and the decoding of the logged data is now described in the Receiver Configuration Document PEG-REC-01 (issue 0B) which is included as a draft version in this delivery.

Appendix C Aquarius Receiver

The receiver configuration , the setup recommended for processing the logged data with the PEGASUS tool and the decoding of the logged data is now described in the Receiver Configuration Document PEG-REC-01 (issue 0B) which is included as a draft version in this delivery.

Appendix D Septentrio PolaRx-1 Receiver

The receiver configuration , the setup recommended for processing the logged data with the PEGASUS tool and the decoding of the logged data is now described in the Receiver Configuration Document PEG-REC-01 (issue 0B) which is included as a draft version in this delivery.

Appendix E NovAtel OEM4 Receiver

The receiver configuration , the setup recommended for processing the logged data with the PEGASUS tool and the decoding of the logged data is now described in the Receiver Configuration Document PEG-REC-01 (issue 0B) which is included as a draft version in this delivery.

Appendix F NovAtel MEDLL Receiver

The receiver configuration , the setup recommended for processing the logged data with the PEGASUS tool and the decoding of the logged data is now described in the Receiver Configuration Document PEG-REC-01 (issue 0B) which is included as a draft version in this delivery.

Appendix G Septentrio PolaRx-2 Receiver

The receiver configuration , the setup recommended for processing the logged data with the PEGASUS tool and the decoding of the logged data is now described in the Receiver Configuration Document PEG-REC-01 (issue 0B) which is included as a draft version in this delivery.

Appendix H Description of the SBAS Message Types

This appendix provides an overview of the different message types of the SBAS and their purpose. A detailed description of the different parameters and the algorithmic use of these values can be found in the relevant documentation ([1] and [7]).

Message Type	Purpose	Content	Max. Update Interval	Default Update Interval	Max. Time-Out Interval	Required Optional
Wide Area Correction Information						
0	Don't use Test Mode – SV must be disregarded	content and format not known	6 s		N/A	required
1	Corrections Co-ordination of PRN and corresponding corrections	PRN mask assignments indication which slot in the corrections corresponds to which SV PRN Issue of Data PRN	120 s		NPA 600 s PA 600 s	required
2-5	Corrections Fast term range corrections	Issue of Data Fast Corrections Issue of Data PRN Fast Corrections User Differential Range Error Indicator	60 s and 6 s [57]		depending on flight phase selection and fast correction degradation factors (MT 7)	required
6	Corrections Protection level & Integrity Evaluation	Issue of Data Fast Corrections User Differential Range Error Indicator	6 s		NPA 18 s PA 12 s	optional
7	Degradation Parameters Degradation of fast term corrections for Protection Levels	System Latency Issue of Data PRN Degradation Factor Indicator	120 s		NPA 360 s PA 240 s	required
10	Degradation Parameters Degradation of long term corrections for Protection Levels	Assortment of Data containing Information about the degradation of the long term corrections applied (3)	120 s		NPA 360 s PA 240 s	optional for NPA required for PA

57 The maximum update interval for fast corrections is 60 s, whereas the maximum update Interval for UDREI is 6 s

Message Type	Purpose	Content	Max. Update Interval	Default Update Interval	Max. Time-Out Interval	Required Optional
24	Corrections Mixed fast term / long term corrections	first half of message fast term corrections as in MT 2 – 5 for six satellites second half of message long term corrections as in MT 25 with velocity code 0	on a “as needed” basis		each time out criteria applies individually	optional
25	Corrections Long term corrections	Velocity Code PRN mask number Issue of Data Position Corrections Time Offset Corrections Velocity Corrections[58] Time Drift Corrections Time of Applicability	120 s		NPA 360 s PA 240 s	required
18	Corrections Ionospheric Grid Points	Number of Bands IGP to be broadcasted Band number IGP to be broadcasted Issue of Data Ionosphere IGP Mask	300 s		NPA 1200 s PA 1200 s	optional for NPA required for PA
26	Corrections Ionospheric Corrections	Band number IGP Block Number IGP Vertical Delay Estimate for 15 points Grid Ionospheric Vertical Error Indicator for 15 points Issue of Data Ionosphere	300 s		NPA 600 s PA 600 s	optional for NPA required for PA

