RINEX

The Receiver Independent Exchange Format

Version 3.03

International GNSS Service (IGS), RINEX Working Group and Radio Technical Commission for Maritime Services Special Committee 104 (RTCM-SC104),

July 14th, 2015

Acknowledgment: RINEX Version 3.02 and 3.03 is based on RINEX Version 3.01 which was developed by: Werner Gurtner, Astronomical Institute of the University of Bern, Switzerland and Lou Estey, UNAVCO, Boulder Colorado, USA.

Table of Contents

0. REVISION HISTORY

	Version 3.00
02 Feb 2006	A few typos and obsolete paragraphs removed.
08 Mar 2006	Epochs of met data of met files version 2.11 are in GPS time only (Table A20).
31 Mar 2006	DCB header record label corrected in Table A6**: `SYS / DCBS APPLIED`.**
June 2006	Filenames for mixed GNSS nav mess files.
10 Aug 2006	Table A3: Error in format of ***`EPOCH`*** record: One 6X removed. Trailing 3X removed.
12 Sep 2006	GNSS navigation message files version 3.00 included (including Galileo).
	Table A4: Example of the kinematic event was wrong (kinematic event record).
	`SYS / DCBS APPLIED` header record simplified.
	Tables A6 and A8: Clarification for adjustment of "Transmission time of message".
03 Oct 2006	Table A11: Mixed GPS/GLONASS navigation message file
26 Oct 2006	Table A4: Removed obsolete antispoofing flag
	Tables A6/8/10: Format error in ***`SV / EPOCH / SV CLK`***: Space between svn and year was missing
	Half-cycle ambiguity flag (re-)introduced (5.4 and Table A4).
	Clarification of reported GLONASS time (8.1).
	New header record **`SYS / PCVS APPLIED`**
	New Table 10: Relations between **`GPS`**, GST, and **`GAL`** weeks
	Recommendation to avoid storing redundant navigation messages (8.3)
14 Nov 2006	Tables A6/10/12: Format error in ***`BROADCAST ORBIT – n`*`:`** `3X` → `4X.` Examples were OK.
21 Nov 2006	Marker type **`NON_PHYSICAL`** added
19-Dec-2006	Table A4: Example of **`SYS / DCBS APPLIED`** was wrong.
13-Mar-2007	Paragraph 3.3: Leftover from RINEX version 2 regarding wavelength factor for squaring- type receiver removed and clarified.
14-Jun-2007	Paragraph 5.11: Clarification regarding the observation record length
28-Nov-2007	Frequency numbers for GLONASS –7..+12 (***`BROADCAST ORBIT – 2`***)
	Version 3.01
22-Jun-2009	Phase cycle shifts

	Galileo: BOC-tracking of an MBOC-modulated signal
	Compass satellite system: Identifier and observation codes
	Code for GPS L1C
	Header records for GLONASS slot and frequency numbers
	Order of data records
	Galileo nav. mess record ***BROADCAST ORBIT – 5***: Bits ¾ reserved for Galileo internal use
	Version 3.02 – IGS and RTCM-SC104
19-Nov-2011	Added Quasi Zenith Satellite System (QZSS) Constellation Updated text, tables and graphics Added Appendix Table 19 - phase alignment table
21-Jan-2012	Split the Constellation table into a table for each GNSS Added QZSS to the documentation Edited text to improve clarity Corrected sign in the phase alignment table, Removed QZSS P signals
9-May-2012	Edited text to improve clarity, Updated phase alignment table, Changed Met `PGM / RUN BY / DATE` to support 4digit year as in all other records also changed format to support 4 digit year for met. Observation record, Changed SYS / PHASE SHIFTS to SHIFT
29-Nov-2012	Changed Table1 and 2 to Figure 1 and 2. Updated all Table numbers. Changed file naming convention, Section 4. Added Appendix Table A1 and increased all, updated all Appendix numbers Removed the option of supporting unknown tracking mode from Section 5.1. Harmonized L1C(new) signal identifiers for QZSS and GPS See : Table 2 and 6. Updated BeiDou System (BDS) (was Compass) information throughout the document added new BDS ephemeris definition to Appendix. (Based on input from the BDS Office) Corrected GLONASS SLOT/FRQ format in section 9.5, changed message status from optional to mandatory (See: Appendix Table A2). Added new mandatory GLONASS Code Phase Bias header record See section 9.9
11-Mar-2013	Updated Sections: 4.x, made .rnx the file name extension and updated Figure 2; 9.1 to clarify the use of the phase alignment header; A1 Edited to reflect file extension of *.rnx; A14 - BDS ephemeris changed AODC to IODC and AODE to IODE (as indicated by BDS Authority and new ICD); Appendix Table A19 (Changed GLONASS Reference Signals to C1-C2) and explicitly identified reference signal for all constellations and frequencies.
26-Mar-2013	Changed BeiDou to BDS for conform to ICD. In table 7 changed BDS signals from: C2x to C1x to more closely

	reflect existing bands in tables 2-6 and Appendix Tables A2 and A21. Updated Section 8.1: First paragraph updated to indicate current number of leap seconds; added a row to Table 12 to show the relationship between GPS week and BDT week. Added a table to show the approximate relationship of BDT to GPS time. Changed order of file type: from OG to GO etc in Appendix Table A1. Updated Appendix table A21 to show X signals and indicate that the X phase is to be aligned to the frequencies reference signal. Fixed a few small typos in A21 for GPS: L1C-D/P and D+P.
	RINEX 3.02 Released
03-Dec-2013	– Corrected Sections 3.1 to read: TIME OF FIRST OBS rather than start time record. – Added text to Section 5.4 and A3 to indicate that the Loss of Lock Bit is the least significant bit. – In section 9.5 GLONASS Slot and Frequency Numbers, changed optional to mandatory (as it was changed from optional to mandatory in version 3.02). – In Table A2 record: **SYS / # / OBS TYPES changed** Satellite system code (**G/R/E/J/C/S/M to G/R/E/J/C/S**). – In Section 5.7 added descriptive text to Table 12 (header- changed Signal to Carrier and in the body) . – In Table A3 record **OBSERVATION** changed 5: from average to good. – In note 4 after A8 …Galileo System Time added (GST) to make the following description more explicit. – Appendix A14 BeiDou Nav. removed the – sign in front of Cis
24-Jan-2014	– Appendix A10 Section ***SV / EPOCH / SV CLK*** changed TauN to –TauN to agree with section 8.3.1
4-Apr-2014	– Galileo Table A8 , BROADCAST ORBIT-5 - Bits 0-2 : changed from non-exclusive to exclusive (only one bit can be set). In ****) section added (GST) – Corrected Table A23 - BeiDou B1 phase correction column signal indicator to agree with BeiDou Table 9. – Corrected Table A2 - Band 1 = E1 (Was E2-L1-E1) to agree with Galileo Table 6. – In Table A5 - optional message TIME SYSTEM CORR added text to clarify the parameters T and W for BeiDou. – Section 8.3.1 Corrected typo in last line of first paragraph.
6-May-2014	– Updated Section 10 Document References – Changed A6 from GPS/QZSS to GPS only as A12 contains a description of the QZSS ephemeris. – Corrected typo in Appendix 23 note 1: L2E changed to L2W
21-May-2014	– Appendix A4 added two observation file header examples

	– Appendix A6 GPS Navigation, Broadcast Orbit-7 Fit Interval, clarified in accordance with IS-GPS-200H section 20.3.3.4.3.1 – Appendix A9 added Galileo navigation file example – Appendix A12 QZSS Navigation, Broadcast Orbit-5 field 4 allow define L2P flag to be set to one section 5.2.2.2.3(6)); Broadcast Orbit-7 Fit Interval clarified in accordance with section 5.2.2.2.4(4), IS-QZSS 1.5. – Appendix A13 added QZSS navigation file example – Appendix A15 added BeiDou navigation file example
26-May-2014	– Removed “Added” from section 9.8, 9.9 and 9.10 titles – Added a note to section 9.9 (GLONASS COD/PHS/BIS) to allow unknown GLONASS code/phase, observation alignment in exceptional cases. Added a note to Appendix A2: GLONASS COD/PHS/BIS record definition.
9-June-2014	– Edited Section 6.11 and Table A6:BO7 (GPS) to indicate that the GPS fit interval field should contain a period in hours. Edited Table A12:BO7 (QZSS) to make it clear that the fit interval is a flag and not a time period. Added support for unknown fit interval (specified as an empty field).
10-June-2014	– Removed the reference to QZSS in Appendix 6 SC/EPOCH/SV CLK record as there is now a QZSS navigation file in Appendix 12. – Corrected A12 QZSS ICD reference from 5.1.2.3.2 to 5.1.2.1.3.2
12-June-2014	– Added text to section 9.9 to indicate that when the GLONASS COD/PHS/BIS measurements are unknown then all fields in the record should be left blank (added an example). Updated the descriptive text in Table A2 GLONASS COD/PHS/BIS.
10-July-2014	– Corrected Appendix numbers in body of the text – Added Note after BeiDou Table 9 to indicate that some RINEX 3.02 files may still use the 3.01 B1 coding convention
16-Jul-2014	- Section 9.1 Replaced: Phase observations must be shifted by the respective fraction of a cycle, either directly by the receiver or by a correction program or the RINEX conversion program, prior to RINEX file generation, to align them to each other with: All phase observations must be aligned to the designated constellation and frequency reference signal as specified in Appendix Table A23, either directly by the receiver or by a correction program or the RINEX conversion program, prior to RINEX file generation. Additionally, all data must be aligned with the appropriate reference signal indicated in Appendix Table A23 even when the receiver or reporting device is not tracking and/or providing data from that reference signal e.g. Galileo L5X phase data must be aligned to L5I.
29-Jul-2014	- Minor edits

	- Updated last paragraph of section 8.4 re TIME SYSTEM CORR - Corrected QZSS Appendix Table A12 PRN/EPOCH/SV CLK record format specification - Reformatted Appendix Table A12 and A14
31-Oct-2014	- BeiDou updates: changed B1 signal identifiers to C2x; observation and navigation Header "LEAP SECONDS messages changed to support both GPS and BDS leap seconds; updated the navigation header message "IONOSPHERIC CORR" to support different ionospheric correction parameters from each satellite. Updated BDS navigation message Table A14. Updated Sections 8.1 and 8.2. - Added Description of the Indian Regional Navigation Satellite System (IRNSS) to the document, Updated RINEX release number to 3.03 Draft 1
19-Jan-2015	- Table 2 grammatical error corrections - Updated broken http: link on page 17 - Updated Leap Second definition in section 8.1 and Appendix A2 and A5 - Update Galileo Appendix A8 navigation line 5 to indicate the exclusive and non-exclusive bits - Added text to further clarify BeiDou Appendix A14 AODE and AODC definition - Updated IRNSS Appendix 18 line 5, week number to indicate that the Week Number is aligned with the GPS week number - Added IRNSS phase alignment information to Appendix 23
15-April-2015	- Editorial changes/corrections: in section 6.6 specified a new acronym Blank Not Known (BNK), 8.1 added text to indicate the relationship between BDT and GPS Time at start of BDT, corrected typo in Section 8.2 last paragraph changed GLO to UTC, clarified Section 9.2 Galileo Tracking, clarified Section 9.6 re BDS, removed Section 9.8 RINEX Meteorological section - Re-formatted Appendix Table A2 and A5 - Clarified Observation (A2) and Navigation (A5) "LEAP SECONDS" record - Clarified Navigation (A5) file "IONOSPHERIC CORR" record - QZSS A12-BO-6, TGD blank if not know - Corrected typo in A22, - Clarified filename start time - Minor punctuation and grammatical corrections throughout the document. - Removed reference to unknown tracking mode in Appendix Table A2 message SYS / # / OBS TYPE. - Updated all table numbers (some tables were not identified), improved table descriptions.

	- Minor format changes
15-May-2015	- Added paragraph to section 8.3.2 to specify that RINEX parsers should expect to encounter F/NAV and I/NAV messages in the same file… - Removed "The attribute can be left blank if not known. See text!" text from the end of A2, SYS/#/OBS TYPES as it was decided in 3.02 not to allow unknown signals therefore this no longer applies - Updated A8 (Galileo Nav. Message), Record 5 Field 2-Description to specify only I/NAV or F/NAV can be specified - Corrected A9 (Galileo Nav. Example), Record 5 Field 2 from 519 to 517 to indicate I/NAV in accordance with the field specification - Corrected A9, Record 6 Field 1 from 107(broadcast raw value) to 3.12m
25-May-2015	- Corrected Table of contents to show Section 10.0, References - Section 2 second last paragraph added IRNSS to list of supported constellations - Section 5.3 last paragraph concerning event flags added reference to Appendix A3 - Section 7, last paragraph, edited second sentence to make it more clear
1-June-2015	- Minor punctuation corrections - Added C2X signal tracking example to Section 5.1 example list - Added paragraph 3 to section 5.1, to indicate only know tracking modes are supported in RINEX 3.02 and 3.03 - Added note to Appendix A2, SYS/#/OBS TYPES to indicate only know tracking modes are allowed in RINEX 3.02 and 3.03 - Table 4 in L1 and L2 frequency bands, changed P to P (AS off) to improve clarity - Added :"(e.g. units employing a Selective Availability Anti-Spoofing Module (SAASM))" to last paragraph on page 18 to improve clarity.
24-June-2015	- Updated the last paragraph of Section 1 (RINEX 3.03) - Clarified Section 4: Changed Obs. Freq. To Data Frequency and update Appendix Table A1 to match - Added text to Section 8.3.2 (Galileo Navigation) to describe Issue of Data and related parameters - Added reference to Galileo ICD in Appendix A8 BROADCAST ORBIT-6 - Added Galileo Examples to Appendix Table A9
29-June-2015	- Updated BeiDou RINEX 3.02 C1x-C2x Note below Table 9 for clarity - Section 8.3.2 added Galileo ICD publication year to reference - Corrected Beidou C1 to C2 encoding in Appendix A2 SYS/#/OBS TYPES and in Appendix A4 example 2 and 3 - Appendix A2 and A5 Clarified LEAP SECONDS Day number to

	be 0-6 for BeiDou and 1-7 for GPS and other constellations. - Updated all Appendix table references to contain Axx, to differentiate between body and Appendix tables.
14-July-2015	- Updated LEAP SECONDS record description in Appendix A2 and A5 - Converted Galileo SISA values in Appendix A9 from broadcast value into metres in accordance with RINEX specification and Galileo ICD Section 5.1.11 Table 76
	- **RINEX 3.03 Released**

1. THE PHILOSOPHY AND HISTORY OF RINEX

The first proposal for the ***Receiver Independent Exchange Format RINEX*** was developed by the Astronomical Institute of the University of Bern for the easy exchange of the Global Positioning System (GPS) data to be collected during the first large European GPS campaign EUREF 89, which involved more than 60 GPS receivers of 4 different manufacturers. The governing aspect during the development was the following fact:

Most geodetic processing software for GPS data use a well-defined set of observables:

- the carrier-phase measurement at one or both carriers (actually being a measurement on the beat frequency between the received carrier of the satellite signal and a receiver-generated reference frequency)
- the pseudorange (code) measurement, equivalent to the difference of the time of reception (expressed in the time frame of the receiver) and the time of transmission (expressed in the time frame of the satellite) of a distinct satellite signal
- the observation time being the reading of the receiver clock at the instant of validity of the carrier-phase and/or the code measurements

Usually the software assumes that the observation time is valid for both the phase **and** the code measurements, **and** for all satellites observed.

Consequently all these programs do not need most of the information that is usually stored by the receivers: they need phase, code, and time in the above mentioned definitions, and some station-related information like station name, antenna height, etc.

Until now two major format versions have been developed and published:

- The original RINEX Version 1 presented at and accepted by the 5th International Geodetic Symposium on Satellite Positioning in Las Cruces, 1989. [Gurtner et al. 1989], [Evans 1989]
- RINEX Version 2 presented at and accepted by the Second International Symposium of Precise Positioning with the Global Positioning system in Ottawa, 1990, mainly adding the possibility to include tracking data from different satellite systems (GLONASS, SBAS). [Gurtner and Mader 1990a, 1990b], [Gurtner 1994].

Several subversions of RINEX Version 2 have been defined:

- Version 2.10: Among other minor changes allowing for sampling rates other than integer seconds and including raw signal strengths as new observables. [Gurtner 2002]

- Version 2.11: Includes the definition of a two-character observation code for L2C pseudoranges and some modifications in the GEO NAV MESS files [Gurtner and Estey 2005]

- Version 2.20: Unofficial version used for the exchange of tracking data from spaceborne receivers within the IGS LEO pilot project [Gurtner and Estey 2002]

As spin-offs of this idea of a receiver-independent GPS exchange format, other RINEX-like exchange file formats have been defined, mainly used by the International GNSS Service IGS:

- Exchange format for **satellite and receiver clock offsets** determined by processing data of a GNSS tracking network [Ray and Gurtner 2010]
- Exchange format for the complete **broadcast data of space-based augmentation systems** SBAS. [Suard et al. 2004]
- IONEX: Exchange format for **ionosphere models** determined by processing data of a GNSS tracking network [Schaer et al. 1998]
- ANTEX: Exchange format for **phase center variations** of geodetic GNSS antennae [Rothacher and Schmid 2010]

The upcoming European Navigation Satellite System Galileo and the enhanced GPS with new frequencies and observation types, especially the possibility to track frequencies on different channels, requires a more flexible and more detailed definition of the observation codes.

To improve the handling of the data files in case of “mixed” files, i.e. files containing tracking data of more than one satellite system, each one with different observation types, the record structure of the data record has been modified significantly and following several requests, the limitation to 80 characters length has been removed.

As the changes are quite significant, they lead to a new RINEX Version 3. The new version also includes the unofficial Version 2.20 definitions for space-borne receivers.

The major change leading to the release of version 3.01 was the requirement to generate consistent phase observations across different tracking modes or channels, i.e. to apply ¼-cycle shifts prior to RINEX file generation, if necessary, to facilitate the processing of such data.

RINEX 3.02 added support for the Japanese, Quasi Zenith Satellite System (QZSS), additional information concerning Beidou (based on the released ICD) and a new message to enumerate GLONASS code phase biases.

RINEX 3.03 adds support for the Indian Regional Satellite System (IRNSS) and clarifies several implementation issues in RINEX 3.02. RINEX 3.03 also changes the BeiDou B1 signal convention back to the 3.01 convention where all B1 signals are identified as C2x (not C1 as in RINEX 3.02). Another issue with the implementation of 3.02 was the GPS navigation message fit interval field. Some implementations wrote the flag and others wrote a time interval. This release specifies that the fit interval should be a time period for GPS and a flag for QZSS. Updated Galileo Navigation section 8.3.2 to clarify the issues related to Issue of Data (IOD). Updated document to clarify that only known tracking modes can be encoded in RINEX 3.03.

2. GENERAL FORMAT DESCRIPTION

The RINEX version 3.XX format consists of three ASCII file types:

1. Observation data file
2. Navigation message file
3. Meteorological data file

Each file type consists of a header section and a data section. The header section contains global information for the entire file and is placed at the beginning of the file. The header section contains **header labels in columns 61-80** for each line contained in the header section. These labels are mandatory and must appear exactly as given in these descriptions and examples.

The format has been optimized for minimum space requirements independent from the number of different observation types of a specific receiver or satellite system by indicating in the header the types of observations to be stored for this receiver and the satellite systems having been observed. In computer systems allowing variable record lengths, the observation records may be kept as short as possible. Trailing blanks can be removed from the records. There is no maximum record length limitation for the observation records.

Each Observation file and each Meteorological Data file basically contain the data from one site and one session. Starting with Version 2 RINEX also allows including observation data from more than one site subsequently occupied by a roving receiver in rapid static or kinematic applications. Although Version 2 and higher allow insertion of certain header records into the data section, it is not recommended to concatenate data from more than one receiver (or antenna) into the same file, even if the data do not overlap in time.

If data from more than one receiver have to be exchanged, it would not be economical to include the identical satellite navigation messages collected by the different receivers several times. Therefore, the navigation message file from one receiver may be exchanged or a composite navigation message file created, containing non-redundant information from several receivers in order to make the most complete file.

The format of the data records of the RINEX Version 1 navigation message file was identical to the former NGS exchange format. RINEX version 3 navigation message files may contain navigation messages of more than one satellite system (GPS, GLONASS, Galileo, Quasi Zenith Satellite System (QZSS), BeiDou System (BDS), Indian Regional Navigation Satellite System (IRNSS) and SBAS).

The actual format descriptions as well as examples are given in the Appendix Tables at the end of the document.

3. BASIC DEFINITIONS

GNSS observables include three fundamental quantities that need to be defined: Time, Phase, and Range.

3.1 Time

The time of the measurement is the receiver time of the received signals. It is identical for the phase and range measurements and is identical for all satellites observed at that epoch. For single-system data files, it is by default expressed in the time system of the respective satellite system. For mixed files, the actual time system used must be indicated in the TIME OF FIRST OBS header record.

3.2 Pseudo-Range:

The pseudo-range (PR) is the distance from the receiver antenna to the satellite antenna including receiver and satellite clock offsets (and other biases, such as atmospheric delays):

PR = distance + c * (receiver clock offset –satellite clock offset + other biases)

so that the pseudo-range reflects the actual behaviour of the receiver and satellite clocks. The pseudo-range is stored in units of meters.

See also clarifications for pseudoranges in mixed GPS/GLONASS/Galileo/QZSS/BDS files in chapter 8.2.

3.3 Phase

The phase is the carrier-phase measured in whole cycles. The half-cycles measured by squaring-type receivers must be converted to whole cycles and flagged by the respective observation code (see Table 4 and Section 5.4, GPS only).

The phase changes in the same sense as the range (negative doppler). The phase observations between epochs must be connected by including the integer number of cycles.

The observables are not corrected for external effects such as: atmospheric refraction, satellite clock offsets, etc.

If necessary, phase observations are corrected for phase shifts needed to guarantee consistency between phases of the same frequency and satellite system based on different signal channels (See Section 9.1 and Appendix A23).

If the receiver or the converter software adjusts the measurements using the real-time-derived receiver clock offsets dT(r), the consistency of the 3 quantities phase / pseudo-range / epoch must be maintained, i.e. the receiver clock correction should be applied to all 3 observables:

Time (corr)	=	Time(r)	-	dT(r)
PR (corr)	=	PR (r)	-	dT(r)*c
phase (corr)	=	phase (r)	-	dT(r)*freq

Table 1: Observation Corrections for Receiver Clock Offset

3.4 Doppler

The sign of the doppler shift as additional observable is defined as usual: Positive for approaching satellites.

3.5 Satellite numbers

Starting with RINEX Version 2 the former two-digit satellite numbers **nn** are preceded by a one-character system identifier **s** as per Figure 1.

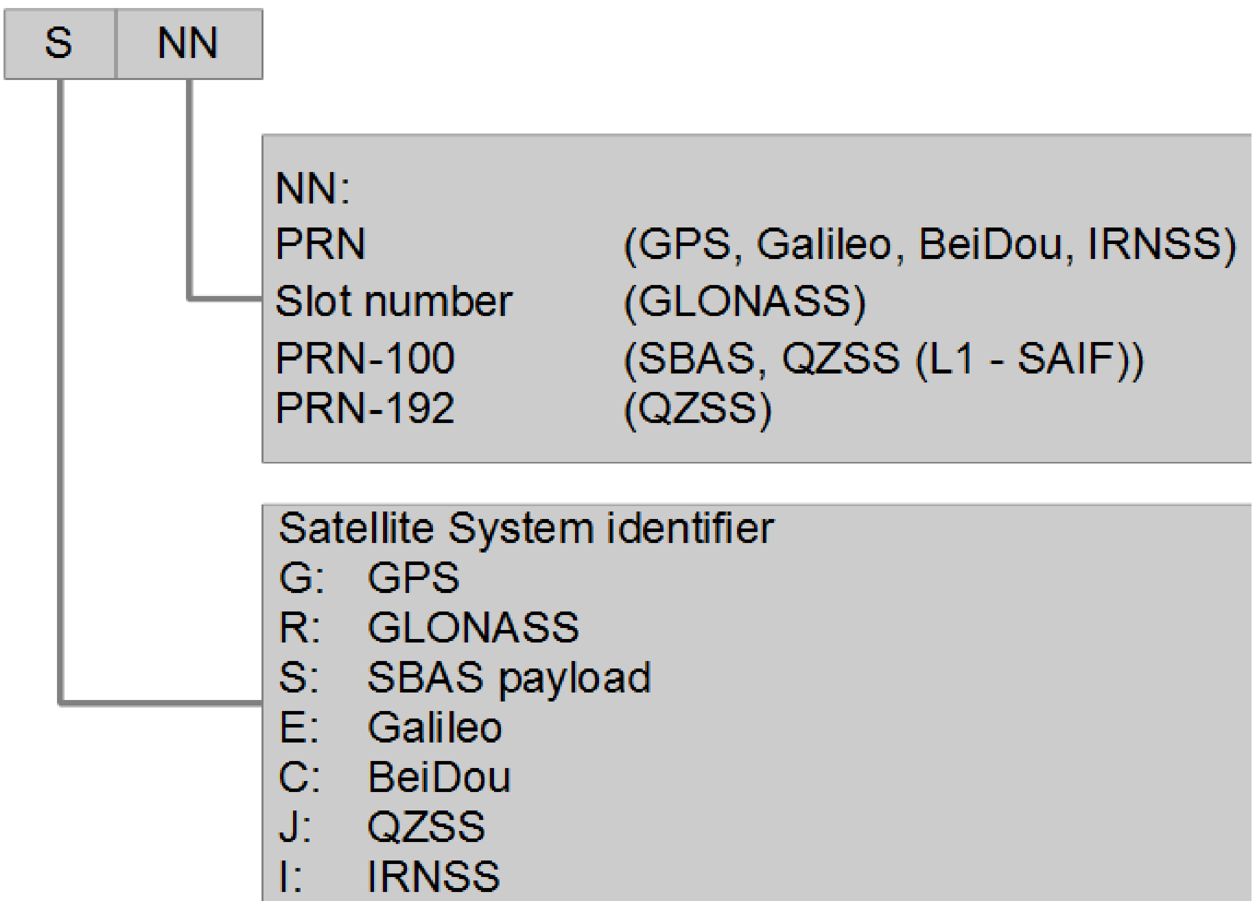

Figure 1: Satellite numbers and Constellation Identifiers

The same satellite system identifiers are also used in all header records when appropriate.

4. THE EXCHANGE OF RINEX FILES

The original RINEX file naming convention was implemented in the MS-DOS era when file names were restricted to 8.3 characters. Modern operating systems typically support 255 character file names. The goal of the new file naming convention is to be more descriptive, flexible and extensible than the RINEX 2.11 file naming convention. Figure 2 below lists the elements of the RINEX 3.02 (and subsequent versions) file naming convention.

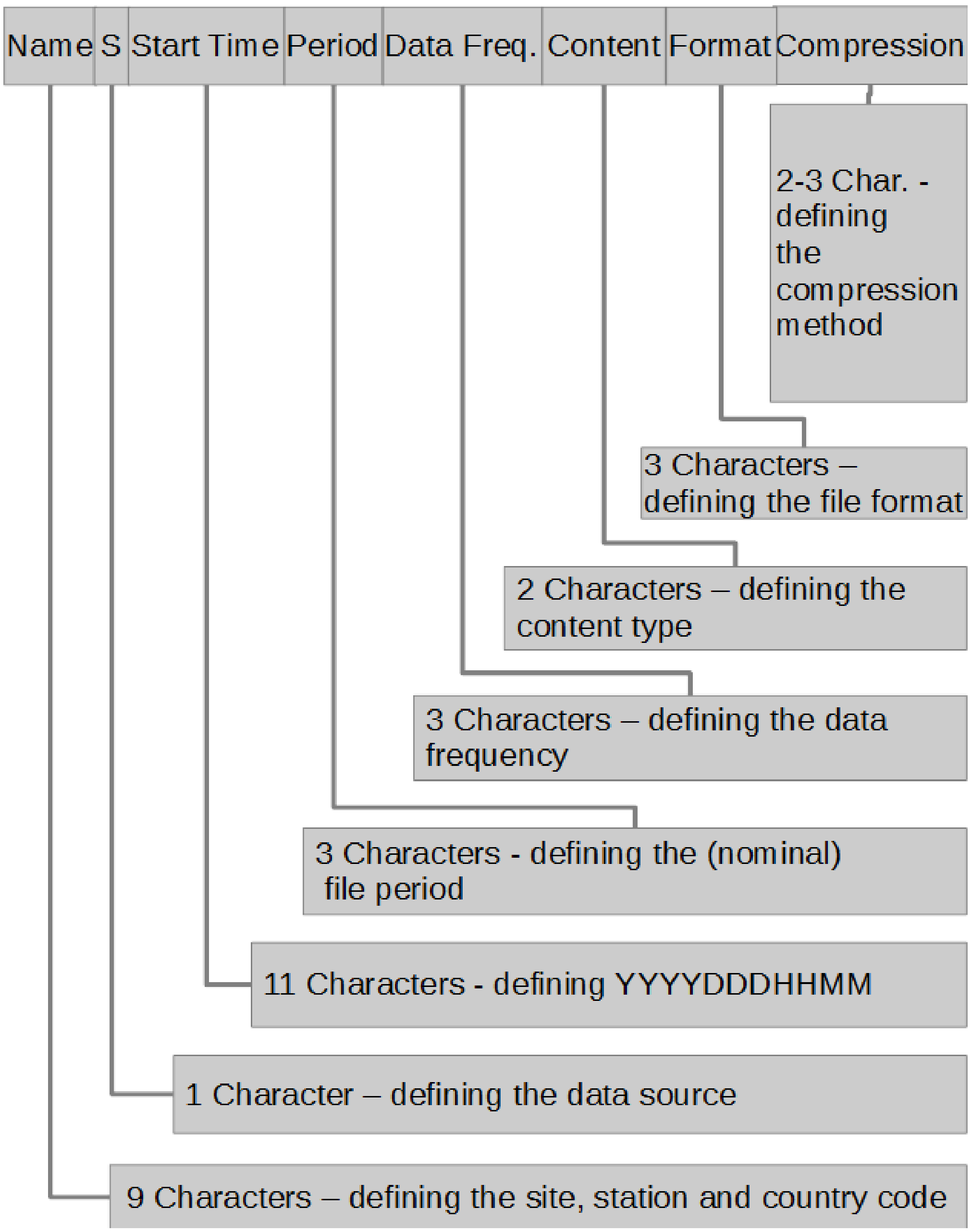

Figure 2: Recommended filename parameters.

All elements are fixed length and are separated by an underscore “_” except for the: file type and compression fields that use a period “.” as a separator. Fields must be padded with zeros to fill the field width. The file compression field is optional. See Appendix A1 for a detailed description of the RINEX 3.02 (and subsequent versions) file naming convention. Table 2 below lists sample file names for GNSS observation and navigation files.

File Name	Comments
ALGO00CAN_R_20121601000_01H_01S_MO.rnx	Mixed RINEX GNSS observation file containing 1 hour of data, with an observation every second.
ALGO00CAN_R_20121601000_15M_01S_GO.rnx	GPS RINEX observation file containing 15 minutes of data, with an observation every second.
ALGO00CAN_R_20121601000_01H_05Z_MO.rnx	Mixed RINEX GNSS observation file containing 1 hour of data, with 5 observations per second.
ALGO00CAN_R_20121601000_01D_30S_GO.rnx	GPS RINEX observation file containing 1 day of data, with an observation every 30 seconds.
ALGO00CAN_R_20121601000_01D_30S_MO.rnx	Mixed RINEX GNSS observation file containing 1 day of data, with an observation every 30 seconds.
ALGO00CAN_R_20121600000_01D_GN.rnx	RINEX GPS navigation file, containing one day’s data.
ALGO00CAN_R_20121600000_01D_RN.rnx	RINEX GLONASS navigation file, containing one day’s data
ALGO00CAN_R_20121600000_01D_MN.rnx	RINEX mixed navigation file, containing one day’s data

Table 2: Description of Filename Parameters

In order to further reduce the size of observation files Yuki Hatanaka developed a compression scheme that takes advantage of the structure of the RINEX observation data by forming higher-order differences in time between observations of the same type and satellite. This compressed file is also an ASCII file that is subsequently compressed again using standard compression programs.

More information on the Hatanaka compression scheme can be found in:

- **http://terras.gsi.go.jp/ja/crx2rnx.html**
- IGSMails 1525,1686,1726,1763,1785,4967,4969,4975

The file naming and compression recommendations are strictly speaking not part of the RINEX format definition. However, they significantly facilitate the exchange of RINEX data in large user communities like IGS.

5. RINEX VERSION 3 FEATURES

This chapter contains features that have been introduced for RINEX Version 3.

5.1 Observation codes

The new signal structures for GPS, Galileo and BDS make it possible to generate code and phase observations based on one or a combination of several channels: Two-channel signals are composed of I and Q components, three-channel signals of A, B, and C components. Moreover a wideband tracking of a combined E5a + E5b Galileo frequency is possible. In order to keep the observation codes short but still allow for a detailed characterization of the actual signal generation, the length of the codes is increased from two (Version 1 and 2) to three by adding a signal generation attribute. The observation code **tna** consists of three parts:

t :observation type	**C** = pseudorange,	**L** = carrier phase,	**D** = doppler,	**S** = signal strength)
n :band / frequency	**1, 2,...,8**			
a : attribute	tracking mode or channel, e.g., **I**, **Q**, etc			

Table 3: Observation Code Components

Examples:

- **L1C:** C/A code-derived L1 carrier phase (GPS, GLONASS) Carrier phase on E2-L1-E1 derived from C channel (Galileo)
- **C2L:** L2C pseudorange derived from the L channel (GPS)
- **C2X:** L2C pseudorange derived from the mixed (M+L) codes (GPS)

Tables 4 to 10 describe each GNSS constellation and the frequencies and signal encoding methods used.

Unknown tracking modes are not supported in RINEX 3.02 and 3.03. Only the complete specification of all signals is allowed i.e. all three fields must be defined as specified in Tables 4-10.

GNSS System	Freq. Band /Frequency	Channel or Code	Observation Codes			
			Pseudo Range	Carrier Phase	Doppler	Signal Strength
GPS	L1/1575.42	C/A	C1C	L1C	D1C	S1C
		L1C (D)	C1S	L1S	D1S	S1S
		L1C (P)	C1L	L1L	D1L	S1L
		L1C (D+P)	C1X	L1X	D1X	S1X
		P (AS off)	C1P	L1P	D1P	S1P
		Z-tracking and similar (AS on)	C1W	L1W	D1W	S1W
		Y	C1Y	L1Y	D1Y	S1Y
		M	C1M	L1M	D1M	S1M
		codeless		L1N	D1N	S1N
	L2/1227.60	C/A	C2C	L2C	D2C	S2C
		L1(C/A)+(P2-P1) (semi-codeless)	C2D	L2D	D2D	S2D
		L2C (M)	C2S	L2S	D2S	S2S
		L2C (L)	C2L	L2L	D2L	S2L
		L2C (M+L)	C2X	L2X	D2X	S2X
		P (AS off)	C2P	L2P	D2P	S2P
		Z-tracking and similar (AS on)	C2W	L2W	D2W	S2W
		Y	C2Y	L2Y	D2Y	S2Y
		M	C2M	L2M	D2M	S2M
		codeless		L2N	D2N	S2N
	L5/1176.45	I	C5I	L5I	D5I	S5I
		Q	C5Q	L5Q	D5Q	S5Q
		I+Q	C5X	L5X	D5X	S5X

Table 4 : RINEX Version 3.03 GPS Observation Codes

GNSS System	Freq. Band /Frequency	Channel or Code	Observation Codes			
			Pseudo Range	Carrier Phase	Doppler	Signal Strength
GLONASS	G1/ 1602+k*9/16 k= -7….+12	C/A	C1C	L1C	D1C	S1C
		P	C1P	L1P	D1P	S1P
	G2/ 1246+k*716	C/A (GLONASS M)	C2C	L2C	D2C	S2C
		P	C2P	L2P	D2P	S2P
	G3 / 1202.025	I	C3I	L3I	D3I	S3I
		Q	C3Q	L3Q	D3Q	S3Q
		I+Q	C3X	L3X	D3X	S3X

Table 5 : RINEX Version 3.03 GLONASS Observation Codes

GNSS System	Freq. Band /Frequency	Channel or Code	Observation Codes			
			Pseudo Range	Carrier Phase	Doppler	Signal Strength
Galileo	E1 / 1575.42	A PRS	C1A	L1A	D1A	S1A
		B I/NAV OS/CS/SoL	C1B	L1B	D1B	S1B
		C no data	C1C	L1C	D1C	S1C
		B+C	C1X	L1X	D1X	S1X
		A+B+C	C1Z	L1Z	D1Z	S1Z
	E5a / 1176.45	I F/NAV OS	C5I	L5I	D5I	S5I
		Q no data	C5Q	L5Q	D5Q	S5Q
		I+Q	C5X	L5X	D5X	S5X
	E5b / 1207.140	I I/NAV OS/CS/SoL	C7I	L7I	D7I	S7I
		Q no data	C7Q	L7Q	D7Q	S7Q
		I+Q	C7X	L7X	D7X	S7X
	E5(E5a+E5b) / 1191.795	I	C8I	L8I	D8I	S8I
		Q	C8Q	L8Q	D8Q	S8Q
		I+Q	C8X	L8X	D8X	S8X
	E6 / 1278.75	A PRS	C6A	L6A	D6A	S6A
		B C/NAV CS	C6B	L6B	D6B	S6B
		C no data	C6C	L6C	D6C	S6C
		B+C	C6X	L6X	D6X	S6X
		A+B+C	C6Z	L6Z	D6Z	S6Z

Table 6 : RINEX Version 3.03 Galileo Observation Codes

For Galileo the band/frequency number **n** does not necessarily agree with the official frequency numbers: **n** = 7 for E5b, **n** = 8 for E5a+b.

GNSS System	Freq. Band/ Frequency	Channel or Code	Observation Codes			
			Pseudo Range	Carrier Phase	Doppler	Signal Strength
SBAS	L1 / 1575.42	C/A	C1C	L1C	D1C	S1C
	L5 / 1176.45	I	C5I	L5I	D5I	S5I
		Q	C5Q	L5Q	D5Q	S5Q
		I+Q	C5X	L5X	D5X	S5X

Table 7 : RINEX Version 3.03 SBAS Observation Codes

GNSS System	Freq. Band / Frequency	Channel or Code	Observation Codes			
			Pseudo Range	Carrier Phase	Doppler	Signal Strength
QZSS	L1 / 1575.42	C/A	C1C	L1C	D1C	S1C
		L1C (D)	C1S	L1S	D1S	S1S
		L1C (P)	C1L	L1L	D1L	S1L
		L1C (D+P)	C1X	L1X	D1X	S1X
		L1-SAIF	C1Z	L1Z	D1Z	S1Z
	L2 / 1227.60	L2C (M)	C2S	L2S	D2S	S2S
		L2C (L)	C2L	L2L	D2L	S2L
		L2C (M+L)	C2X	L2X	D2X	S2X
	L5 / 1176.45	I	C5I	L5I	D5I	S5I
		Q	C5Q	L5Q	D5Q	S5Q
		I+Q	C5X	L5X	D5X	S5X
	LEX(6) / 1278.75	S	C6S	L6S	D6S	S6S
		L	C6L	L6L	D6L	S6L
		S+L	C6X	L6X	D6X	S6X

Table 8 : RINEX Version 3.03 QZSS Observation Codes

GNSS System	Freq. Band / Frequency	Channel or Code	Observation Codes			
			Pseudo Range	Carrier Phase	Doppler	Signal Strength
BDS	B1 / 1561.098	I	C2I	L2I	D2I	S2I
		Q	C2Q	L2Q	D2Q	S2Q
		I+Q	C2X	L2X	D2X	S2X
	B2 / 1207.14	I	C7I	L7I	D7I	S7I
		Q	C7Q	L7Q	D7Q	S7Q
		I+Q	C7X	L7X	D7X	S7X
	B3 / 1268.52	I	C6I	L6I	D6I	S6I
		Q	C6Q	L6Q	D6Q	S6Q
		I+Q	C6X	L6X	D6X	S6X

Table 9 : RINEX Version 3.03 BDS Observation Codes

Note: When reading a RINEX 3.02 file, both C1x and C2x coding should be accepted and treated as C2x in RINEX 3.03.

GNSS System	Freq. Band / Frequency	Channel or Code	Observation Codes			
			Pseudo Range	Carrier Phase	Doppler	Signal Strength
IRNSS	L5 / 1176.45	A SPS	C5A	L5A	D5A	S5A
		B RS (D)	C5B	L5B	D5B	S5B
		C RS (P)	C5C	L5C	D5C	S5C
		B+C	C5X	L5X	D5X	S5X
	S / 2492.028	A SPS	C9A	L9A	D9A	S9A
		B RS (D)	C9B	L9B	D9B	S9B
		C RS (P)	C9C	L9C	D9C	S9C
		B+C	C9X	L9X	D9X	S9X

Table 10 : RINEX Version 3.03 IRNSS Observation Codes

GPS-SBAS and –pseudorandom noise (PRN) code assignments:
See e.g., http://www.losangeles.af.mil/library/factsheets/factsheet.asp?id=8618

Antispoofing (AS) of GPS: True codeless GPS receivers (squaring-type receivers) use the attribute **N**. Semi-codeless receivers tracking the first frequency using C/A code and the second frequency using some codeless options use attribute **D**. Z-tracking under AS or similar techniques to recover pseudorange and phase on the "P-code" band use attribute **W**. Y-code tracking receivers (e.g. units employing a Selective Availability Anti-Spoofing Module (SAASM)) use attribute **Y**.