58 The velocity related values are provided, if the velocity code equals 1. For velocity code equal to 0, the first part is repeated for a different satellite

Message Type	Purpose	Content	Max. Update Interval	Default Update Interval	Max. Time-Out Interval	Required Optional
SBAS Ranging						
17	Ranging SBAS Almanac	Data ID PRN number Health and Status Position Information Velocity Information Time of Applicability	300 s		NPA none PA none	optional
9	Ranging SBAS Ephemeris	Issue of Data SBAS Ephemeris Time of Applicability Accuracy Indicator Position Information Velocity Information Acceleration Information Time Offset Information Time Drift Information	120 s		NPA 360 s PA 240 s	required for SBAS ranging functionality
12	Timing Synchronisation of SBAS Network time with UTC	UTC Time Offset/Drift information including leap seconds UTC Standard Identifier GPS Time-Of-Week and Week Number GLONASS Information	300 s		NPA 86400 s PA 86400.0 s	optional
27	Service Region	Lat/Lon/Radius Information Service Indicator Number of Service Messages Issue of Data Service Messages	300 s if used		NPA 86400 s PA 86400.0 s	optional

Internal Messages						
62	Internal	content and format not known	N/A		N/A	optional
63	Null	zeros – no content	N/A		N/A	optional

Table G**.20**: Overview of the SBAS Message Types

Appendix I Examples for File formats

I.1 Files and Format Options

The data described in the chapters 2 and 7 shall be provided in 3 different files relating to the update rate of the parameters. The data described in the chapter 4 shall be provided in 12 different files relating to the message type of the SBAS transmissions. The values shall be expressed as ASCII-numbers in table form with the header in the first row and the corresponding figures in the columns, where:

Column and String Delimiter	
;	shall be used as the column delimiter (default value)
,	can be used as the column delimiter
<tab>	can be used as the column delimiter
< >	can be used as the column delimiter
<CR><LF>	shall be used as the row delimiter
"	shall be used as the string delimiter (required for the strings in the first row of any file)

Table **H.21**: Column and String Delimiter

Due to the amount of data described in this Interface Control Document, it has been decided to store the data in different files. In order to facilitate the organisation of the different data, the following naming convention for the different files shall be followed.

Data	Chapter	Naming Convention	Remarks
GNSS measurements	2	xxxx.1Hz	see remark 1
GPS almanac GPS ephemeris	3.1 3.2	xxxx_GPSyyyy.ALM xxxx_BRDCttt0.zzN xxxx_ttt.zzN	see remarks 1, 2 see remarks 1,3
SBAS MT 0	4	xxxx.M00	see remark 1

Data	Chapter	Naming Convention	Remarks
SBAS MT 1	4	xxxx.M01	see remark 1
SBAS MT 2 - 5	4	xxxx.MFC	see remark 1
SBAS MT 6	4	xxxx.M06	see remark 1
SBAS MT 7	4	xxxx.M07	see remark 1
SBAS MT 10	4	xxxx.M10	see remark 1
SBAS MT 12	4	xxxx.M12	see remark 1
SBAS MT 18	4	xxxx.M18	see remark 1
SBAS MT 25	4	xxxx.M25	see remark 1
SBAS MT 26	4	xxxx.M26	see remark 1
SBAS MT 27	4	xxxx.M27	see remark 1
SBAS MT 17	5.1	xxxx_GEOyyyy.ALM	see remark 1, 2
SBAS MT 9	5.2	xxxx_BRDCttt0.zzE	see remark 1, 3
		xxxx_ttt.zzE	
GLONASS almanac	6.1	xxxx_GLOyyyy.ALM	see remark 1, 2
GLONASS ephemeris	6.2	xxxx_ttt.zzG	see remark 1, 3
Aircraft data 1 Hz	2	xxxx.1Hz	see remark 1
Aircraft data 8 Hz	7	xxxx.8Hz	see remark 1
Aircraft data 16 Hz	7	xxxx.16H	see remark 1
MEDLL Multipath data	9	xxxx.mpm	see remark 1
MEDLL satellite specific data	9	xxxx.sat	see remark 1