Appendix Table A23 enumerates the fractional phase corrections required to align each signal to the frequencies reference signal.

As all observations affected by "AS on" now get their own attribute (codeless, semi-codeless, Z-tracking and similar) the Antispoofing flag introduced into the observation data records of RINEX Version 2 has become obsolete.

5.2 Satellite system-dependent list of observables

The order of the observations stored per epoch and satellite in the observation records is given by a list of observation codes in a header record. As the types of the observations actually generated by a receiver may heavily depend on the satellite system, RINEX Version 3 requests system-dependent observation code lists (header record type **`SYS / # / OBS TYPES`**).

5.3 Marker type

In order to indicate the nature of the marker, a **`MARKER TYPE`** header record has been defined. Proposed keywords are given in Table 11.

Marker Type	Description
Geodetic	Earth-fixed high-precision monument
Non Geodetic	Earth-fixed low-precision monument
Non_Physical	Generated from network processing
Space borne	Orbiting space vehicle
Air borne	Aircraft, balloon, etc.
Water Craft	Mobile water craft
Ground Craft	Mobile terrestrial vehicle
Fixed Buoy	"Fixed" on water surface
Floating Buoy	Floating on water surface
Floating Ice	Floating ice sheet, etc
Glacier	"Fixed" on a glacier
Ballistic	Rockets, shells, etc
Animal	Animal carrying a receiver
Human	Human being

Table 11: Proposed Marker Type Keywords

The record is required except for **`GEODETIC`** and **`NON_GEODETIC`** marker types.

Attributes other than **`GEODETIC`** and **`NON_GEODETIC`** will tell the user program that the data were collected by a moving receiver. The inclusion of a "start moving antenna" record (event flag 2) into the data body of the RINEX file is therefore not necessary. Event flags 2 and 3 (See Appendix A3) are still necessary to flag alternating kinematic and static phases of a receiver visiting multiple earth-fixed monuments, however. Users may define other project-dependent keywords.

5.4 Half-wavelength observations, half-cycle ambiguities

Half-wavelength observations (collected by **codeless** squaring techniques) get their own observation codes. A special wavelength factor header line and bit 1 of the LLI flag in the observation records are no longer necessary. If a receiver changed between squaring and full cycle tracking within the time period of a RINEX file, observation codes for both types of observations have to be inserted into the respective **`SYS / # / OBS TYPES`** header record.

Half-wavelength phase observations are stored in full cycles. Ambiguity resolution however has to account for half wavelengths!

Full-cycle observations collected by receivers with possible half cycle ambiguity (e.g., during acquisition or after loss of lock) are to be flagged with Loss of Lock Indicator bit 1 set (see Appendix Table A3). Note: The loss of lock bit is the least significant bit.

5.5 Scale factor

The *optional* **`SYS / SCALE FACTOR`** record allows the storage of phase data with 0.0001 of a cycle resolution, if the data was multiplied by a scale factor of 10 before being stored into the RINEX file. This feature is used to increase resolution by 10, 100, etc only. It is a modification of the Version 2.20 **`OBS SCALE FACTOR`** record.

5.6 Information about receivers on a vehicle

For the processing of data collected by receivers on a vehicle, the following additional information can be provided by special header records:

- Antenna position (position of the antenna reference point) in a body-fixed coordinate system: **`ANTENNA: DELTA X/Y/Z`**
- Boresight of antenna: The unit vector of the direction of the antenna axis towards the GNSS satellites. It corresponds to the vertical axis on earth-bound antenna: **`ANTENNA: B.SIGHT XYZ`**
- Antenna orientation: Zero-direction of the antenna. Used for the application of "azimuth"-dependent phase center variation models (see 6.14 below): **`ANTENNA: ZERODIR XYZ`**
- Current center of mass of the vehicle (for space borne receivers): **`CENTER OF MASS: XYZ`**
- Average phase center position: **`ANTENNA: PHASECENTER (`**see below)

All three quantities have to be given in the same body-fixed coordinate system. The attitude of the vehicle has to be provided by separate attitude files in the same body-fixed coordinate system.

5.7 Signal strength

The generation of the RINEX signal strength indicators sn_rnx in the data records (1 = very weak,…,9 = very strong) are standardized in case the raw signal strength[1] sn_raw is given in **dbHz**:

```
sn_rnx  =  MIN(MAX(INT(sn_raw/6),1),9)
```

Carrier to Noise ratio(dbHz)	Carrier to Noise ratio(RINEX)
< 12	1 (minimum possible signal strength)
12-17	2
18-23	3
24-29	4
30-35	5 (threshold for good tracking)
36-41	6
42-47	7
48-53	8
≥ 54	9 (maximum possible signal strength)

Table 12: Standardized S/N Indicators

The raw carrier to noise ratio can be optionally (preferred) stored as **`Sna`** observations in the data records and should be given in dbHz if possible. The new **`SIGNAL STRENGTH UNIT`** header record can be used to indicate the units of these observations.

5.8 Date/time format in the PGM / RUN BY / DATE header record

The format of the generation time of the RINEX files stored in the second header record **`PGM / RUN BY / DATE`** is now defined to be

`yyyymmdd hhmmss zone`

`zone:` 3 – 4 character code for the time zone

It is recommended to use **`UTC`** as the time zone. Set **`zone`** to **`LCL`** if local time was used with unknown local time system code.

[1]S/N is the raw S/N at the output of the correlators, without attempting to recover any correlation losses

5.9 Antenna phase center header record

An *optional* header record for antenna phase center positions **ANTENNA: PHASECENTER** is defined to allow for higher precision positioning without need of additional external antenna information. It can be useful in well-defined networks or applications. It contains the position of an *average* phase center relative to the antenna reference point (ARP) for a specific frequency and satellite system. On vehicles the phase center position can be reported in the body-fixed coordinate system (**ANTENNA: DELTA X/Y/Z**). See 6.14 below. See section 5.15 regarding the use of phase center variation corrections.

5.10 Antenna orientation

Header records have been defined to report the orientation of the antenna zero-direction as well as the direction of its vertical axis (bore-sight) if mounted tilted on a fixed station. The header records can also be used for antennas on vehicles. See 6.14 below.

5.11 Observation data records

Aside from the new observation code definitions, the most conspicuous modification of the RINEX format concerns the observation records. As the types of the observations and their order within a data record depend on the satellite system, the new format should make it easier for programs as well as human beings to read the data records. Each observation record begins with the satellite number **snn**, the epoch record starts with special character **>**. It is now also much easier to synchronize the reading program with the next epoch record in case of a corrupted data file or when streaming observation data in a RINEX-like format. The record length limitation to 80 characters of RINEX Versions 1 and 2 ***has been removed***.

For the following list of observation types for the four satellite systems **G,S,E,R :**

```
G    5 C1P L1P L2X C2X S2X                                  SYS / # / OBS TYPES
R    2 C1C L1C                                              SYS / # / OBS TYPES
E    2 L1B L5I                                              SYS / # / OBS TYPES
S    2 C1C L1C                                              SYS / # / OBS TYPES
```

Table 13: Example Observation Type Records

The epoch and observation records are as follows:

```
> 2006 03 24 13 10 54.0000000  0  7      -0.123456789210
G06  23619095.450      -53875.632 8    -41981.375 5  23619112.008          24.158
G09  20886075.667      -28688.027 9    -22354.535 6  20886082.101          38.543
G12  20611072.689       18247.789 9     14219.770 8  20611078.410          32.326
R21  21345678.576       12345.567 5
R22  22123456.789       23456.789 5
E11     65432.123 5     48861.586 7
S20  38137559.506      335849.135 9
```

Table 14: Example Observation Data Records

The receiver clock correction in the epoch record has been placed such that it could be preceded by an identifier to make it system-dependent in a later format revision, if necessary. The clock correction is optional and is given in units of seconds.

5.12 Ionosphere delay as pseudo-observables

RINEX files could also be used to make available additional information linked to the actual observations. One such element is the ionosphere delay having been determined or derived from an ionosphere model. We add the ionosphere phase delay expressed in full cycles of the respective satellite system-dependent wavelength as pseudo-observable to the list of the RINEX observables.

`T`: observation type	`I =` Ionosphere phase delay
`n`: band/frequency	`1, 2, ...,8`
`a`: attribute	blank

Table 15: Ionosphere Pseudo-Observable Coding

The ionosphere pseudo-observable has to be included into the list of observables of the respective satellite system. Only one ionosphere observable per satellite is allowed.

The user adds the ionosphere delay to the raw phase observation of the same wavelength and converts it to other wavelengths and to pseudorange corrections in meters:

corr_phase(fi)	=	raw_phase(fi)	+	d_ion(fi)
corr_prange(fi)	=	raw_prange(fi)	-	d_ion(fi) • c/fi
d_ion(fk)	=	d_ion(fi)	•	(fi/fk)**2 (accounting for 1st order effects only)

Table 16: Ionosphere Pseudo-Observable Corrections to Observations

d_ion(fi): Given ionospheric phase correction for frequency fi

5.13 Channel numbers as pseudo-observables

For special applications it might be necessary to know the receiver channel numbers having been assigned by the receiver to the individual satellites. We may include this information as another pseudo-observable:

- `t` : observation type: `X` = Receiver channel number
- `n` : band / frequency : `1`
- `a` : attribute: blank

The lowest channel number allowed is 1 (re-number channels beforehand, if necessary). In case of a receiver using multiple channels for one satellite, the channels could be packed with two digits each right-justified into the same data field, order corresponding to the order of the observables concerned. Format F14.3 according to (<5-nc>(2X),<nc>I2.2,'.000'), nc being the number of channels.

Restriction: Not more than 5 channels and channel numbers <100.

Examples:

- **0910.000** for channels 9 and 10
- **010203.000** for channels 1, 2, and 3

-----F14.3----

5.14 Corrections of differential code biases (DCBs)

For special high-precision applications it might be useful to generate RINEX files with corrections of the differential code biases (DCBs) already applied. There are programs available to correct the observations in RINEX files for differential code biases (e.g., **cc2noncc**, J. Ray 2005). This can be reported by special header records **`SYS / DCBS APPLIED`** pointing to the file containing the applied corrections.

5.15 Corrections of antenna phase center variations (PCVs)

For more precise applications, an elevation-dependent or elevation and azimuth-dependent phase center variation (pcv) model for the antenna (referring to the agreed-upon ARP) should be used. For special applications it might be useful to generate RINEX files with these variations already applied. This can be reported by special header records **`SYS / PCVS APPLIED`** pointing to the file containing the PCV correction models.

5.16 Navigation message files

The header portion has been unified (with respect to the format definitions) for all satellite systems. The first record of each data block now contains the code for the satellite system and the satellite number.

```
G06 1999 09 02 17 51 44 -.839701388031D-03 -.165982783074D-10  .000000000000D+00
```

Table 17: Example of Navigation File Satellite System and Number Definition Record

Header records with system-dependent contents also contain the system identifier. They are repeated for each system, if applicable.

```
GPSA    .1676D-07   .2235D-07   .1192D-06   .1192D-06       IONOSPHERIC CORR
GPSB    .1208D+06   .1310D+06  -.1310D+06  -.1966D+06       IONOSPHERIC CORR
GAL     .1234D+05   .2345D+04  -.3456D+03                   IONOSPHERIC CORR
```

Table 18: Example of Navigation File Header IONOSPHERIC CORR Record

6. ADDITIONAL HINTS AND TIPS

6.1 Versions

Programs developed to read RINEX files have to verify the version number. Files of newer versions may look different even if they do not use any of the newer features

6.2 Leading blanks in CHARACTER fields

We propose that routines to read files automatically delete leading blanks in any CHARACTER input field. Routines creating RINEX files should also left-justify all variables in the CHARACTER fields.

6.3 Variable-length records

ASCII files usually have variable record lengths, so we recommend to first read each observation record into a blank string long enough to accommodate the largest possible observation record[2] and decode the data afterwards. In variable length records, empty data fields at the end of a record may be missing, especially in the case of the optional receiver clock offset.

6.4 Blank fields

In view of future modifications we recommend to carefully skip any fields currently defined to be blank (format fields nX), because they may be assigned to new contents in future versions.

6.5 Order of the header records, order of data records

As the header record descriptors in columns 61-80 are mandatory, the programs reading a RINEX Version 3 header must decode the header records with formats according to the record descriptor, provided the records have been first read into an internal buffer.

We therefore propose to allow free ordering of the header records, with the following exceptions:

- The **RINEX VERSION / TYPE** record must be the first record in a file
- The **SYS / # / OBS TYPES** record(s) should precede any **SYS / DCBS APPLIED** and **SYS / SCALE FACTOR** records
- The **# OF SATELLITES** record (if present) should be immediately followed by the corresponding number of **PRN / # OF OBS** records. These records may be handy for documentary purposes. However, since they may only be created after having read whole raw data file we define them to be optional.
- The **END OF HEADER** of course is the last record in the header

[2] Record is defined by the satellite system with the largest number of possible observables plus any "pseudo-observables" such as ionosphere etc. The length limitation to 80 characters of RINEX Versions 1 and 2 has been removed.

Data records: Multiple epoch observation data records with identical time tags are not allowed (exception: Event records). Epochs have to appear ordered in time.

6.6 Missing items, duration of the validity of values

Items that are not known at the file creation time can be set to zero or blank (Blank if Not Known - BNK) or the respective record may be completely omitted. Consequently items of missing header records will be set to zero or blank by the program reading RINEX files. Trailing blanks may be truncated from the record.

Each value remains valid until changed by an additional header record.

6.7 Unknown / Undefined observation types and header records

It is a good practice for a program reading RINEX files to make sure that it properly deals with unknown observation types, header records or event flags by skipping them and/or reporting them to the user. The program should also check the RINEX version number in the header record and take proper action if it cannot deal with it.

6.8 Event flag records

The "number of satellites" also corresponds to the number of records of the same epoch following the ***EPOCH*** record. Therefore, it may be used to skip the appropriate number of data records if certain event flags are not to be evaluated in detail.

6.9 Receiver clock offset

A receiver-derived clock offset can optionally be reported in the RINEX observation files. In order to remove uncertainties about whether the data (epoch, pseudorange, phase) have been corrected or not by the reported clock offset, RINEX Versions 2.10 onward requests a clarifying header record: **RCV CLOCK OFFS APPL**. It would then be possible to reconstruct the original observations, if necessary.

6.10 Two-digit years

RINEX version 2 stores the years of data records with two digits only. The header of observation files contains a **TIME OF FIRST OBS** record with the full four-digit year; the GPS nav. messages contain the GPS week numbers. From these two data items the unambiguous year can easily be reconstructed.

A hundred-year ambiguity occurs in the met data and GLONASS and GEO nav. messages: instead of introducing a new **TIME OF FIRST OBS** header line it is safe to stipulate that any two-digit years in RINEX Version 1 and Version 2.xx files are understood to represent

80-99:	1980-1999
00-79:	2000-2079

Full 4-digit year fields are defined in RINEX version 3 files.

6.11 Fit interval (GPS navigation message file)

Bit 17 in word 10 of subframe 2 is a "fit interval" flag which indicates the curve-fit interval used by the GPS Control Segment in determining the ephemeris parameters, as follows (see IS-GPS-200H, 20.3.3.4.3.1):

0 = 4 hours
1 = greater than 4 hours.

Together with the IODC values and Table 20-XII (of the ICD) the actual fit interval can be determined. The second value in the last record of each message shall contain the fit interval in hours determined using IODC, fit flag, and Table 20-XII, according to the Interface Document IS-GPS-200H. Note: The QZSS fit interval is not defined the same way as it is in GPS, See Appendix 12.

6.12 Satellite health (GPS navigation message file)

The health of the signal components (bits 18 to 22 of word three in subframe one) are included from version 2.10 on using the health value reported in the second field of the sixth navigation message record.

A program reading RINEX files could easily decide if bit 17 only or all bits (17-22) have been written:

RINEX Value:	0	Health OK
RINEX Value:	1	Health not OK (bits 18-22 not stored)
RINEX Value:	>32	Health not OK (bits 18-22 stored)

Table 19: Description of GPS Satellite Health Field

6.13 Transmission time of message (GPS navigation message file)

The transmission time of a message can be shortly before midnight Saturday/Sunday, with the ToE and ToC of the message already in the next week.

As the reported week in the RINEX nav message (***BROADCAST ORBIT -5*** record) goes with ToE (this is different from the GPS week in the original satellite message!), the transmission time of message should be reduced by 604800 (i.e., will become negative) to also refer to the same week.

6.14 Antenna references, phase centers

We distinguish between

- The ***marker***, i.e. the geodetic reference monument, on which an antenna is mounted directly with forced centering or on a tripod

- The ***antenna reference point*** (ARP), i.e., a well-defined point on the antenna, e.g., the center of the bottom surface of the preamplifier. The antenna height is measured from the marker to the ARP and reported in the **ANTENNA: DELTA H/E/N** header record.

Small horizontal eccentricities of the ARP w/r to the marker can be reported in the same record. On vehicles the position of the ARP is reported in the body-fixed coordinate system in an **`ANTENNA: DELTA X/Y/Z`** header record.

- The ***average phase center***: A frequency-dependent and minimum elevation-angle-dependent position of the average phase center above the antenna reference point. Its position is important to know in mixed-antenna networks. It can be given in an absolute sense or relative to a reference antenna using the optional header record: **`ANTENNA: PHASECENTER`**. For fixed stations the components are in north/east/up direction, on vehicles the position is reported in the body-fixed system X,Y,Z. For more precise applications an elevation-dependent or elevation and azimuth-dependent phase center variation (PCV) model for the antenna (referring to the agreed-upon ARP) should be used. For special applications it might be useful to generate RINEX files with these corrections already applied. This can be reported by special header records **`SYS / PCVS APPLIED`** pointing to the file containing the PCV correction models.

- The ***orientation*** of the antenna: The “zero direction” is usually oriented towards north on fixed stations. Deviations from the north direction can be reported with the azimuth of the zero-direction in an **`ANTENNA: ZERODIR AZI`** header record. On vehicles the zero-direction is reported as a unit vector in the body-fixed coordinate system in an **`ANTENNA: ZERODIR XYZ`** header record. The zero direction of a tilted antenna on a fixed station can be reported as unit vector in the left-handed north/east/up local coordinate system in an **`ANTENNA: ZERODIR XYZ`** header record.

- The ***boresight direction*** of an antenna on a vehicle: The “vertical” symmetry axis of the antenna pointing towards the GNSS satellites. It can be reported as unit vector in the body-fixed coordinate system in the **`ANTENNA: B.SIGHT XYZ`** record. A tilted antenna on a fixed station could be reported as unit vector in the left-handed north/east/up local coordinate system in the same type of header record.

To be able to interpret the various positions correctly it is important that the **`MARKER TYPE`** record is included in the RINEX header.

7. RINEX UNDER ANTISPOOFING (AS)

Some receivers generate code (pseudorange) delay differences between the first and second frequency using cross-correlation techniques when AS is on and may recover the phase observations on L2 in full cycles. Using the C/A code delay on L1 and the observed difference it is possible to generate a code delay observation for the second frequency. Other receivers recover P code observations by breaking down the Y code into P and W code.

Most of these observations may suffer from an increased noise level. To enable post-processing programs to take special actions, AS-infected observations have been flagged in RINEX Version 2 using bit number 2 of the Loss of Lock Indicators (i.e. their current values are increased by 4). In Version 3 there are special attributes for the observation type to more precisely characterize the observable (codeless, semi-codeless, Z-tracking or similar techniques when AS on, L2C, P-code when AS off, Y-code tracking), making the AS flag obsolete.

8. DEALING WITH DIFFERENT SATELLITE SYSTEMS

8.1 Time system identifier

GPS time runs, apart from small differences (<< 1 microsecond), parallel to UTC. But it is a continuous time scale, i.e. it does not insert any leap seconds. GPS time is usually expressed in GPS weeks and GPS seconds past 00:00:00 (midnight) Saturday/Sunday. GPS time started with week zero at 00:00:00 UT (midnight) on January 6, 1980. Between 1980 and 2012 16 leap seconds have been introduced into UTC.

The GPS week is transmitted by the satellites as a 10 bit number. It has a roll-over after week 1023. The first roll-over happened on August 22, 1999, 00:00:00 GPS time.

In order to avoid ambiguities, the GPS week reported in the RINEX navigation message files is a continuous number without roll-over, i.e. …1023, 1024, 1025, …

We use **GPS** as time system identifier for the reported GPS time.

QZSS runs on QZSS time, which conforms to UTC Japan Standard Time Group (JSTG) time and the offset with respect to GPS time is controlled. The following properties apply to the QZSS time definition: the length of one second is defined with respect to International Atomic Time (TAI); QZSS time is aligned with GPS time (offset from TAI by integer seconds); the QZSS week number is defined with respect to the GPS week.

We use **QZS** as a time system identifier for the reported QZSS time

GLONASS is basically running on UTC (or, more precisely, GLONASS system time linked to UTC(SU)), i.e. the time tags are given in UTC and not GPS time. It is not a continuous time, i.e. it introduces the same leap seconds as UTC. The reported GLONASS time has the same hours as UTC and not UTC+3 h as the original GLONASS System Time!

We use **GLO** as time system identifier for the reported GLONASS time.

Galileo runs on Galileo System Time (GST), which is, apart from small differences (tens of nanoseconds), nearly identical to GPS time:

- The Galileo week starts at midnight Saturday/Sunday at the same second as the GPS week
- The GST week as transmitted by the satellites is a 12 bit value with a roll-over after week 4095. The GST week started at zero at the first roll-over of the broadcast GPS week after 1023, i.e. at Sun, 22-Aug-1999 00:00:00 GPS time.

In order to remove possible misunderstandings and ambiguities, the Galileo week reported in the

RINEX navigation message files is a continuous number without roll-over, i.e., …4095,4096,4097,… and *it is aligned to the GPS week.*

We use **GAL** as time system identifier for this reported Galileo time.

The **BDS** Time (BDT) System is a continuous timekeeping system, with its length of second being an SI second. BDT zero time started at 00:00:00 UTC on January 1st, 2006 (GPS week 1356) therefore BDT is 14 seconds behind GPS time. BDT is synchronized with UTC within 100 nanoseconds (modulo 1 second).

- The **BDT** week starts at midnight Saturday/Sunday
- The **BDT** week is transmitted by the satellites as a 13 bit number. It has a roll-over after week 8191. In order to avoid ambiguities, the BDT week reported in the RINEX navigation message files is a continuous number without roll-over, i.e. …8191, 8192, 8193, …

We use **BDT** as time system identifier for the reported BDS time.

IRNSS runs on Indian Regional Navigation Satellite System Time (**IRNSST**). The **IRNSST** start epoch is 00:00:00 on Sunday August 22nd, 1999, which corresponds to August 21st, 1999, 23:59:47 UTC (same time as the first GPS week roll over). Seconds of week are counted from 00:00:00 **IRNSST** hours Saturday/Sunday midnight which also corresponds to the start of the GPS week. Week numbers are consecutive from the start time and will roll over after week 1023 (at the same time as GPS and QZSS roll over).

We use **IRN** as the time system identifier for the reported IRNSS time.

Constellation /Archival Time Representation	GPS Ephemeris Week Period #1	GPS Ephemeris Week Period #2	GPS Ephemeris Week Period #3	GPS Ephemeris Week Period #4	GPS Ephemeris Week Period #5	GPS Ephemeris Week Period #6
GPS Broadcast	0 – 1023	0 – 1023	0 – 1023	0 – 1023	0 – 1023	0 – 1023
QZSS Broadcast		0 – 1023	0 – 1023	0 – 1023	0 – 1023	0 – 1023
IRNSS Broadcast		0 – 1023	0 – 1023	0 – 1023	0 – 1023	0 – 1023
GST Broadcast		0 – 1023	1024 – 2047	2048 – 3071	3072 – 4095	0 – 1023
BDS Broadcast and RINEX		0(RINEX Week 1356) – 691	692 – 1715	1716 – 2739	2740 – 3763	3764 – 4787
GPS/QZS/IRN/ GAL RINEX	0 – 1023	1024 – 2047	2048 – 3071	3072 – 4095	4096 – 5119	5120 -6143

Table 20: Relationship between GPS, QZSS, IRN, GST, GAL, BDS and RINEX Week Numbers

The header records **`TIME OF FIRST OBS`** and (if present) **`TIME OF LAST OBS`** in pure GPS, GLONASS, Galileo, QZSS or BDS observation files **can** (in mixed

GPS/GLONASS/Galileo/QZSS/BDS/IRNSS observation files **must)** contain the time system identifier defining the system that all time tags in the file are referring to:

- **GPS** to identify GPS time
- **GLO** to identify the GLONASS UTC time system
- **GAL** to identify Galileo time
- **QZS** to identify QZSS time
- **BDT** to identify BDS time
- **IRN** to identify IRNSS time

Pure GPS observation files default to **GPS**, pure GLONASS files default to **GLO**, pure Galileo files default to **GAL** and similarly pure BDS observation files default to BDT (same for QZSS and IRNSS).

Apart from the small errors in the realizations of the different time systems, the relations between the systems are:

GLO	=	UTC	=	GPS	-	ΔtLS
GPS	=	GAL	=	UTC	+	ΔtLS
GPS	=	QZS	=	UTC	+	ΔtLS
GPS	=	IRN	=	UTC	+	ΔtLS
BDT	=			UTC	+	ΔtLS_{BDS}

Table 21: Constellation Time Relationships

Where:

ΔtLS	=	Delta time between GPS and UTC due to leap seconds, as transmitted by the GPS satellites in the almanac (2005: ΔtLS = 13, 2006: ΔtLS = 14, 2008: ΔtLS = 15 and 2012: ΔtLS = 16).
ΔtLS_{BDS}	=	Delta time between BDT and UTC due to leap seconds, as transmitted by the BDS satellites in the almanac (2006: $\Delta tLS_{BDS} = 0$, 2008: $\Delta tLS_{BDS} = 1$ and 2012: $\Delta tLS_{BDS} = 2$). See BDS-SIS-ICD-2.0 Section 5.2.4.17

Table 22: GPS and BeiDou UTC Leap Second Relationship

In order to have the current number of leap seconds available, we recommend including ΔtLS by adding a **LEAP SECOND** line into the RINEX file header.

If there are known non-integer biases between “GPS receiver clock”, “GLONASS receiver clock”, “BDS receiver clock” or “Galileo receiver clock” in the same receiver, they should be applied in the process of RINEX conversion. In this case, the respective code and phase observations have to be corrected too (c * bias if expressed in meters).

Unknown biases will have to be solved for during the post processing.

The small differences (modulo 1 second) between: BDS system time, Galileo system time, GLONASS system time, UTC(SU), UTC(USNO) and GPS system time have to be dealt with during the post-processing and not before the RINEX conversion. It may also be necessary to solve for remaining differences during the post-processing.

8.2 Pseudorange definition

The pseudorange (code) measurement is defined to be equivalent to the difference of the time of reception (expressed in the time frame of the receiver) and the time of transmission (expressed in the time frame of the satellite) of a distinct satellite signal.

In a mixed-mode GPS/GLONASS/Galileo/QZSS/BDS receiver referring all pseudorange observations to one receiver clock only,

- the raw GLONASS pseudoranges will show the current number of leap seconds between GPS/GAL/BDT time and GLONASS time if the receiver clock is running in the GPS, GAL or BDT time frame
- the raw GPS, Galileo and BDS pseudoranges will show the negative number of leap seconds between GPS/GAL/BDT time and GLONASS time if the receiver clock is running in the GLONASS time frame

In order to avoid misunderstandings and to keep the code observations within the format fields, the pseudo-ranges must be corrected in this case as follows:

PR_mod(GPS)	=	PR(GPS)	+	C* ΔtLS	if generated with a receiver clock running in the GLONASS time frame
PR_mod(GAL)	=	PR(GAL)	+	C* ΔtLS	if generated with a receiver clock running in the GLONASS time frame
PR_mod(BDT)	=	PR(BDT)	+	C* ΔtLS_{BDS}	if generated with a receiver clock running in the GLONASS time frame
PR_mod(GLO)	=	PR(GLO)	-	C* ΔtLS	if generated with a receiver clock running in the GPS or GAL time frame
PR_mod(GLO)	=	PR(GLO)	-	C*ΔtLS_{BDS}	if generated with a receiver clock running in the BDT time frame
PR_mod(GPS)	=	PR(GPS)	+	C*(ΔtLS-ΔtLS_{BDS})	if generated with a receiver clock running in the BDT time frame

Table 23: Constellation Pseudorange Corrections

to remove the contributions of the leap seconds from the pseudoranges.

ΔtLS is the actual number of leap seconds between GPS/GAL and GLO time, as broadcast in the GPS almanac and distributed in Circular T of BIPM.

ΔtLS_{BDS} is the actual number of leap seconds between BDT and UTC time, as broadcast in the BDT almanac.

8.3 RINEX navigation message files

The header section of the RINEX version 3.XX navigation message files have been slightly changed compared to the previous version 2. The format of the header section is identical for all satellite systems: GPS, GLONASS, Galileo, SBAS, QZSS and IRNSS. One exception is that BDS “IONOSPHERIC CORR” message has a few extra fields (See: Appendix Table A5).

The data portion of the navigation message files contains records with floating point numbers. The format is identical for all satellite systems; the number of records per message and the contents, however, are satellite system-dependent. The format of the version 3 data records has been changed slightly; the satellite codes now also contain the satellite system identifier.

It is possible to generate mixed navigation message files, i.e. files containing navigation messages of more than one satellite system. Header records with system-dependent contents have to be repeated for each satellite system, if applicable. Using the satellite system identifier of the satellite code the reading program can determine the number of data records to be read for each message block.

The time tags of the navigation messages (e.g., time of ephemeris, time of clock) are given in the respective satellite time systems!

It is recommended to avoid storing redundant navigation messages (e.g., the same message broadcast at different times) in the RINEX file.

8.3.1 RINEX navigation message files for GLONASS

The header section and the first data record (epoch, satellite clock information) are equal to the GPS navigation file. The following three records contain the satellite position, velocity and acceleration, the clock and frequency biases, as well as auxiliary information such as health, satellite frequency (channel) and age of the information.

The corrections of the satellite time to UTC are as follows:

GPS: Tutc = Tsv –af0 –af1 *(Tsv-Toc) -... –A0 -... –ΔtLS
GLONASS: Tutc = Tsv + TauN –GammaN*(Tsv-Tb) + TauC

In order to use the same sign conventions for the GLONASS corrections as in the GPS navigation files, the broadcast GLONASS values are stored as: -TauN, +GammaN, -TauC.

Table 24: GLONASS Navigation File Data, Sign Convention

The time tags in the GLONASS navigation files are given in UTC (i.e. **not** Moscow time or GPS time).

8.3.2 RINEX navigation message files for Galileo

The Galileo Open Service allows access to two navigation message types: F/NAV (Freely Accessible Navigation) and I/NAV (Integrity Navigation). The content of the two messages differs in various items, however, in general it is very similar to the content of the GPS navigation message, e.g. the orbit parameterization is the same.

There are items in the navigation message that depend on the origin of the message (F/NAV or I/NAV): The SV clock parameters actually define the satellite clock for the dual-frequency ionosphere-free linear combination. F/NAV reports the clock parameters valid for the E5a-E1 combination, the I/NAV reports the parameters for the E5b-E1 combination. The second parameter in the ***`Broadcast Orbit 5`*** record (bits 8 and 9) indicate the frequency pair the stored clock corrections are valid for.

Some parameters contain the information stored bitwise. The interpretation is as follows:

- Convert the floating point number read from the RINEX file into the nearest integer
- Extract the values of the requested bits from the integer

Example:

0.170000000000D+02 -> 17 = 2^4+2^0 -> Bits 4 and 0 are set, all others are zero

RINEX file encoders should encode one RINEX Galileo navigation message for each I/NAV and F/NAV signal decoded. Therefore if both: I/Nav and F/Nav messages are decode, then the relevant bit fields must be set in the RINEX message and both should be written in separate messages. The Galileo ICD (2010) Section 5.1.9.2 indicates that some of the contents of the broadcast navigation message may change, yet the issue of data (IOD) may not change. So that all relevant information is available message encoders should monitor the contents of the file and write new navigation messages when the contents have changed.

RINEX file parsers should expect to encounter F/NAV and I/NAV messages with the same IOD in the same file. Additionally, parsers should also expect to encounter more than one F/NAV or I/NAV ephemeris message with the same IOD, as the navigation message Data Validity Status (DVS) and other parameters may change independently of the IOD, yet some other data may be the same, however, the transmission time will be updated (See Note in Galileo ICD (2010) Section 5.1.9.2 Issue of Data).

As mentioned above, the GAL week in the RINEX navigation message files is a continuous number; it has been aligned to the GPS week by the program creating the RINEX file.

8.3.3 RINEX navigation message files for GEO satellites

As the GEO broadcast orbit format differs from the GPS message, a special GEO navigation message file format has been defined which is nearly identical with the GLONASS navigation message file format.

The header section contains information about the generating program, comments, and the difference between the GEO system time and UTC.

The first data record contains the epoch and satellite clock information; the following records contain the satellite position, velocity and acceleration and auxiliary information (health, URA and IODN).

The time tags in the GEO navigation files are given in the GPS time frame, i.e. **not** UTC.

The corrections of the satellite time to UTC are as follows:

GEO: Tutc = Tsv –aGf0 –aGf1 *(Tsv-Toe) –W0 –ΔtLS

W0 being the correction to transform the GEO system time to UTC. See Toe, aGf0, aGf1 in the Appendix A16 format definition table.

The *Transmission Time of Message* (**`PRN / EPOCH / SV CLK`** header record) is expressed in GPS seconds of the week. It marks the beginning of the message transmission. It has to refer to the same GPS week as the *Epoch of Ephemerides*. It has to be adjusted by –or + 604800 seconds, if necessary (which would make it lower than zero or larger than 604800, respectively). It is a redefinition of the Version 2.10 *Message frame time*.

Health shall be defined as follows:

- bits 0 to 3 equal to *health* in Message Type 17 (MT17)
- bit 4 is set to 1 if MT17 health is unavailable
- bit 5 is set to 1 if the URA index is equal to 15

8.3.4 RINEX navigation message files for QZSS L1-SAIF

As the QZSS L1-SAIF broadcast orbit format differs from the GPS message, a special L1-SAIF navigation message file format has been defined which is nearly identical with the GEO navigation message file format (See A16).

The header section contains information about the generating program, comments, and the difference between the L1-SAIF system time and UTC.

The first data record contains the epoch and satellite clock information, the following records contain the satellite position, velocity and acceleration and auxiliary information such as health, age of the data, etc. To compute L1-SAIF satellite position, note that acceleration in navigation message represents only perturbation term and it is necessary to add :

The time tags in the L1-SAIF navigation files are given in the GPS time frame, i.e. **not** UTC.

The corrections of the satellite time to UTC are as follows:

SAIF: Tutc = Tsv –aGf0 –aGf1 *(Tsv-Toe) –W0 –ΔtLS

W0 being the correction to transform the L1-SAIF system time to UTC. Toe, aGf0, aGf1 see below in the format definition tables.

The *Transmission Time of Message* (**`PRN / EPOCH / SV CLK`** header record) is expressed in GPS seconds of the week. It marks the beginning of the message transmission. It has to refer to the same GPS week as the *Epoch of Ephemerides*. It has to be adjusted by –or + 604800 seconds, if necessary (which would make it lower than zero or larger than 604800, respectively).

Health shall be defined as follows:

- bits 0 to 3 equal to *health* in Message Type 17 (MT17)
- bit 4 is set to 1 if MT17 health is unavailable
- bit 5 is set to 1 if the URA index is equal to 15

Note that accelerations represent only lunar and solar perturbation terms and satellite position can be computed based on equations in Section A.3.1.2 of GLONASS ICD version 5.0. See Appendix A16

8.3.5 RINEX navigation message files for BDS

The BDS Open Service broadcast navigation message is similar in content to the GPS navigation message.

The header section and the first data record (epoch, satellite clock information) are equal to the GPS navigation file. The following six records are similar to GPS.

The BDT week number is a continuous number. The broadcast 13-bit BDS System Time week has a roll-over after 8191. It starts at zero on: 1-Jan-2006, hence BDT week = BDT week_BRD + (n*8192) (Where n: number of BDT roll-overs). See Appendix Table A14 for details.

8.3.6 RINEX navigation message files for IRNSS

The IRNSS Open Service broadcast navigation message is similar in content to the GPS navigation message.

The header section and the first data record (epoch, satellite clock information) are equal to the GPS navigation file. See Appendix Tables A18 and A19 for a description and example of each field.

8.4 RINEX observation files for GEO satellites

A separate satellite system identifier has been defined for the Satellite-Based Augmentation System (SBAS) payloads. **`S`**, is to be used in the **`RINEX VERSION / TYPE`** header line and in the satellite identifier **`snn`**, **`nn`** being the GEO PRN number minus 100.

e.g.: PRN = 120 ⇒**`snn`** = **`S20`**

In mixed dual frequency GPS satellite / single frequency GEO payload observation files, the fields for the second frequency observations of SBAS satellites remain blank, are set to zero values or (if last in the record) can be truncated.

The time system identifier of GEO satellites generating GPS signals defaults to GPS time. In the SBAS message definitions, bit 3 of the health word is currently marked as *reserved*. In case of bit 4 set to 1, it is recommended to set bits 0,1,2,3 to 1, as well.

User Range Accuracy (URA):

The same convention for converting the URA index to meters is used as with GPS. Set URA = 32767 meters if URA index = 15.

Issue Of Data Navigation (IODN)

The IODN is defined as the 8 first bits after the message type 9, called *IODN* in RTCA DO229, Annex A and Annex B and called *spare* in Annex C.

The **D-UTC A0, A1, T, W, S, U** record in Version 2.11 has been renamed the **TIME SYSTEM CORR** record in RINEX 3.x.

9. MODIFICATIONS FOR VERSION 3.01, 3.02 and 3.03

9.1 Phase Cycle Shifts

Carrier phases tracked on different signal channels or modulation bands of the same frequency may differ in phase by 1/4 (e.g., GPS: P/Y-code-derived L2 phase vs. L2C-based phase) or, in some exceptional cases, by other fractional parts of a cycle. Appendix Table23 specifies the reference signal and the phase shifts that are specified by the Interface Control Documentation (ICD) for each constellation.

All phase observations **must** be aligned in RINEX 3.01 and later files and the new **`SYS / PHASE SHIFT`** header is mandatory. See Appendix Table A2 for the messages definition. If the phase alignment is not known, then the observation data **should not** be published in a RINEX 3.0x file. In order to facilitate data processing, phase observations stored in RINEX files **must** be consistent across all satellites of a satellite system and across each frequency band. Within a RINEX 3.0x file:

- All phase observations must be aligned to the designated constellation and frequency reference signal as specified in Appendix Table A23, either directly by the receiver or by a correction program or the RINEX conversion program, prior to RINEX file generation. Additionally, all data must be aligned with the appropriate reference signal indicated in Appendix Table A23 even when the receiver or reporting device is not tracking and/or providing data from that reference signal e.g. Galileo L5X phase data must be aligned to L5I.

- Phase corrections must be reported in a new mandatory **`SYS / PHASE SHIFT`** header record to allow the reconstruction of the original values, if needed. The uncorrected reference signal group of observations are left blank in the **`SYS / PHASE SHIFT`** records. Appendix Table A23 specifies the reference signal that should be used by each constellation and frequency band. Additionally, Appendix Table A23 indicates the relationship between the phase observations for each frequency's signals.

Concerning the mandatory **`SYS / PHASE SHIFT header`** records:

- If the **`SYS / PHASE SHIFT`** record values are set to zero in the RINEX file, then either the raw data provided by the receiver or the data format (RTCM-Multiple Signal Messages format for example) have already been aligned and the RINEX conversion program did not apply any phase corrections since they had already been applied. In this case Appendix Table A23 can be used to determine the fractional cycles that had been added to each signal's phase observation to align the phase observations to the reference signal.
- If the file does not contain any observation pairs affected by phase shifts (i.e. only reference signals reported), the observation code field is defined and the rest of the **`SYS / PHASE SHIFT`** header record field of the respective satellite system(s) are left blank.
- If the reported phase correction of an observation type does not affect all satellites of the same system, the header record allows for the affected satellites to be indicated.
- If the applied phase corrections or the phase alignment is unknown, the observation code field and the rest of the **`SYS / PHASE SHIFT`** header record field of the respective satellite system(s) are left blank. This use case is intended for exceptional situations where the data is intended for special projects and analysis.