(1) xxxx stands for a common file name basis for the data evaluation
(2) yyyy stands for the GNSS week number of the data (leading zeros optional)
(3) ttt stands for the julian day of the data in the year zz

Table **H.22**: File Naming Convention

Furthermore, the data shall be kept together in one directory. Thus, the evaluation using the PEGASUS project will be facilitated. This files are used as input for the PEGASUS prototype. They can be displayed in a tabular form with appropriate user programs like Microsoft's EXCEL as well, where they will be displayed format shown in the following sections.

I.2 File Format for 1 Hz Data

Sample	ACUTC_year	ACUTC_month	ACUTC_day	ACUTC_hrs	ACUTC_mins	ACUTC_secs	ALT	AOA	AZIM	CAS	CNO0
1	96	5	31	3	32	44	32139	3.3837881	49.042899	253.451	45
2	96	5	31	3	32	45	32140	3.3398428	49.042899	253.504	45
3	96	5	31	3	32	46	32141	3.4277334	49.042899	253.723	45

CNO1	CNO2	CNO3	CNO4	CNO5	...	CN15	DR0	DR1	DR2	DR3	DR4
52	53	53	51	47	...	51	187.6367188	252.875	-159.8007813	-187.5273438	-475.3515625
52	53	53	51	47	...	52	187.8164063	252.91	-159.6835938	-187.4023438	-475.3242188
52	53	53	51	47	...	52	187.9804688	252.949	-159.5820313	-187.2773438	-475.3007813

DR5	...	DR15	ELEV	GALT	GLAT	GLATF	GLON	GLONF	GMODE
-316.5390625	...	727.3710938	10.3710967	37252.125	48.090549	0.00007301	-57.16861644	-0.00014207	3
-316.5234375	...	727.53125	10.3710967	37254.250	48.091579	0.00016278	-57.16518324	-0.00012506	3
-316.53125	...	727.6992188	10.3710967	37256.000	48.092781	0.00008097	-57.16175004	-0.00010813	3

GSEC	GUTC0	GUTC1	GUTC2	GUTC3	GUTC4	GUTC5	...	GUTC15	GWEEK	HDOP	HINTL
323405.00	5.0027283	5.0027283	5.0027283	5.0027283	5.0027283	5.0027283	...	5.0027283	1021	1.15625	0.3000116
323406.00	6.0030736	6.0030736	6.0030736	6.0030736	6.0030736	6.0030736	...	6.0030736	1021	1.15625	0.3000116
323407.00	7.0034189	7.0034189	7.0034189	7.0034189	7.0034189	7.0034189	...	7.0034189	1021	1.15625	0.3000116

HYAF	HYAL	HYIL	HYLA	HYLO	HYOF	IALT	ILSD	LATP	LONP	MN
0.00003814	36880.5	0	48.09106398	-57.16604154	0.00015062	36993.375	0.828125	48.1085733	-57.17153466	0.7825
0.00011156	36880.5	0	48.0922656	-57.16260834	0.00016982	36993.5	0.828125	48.1096033	-57.1679298	0.7827
0.00003998	36880.6	0	48.09329556	-57.15917514	0.00001442	36993.5	0.828125	48.1108049	-57.1644966	0.7828

MS0	MS1	MS2	MS3	MS4	MS5	...	MS15	OPM0	OPM1	OPM2	OPM3	.....	OPM15	PRC0
13	13	13	13	13	13	...	13	0	0	0	0	.....	0	25150720
13	13	13	13	13	13	...	13	0	0	0	0	.....	0	25150720
13	13	13	13	13	13	...	13	0	0	0	0	.....	0	25150976