Sign of the correction Δφ:

φRINEX	=	φ original	+	Δφ
φ original	:	Uncorrected or corrected, i.e. as issued by the GNSS receiver or in a standardized data stream such as RTCM-MSM		
Δφ	:	Phase correction to align the phase to other phases of the same frequency but different channel / modulation band		

Table 25: RINEX Phase Alignment Correction Convention

Example (Definition see Appendix Table A2):

```
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
G L2S -0.25000  03 G15  G16 G17                              SYS / PHASE SHIFT
```

Table 26: Example SYS / PHASE SHIFT Record

9.2 Galileo: BOC-Tracking of an MBOC-Modulated Signal

Galileo E1 will be modulated by the so-called MBOC modulation. Obviously it is possible for a receiver to track the signal also in a BOC mode, though leading to different noise characteristics. In order to keep this non-standard tracking mode of a MBOC signal apart, bit 2 of the loss-of-lock indicator LLI (the antispoofing flag not used for Galileo) in the observation data records is used.

Non-standard BOC tracking of an MBOC-modulated signal: Increase the LLI by 4.

Note: This flag is intended for experimental applications and is optional. In future releases of RINEX this non-standard tracking mode flag may be removed.

Example: Satellite E11, BOC tracking on L1C, LLI = 4:

```
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
G    5 C1C L1W L2W C1W S2W                                  SYS / # / OBS TYPES
R    2 C1C L1C                                              SYS / # / OBS TYPES
E    2 L1C L5I                                              SYS / # / OBS TYPES
S    2 C1C L1C                                              SYS / # / OBS TYPES
    18.000                                                  INTERVAL
                                                            END OF HEADER
> 2006 03 24 13 10 36.0000000  0  5      -0.123456789012
G06  23629347.915            .300 8         -.353 4  23629347.158          24.158
G09  20891534.648           -.120 9         -.358 6  20891545.292          38.123
G12  20607600.189           -.430 9          .394 5  20607600.848          35.234
E11          .32448          .178 7
S20  38137559.506      335849.135 9
```

Table 27: Example of RINEX Coding of Galileo BOC Tracking of an MBOC Signal Record

9.3 BDS Satellite System Code

The satellite system code for BeiDou navigation satellite System (BDS) has been defined as “C”, see Figure 1.

9.4 New Observation Codes for GPS L1C and BDS

New observation codes for GPS L1C and BDS observables have been defined: See Tables 4 and 9.

9.5 Header Records for GLONASS Slot and Frequency Numbers

In order to make available a cross-reference list between the GLONASS slot numbers used in the RINEX files to designate the GLONASS satellites and the allotted frequency numbers, a mandatory observation file header record is assigned. This allows processing of GLONASS files without having to get this information from GLONASS navigation message files or other sources.

Example (Definition See Appendix Table A2):

```
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
 18 R01  1 R02  2 R03  3 R04  4 R05  5 R06 -6 R07 -5 R08 -4 GLONASS SLOT / FRQ #
    R09 -3 R10 -2 R11 -1 R12  0 R13  1 R14  2 R15  3 R16  4 GLONASS SLOT / FRQ #
```

```
   R17  5 R18 -5                                              GLONASS SLOT / FRQ #
```

Table 28: Example of a GLONASS Slot- Frequency Records

9.6 GNSS Navigation Message File: Leap Seconds Record

The optional **LEAP SECONDS** record was modified to also include ΔtLS (or ΔtLS_{BDS} for BDS), WN_{LSF} (adjusted to continuous week number) and DN.

9.7 Clarifications in the Galileo Navigation Message File:

Some clarifications in the Galileo ***BROADCAST ORBIT – 5*** and ***BROADCAST ORBIT – 6*** records were added (see Table A8).

9.8 Quasi-Zenith Satellite System (QZSS) Version 3.02

The version number is adjusted to 3.02. Version 3.02 added QZSS: specifications, parameters and definitions to the document. Each QZSS satellite broadcasts signals using two PRN codes. The GPS compatible signals are broadcast using PRN codes in the range of 193-197. In a RINEX observation file the PRN code is: broadcast prn - 192, yielding: J01, J02 etc.. QZSS satellites also broadcast a SBAS signal (QZSS-SAIF) using PRN codes in the range of 183-187. In a RINEX SBAS file the PRN code is: broadcast prn - 100, yielding: S83, S84 etc..

See Appendix Table A23 to convert each signal's aligned phase observations back to raw satellite phase.

9.9 GLONASS Mandatory Code-Phase Alignment Header Record

Recent analysis has revealed that some GNSS receivers produce biased GLONASS observations. The code-phase bias results in the code and phase observations not being measured at the same time. To remedy this problem, a mandatory GLONASS Code-Phase header bias record is required. Although this header message is mandatory, it can contain zeros if the GLONASS data issued by the receiver is aligned. See the GLONASS CODE/PHASE BIAS (**GLONASS COD/PHS/BIS**) definition in Appendix Table A2. The GLONASS code-phase alignment message contains: L1C, L1P, L2C and L2P corrections. Phase data from GNSS receivers that issue biased data has to be corrected by the amount specified in the **GLONASS COD/PHS/BIS** record before it is written in RINEX format.

To align the non-aligned L1C phase to the pseudo range observation, the following correction is required:

AlignedL1Cphase = ObservedL1Cphase + (GLONASSC1C_CodePhaseBias_M / Lambda)

where:

- AlignedL1C phase in cycles (written to RINEX file)
- ObservedL1C phase in cycles
- GLONASSC1C_CodePhaseBias_M is in metres
- Lamba is the wavelength for the particular GLONASS frequency

GLONASS L1P, L2C and L2P are handled in the same manner.

Example (See Appendix Table A2 for details) :

```
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
 C1C  -10.000 C1P  -10.123 C2C  -10.432 C2P  -10.634        GLONASS COD/PHS/BIS#
```

Table 29: Example of GLONASS Code Phase Bias Correction Record

Note: If the GLONASS code phase alignment is unknown, then all fields within GLONASS COD/PHS/BIS header record are left blank (see example below). This use case is intended for exceptional situations where the data is intended for special projects and analysis.

```
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
                                                            GLONASS COD/PHS/BIS#
```

Table 30: Example of Unknown GLONASS Code Phase Bias Record

9.10 BDS system (Replaces Compass)

Added BDS: naming convention, time system definition, header section description, and parameters throughout the document. Updated: Sections: 8.1, 8.2, 8.3.5, 9.11 and Appendix Table A2, added ephemeris Table A14 and updated Table A23.

9.11 Indian Regional Navigation Satellite System (IRNSS) Version 3.03

The RINEX version number was changed to 3.03. Version 3.03 adds IRNSS, specifications, parameters and definitions to this document.

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Document: RTCM Standard 10403.2, Differential GNSS (Global Navigation Satellite Systems) Services – Version 3, November 7, 2013.

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APPENDIX: RINEX FORMAT DEFINITIONS AND EXAMPLES

A 1 RINEX File name description

Table A1
RINEX File name description

Field	**Field Description**	**Example**	**Required**	**Comment/Example**
<SITE/ STATION-MONUMENT/ RECEIVER/ COUNTRY/	XXXXMRCCC Where: XXXX - existing IGS station name M – monument or marker number (0-9) R – receiver number (0-9) CCC – ISO Country code (Total 9 characters)	ALGO00CAN	Yes	File name supports a maximum of 10 monuments at the same station and a maximum of 10 receivers per monument. Country codes follow : ISO 3166-1 alpha-3
<DATA SOURCE>	Data Source R – From Receiver data using vendor or other software S – From data Stream (RTCM or other) U – Unknown (1 character)	R	Yes	This field is used to indicate how the data was collected either from the receiver at the station or from a data stream
<START TIME>	YYYYDDDHHMM YYYY – Gregorian year 4 digits, DDD – day of Year, HHMM – hours and minutes of day (11 characters)	2012150 1200	Yes	For GPS files use : GPS Year, day of year, hour of day, minute of day (see text below for details) Start time should be the nominal start time of the first observation. GLONASS, Galileo, BeiDou etc use respective time system.
<FILE PERIOD>	DDU DD – file period U – units of file period. File period is used to specify intended collection period of the file. (3 characters)	15M	Yes	File Period 15M–15 Minutes 01H–1 Hour 01D–1 Day 01Y–1 Year 00U-Unspecified
<DATA FREQ>	DDU	05Z	Mandatory for	XXC – 100 Hertz XXZ – HertZ,

Table A1

RINEX File name description

Field	Field Description	Example	Required	Comment/Example
	DD – data frequency U – units of data rate (3 characters)		RINEX Obs. Data. NOT required for Navigation Files.	XXS – Seconds, XXM – Minutes, XXH – Hours, XXD – Days XXU – Unspecified
<DATA TYPE >	DD DD – Data type (2 characters)	MO	Yes	Two characters represent the data type: GO - GPS Obs., RO - GLONASS Obs., EO - Galileo Obs. JO - QZSS Obs. CO - BDS Obs. IO – IRNSS Obs. SO - SBAS Obs. MO Mixed Obs. GN - Nav. GPS, RN- Glonass Nav., EN- Galileo Nav., JN- QZSS Nav., CN- BDS Nav. IN – IRNSS Nav. SN- SBAS Nav. MN- Nav. All GNSS Constellations) MM-Meteorological Observation Etc
<FORMAT>	FFF FFF – File format (3 characters)	rnx	Yes	Three character indicating the data format : RINEX - rnx, Hatanaka Compressed RINEX – crx, ETC
<COMPRESSION>	(2-3 Characters)	gz	No	gz
Sub Total	34 or 35			Fields
Separators	(7 characters –Obs. File) (6 characters –Eph. File)			_ under score between all fields and "." Between data type and file format and the compression method
Total	41-42(Obs. File) 37-38 (Eph. File)			Mandatory IGS RINEX obs. Characters

Filename Details and Examples:

<STATION/PROJECT NAME>: IGS users should follow XXXXMRCCC (9 char) site nd station naming convention described above.

GNSS industry users could use the 9 characters to indicate the project name and/or number.

<**DATA SOURCE**>: With real-time data streaming RINEX files for the same station can be created at many locations. If the RINEX file is derived from data collected at the receiver (official file) then the source is specified as R. On the other hand if the RINEX file is derived from a real-time data stream then the data source is marked as S to indicate Streamed data source. If the data source is unknown the source is marked as U.

<START TIME>: The start time is the file start time which should coincide with the first observation in the file. GPS file start time is specified in GPS Time. Mixed observation file start times are defined in the same time system as the file observation time system specified in the header. Files containing only: GLONASS, Galileo, QZSS, BDS or SBAS observations are all based on their respective time system.

<FILE PERIOD>: Is used to specify the data collection period of the file.

GNSS observation file name - file period examples:

ALGO00CAN_R_20121601000_15M_01S_GO.rnx.gz //15 min, GPS Obs. 1 sec.
ALGO00CAN_R_20121601000_01H_05Z_MO.rnx.gz //1 hour, Obs Mixed and 5Hz
ALGO00CAN_R_20121601000_01D_30S_GO.rnx.gz //1 day, Obs GPS and 30 sec
ALGO00CAN_R_20121601000_01D_30S_MO.rnx.gz //1 day, Obs. Mixed, 30 sec

GNSS navigation file name - file period examples:

ALGO00CAN_R_20121600000_15M_GN.rnx.gz // 15 minute GPS only
ALGO00CAN_R_20121600000_01H_GN.rnx.gz // 1 hour GPS only
ALGO00CAN_R_20121600000_01D_MN.rnx.gz // 1 day mixed

<DATA FREQ>: Used to distinguish between observation files that cover the same period but contain data at a different sampling rate. GNSS data file - observation frequency examples:

ALGO00CAN_R_20121601000_01D_01C_GO.rnx.gz //100 Hz data rate
ALGO00CAN_R_20121601000_01D_05Z_RO.rnx.gz //5 Hz data rate
ALGO00CAN_R_20121601000_01D_01S_EO.rnx.gz //1 second data rate

ALGO00CAN_R_20121601000_01D_05M_JO.rnx.gz //5 minute data rate
ALGO00CAN_R_20121601000_01D_01H_CO.rnx.gz //1 hour data rate
ALGO00CAN_R_20121601000_01D_01D_SO.rnx.gz //1 day data rate
ALGO00CAN_R_20121601000_01D_00U_MO.rnx.gz //Unspecified

Note : Data frequency field not required for RINEX Navigation files.

< DATA TYPE/ FORMAT/>: The data type describes the content of the file. The first character indicates constellation and the second indicates whether the files contains observations or navigation data. The next three characters indicate the data file format. GNSS observation filename - format/data type examples:

ALGO00CAN_R_20121601000_15M_01S_GO.rnx.gz //RINEX obs. GPS
ALGO00CAN_R_20121601000_15M_01S_RO.rnx.gz //RINEX obs. GLONASS
ALGO00CAN_R_20121601000_15M_01S_EO.rnx.gz //RINEX obs. Galileo
ALGO00CAN_R_20121601000_15M_01S_JO.rnx.gz //RINEX obs. QZSS
ALGO00CAN_R_20121601000_15M_01S_CO.rnx.gz //RINEX obs. BDS
ALGO00CAN_R_20121601000_15M_01S_SO.rnx.gz //RINEX obs. SBAS
ALGO00CAN_R_20121601000_15M_01S_MO.rnx.gz //RINEX obs. mixed

GNSS navigation filename examples:

ALGO00CAN_R_20121600000_01H_GN.rnx.gz //RINEX nav. GPS
ALGO00CAN_R_20121600000_01H_RN.rnx.gz //RINEX nav. GLONASS
ALGO00CAN_R_20121600000_01H_EN.rnx.gz //RINEX nav. Galileo
ALGO00CAN_R_20121600000_01H_JN.rnx.gz //RINEX nav. QZSS
ALGO00CAN_R_20121600000_01H_CN.rnx.gz //RINEX nav. BDS
ALGO00CAN_R_20121600000_01H_SN.rnx.gz //RINEX nav. SBAS
ALGO00CAN_R_20121600000_01H_MN.rnx.gz //RINEX nav. mixed

<COMPRESSION>:

Valid compression methods include: gzip - “.gz”, bzip2 - “.bz2” and “.zip”.

A 2 GNSS Observation Data File -Header Section Description

TABLE A2 GNSS OBSERVATION DATA FILE - HEADER SECTION DESCRIPTION		
HEADER LABEL (Columns 61-80)	**DESCRIPTION**	**FORMAT**
RINEX VERSION / TYPE	– Format version : **3.03** – File type: **O** for Observation Data – Satellite System: **G**: GPS **R**: GLONASS **E**: Galileo **J**: QZSS **C:** BDS **I:** IRNSS **S**: SBAS payload **M**: Mixed	F9.2, 11X, A1,19X, A1,19X
PGM / RUN BY / DATE	– Name of program creating current file – Name of agency creating current file – Date and time of file creation Format: yyyymmdd hhmmss zone zone: 3-4 char. code for time zone. '**UTC** ' recommended! '**LCL** ' if local time with unknown local time system code	A20, A20, A20
*** COMMENT**	– Comment line(s)	A60
MARKER NAME	– Name of antenna marker	A60
*** MARKER NUMBER**	– Number of antenna marker	A20
MARKER TYPE	– Type of the marker: **GEODETIC** : Earth-fixed, high- precision monument **NON_GEODETIC** : Earth-fixed, low-precision monument **NON_PHYSICAL** : Generated from network processing **SPACEBORNE** : Orbiting space vehicle **GROUND_CRAFT** : Mobile terrestrial vehicle **WATER_CRAFT** : Mobile water craft **AIRBORNE:** Aircraft, balloon, etc. **FIXED_BUOY** : "Fixed" on water surface **FLOATING_BUOY**: Floating on water surface **FLOATING_ICE** : Floating ice sheet, etc. **GLACIER** : "Fixed" on a glacier **BALLISTIC** : Rockets, shells, etc **ANIMAL** : Animal carrying a receiver **HUMAN** : Human being	A20,40X

TABLE A2 GNSS OBSERVATION DATA FILE - HEADER SECTION DESCRIPTION		
	Record required except for **GEODETIC** and **NON_GEODETIC** marker types. Users may define other project-dependent keywords.	
OBSERVER / AGENCY	– Name of observer / agency	A20,A40
REC # / TYPE / VERS	– Receiver number, type, and version (Version: e.g. Internal Software Version)	3A20
ANT # / TYPE	– Antenna number and type	2A20
APPROX POSITION XYZ	– Geocentric approximate marker position (Units: Meters, System: ITRS recommended) Optional for moving platforms	3F14.4
ANTENNA: DELTA H/E/N	– Antenna height: Height of the antenna reference point (ARP) above the marker – Horizontal eccentricity of ARP relative to the marker (east/north) All units in meters	F14.4, 2F14.4
*** ANTENNA: DELTA X/Y/Z**	- Position of antenna reference point for antenna on vehicle (m): XYZ vector in body-fixed coord. system	3F14.4
***ANTENNA:PHASECENTER**	Average phase center position w/r to antenna reference point (m) – Satellite system (G/R/E/J/C/I/S) – Observation code – North/East/Up (fixed station) or – X/Y/Z in body-fixed system (vehicle)	 A1, 1X,A3, F9.4, 2F14.4
*** ANTENNA: B.SIGHT XYZ**	– Direction of the “vertical” antenna axis towards the GNSS satellites. Antenna on vehicle: Unit vector in body-fixed coordinate system. Tilted antenna on fixed station: Unit vector in N/E/Up left-handed system.	3F14.4
*** ANTENNA: ZERODIR AZI**	– Azimuth of the zero-direction of a fixed antenna (degrees, from north)	F14.4
*** ANTENNA: ZERODIR XYZ**	– Zero-direction of antenna Antenna on vehicle: Unit vector in body-fixed coordinate system Tilted antenna on fixed station: Unit vector in N/E/Up left-handed system	3F14.4
*** CENTER OF MASS: XYZ**	– Current center of mass (X,Y,Z, meters) of vehicle in body-fixed coordinate system. Same system as used for attitude.	3F14.4
SYS / # / OBS TYPES	– Satellite system code (G/R/E/J/C/I/S) – Number of different observation types for the	A1, 2X,I3,

TABLE A2 GNSS OBSERVATION DATA FILE - HEADER SECTION DESCRIPTION		
	specified satellite system – Observation descriptors: Type Band Attribute – Use continuation line(s) for more than 13 observation descriptors. In mixed files: Repeat for each satellite system. These records should precede any **SYS / SCALE FACTOR** records (see below). The following observation descriptors are defined in RINEX Version 3.XX: Type: **C** = Code / Pseudorange **L** = Phase **D** = Doppler **S** = Raw signal strength(carrier to noise ratio) **I** = Ionosphere phase delay **X** = Receiver channel numbers Band: **1** = L1 (GPS, QZSS, SBAS) G1 (GLO) E1 (GAL) **2** = L2 (GPS, QZSS) G2 (GLO) B1 (BDS) **5** = L5 (GPS, QZSS, SBAS) E5a (GAL) L5 (IRNSS) **6** = E6 (GAL) LEX (QZSS) B3 (BDS) **7** = E5b (GAL) B2 (BDS) **8** = E5a+b (GAL) **9** = S (IRNSS) **0** for type **X** (all) Attribute: **P** = P code-based (GPS,GLO) **C** = C code-based (SBAS,GPS,GLO, QZSS) **D** = semi-codeless (GPS) **Y** = Y code-based (GPS) **M** = M code-based (GPS)	13(1X,A3) 6X, 13(1X,A3)

TABLE A2 GNSS OBSERVATION DATA FILE - HEADER SECTION DESCRIPTION		
	N = codeless (GPS) **A** = A channel (GAL, IRNSS) **B** = B channel (GAL, IRNSS) **C** = C channel (GAL, IRNSS) **I** = I channel (GPS,GAL, QZSS, BDS) **Q** = Q channel (GPS,GAL, QZSS, BDS) **S** = M channel (L2C GPS, QZSS) **L** = L channel (L2C GPS, QZSS) **S** = D channel (GPS, QZSS) **L =** P channel (GPS, QZSS) **X** = B+C channels (GAL, IRNSS) I+Q channels (GPS,GAL, QZSS, BDS) M+L channels (GPS, QZSS) D+P channels (GPS, QZSS) **W** = based on Z-tracking (GPS) (see text) **Z** = A+B+C channels (GAL) All characters in uppercase only! Units : Phase : full cycles Pseudorange : meters Doppler : Hz SNR etc : receiver-dependent Ionosphere : full cycles Channel # : See text Sign definition: See text. The sequence of the observations in the observation records has to correspond to the sequence of the types in this record of the respective satellite system. **Note: In RINEX 3.02 and 3.03 all fields (Type, Band and Attribute) must be defined. Only known tracking modes are allowed.**	
*** SIGNAL STRENGTH UNIT**	– Unit of the carrier to noise ratio observables **Snn** (if present) **DBHZ** : S/N given in dbHz	A20,40X
*** INTERVAL**	– Observation interval in seconds	F10.3
TIME OF FIRST OBS	– Time of first observation record (4-digit-year,	5I6,F13.7,

TABLE A2 GNSS OBSERVATION DATA FILE - HEADER SECTION DESCRIPTION		
	month, day, hour, min, sec) – Time system: **GPS** (=GPS time system) **GLO** (=UTC time system) **GAL** (=Galileo time system) **QZS** (= QZSS time system) **BDT** (= BDS time system) **IRN** (= IRNSS time system) Compulsory in mixed GNSS files Defaults: **GPS** for pure GPS files **GLO** for pure GLONASS files **GAL** for pure Galileo files **QZS** for pure QZSS files **BDT** for pure BDS files **IRN** for pure IRNSS files	5X,A3
*** TIME OF LAST OBS**	– Time of last observation record (4-digit-year, month,day,hour,min,sec) – Time system: Same value as in **TIME OF FIRST OBS** record	5I6,F13.7, 5X,A3
*** RCV CLOCK OFFS APPL**	– Epoch, code, and phase are corrected by applying the realtime-derived receiver clock offset: 1=yes, 0=no; default: 0=no Record required if clock offsets are reported in the **EPOCH/SAT** records	I6
*** SYS / DCBS APPLIED**	– Satellite system (G/R/E/J/C/I/S) – Program name used to apply differential code bias corrections – Source of corrections (URL) Repeat for each satellite system. No corrections applied: Blank fields or record not present.	A1, 1X,A17, 1X,A40
*** SYS / PCVS APPLIED**	– Satellite system (G/R/E/J/C/I/S) – Program name used to apply phase center variation corrections – Source of corrections (URL) Repeat for each satellite system. No corrections applied: Blank fields or record not present.	A1, 1X,A17, 1X,A40
*** SYS / SCALE FACTOR**	– Satellite system (G/R/E/J/C/I/S) – Factor to divide stored observations with before use (1,10,100,1000)	A1, 1X,I4,

TABLE A2 GNSS OBSERVATION DATA FILE - HEADER SECTION DESCRIPTION		
	– Number of observation types involved. 0 or blank: All observation types – List of observation types – Use continuation line(s) for more than 12 observation types. Repeat record if different factors are applied to different observation types. A value of 1 is assumed if record is missing.	2X,I2, 12(1X,A3) 10X, 12(1X,A3)
SYS / PHASE SHIFT	Phase shift correction used to generate phases consistent w/r to cycle shifts – Satellite system (G/R/E/J/C/I/S) – Carrier phase observation code: **Type** **Band** **Attribute** – Correction applied (cycles) – Number of satellites involved 0 or blank: All satellites of system – List of satellites – Use continuation line(s) for more than 10 satellites. Repeat the record for all affected codes. See chapter 9.1 for more details!	A1,1X, A3,1X, F8.5 2X,I2.2, 10(1X,A3) 18X, 10(1X,A3)
GLONASS SLOT / FRQ #	GLONASS slot and frequency numbers – Number of satellites in list List of : – Satellite numbers (system code, slot) – Frequency numbers (-7...+6) – Use continuation lines for more than 8 Satellites	I3,1X, 8(A1,I2.2, 1X,I2,1X) 4X,8(A1, I2.2,1X,I2,1 X)
GLONASS COD/PHS/BIS	– GLONASS Phase bias correction used to align code and phase observations. • GLONASS signal identifier : C1C and Code Phase bias correction (metres) • GLONASS signal identifier : C1P and Code Phase bias correction (metres) • GLONASS signal identifier : C2C and Code Phase bias correction (metres) • GLONASS signal identifier : C2P and Code Phase bias correction (metres)	4(X1,A3,X1 ,F8.3)

TABLE A2 GNSS OBSERVATION DATA FILE - HEADER SECTION DESCRIPTION		
	Note: If the GLONASS code phase bias values are unknown then all fields in the record are left blank (see example in Section 9.9) and only the record header is defined.	
*** LEAP SECONDS**	– Current Number of leap seconds – Future or past leap seconds ΔtLSF(BNK) , i.e. future leap second if the week and day number are in the future. – Respective week number WN_LSF (continuous number) (BNK). For GPS, GAL, QZS and IRN, weeks since 6-Jan-1980. When BDS only file leap seconds specified, weeks since 1-Jan-2006. – Respective day number DN (0-6) BeiDou and (1-7) for GPS and others constellations, (BNK). The day number is the GPS or BeiDou day before the leap second (See Note 1 below). In the case of the Tuesday, June 30/2015 (GPS Week 1851, DN 3) the UTC leap second actually occurred 16 seconds into the next GPS day. – Time system identifier: only GPS and BDS are valid identifiers. Blank defaults to GPS see Notes section below. Notes: 1. GPS, GAL, QZS and IRN time systems are aligned and are equivalent with respect to leap seconds (Leap seconds since 6-Jan-1980).See the GPS almanac, and DN reference IS-GPS-200H 20.3.3.5.2.4. 2. For BDS only observation files, the Number of leap seconds since 1-Jan-2006 as transmitted by the BDS almanac ΔtLS(see BDS-SIS-ICD-2.0 5.2.4.17)	I6, I6, I6, I6 A3
*** # OF SATELLITES**	– Number of satellites, for which observations are stored in the file	I6
*** PRN / # OF OBS**	– Satellite numbers, number of observations for each observation type indicated in the **SYS / # / OBS TYPES** record. – If more than 9 observation types: Use continuation line(s) In order to avoid format overflows, 99999 indicates >= 99999 observations in the RINEX file.	3X, A1,I2.2, 9I6 6X,9I6

TABLE A2 GNSS OBSERVATION DATA FILE - HEADER SECTION DESCRIPTION		
	This record is (these records are) repeated for each satellite present in the data file.	
END OF HEADER	Last record in the header section.	60X

Records marked with * are optional

A 3 GNSS Observation Data File -Data Record Description

TABLE A3 **GNSS OBSERVATION DATA FILE – DATA RECORD DESCRIPTION**	
DESCRIPTION	**FORMAT**
EPOCH record	
– Record identifier : >	A1,
Epoch	
– year (4 digits):	1X,I4,
– month, day, hour, min (two digits)	4(1X,I2.2),
– sec	F11.7,
– Epoch flag, 0: OK 1: power failure between previous and current epoch >1: Special event	2X,I1,
– Number of satellites observed in current epoch	I3,
– (reserved)	6X,
– Receiver clock offset (seconds, optional)	F15.12
Epoch flag = 0 or 1: ***OBSERVATION*** records follow	
– Satellite number	A1,I2.2,
– Observation - repeat within record for each observation	m(F14.3,
– LLI - type (same sequence as given in the respective **SYS / # / OBS TYPES** record)	I1,
– Signal strength	I1)
This record is repeated for each satellite having been observed in the current epoch. The record length is given by the number of observation types for this satellite. Observations: For definition see text. Missing observations are written as 0.0 or blanks. Phase values overflowing the fixed format F14.3 have to be clipped into the valid interval (e.g add or subtract 10**9), set bit 0 of LLI indicator. Loss of lock indicator (LLI). 0 or blank: OK or not known Bit 0 set: Lost lock between previous and current observation: Cycle slip possible. For phase observations only. Note: Bit 0 is the least significant bit. Bit 1 set: Half-cycle ambiguity/slip possible. Software not capable of handling half cycles should skip this observation. Valid for the current epoch only. Bit 2 set: Galileo BOC-tracking of an MBOC-modulated signal (may suffer from increased noise).	

TABLE A3 GNSS OBSERVATION DATA FILE – DATA RECORD DESCRIPTION	
Signal strength projected into interval 1-9: 1: minimum possible signal strength 5: average/good S/N ratio 9: maximum possible signal strength 0 or blank: not known, don't care Standardization for S/N values given in dbHz: See text.	
Epoch flag 2-5: ***EVENT***: *Special records* may follow – Epoch flag • 2: start moving antenna • 3: new site occupation (end of kinematic data) (at least MARKER NAME record follows) • 4: header information follows • 5: external event (epoch is significant, same time frame as observation time tags) – "Number of satellites" contains number of special records to follow. 0 if no special records follow. Maximum number of records: 999 For events without significant epoch the epoch fields in the EPOCH RECORD can be left blank	[2X,I1] [I3]
Epoch flag = 6: ***EVENT***: *Cycle slip records* follow – Epoch flag • 6: cycle slip records follow to optionally report detected and repaired cycle slips (same format as ***OBSERVATIONS*** records; • slip instead of observation; • LLI and signal strength blank or zero)	[2X,I1]

A 4 GNSS Observation Data File – Example #1

```
+--------------------------------------------------------------------------------+
|                                   TABLE A4                                     |
|                     GNSS OBSERVATION DATA FILE - EXAMPLE #1                    |
+--------------------------------------------------------------------------------+

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

     3.03           OBSERVATION DATA    M                   RINEX VERSION / TYPE
G = GPS  R = GLONASS  E = GALILEO  S = GEO  M = MIXED       COMMENT
XXRINEXO V9.9       AIUB                20060324 144333 UTC PGM / RUN BY / DATE
EXAMPLE OF A MIXED RINEX FILE VERSION 3.03                  COMMENT
The file contains L1 pseudorange and phase data of the      COMMENT
geostationary AOR-E satellite (PRN 120 = S20)               COMMENT
A 9080                                                      MARKER NAME
9080.1.34                                                   MARKER NUMBER
BILL SMITH          ABC INSTITUTE                           OBSERVER / AGENCY
X1234A123           GEODETIC            1.3.1               REC # / TYPE / VERS
G1234               ROVER                                   ANT # / TYPE
  4375274.       587466.      4589095.                      APPROX POSITION XYZ
         .9030         .0000         .0000                  ANTENNA: DELTA H/E/N
     0                                                      RCV CLOCK OFFS APPL
G    5 C1C L1W L2W C1W S2W                                  SYS / # / OBS TYPES
R    2 C1C L1C                                              SYS / # / OBS TYPES
E    2 L1B L5I                                              SYS / # / OBS TYPES
S    2 C1C L1C                                              SYS / # / OBS TYPES
    18.000                                                  INTERVAL
G APPL_DCB          xyz.uvw.abc//pub/dcb_gps.dat            SYS / DCBS APPLIED
DBHZ                                                        SIGNAL STRENGTH UNIT
  2006    03    24    13    10   36.0000000     GPS         TIME OF FIRST OBS
 18 R01  1 R02  2 R03  3 R04  4 R05  5 R06 -6 R07 -5 R08 -4 GLONASS SLOT / FRQ #
    R09 -3 R10 -2 R11 -1 R12  0 R13  1 R14  2 R15  3 R16  4 GLONASS SLOT / FRQ #
    R17  5 R18 -5                                           GLONASS SLOT / FRQ #
G L1C                                                       SYS / PHASE SHIFT
G L1W  0.00000                                              SYS / PHASE SHIFT
G L2W                                                       SYS / PHASE SHIFT
R L1C                                                       SYS / PHASE SHIFT
E L1B                                                       SYS / PHASE SHIFT
E L5I                                                       SYS / PHASE SHIFT
S L1C                                                       SYS / PHASE SHIFT
 C1C  -10.000 C1P  -10.123 C2C  -10.432 C2P  -10.634        GLONASS COD/PHS/BIS
                                                            END OF HEADER
> 2006 03 24 13 10 36.0000000  0  5      -0.123456789012
G06  23629347.915            .300 8         -.353 4  23629347.158          24.158
G09  20891534.648           -.120 9         -.358 6  20891545.292          38.123
G12  20607600.189           -.430 9          .394 5  20607600.848          35.234
E11          .324 8          .178 7
S20  38137559.506      335849.135 9
> 2006 03 24 13 10 54.0000000  0  7      -0.123456789210
G06  23619095.450      -53875.632 8    -41981.375 4  23619095.008          25.234
G09  20886075.667      -28688.027 9    -22354.535 7  20886076.101          42.231
G12  20611072.689       18247.789 9     14219.770 6  20611072.410          36.765
R21  21345678.576       12345.567 5
R22  22123456.789       23456.789 5
E11     65432.123 5     48861.586 7
S20  38137559.506      335849.135 9
> 2006 03 24 13 11 12.0000000  2  2
      *** FROM NOW ON KINEMATIC DATA! ***                   COMMENT
      TWO COMMENT LINES FOLLOW DIRECTLY THE EVENT RECORD    COMMENT
```

```
> 2006  3 24 13 11 12.0000000  0  4      -0.123456789876
G06  21110991.756       16119.980 7     12560.510 4  21110991.441          25.543
G09  23588424.398     -215050.557 6   -167571.734 6  23588424.570          41.824
G12  20869878.790     -113803.187 8    -88677.926 6  20869878.938          36.961
G16  20621643.727       73797.462 7     57505.177 2  20621644.276          15.368
>                              3  4
A 9081                                                      MARKER NAME
9081.1.34                                                   MARKER NUMBER
         .9050         .0000         .0000                  ANTENNA: DELTA H/E/N
          --> THIS IS THE START OF A NEW SITE <--           COMMENT
> 2006 03 24 13 12  6.0000000  0  4      -0.123456987654
G06  21112589.384       24515.877 6     19102.763 4  21112589.187          25.478
G09  23578228.338     -268624.234 7   -209317.284 6  23578228.398          41.725
G12  20625218.088       92581.207 7     72141.846 5  20625218.795          35.143
G16  20864539.693     -141858.836 8   -110539.435 2  20864539.943          16.345
> 2006 03 24 13 13  1.2345678  5  0
>                              4  2
      AN EVENT FLAG 5 WITH A SIGNIFICANT EPOCH              COMMENT
  AND AN EVENT FLAG 4 TO ESCAPE FOR THE TWO COMMENT LINES   COMMENT
> 2006 03 24 13 14 12.0000000  0  4      -0.123456012345
G06  21124965.133           0.30213        -0.62614  21124965.275          27.528
G09  23507272.372     -212616.150 7   -165674.789 7  23507272.421          42.124
G12  20828010.354     -333820.093 6   -260119.395 6  20828010.129          37.002
G16  20650944.902      227775.130 7    177487.651 3  20650944.363          18.040
>                              4  1
           *** LOST LOCK ON G 06                            COMMENT
 .
 .
 .
>                              4  1
END OF FILE                                                 COMMENT
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
```

A 4 GNSS Observation Data File – Example #2

```
+------------------------------------------------------------------------------+
|                                   TABLE A4                                   |
|                     GNSS OBSERVATION DATA FILE - EXAMPLE #2                  |
+------------------------------------------------------------------------------+
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
     3.03           OBSERVATION DATA    M                   RINEX VERSION / TYPE
sbf2rin-9.3.3                           20140511 000610 LCL PGM / RUN BY / DATE
faa1                                                        MARKER NAME
92201M012                                                   MARKER NUMBER
Unknown             Unknown                                 OBSERVER / AGENCY
3001320             SEPT POLARX4        2.5.1p1             REC # / TYPE / VERS
725235              LEIAR25.R4      NONE                    ANT # / TYPE
 -5246415.0000 -3077260.0000 -1913842.0000                  APPROX POSITION XYZ
        0.1262        0.0000        0.0000                  ANTENNA: DELTA H/E/N
G   18 C1C L1C D1C S1C C1W S1W C2W L2W D2W S2W C2L L2L D2L  SYS / # / OBS TYPES
       S2L C5Q L5Q D5Q S5Q                                  SYS / # / OBS TYPES
E   16 C1C L1C D1C S1C C5Q L5Q D5Q S5Q C7Q L7Q D7Q S7Q C8Q  SYS / # / OBS TYPES
       L8Q D8Q S8Q                                          SYS / # / OBS TYPES
S    4 C1C L1C D1C S1C                                      SYS / # / OBS TYPES
R   12 C1C L1C D1C S1C C2P L2P D2P S2P C2C L2C D2C S2C      SYS / # / OBS TYPES
C    8 C2I L2I D2I S2I C7I L7I D7I S7I                      SYS / # / OBS TYPES
J   12 C1C L1C D1C S1C C2L L2L D2L S2L C5Q L5Q D5Q S5Q      SYS / # / OBS TYPES
G L1C                                                       SYS / PHASE SHIFT
G L2W                                                       SYS / PHASE SHIFT
G L2L  0.00000                                              SYS / PHASE SHIFT
G L5Q  0.00000                                              SYS / PHASE SHIFT
E L1C  0.00000                                              SYS / PHASE SHIFT
E L5Q  0.00000                                              SYS / PHASE SHIFT
E L7Q  0.00000                                              SYS / PHASE SHIFT
E L8Q  0.00000                                              SYS / PHASE SHIFT
S L1C                                                       SYS / PHASE SHIFT
R L1C                                                       SYS / PHASE SHIFT
R L2P  0.00000                                              SYS / PHASE SHIFT
R L2C                                                       SYS / PHASE SHIFT
C L2I                                                       SYS / PHASE SHIFT
C L7I                                                       SYS / PHASE SHIFT
J L1C                                                       SYS / PHASE SHIFT
J L2L  0.00000                                              SYS / PHASE SHIFT
J L5Q  0.00000                                              SYS / PHASE SHIFT
    30.000                                                  INTERVAL
  2014     5    10     0     0    0.0000000     GPS         TIME OF FIRST OBS
  2014     5    10    23    59   30.0000000     GPS         TIME OF LAST OBS
    72                                                      # OF SATELLITES
 C1C    0.000 C2C    0.000 C2P    0.000                     GLONASS COD/PHS/BIS
DBHZ                                                        SIGNAL STRENGTH UNIT
 24 R01  1 R02 -4 R03  5 R04  6 R05  1 R06 -4 R07  5 R08  6 GLONASS SLOT / FRQ #
    R09 -2 R10 -7 R11  0 R12 -1 R13 -2 R14 -7 R15  0 R16 -1 GLONASS SLOT / FRQ #
    R17  4 R18 -3 R19  3 R20  2 R21  4 R22 -3 R23  3 R24  2 GLONASS SLOT / FRQ #
                                                            END OF HEADER
> 2014 05 10 00 00  0.0000000  0 28
END OF FILE                                                 COMMENT
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
```

A 4 GNSS Observation Data File – Example #3

```
+------------------------------------------------------------------------------+
|                                  TABLE A4                                    |
|                   GNSS OBSERVATION DATA FILE - EXAMPLE #3                    |
+------------------------------------------------------------------------------+
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
     3.03           OBSERVATION DATA    M: MIXED            RINEX VERSION / TYPE
GR25 V3.08                              20140513 072944 UTC PGM / RUN BY / DATE
SNR is mapped to RINEX snr flag value [1-9]                 COMMENT
LX:     < 12dBHz -> 1; 12-17dBHz -> 2; 18-23dBHz -> 3       COMMENT
       24-29dBHz -> 4; 30-35dBHz -> 5; 36-41dBHz -> 6       COMMENT
       42-47dBHz -> 7; 48-53dBHz -> 8; >= 54dBHz -> 9       COMMENT
Tokio                                                       MARKER NAME
TOKI                                                        MARKER NUMBER
SU Japan - Leica Geosystems                                 OBSERVER / AGENCY
1870023             LEICA GR25          3.08/6.401          REC # / TYPE / VERS
                    LEIAS10         NONE                    ANT # / TYPE
 -3956196.8609  3349495.1794  3703988.8347                  APPROX POSITION XYZ
        0.0000        0.0000        0.0000                  ANTENNA: DELTA H/E/N
G   16 C1C L1C D1C S1C C2S L2S D2S S2S C2W L2W D2W S2W C5Q  SYS / # / OBS TYPES
       L5Q D5Q S5Q                                          SYS / # / OBS TYPES
R   12 C1C L1C D1C S1C C2P L2P D2P S2P C2C L2C D2C S2C      SYS / # / OBS TYPES
E   16 C1C L1C D1C S1C C5Q L5Q D5Q S5Q C7Q L7Q D7Q S7Q C8Q  SYS / # / OBS TYPES
       L8Q D8Q S8Q                                          SYS / # / OBS TYPES
C    8 C2I L2I D2I S2I C7I L7I D7I S7I                      SYS / # / OBS TYPES
J   12 C1C L1C D1C S1C C2S L2S D2S S2S C5Q L5Q D5Q S5Q      SYS / # / OBS TYPES
S    4 C1C L1C D1C S1C                                      SYS / # / OBS TYPES
DBHZ                                                        SIGNAL STRENGTH UNIT
     1.000                                                  INTERVAL
  2014    05    13    07    30    0.0000000     GPS         TIME OF FIRST OBS
  2014    05    13    07    34   59.0000000     GPS         TIME OF LAST OBS
     0                                                      RCV CLOCK OFFS APPL
G L1C                                                       SYS / PHASE SHIFT
G L2S -0.25000                                              SYS / PHASE SHIFT
G L2W                                                       SYS / PHASE SHIFT
G L2Q -0.25000                                              SYS / PHASE SHIFT
R L1C                                                       SYS / PHASE SHIFT
R L2P  0.25000                                              SYS / PHASE SHIFT
R L2C                                                       SYS / PHASE SHIFT
E L1C +0.50000                                              SYS / PHASE SHIFT
E L5Q -0.25000                                              SYS / PHASE SHIFT
E L7Q -0.25000                                              SYS / PHASE SHIFT
E L8Q -0.25000                                              SYS / PHASE SHIFT
C L2I                                                       SYS / PHASE SHIFT
C L7I                                                       SYS / PHASE SHIFT
J L1C                                                       SYS / PHASE SHIFT
J L2S                                                       SYS / PHASE SHIFT
J L5Q -0.25000                                              SYS / PHASE SHIFT
S L1C                                                       SYS / PHASE SHIFT
 24 R01  1 R02 -4 R03  5 R04  6 R05  1 R06 -4 R07  5 R08  6 GLONASS SLOT / FRQ #
    R09 -2 R10 -7 R11  0 R12 -1 R13 -2 R14 -7 R15  0 R16 -1 GLONASS SLOT / FRQ #
    R17  4 R18 -3 R19  3 R20  2 R21  4 R22 -3 R23  3 R24  2 GLONASS SLOT / FRQ #
 C1C    0.000 C1P    0.000 C2C    0.000 C2P    0.000        GLONASS COD/PHS/BIS
    16        1694      7                                   LEAP SECONDS
                                                            END OF HEADER
> 2014 05 13 07 30  0.0000000  0 25
END OF FILE                                                 COMMENT
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
```