PRC1	PRC2	PRC3	PRC4	PRC5	...	PRC15	PRF0	PRF1	PRF2	PRF3	PRF4	PRF5	...	PRF15
21499904	20268800	20173824	22493952	24852224	...	21425408	37.5	205.125	151.5	171.75	44.125	148	...	20.625
21500160	20268544	20173568	22493440	24851968	...	21425920	225.3	202	247.9	240.25	80.875	87.38	...	236.38
21500416	20268544	20173568	22492928	24851712	...	21426688	157.1	198.875	88.13	53.125	117.5	26.75	...	196

PSTAT	PT	PTCH	ROLL	RR0	RR1	RR2	RR3	RR4	RR5
216.703125	324.578125	3.41674552	-0.20324692	-187.5625	-252.765625	159.8085938	187.3164063	475.1796875	316.890625
216.695313	324.453125	3.42223868	-0.25268536	-187.9297	-252.699219	159.578125	187.3515625	475.328125	316.503906
216.679688	324.390625	3.43871816	-0.26916484	-187.7773	-253.15625	159.6835938	187.1523438	475.171875	316.710938

...	RR15	SAT	SATT	SATV	SQUAL	SVN0	SVN1	SVN2	SVN3	SVN4	SVN5	...	SVN15	TAS	TAT
...	-727.6953125	-52.25	8	9	0	31	26	23	9	21	1	...	17	452.2354	-25.25
...	-727.5546875	-52.25	8	9	0	31	26	23	9	21	1	...	17	453.5456	-25.25
...	-727.6171875	-52.26	8	9	0	31	26	23	9	21	1	...	17	544.1510	-25.25

THDG	UTC_hrs	UTC_mins	UTC	UTCF	UTCFF	VDOP	WD	WS
66.02229004	3	32	44	0.0010241	0.00000083	1.40625	-123.9476622	104.3203125
66.0277832	3	32	45	0.0010241	0.00000079	1.40625	-123.9641417	104.3515625
66.055249	3	32	46	0.0010241	0.00000076	1.40625	-124.0630186	104.5859375

I.3 File Format for 8 Hz Data

Sample	ACUTC_year	ACUTC_month	ACUTC_day	ACUTC_hrs	ACUTC_mins	ACUTC_secs	GLS.1	LOCD.1	RALT.1
1	96	5	31	3	32	44	0	-0.00576194	8188.875
1	96	5	31	3	32	44	0	-0.01084026	8188.875
1	96	5	31	3	32	44	0	0.00009766	8188.875
1	96	5	31	3	32	44	0	-0.0058596	8188.875
1	96	5	31	3	32	44	0	0.00136724	8188.875
1	96	5	31	3	32	44	0	-0.01152388	8188.875
1	96	5	31	3	32	44	0	-0.0068362	8188.875
1	96	5	31	3	32	44	0	-0.00957068	8188.875
2	96	5	31	3	32	45	0	0.0063479	8188.875
2	96	5	31	3	32	45	0	-0.01425836	8188.875

I.4 File Format for 16 Hz Data

Sample	ACUTC_year	ACUTC_month	ACUTC_day	ACUTC_hrs	ACUTC_mins	ACUTC_secs	GS.1	IVV.1	LATG.1	LONG.1	PTCR.1
1	96	5	31	3	32	44	555.625	5	-0.00012207	0.0598143	-0.0078125
1	96	5	31	3	32	44	555.625	5	-0.00109863	0.059326	-0.0117188
1	96	5	31	3	32	44	555.625	4	-0.00085449	0.059204	-0.0117188
1	96	5	31	3	32	44	555.625	4	-0.00024414	0.0588377	-0.0078125
1	96	5	31	3	32	44	555.625	4	0.00048828	0.0588377	-0.0117188
1	96	5	31	3	32	44	555.625	3	0.00048828	0.0587157	-0.0078125