A 5 GNSS Navigation Message File – Header Section Description

TABLE A5 GNSS NAVIGATION MESSAGE FILE - HEADER SECTION DESCRIPTION		
HEADER LABEL (Columns 61-80)	**DESCRIPTION**	**FORMAT**
RINEX VERSION / TYPE	– Format version : **3.03** – File type ('**N**' for navigation data) – Satellite System: **G**: GPS **R**: GLONASS **E**: Galileo **J**: QZSS **C**: BDS **I:** IRNSS **S**: SBAS Payload **M**: Mixed	F9.2,11X, A1,19X, A1,19X
PGM / RUN BY / DATE	– Name of program creating current file – Name of agency creating current file – Date and time of file creation Format: yyyymmdd hhmmss zone zone: 3-4 char. code for time zone. '**UTC** ' recommended! '**LCL** ' if local time with unknown local time system code	A20, A20, A20
*** COMMENT**	Comment line(s)	A60
*** IONOSPHERIC CORR**	Ionospheric correction parameters – Correction type: **GAL**= Galileo ai0 – ai2 **GPSA**= GPS alpha0 - alpha3 **GPSB**= GPS beta0 - beta3 **QZSA** = QZS alpha0 - alpha3 **QZSB** = QZS beta0 - beta3 **BDSA** = BDS alpha0 - alpha3 **BDSB** = BDS beta0 - beta3 **IRNA** = IRNSS alpha0 - alpha3 **IRNB** = IRNSS beta0 - beta3 – Parameters: GPS: alpha0-alpha3 or beta0-beta3 GAL: ai0, ai1, ai2, Blank QZS: alpha0-alpha3 or beta0-beta3 BDS: alpha0-alpha3 or beta0-beta3 IRN: alpha0-alpha3 or beta0-beta3 – Time mark, Transmission Time (seconds of week) converted to hours of day and then to A-X. See BDS example below:	A4,1X, 4D12.4 1X,A1

TABLE A5 GNSS NAVIGATION MESSAGE FILE - HEADER SECTION DESCRIPTION		
HEADER LABEL (Columns 61-80)	**DESCRIPTION**	**FORMAT**
	A=BDT 00h-01h; B=BDT 01h-02h; ... X= BDT 23h-24h. This field is mandatory for BDS and optional for the other constellations, (BNK). – SV ID, identify which satellite provided the ionospheric parameters. This field is mandatory for BDS and optional for the other constellations (BNK). Note 1: Multiple **IONOSPHERIC CORR** message can be written in the header. Note 2: It is recommended that BDS ionospheric broadcast model parameters from BDS GEO satellites, be given the most priority. Then the parameters from BDS IGSO satellites should be given secondary priority and then tertiary priority is given to BDS MEO satellite ionospheric correction parameters.	 1X,I2
* **TIME SYSTEM CORR**	Corrections to transform the system time to UTC or other time systems – Correction type: **GAUT** = GAL to UTC a0, a1 **GPUT** = GPS to UTC a0, a1 **SBUT** = SBAS to UTC a0, a1 **GLUT** = GLO to UTC a0= -TauC, a1=zero **GPGA** = GPS to GAL a0=A0G, a1=A1G **GLGP** = GLO to GPS a0=TauGPS, a1=zero **QZGP** = QZS to GPS a0, a1 **QZUT** = QZS to UTC a0, a1 **BDUT** =BDS to UTC a0=A_{0UTC}, a1=A_{1UTC} **IRUT** =IRN to UTC a0=A_{0UTC}, a1=A_{1UTC} **IRGP** =IRN to GPS a0=A_0, a1=A_1 – a0,a1 Coefficients of 1-deg polynomial (a0 sec, a1 sec/sec) CORR(s) = a0 + a1*DELTAT – T Reference time for polynomial (Seconds into GPS/GAL/ BDS week) – W Reference week number	 A4,1X, D17.10, D16.9, I7, I5,

TABLE A5 GNSS NAVIGATION MESSAGE FILE - HEADER SECTION DESCRIPTION		
HEADER LABEL (Columns 61-80)	**DESCRIPTION**	**FORMAT**
	(GPS/GAL/BDS/IRN/SBAS week, continuous number from 6-Jan-1980), T and W zero for GLONASS. BDS week, continuous from: 1-Jan-2006 – S **EGNOS**, **WAAS**, or **MSAS** ... (left-justified) Derived from MT17 service provider. If not known: Use **Snn** with: nn = PRN-100 of satellite broadcasting the MT12 – U UTC Identifier (0 if unknown) 1=UTC(NIST), 2=UTC(USNO), 3=UTC(SU), 4=UTC(BIPM), 5=UTC(Europe Lab), 6=UTC(CRL), 7=UTC(NTSC) (BDS), >7 = not assigned yet S and U for SBAS only.	 1X,A5,1X I2,1X
*** LEAP SECONDS**	– Current Number of leap seconds – Future or past leap seconds ΔtLSF (BNK), i.e. future leap second if the week and day number are in the future. – Respective week number WN_LSF (continuous number) (BNK). For GPS, GAL, QZS and IRN, weeks since 6-Jan-1980. When BDS only file leap seconds specified, weeks since 1-Jan-2006. – Respective day number DN (0-6) BeiDou and (1-7) for GPS and others constellations, (BNK). The day number is the GPS or BeiDou day before the leap second (See Note 1 below). In the case of the Tuesday, June 30/2015 (GPS Week 1851, DN 3) the UTC leap second actually occurred 16 seconds into the next GPS day. – Time system identifier: only GPS and BDS are valid identifiers. Blank defaults to GPS, see Notes section below. Notes: 1. GPS, GAL, QZS and IRN time systems are aligned and are equivalent with respect to leap seconds (Leap seconds since 6-Jan-1980).See the GPS almanac and DN reference IS-GPS-200H 20.3.3.5.2.4. 2. For BDS only navigation files, the Number of leap seconds since 1-Jan-2006 as transmitted by the BDS almanac ΔtLS(see BDS-SIS-ICD-2.0	I6, I6, I6, I6 A3

TABLE A5 GNSS NAVIGATION MESSAGE FILE - HEADER SECTION DESCRIPTION		
HEADER LABEL (Columns 61-80)	**DESCRIPTION**	**FORMAT**
	5.2.4.17)	
END OF HEADER		

Records marked with * are optional, BNK- Blank if Not Know/Defined

A 6 GNSS Navigation Message File – GPS Data Record Description

TABLE A6 GNSS NAVIGATION MESSAGE FILE – GPS DATA RECORD DESCRIPTION		
OBS. RECORD	**DESCRIPTION**	**FORMAT**
SV / EPOCH / SV CLK	- Satellite system (**G**), sat number (PRN) - Epoch: Toc - Time of Clock (GPS) year (4 digits) - month, day, hour, minute, second - SV clock bias (seconds) - SV clock drift (sec/sec) - SV clock drift rate (sec/sec2)	A1,I2.2, 1X,I4, 5(1X,I2.2), 3D19.12 *)
BROADCAST ORBIT - 1	- IODE Issue of Data, Ephemeris - Crs (meters) - Delta n (radians/sec) - M0 (radians)	4X,4D19.12 ***)
BROADCAST ORBIT - 2	- Cuc (radians) - e Eccentricity - Cus (radians) - sqrt(A) (sqrt(m))	4X,4D19.12
BROADCAST ORBIT - 3	- Toe Time of Ephemeris (sec of GPS week) - Cic (radians) - OMEGA0 (radians) - Cis (radians)	4X,4D19.12
BROADCAST ORBIT - 4	- i0 (radians) - Crc (meters) - omega (radians) - OMEGA DOT (radians/sec)	4X,4D19.12
BROADCAST ORBIT - 5	- IDOT (radians/sec) - Codes on L2 channel - GPS Week # (to go with TOE) Continuous number, not mod(1024)! - L2 P data flag	4X,4D19.12
BROADCAST ORBIT - 6	- SV accuracy (meters) See GPS ICD 200H Section 20.3.3.3.1.3 use specified equations to define nominal values, N = 0-6: use $2^{(1+N/2)}$ (round to one decimal place i.e. 2.8, 5.7 and 11.3) , N= 7-15:use $2^{(N-2)}$, 8192 specifies use at own risk - SV health (bits 17-22 w 3 sf 1) - TGD (seconds) - IODC Issue of Data, Clock	4X,4D19.12
BROADCAST ORBIT - 7	- Transmission time of message **) (sec of GPS week, derived e.g.from Z-count in Hand Over Word (HOW)) - Fit Interval in hours see section 6.11. (BNK).	4X,4D19.12

TABLE A6 GNSS NAVIGATION MESSAGE FILE – GPS DATA RECORD DESCRIPTION		
OBS. RECORD	**DESCRIPTION**	**FORMAT**
	- Spare - Spare	

*) In order to account for the various compilers, E,e,D, and d are allowed letters between the fraction and exponent of all floating point numbers in the navigation message files. Zero-padded two-digit exponents are required, however.

) Adjust the *Transmission time of message* by + or -604800 to refer to the reported week in ***BROADCAST ORBIT 5*, if necessary. Set value to 0.9999E9 if not known.

A 7 GPS Navigation Message File – Example

```
+------------------------------------------------------------------------------+
|                                  TABLE A7                                    |
|                       GPS NAVIGATION MESSAGE FILE - EXAMPLE                  |
+------------------------------------------------------------------------------+
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|

     3.03           N: GNSS NAV DATA    G: GPS              RINEX VERSION / TYPE
XXRINEXN V3         AIUB                19990903 152236 UTC PGM / RUN BY / DATE
EXAMPLE OF VERSION 3.03 FORMAT                              COMMENT
GPSA    .1676D-07   .2235D-07   .1192D-06   .1192D-06       IONOSPHERIC CORR
GPSB    .1208D+06   .1310D+06  -.1310D+06  -.1966D+06       IONOSPHERIC CORR
GPUT   .1331791282D-06  .107469589D-12 552960 1025          TIME SYSTEM CORR
    13                                                      LEAP SECONDS
                                                            END OF HEADER
G06 1999 09 02 17 51 44 -.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  .102500000000D+04  .000000000000D+00
      .000000000000D+00  .000000000000D+00  .000000000000D+00  .910000000000D+02
      .406800000000D+06  .400000000000E+01
G13 1999 09 02 19 00 00  .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  .102500000000D+04  .000000000000D+00
      .000000000000D+00  .000000000000D+00  .000000000000D+00  .389000000000D+03
      .410400000000D+06  .400000000000E+01

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

A 8 GNSS Navigation Message File – GALILEO Data Record Description

TABLE A8 GNSS NAVIGATION MESSAGE FILE - GALILEO DATA RECORD DESCRIPTION		
OBS. RECORD	**DESCRIPTION**	**FORMAT**
SV / EPOCH / SV CLK	- Satellite system (**E**), satellite number - Epoch: Toc - Time of Clock GALyear (4 digits) - month, day, hour, minute, second - SV clock bias (seconds) af0 - SV clock drift (sec/sec) af1 - SV clock drift rate (sec/sec2) af2 (see *Br.Orbit-5*, data source, bits 8+9)	A1,I2.2, 1X,I4, 5(1X,I2.2), 3D19.12 *)
BROADCAST ORBIT - 1	- IODnav Issue of Data of the nav batch - Crs (meters) - Delta n (radians/sec) - M0 (radians)	4X,4D19.12 ***)
BROADCAST ORBIT - 2	- Cuc (radians) - e Eccentricity - Cus (radians) - sqrt(a) (sqrt(m))	4X,4D19.12
BROADCAST ORBIT - 3	- Toe Time of Ephemeris (sec of GAL week) - Cic (radians) - OMEGA0 (radians) - Cis (radians)	4X,4D19.12
BROADCAST ORBIT - 4	- i0 (radians) - Crc (meters) - omega (radians) - OMEGA DOT (radians/sec)	4X,4D19.12
BROADCAST ORBIT - 5	- IDOT (radians/sec) - Data sources (FLOAT --> INTEGER) Bit 0 set: I/NAV E1-B Bit 1 set: F/NAV E5a-I Bit 2 set: I/NAV E5b-I Bits 0 and 2 : Both can be set if the navigation messages were merged, however, bits 0-2 cannot all be set, as the I/NAV and F/NAV messages contain different information Bit 3 reserved for Galileo internal use Bit 4 reserved for Galileo internal use Bit 8 set: af0-af2, Toc, SISA are for E5a,E1 Bit 9 set: af0-af2, Toc, SISA are for E5b,E1 Bits 8-9 : exclusive (only one bit can be set) - GAL Week # (to go with Toe) - spare	4X,4D19.12 ****)
BROADCAST ORBIT - 6	- SISA Signal in space accuracy (meters)	4X,4D19.12

TABLE A8 GNSS NAVIGATION MESSAGE FILE - GALILEO DATA RECORD DESCRIPTION		
OBS. RECORD	**DESCRIPTION**	**FORMAT**
	Undefined/unknown: -1.0 - SV health (FLOAT converted to INTEGER) See Galileo ICD Section 5.1.9.3 Bit 0: E1B DVS Bits 1-2: E1B HS Bit 3: E5a DVS Bits 4-5: E5a HS Bit 6: E5b DVS Bits 7-8: E5b HS - BGD E5a/E1 (seconds) - BGD E5b/E1 (seconds)	 *****)
BROADCAST ORBIT - 7	- Transmission time of message **) (sec of GAL week, derived from WN and TOW of page type 1) - spare - spare - spare	4X,4D19.12

*) In order to account for the various compilers, E,e,D, and d are allowed letters between the fraction and exponent of all floating point numbers in the navigation message files. Zero-padded two-digit exponents are required, however.

) Adjust the *Transmission time of message* by + or -604800 to refer to the reported week in ***BROADCAST ORBIT 5*, if necessary. Set value to 0.9999E9 if not known.

***) Angles and their derivatives transmitted in units of semi-circles and semi-circles/sec have to be converted to radians by the RINEX generator.

****) The GAL week number is a continuous number, aligned to (and hence identical to) the continuous GPS week number used in the RINEX navigation message files. The broadcast 12-bit Galileo System Time (GST) week has a roll-over after 4095. It started at zero at the first GPS roll-over (continuous GPS week 1024). Hence GAL week = GST week + 1024 + n*4096 (n: number of GST roll-overs).

*****)
-If bit 0 or bit 2 of Data sources (***BROADCAST ORBIT – 5)*** is set, `E1B DVS` & `HS`, `E5b DVS` & `HS` and both `BGD`s are valid. -If bit 1 of Data sources is set, `E5a DVS` & `HS` and `BGD E5a/E1` are valid. -Non valid parameters are set to 0 and to be ignored

A 9 GALILEO Navigation Message File – Examples

```
+------------------------------------------------------------------------------+
|                                   TABLE A9                                   |
|                    GALILEO NAVIGATION MESSAGE FILE - EXAMPLES                |
+------------------------------------------------------------------------------+

----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
     3.03           N: GNSS NAV DATA    E: GALILEO NAV DATA RINEX VERSION / TYPE
NetR9 5.01          Receiver Operator   20150619 000000 UTC PGM / RUN BY / DATE
GAL      .1248D+03   .5039D+00   .2377D-01   .0000D+00       IONOSPHERIC CORR
GAUT   .3725290298D-08  .532907052D-14 345600 1849          TIME SYSTEM CORR
    16    17  1851     3                                    LEAP SECONDS
                                                            END OF HEADER
E12 2015 06 19 02 10 00 -.138392508961D-02 -.131464616970D-09  .000000000000D+00
      .930000000000D+02 -.165531250000D+03  .285797618904D-08  .138275888459D+01
     -.782497227192D-05  .346679124050D-03  .114385038614D-04  .544062509727D+04
      .439800000000D+06  .298023223877D-07 -.296185101312D+01 -.111758708954D-07
      .965683294025D+00  .993750000000D+02 -.629360976005D+00 -.541593988135D-08
     -.571452374714D-11  .516000000000D+03  .184900000000D+04
      .312000000000D+01  .000000000000D+00 -.651925802231D-08 -.605359673500D-08
      .440734000000D+06
E12 2015 06 19 02 10 00 -.138392508961D-02 -.131464616970D-09  .000000000000D+00
      .930000000000D+02 -.165531250000D+03  .285797618904D-08  .138275888459D+01
     -.782497227192D-05  .346679124050D-03  .114385038614D-04  .544062509727D+04
      .439800000000D+06  .298023223877D-07 -.296185101312D+01 -.111758708954D-07
      .965683294025D+00  .993750000000D+02 -.629360976005D+00 -.541593988135D-08
     -.571452374714D-11  .513000000000D+03  .184900000000D+04
      .312000000000D+01  .000000000000D+00 -.651925802231D-08 -.605359673500D-08
      .440725000000D+06
E12 2015 06 19 02 10 00 -.138392532244D-02 -.131450406116D-09  .000000000000D+00
      .930000000000D+02 -.165531250000D+03  .285797618904D-08  .138275888459D+01
     -.782497227192D-05  .346679124050D-03  .114385038614D-04  .544062509727D+04
      .439800000000D+06  .298023223877D-07 -.296185101312D+01 -.111758708954D-07
      .965683294025D+00  .993750000000D+02 -.629360976005D+00 -.541593988135D-08
     -.571452374714D-11  .258000000000D+03  .184900000000D+04
      .312000000000D+01  .000000000000D+00 -.651925802231D-08  .000000000000D+00
      .440730000000D+06
     3.03           NAVIGATION DATA     M (Mixed)           RINEX VERSION / TYPE
BCEmerge            congo               20150620 012902 GMT PGM / RUN BY / DATE
Merged GPS/GLO/GAL/BDS/QZS/SBAS navigation file             COMMENT
based on CONGO and MGEX tracking data                       COMMENT
DLR: O. Montenbruck;  TUM: P. Steigenberger                 COMMENT
BDUT  5.5879354477e-09-2.042810365e-14     14 1849          TIME SYSTEM CORR
GAUT  3.7252902985e-09 5.329070518e-15 345600 1849          TIME SYSTEM CORR
GLGP -3.7252902985e-09 0.000000000e+00 345600 1849          TIME SYSTEM CORR
GLUT  1.0710209608e-08 0.000000000e+00 345600 1849          TIME SYSTEM CORR
GPGA -2.0081643015e-09-9.769962617e-15 432000 1849          TIME SYSTEM CORR
GPUT  4.5110937208e-09 7.105427358e-15 372608 1849          TIME SYSTEM CORR
QZUT  1.9557774067e-08 1.598721155e-14  61440 1850          TIME SYSTEM CORR
    16                                                      LEAP SECONDS
                                                            END OF HEADER
E12 2015 06 19 02 10 00-1.383925089613e-03-1.314646169703e-10 0.000000000000e+00
     9.300000000000e+01-1.655312500000e+02 2.857976189037e-09 1.382758884589e+00
    -7.824972271919e-06 3.466791240498e-04 1.143850386143e-05 5.440625097275e+03
     4.398000000000e+05 2.980232238770e-08-2.961851013120e+00-1.117587089539e-08
     9.656832940254e-01 9.937500000000e+01-6.293609760051e-01-5.415939881349e-09
    -5.714523747137e-12 5.130000000000e+02 1.849000000000e+03
     3.120000000000e+00 0.000000000000e+00-6.519258022308e-09-6.053596735001e-09
     4.404850000000e+05
```