ROLR	TRK	VRTG	YAW
-0.0625	64.1601088	-0.0107256	-0.015625
-0.0625	64.1612325	-0.0108654	-0.023215
-0.0508	64.1625456	-0.0121385	-0.019875
-0.0469	64.1645654	-0.0154005	-0.017895
-0.0430	64.1633254	-0.0165004	-0.020128

I.5 File Format for SBAS MTX

Sample	GWEEK_SMT	GSEC_SMT	PRN_SMT	MT_SMT
1	1030	232020.25	122	0
2	1030	232024.25	122	3
3	1030	232028.25	122	24

I.6 File Format for SBAS MT 0

Sample	GWEEK_S0	GSEC_S0	PRN_S0
1	1030	232020.25	122
2	1030	232024.25	122
3	1030	232028.25	122

I.7 H.6 File Format for SBAS MT 1

Sample	GWEEK_S1	GSEC_S1	PRN_S1	SVMASK_S1	IODP_S1
1	1030	232101.00	122	F300BF0023055504FF001000B8000000000000000000000000000000	0
2	1030	232180.00	122	F300BC0022055504FF001000B8000000000000000000000000000000	0
3	1030	232211.00	122	AF20BC0028055504FF001000B8400000000000000000000000000000	1

I.8 File Format for SBAS MT 2-5 and MT 24 (fast corrections)

The numbering of the correction information fields (pseudorange corrections and user differential range error indicators) is performed from 1 to 13. The message type identifiers allows the determination of the correct PRN number together with the current information provided by the SBAS MT 1 (e.g. PRC13_FC in TYPE_FC 4 corresponds to the pseudorange correction for the 39th satellite indicated in the PRN mask assignment).

If the data is extracted from MT 24 (i.e. from the mixed fast & slow corrections), then the corrections are only provided for 6 satellites. The remaining 7 correction information fields (pseudorange corrections and user differential range error indicators) should be set to zero

Sample	GWEEK_SFC	GSEC_SFC	PRN_SFC	TYPE_SFC	IODF_SFC	IODP_SFC	PRC1_SFC	PRC2_SFC
1	1030	232200.00	122	2	0	1	23.513	-67.898
2	1030	232203.00	122	3	1	2	24.523	-72.568
3	1030	232206.00	122	4	2	3	26.735	-75.234

...	PRC13_SFC	UDREI1_SFC	UDREI2_SFC	…	UDREI13_SFC
	123.345	1	2		11
	125.945	1	2		11
	128.166	1	4		11

I.9 File Format for SBAS MT 6

Sample	GWEEK_S6	GSEC_S6	PRN_S6	IODF2_S6	IODF3_S6	IODF4_S6	IODF5_S6	UDREI1_S6	UDREI2_S6	...	UDREI51_S6
1	1030	232300.00	122	1	1	0	3	2	3	...	11
2	1030	232304.00	122	2	2	1	0	2	4	...	11
3	1030	232308.00	122	3	3	2	1	2	4	...	12

I.10 File Format for SBAS MT 7

Sample	GWEEK_S7	GSEC_S7	PRN_S7	TLAT_S7	IODP_S7	AI1_S7	AI2_S7	...	AI51_S7
1	1030	232350.00	122	2	1	4	6	...	15
2	1030	232450.00	122	2	1	4	6	...	14
3	1030	232550.00	122	4	2	3	3	...	6

I.11 File Format for SBAS MT 10

Sample	GWEEK_S10	GSEC_S10	PRN_S10	BRRC_S10	CLTCLSB_S10	CLTCV1_S10	ILTCV1_S10	CLTCV0_S10	ILTCV0_S10	CGEOLSB_S10
1	1030	232400.00	122	1.022	2.234	0.02125	233	1.008	150	0.1205
2	1030	232480.00	122	1.234	2.456	0.03200	240	1.006	157	0.1510

CGEOV_S10	IGEO_S10	CER_S10	CIONOSTEP_S10	IIONO_S10	CIONORAMP_S10	RSSUDRE_S10	RSSIONO_S10
0.04315	120	15.5	0.982	310	0.003445	0	1
0.04340	113	17.0	0.983	311	0.003450	1	0

I.12 File Format for SBAS MT 12

Sample	GWEEK_S12	GSEC_S12	PRN_12	A1WNT_S12	AOWNT_S12	TOT_S12	WNT_S12	DTLS_S12	WNLSF_S12	DN_S12	DTLSF_S12
1	1030	232500.00	122	3.214645E-9	1.233E-6	4096	6	13	6	3	-24
2	1030	232660.00	122	3.243300E-9	2.345E-6	20480	6	13	6	3	-24

UTCID_S12	GPSTOW_S12	GPSWN_S12	GLONASSIND_S12	GLONASSOFF_S12
3	232500	6	1	TBD in [6]
3	232660	6	1	TBD in [6]

I.13 File Format for SBAS MT 18

Sample	GWEEK_S18	GSEC_S18	PRN_S18	NB_S18	BN_S18	IODI_S18	IGP_S18
1	1030	232800.00	122	5	4	0	FAC2424445344003440087A9F00000000000000000000000000
2	1030	233060.00	122	5	4	1	EBC2424AA0344003440087A9F00000000000000000000000000

I.14 File Format for SBAS MT 25 and MT 24 (long term corrections)

If the data is extracted from MT 24 (i.e. the mixed fast & slow corrections), then only two sets can be filled. The parameters of the remaining two sets should be filled with zero.

Sample	GWEEK_SSC	GSEC_SSC	PRN_SSC	VC0_SSC	PRN0_SSC	IODS0_SSC	DX0_SSC	DY0_SSC	DZ0_SSC	DAF00_SSC
1	1030	233100.00	122	0	24	123	23.125	34.750	-56.000	1.183E-7
2	1030	233220.00	122	1	24	124	22.250	30.500	-50.825	1.184E-7

DXROC0_SSC	DYROC0_SSC	DZROC0_SSC	DAF10_SSC	TOA0_SSC	IODP0_SSC	VC1_SSC	next 3 sets
0	0	0	0	0	2	0	...
0.0045	0.0015	0.0620	1.210E-10	23616	3	0	...

I.15 File Format for SBAS MT 26

Sample	GWEEK_S26	GSEC_S26	PRN_S26	BN_S26	BI_S26	IODI_S26	DELAY1_S26	GIVEI1_S26	...	...	DELAY15_S26	GIVEI15_S26
1	1030	233100.00	122	4	9	2	12.250	7	...	...	45.750	8
2	1030	233300.00	122	4	10	2	34.125	4	...	...	3.125	2

I.16 File Format for SBAS MT 27

Sample	GWEEK_S27	GSEC_S27	PRN_S27	NS_S27	IODS_S27	LAT1_S27	LON1_S27	RAD1_S27	SID1_S27	next 6 sets
1	1030	233400.00	122	11	5	52.25	10.5	2	12	
2	1030	240000.00	122	2	6	-20.75	-3.50	4	14	

I.17 File Format for Reference Track Data

In contrast to the file format for the GNSS and SBAS data, it is assumed that the file for the reference track data is organized in the following way:

A header line is present that provides the names of the parameters that are contained in the file. The data for one particular epoch is provided by ASCII data in one line. Each value is delimited by a space character. There is no parameter acronym name checking implemented. The parameters must be provided in the exact sequence that is given here.

REFWEEK	REFSEC	REFLAT	REFLON	REFALT
1090	301501.050000	52.624957049	10.638746218	837.318
1090	301502.050000	52.625631824	10.638713138	837.694
1090	301503.050000	52.626306692	10.638678973	837.900
1090	301504.050000	52.626982064	10.638643141	837.973
1090	301505.050000	52.627658240	10.638606761	838.211
1090	301506.050000	52.628334895	10.638569993	838.626

I.18 File Format for Multipath Assessment

The MEDLL data, after being decoded by the CONVERTOR module in PEGASUS, shall be output in three separate files:

- *.mpm shall contain data from the multipath log (i.e. the converted NovAtel MPMB log)
- *.sat shall contain data from the satellite log (i.e. the converted NovAtel SATB log)
- *.1hz shall contain data from the range information

The range measurements (and in particular the C/N0 values) are already decoded and output in the 1-Hz file, as detailed in Section H.2.

The MEDLL receiver outputs one MPMB log per tracked satellite, at each epoch. Therefore, the data output in the medll.mpm file shall consist of several rows of data per epoch. Each row shall contain the log's contents for a given satellite at a given epoch, as seen below:

Sample	medll_WeekNo	medll_Seconds	SVN	medll_ChStatus	medll_Status	medll_MPDelay	medll_MPAmp	medll_MPPhase
1	1197	394489.09	5	24132	259	1.091122508	0.045466129	-0.457752764
2	1197	394489.06	6	24084	259	1.201196551	0.031952947	-0.819887877
3	1197	394489.06	30	24068	259	1.299999952	0.019168034	-0.76285696
4	1197	394489.09	24	23076	259	0.940605819	0.031085359	1.084007502
5	1197	394489.09	1	24164	259	1.190441489	0.058649871	-2.448562622
6	1197	394489.09	4	24180	259	0.822232425	0.116276734	-1.409668684
7	1197	394489.16	25	23124	259	0.397125304	0.051035512	-1.142439604

medll_Ires0	medll_Ires1	…..	medll_Ires10	medll_Ires11
-0.002530819	2.65E-05	…..	4.87E-05	-0.012041193
-0.004685242	-0.004173454	…..	-0.002506301	-0.000220729
-0.001408112	-0.001073912	…..	0.000701343	-8.87E-05
-0.004126452	-0.002101031	…..	7.89E-05	0.005546485
-0.000928271	-0.00166808	…..	-0.009871418	-0.000413923
-0.00717309	-0.004226005	…..	-0.000610348	0.014702239
-0.003626749	-0.00281831	…..	0.021853194	0.027098402

medll_Qres0	medll_Qres1	…..	medll_Qres10	medll_Qres11
-0.003834799	-0.002539997	…..	9.38E-05	-0.01442
-0.002328964	-0.002537715	…..	-0.00199	-0.00021
-0.009036291	-0.008916856	…..	0.003155	-9.28E-05
-0.00348243	-0.004648737	…..	-2.59E-05	-0.00502
-0.015410305	-0.011981118	…..	0.032141	0.000496
-0.00148732	-0.002289222	…..	-0.00015	0.028243
-0.006076927	-0.004900563	…..	-0.00216	-0.01059

The structure of the file containing Satellite Specific data is as follows. For each epoch, one row of data is produced, separated by comma or semicolon.

Sample	GWEEK	GSEC	nObs	SVN0	SV_AZ0	SV_El0	SV_RjC0	SV_HLTH0	SVN1	SV_AZ1	SV_El1	SV_RjC1	SV_HLTH1
1	1197	394489	9	30	84.16	67.91	0	-1	6	200.64	77.34	0	-1
2	1197	394490	9	30	84.17	67.9	0	-1	6	200.64	77.35	0	-1
3	1197	394491	9	30	84.18	67.89	0	-1	6	200.63	77.36	0	-1
4	1197	394492	9	30	84.19	67.89	0	-1	6	200.62	77.37	0	-1
5	1197	394493	9	30	84.2	67.88	0	-1	6	200.61	77.38	0	-1
6	1197	394494	9	30	84.21	67.87	0	-1	6	200.6	77.38	0	-1
7	1197	394495	9	30	84.23	67.87	0	-1	6	200.6	77.39	0	-1

…..	SVN11	SV_AZ11	SV_El11	SV_RjC11	SV_HLTH11
…..	-1	0	0	0	0
…..	-1	0	0	0	0
…..	-1	0	0	0	0
…..	-1	0	0	0	0
…..	-1	0	0	0	0
…..	-1	0	0	0	0
…..	-1	0	0	0	0

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