```
E12 2015 06 19 02 10 00-1.383925322443e-03-1.314504061156e-10 0.000000000000e+00
     9.300000000000e+01-1.655312500000e+02 2.857976189037e-09 1.382758884589e+00
    -7.824972271919e-06 3.466791240498e-04 1.143850386143e-05 5.440625097275e+03
     4.398000000000e+05 2.980232238770e-08-2.961851013120e+00-1.117587089539e-08
     9.656832940254e-01 9.937500000000e+01-6.293609760051e-01-5.415939881349e-09
    -5.714523747137e-12 2.580000000000e+02 1.849000000000e+03
     3.120000000000e+00 0.000000000000e+00-6.519258022308e-09 0.000000000000e+00
     4.405300000000e+05
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
```

A 10 GNSS Navigation Message File – GLONASS Data Record Description

TABLE A10 GNSS NAVIGATION MESSAGE FILE – GLONASS DATA RECORD DESCRIPTION		
OBS. RECORD	**DESCRIPTION**	**FORMAT**
SV / EPOCH / SV CLK	- Satellite system (**R**), satellite number (slot number in sat. constellation) - Epoch: Toc - Time of Clock (UTC) year (4 digits) - month, day, hour, minute, second - SV clock bias (sec) (-TauN) - SV relative frequency bias (+GammaN) - Message frame time (tk+nd*86400) in seconds of the UTC week	A1,I2.2, 1X,I4, 5(1X,I2.2), 3D19.12 *)
BROADCAST ORBIT - 1	- Satellite position X (km) - velocity X dot (km/sec) - X acceleration (km/sec2) - health (0=OK) (Bn)	4X,4D19.12
BROADCAST ORBIT - 2	- Satellite position Y (km) - velocity Y dot (km/sec) - Y acceleration (km/sec2) - frequency number(-7...+13) (-7...+6 ICD 5.1)	4X,4D19.12
BROADCAST ORBIT - 3	- Satellite position Z (km) - velocity Z dot (km/sec) - Z acceleration (km/sec2) - Age of oper. information (days) (E)	4X,4D19.12

*) In order to account for the various compilers, E,e,D, and d are allowed letters between the fraction and exponent of all floating point numbers in the navigation message files. Zero-padded two-digit exponents are required, however.

A 11 GNSS Navigation Message File – Example: Mixed GPS / GLONASS

```
+------------------------------------------------------------------------------+
|                                   TABLE A11                                  |
|                GNSS NAVIGATION MESSAGE FILE - EXAMPLE MIXED GPS/GLONASS      |
+------------------------------------------------------------------------------+

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

     3.03           N: GNSS NAV DATA    M: MIXED            RINEX VERSION / TYPE
XXRINEXN V3         AIUB                20061002 000123 UTC PGM / RUN BY / DATE
EXAMPLE OF VERSION 3.03 FORMAT                              COMMENT
GPSA   0.1025E-07  0.7451E-08 -0.5960E-07 -0.5960E-07       IONOSPHERIC CORR
GPSB   0.8806E+05  0.0000E+00 -0.1966E+06 -0.6554E+05       IONOSPHERIC CORR
GPUT  0.2793967723E-08 0.000000000E+00 147456 1395          TIME SYSTEM CORR
GLUT  0.7823109626E-06 0.000000000E+00      0 1395          TIME SYSTEM CORR
    14                                                      LEAP SECONDS
                                                            END OF HEADER
G01 2006 10 01 00 00 00 0.798045657575E-04 0.227373675443E-11 0.000000000000E+00
     0.560000000000E+02-0.787500000000E+01 0.375658504827E-08 0.265129935612E+01
    -0.411644577980E-06 0.640150101390E-02 0.381097197533E-05 0.515371852875E+04
     0.000000000000E+00 0.782310962677E-07 0.188667086536E+00-0.391155481338E-07
     0.989010441512E+00 0.320093750000E+03-0.178449589759E+01-0.775925177541E-08
     0.828605943335E-10 0.000000000000E+00 0.139500000000E+04 0.000000000000E+00
     0.200000000000E+01 0.000000000000E+00-0.325962901115E-08 0.560000000000E+02
    -0.600000000000E+02 0.400000000000E+01
G02 2006 10 01 00 00 00 0.402340665460E-04 0.386535248253E-11 0.000000000000E+00
     0.135000000000E+03 0.467500000000E+02 0.478269921862E-08-0.238713891022E+01
     0.250712037086E-05 0.876975362189E-02 0.819191336632E-05 0.515372778320E+04
     0.000000000000E+00-0.260770320892E-07-0.195156738598E+01 0.128522515297E-06
     0.948630520258E+00 0.214312500000E+03 0.215165003775E+01-0.794140221985E-08
    -0.437875382124E-09 0.000000000000E+00 0.139500000000E+04 0.000000000000E+00
     0.200000000000E+01 0.000000000000E+00-0.172294676304E-07 0.391000000000E+03
    -0.600000000000E+02 0.400000000000E+01
R01 2006 10 01 00 15 00-0.137668102980E-04-0.454747350886E-11 0.900000000000E+02
     0.157594921875E+05-0.145566368103E+01 0.000000000000E+00 0.000000000000E+00
    -0.813711474609E+04 0.205006790161E+01 0.931322574615E-09 0.700000000000E+01
     0.183413398438E+05 0.215388488770E+01-0.186264514923E-08 0.100000000000E+01
R02 2006 10 01 00 15  0-0.506537035108E-04 0.181898940355E-11 0.300000000000E+02
     0.155536342773E+05-0.419384956360E+00 0.000000000000E+00 0.000000000000E+00
    -0.199011298828E+05 0.324192047119E+00-0.931322574615E-09 0.100000000000E+01
     0.355333544922E+04 0.352666091919E+01-0.186264514923E-08 0.100000000000E+01
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
```

A 12 GNSS Navigation Message File – QZSS Data Record Description

TABLE A12 QZSS NAVIGATION MESSAGE FILE – QZSS DATA RECORD DESCRIPTION		
OBS. RECORD (Columns 61-80)	**DESCRIPTION**	**FORMAT**
PRN / EPOCH / SV CLK	- Satellite system (J), Satellite PRN-192 - Epoch: Toc - Time of Clock year (4 digits) - month, day, hour, minutes, seconds - SV clock bias (seconds) - SV clock drift (sec/sec) - SV clock drift rate (sec/sec2)	A1,I2, 1X,I4, 5(1X,I2), 3D19.12 ***)**
BROADCAST ORBIT - 1	- IODE Issue of Data, Ephemeris - Crs (meters) - Delta n (radians/sec) - M0 (radians)	4X,4D19.12
BROADCAST ORBIT - 2	- Cuc (radians) - e Eccentricity - Cus (radians) - sqrt(A) (sqrt(m))	4X,4D19.12
BROADCAST ORBIT - 3	- Toe Time of Ephemeris (sec of GPS week) - Cic (radians) - OMEGA (radians) - CIS (radians)	4X,4D19.12
BROADCAST ORBIT - 4	- i0 (radians) - Crc (meters) - omega (radians) - OMEGA DOT (radians/sec)	4X,4D19.12
BROADCAST ORBIT – 5	- IDOT (radians/sec) - Codes on L2 channel (see IS-QZSS 5.2.2.2.3(2)) - GPS Week # (to go with TOE) Continuous number, not mod(1024)! - L2P data flag set to 1 since QZSS does not track L2P	4X,4D19.12
BROADCAST ORBIT – 6	- SV accuracy (meters) (IS -QZSS, Section 5.1.2.1.3.2) which refers to: IS GPS 200H Section 20.3.3.3.1.3 use specified equations to define nominal values, N = 0-6: use $2^{(1+N/2)}$ (round to one decimal place i.e. 2.8, 5.7 and 11.3) , N= 7-15:use $2^{(N-2)}$, 8192 specifies use at own risk - SV health (bits 17-22 w 3 sf 1) (see IS-QZSS 5.2.2.2.3(4))	4X,4D19.12

TABLE A12 QZSS NAVIGATION MESSAGE FILE – QZSS DATA RECORD DESCRIPTION		
OBS. RECORD (Columns 61-80)	**DESCRIPTION**	**FORMAT**
	- TGD (seconds) The QZSS ICD specifies a do not use bit pattern "10000000" this condition is represented by a blank field. - 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) - Fit interval flag (0 / 1) (see IS-QZSS, 5.2.2.2.4(4) 0 – two hours), 1 – more than 2 hours. Blank if not known. - Spare - Spare	4X,4D19.12

Records marked with * are optional

**) Adjust the Transmission time of message by -604800 to refer to the reported week, if necessary.

*) In order to account for the various compilers, letters E,e,D, and d are allowed between the fraction and exponent of all floating point numbers in the navigation message files. Zero-padded two-digit exponents are required, however.

A 13 QZSS Navigation Message File – Example

```
+------------------------------------------------------------------------------+
|                                 TABLE A13                                    |
|                   QZSS NAVIGATION MESSAGE FILE - EXAMPLE                     |
+------------------------------------------------------------------------------+
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
     3.03           N: GNSS NAV DATA    J: QZSS             RINEX VERSION / TYPE
GR25 V3.08                              20140513 072944 UTC PGM / RUN BY / DATE
    16         1694     7                                   LEAP SECONDS
                                                            END OF HEADER
J01 2014 05 13 08 15 12 3.323303535581D-04-1.818989403546D-11 0.000000000000D+00
     6.900000000000D+01-4.927812500000D+02 2.222949737636D-09 7.641996743610D-01
    -1.654587686062D-05 7.542252133135D-02 1.197867095470D-05 6.492895933151D+03
     2.025120000000D+05-8.381903171539D-07-9.211997910060D-01-2.041459083557D-06
     7.082252892260D-01-1.558437500000D+02-1.575843337115D+00-2.349740733276D-09
    -6.793140104410D-10 2.000000000000D+00 1.792000000000D+03 1.000000000000D+00
     2.000000000000D+00 1.000000000000D+00-4.656612873077D-09 6.900000000000D+01
     1.989000000000D+05 0.000000000000D+00
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
```

A 14 GNSS Navigation Message File – BDS Data Record Description

Table A14
GNSS NAVIGATION MESSAGE FILE – BDS DATA RECORD DESCRIPTION

OBS. RECORD	DESCRIPTION	FORMAT
SV /EPOCH / SV CLK	- Satellite system (C), sat number (PRN) - Epoch: Toc - Time of Clock (BDT) year (4 digits) - month, day, hour, minute, second - SV clock bias (seconds) - SV clock drift (sec/sec) - SV clock drift rate (sec/sec^2)	A1,I2.2, 1X,I4 5,1X,I2.2, 3D19.12 *)
BROADCAST ORBIT – 1	- AODE Age of Data, Ephemeris (as specified in BeiDou ICD Table Section 5.2.4.11 Table 5-8) and field range is: 0-31. - Crs (meters) - Delta n (radians/sec) - M0 (radians)	4X,4D19.12 **)
BROADCAST ORBIT – 2	- Cuc (radians) - e Eccentricity - Cus (radians) - sqrt(A) (sqrt(m))	4X,4D19.12
BROADCAST ORBIT – 3	- Toe Time of Ephemeris (sec of BDT week) - Cic (radians) - OMEGA0 (radians) - Cis (radians)	4X,4D19.12
BROADCAST ORBIT – 4	- i0 (radians) - Crc (meters) - omega (radians) - OMEGA DOT (radians/sec)	4X,4D19.12
BROADCAST ORBIT – 5	- IDOT (radians/sec) - Spare - BDT Week # - Spare	4X,4D19.12 ***)
BROADCAST ORBIT – 6	- SV accuracy (meters See: BDS ICD Section 5.2.4.: to define nominal values, N = 0-6: use $2^{(1+N/2)}$ (round to one decimal place i.e. 2.8, 5.7 and 11.3) , N= 7-15:use $2^{(N-2)}$, 8192 specifies use at own risk) - SatH1 - TGD1 B1/B3 (seconds) - TGD2 B2/B3 (seconds)	4X,4D19.12

BROADCAST ORBIT – 7	- Transmission time of message ****) (sec of BDT week,) - AODC Age of Data Clock (as specified in BeiDou ICD Table Section 5.2.4.9 Table 5-6) and field range is: 0-31. - Spare - Spare	4X,4D19.12

*) In order to account for the various compilers, E,e,D, and d are allowed letters between the fraction and exponent of all floating point numbers in the navigation message files. Zero-padded two-digit exponents are required, however.

**) Angles and their derivatives transmitted in units of semi-circles and semi-circles/sec have to be converted to radians by the RINEX generator.

***) The BDT week number is a continuous number. The broadcast 13-bit BDS System Time week has a roll-over after 8191. It started at zero at 1-Jan-2006, Hence BDT week = BDT week_BRD + (n*8192) where (n: number of BDT roll-overs).

****) Adjust the Transmission time of message by + or -604800 to refer to the reported week in BROADCAST ORBIT -5, if necessary. Set value to 0.9999E9 if not known.

A 15 BeiDou Navigation Message File – Example

```
+------------------------------------------------------------------------------+
|                                  TABLE A15                                   |
|                    BeiDou NAVIGATION MESSAGE FILE - EXAMPLE                  |
+------------------------------------------------------------------------------+
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
     3.03           NAVIGATION DATA     M (Mixed)           RINEX VERSION / TYPE
BCEmerge            montenbruck         20140517 072316 GMT PGM / RUN BY / DATE
DLR: O. Montenbruck;  TUM: P. Steigenberger                 COMMENT
BDUT -9.3132257462e-10 9.769962617e-15     14   435         TIME SYSTEM CORR
                                                            END OF HEADER
C01 2014 05 10 00 00 00 2.969256602228e-04 2.196998138970e-11 0.000000000000e+00
     1.000000000000e+00 4.365468750000e+02 1.318269196918e-09-3.118148933476e+00
     1.447647809982e-05 2.822051756084e-04 8.092261850834e-06 6.493480609894e+03
     5.184000000000e+05-2.654269337654e-08 3.076630958509e+00-3.864988684654e-08
     1.103024081152e-01-2.506406250000e+02 2.587808789012e+00-3.039412318009e-10
     2.389385241772e-10 0.000000000000e+00 4.350000000000e+02 0.000000000000e+00
     2.000000000000e+00 0.000000000000e+00 1.420000000000e-08-1.040000000000e-08
     5.184000000000e+05 0.000000000000e+00
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
```

A 16 GNSS Navigation Message File – SBAS Data Record Description

TABLE A16 GNSS NAVIGATION MESSAGE FILE – SBAS/QZSS L1 SAIF DATA RECORD DESCRIPTION		
OBS. RECORD	**DESCRIPTION**	**FORMAT**
SV / EPOCH / SV CLK	- Satellite system (**S**), satellite number (slot number in sat. constellation) - Epoch: Toc - Time of Clock (GPS) year (4 digits) - month, day, hour, minute, second - SV clock bias (sec) (aGf0) - SV relative frequency bias (aGf1) - Transmission time of message (start of the message) in GPS seconds of the week	A1,I2.2, 1X,I4, 5(1X,I2.2), 3D19.12, *)
BROADCAST ORBIT - 1	- Satellite position X (km) - velocity X dot (km/sec) - X acceleration (km/sec2) - health (0=OK)	4X,4D19.12
BROADCAST ORBIT - 2	- Satellite position Y (km) - velocity Y dot (km/sec) - Y acceleration (km/sec2) - Accuracy code (URA, meters)	4X,4D19.12
BROADCAST ORBIT - 3	- Satellite position Z (km) - velocity Z dot (km/sec) - Z acceleration (km/sec2) - IODN (Issue of Data Navigation, DO229, 8 first bits after Message Type if MT9)	4X,4D19.12

*) In order to account for the various compilers, E,e,D, and d are allowed letters between the fraction and exponent of all floating point numbers in the navigation message files. Zero-padded two-digit exponents are required, however.

For QZSS L1-SAIF, note that accelerations represent only lunar and solar perturbation terms and satellite position can be computed based on equations in Section A.3.1.2 of GLONASS ICD version 5.0.

A 17 SBAS Navigation Message File -Example

```
+------------------------------------------------------------------------------+
|                                 TABLE A17                                    |
|                   SBAS NAVIGATION MESSAGE FILE - EXAMPLE                     |
+------------------------------------------------------------------------------+
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|

     3.03           N: GNSS NAV DATA    S: SBAS             RINEX VERSION / TYPE
SBAS2RINEX 3.0      CNES                20031018 140100     PGM / RUN BY / DATE
EXAMPLE OF VERSION 3.03 FORMAT                              COMMENT
SBUT  -.1331791282D-06 -.107469589D-12 552960 1025 EGNOS  5 TIME SYSTEM CORR
    13                                                      LEAP SECONDS
This file contains navigation message data from a SBAS      COMMENT
(geostationary) satellite, here AOR-W (PRN 122 = # S22)     COMMENT
                                                            END OF HEADER
S22 2003 10 18  0  1  4-1.005828380585D-07 6.366462912410D-12 5.184420000000D+05
     2.482832392000D+04-3.593750000000D-04-1.375000000000D-07 0.000000000000D+00
    -3.408920872000D+04-1.480625000000D-03-5.000000000000D-08 4.000000000000D+00
    -1.650560000000D+01 8.360000000000D-04 6.250000000000D-08 2.300000000000D+01
S22 2003 10 18  0  5 20-9.872019290924D-08 5.456968210638D-12 5.186940000000D+05
     2.482822744000D+04-3.962500000000D-04-1.375000000000D-07 0.000000000000D+00
    -3.408958936000D+04-1.492500000000D-03-5.000000000000D-08 4.000000000000D+00
    -1.628960000000D+01 8.520000000000D-04 6.250000000000D-08 2.400000000000D+01
S22 2003 10 18  0  9 36-9.732320904732D-08 4.547473508865D-12 5.189510000000D+05
     2.482812152000D+04-4.325000000000D-04-1.375000000000D-07 0.000000000000D+00
    -3.408997304000D+04-1.505000000000D-03-5.000000000000D-08 4.000000000000D+00
    -1.606960000000D+01 8.800000000000D-04 6.250000000000D-08 2.500000000000D+01
S22 2003 10 18  0 13 52-9.592622518539D-08 4.547473508865D-12 5.192110000000D+05
     2.482800632000D+04-4.681250000000D-04-1.375000000000D-07 0.000000000000D+00
    -3.409035992000D+04-1.518125000000D-03-3.750000000000D-08 4.000000000000D+00
    -1.584240000000D+01 8.960000000000D-04 6.250000000000D-08 2.600000000000D+01

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

A 18 GNSS Navigation Message File – IRNSS Data Record Description

TABLE A18 GNSS NAVIGATION MESSAGE FILE – IRNSS DATA RECORD DESCRIPTION		
OBS. RECORD	**DESCRIPTION**	**FORMAT**
SV / EPOCH / SV CLK	- Satellite system (**I**), sat number (PRN) - Epoch: Toc - Time of Clock (IRNSS) year (4 digits) - month, day, hour, minute, second - SV clock bias (seconds) - SV clock drift (sec/sec) - SV clock drift rate (sec/sec2)	A1,I2.2, 1X,I4, 5(1X,I2.2), 3D19.12 *)
BROADCAST ORBIT - 1	- IODEC Issue of Data, Ephemeris and Clock - Crs (meters) - Delta n (radians/sec) - M0 (radians)	4X,4D19.12 ***)
BROADCAST ORBIT - 2	- Cuc (radians) - e Eccentricity - Cus (radians) - sqrt(A) (sqrt(m))	4X,4D19.12
BROADCAST ORBIT - 3	- Toe Time of Ephemeris (sec of IRNSS week) - Cic (radians) - OMEGA0 (radians) - Cis (radians)	4X,4D19.12
BROADCAST ORBIT - 4	- i0 (radians) - Crc (meters) - omega (radians) - OMEGA DOT (radians/sec)	4X,4D19.12
BROADCAST ORBIT - 5	- IDOT (radians/sec) - Blank - IRN Week # (to go with TOE) Continuous number, not mod (1024), counted from 1980 (same as GPS). - Blank	4X,4D19.12
BROADCAST ORBIT - 6	- User Range Accuracy(m), See IRNSS ICD Section 6.2.1.4 , use specified equations to define nominal values, N = 0-6: use $2^{(1+N/2)}$ (round to one decimal place i.e. 2.8, 5.7 and 11.3) , N= 7-15:use $2^{(N-2)}$, 8192 specifies use at own risk - Health (Sub frame 1,bits 155(most significant) and 156(least significant)), where 0 = L5 and S healthy, 1 = L5 healthy and S unhealthy, 2= L5 unhealthy and S healthy, 3= both L5 and S unhealthy	4X,4D19.12

TABLE A18 GNSS NAVIGATION MESSAGE FILE – IRNSS DATA RECORD DESCRIPTION		
OBS. RECORD	**DESCRIPTION**	**FORMAT**
	- TGD (seconds) - Blank	
BROADCAST ORBIT - 7	- Transmission time of message **) (sec of IRNSS week) - Blank - Blank - Blank	4X,4D19.12

*) In order to account for the various compilers, E,e,D, and d are allowed letters between the fraction and exponent of all floating point numbers in the navigation message files. Zero-padded two-digit exponents are required, however.

) Adjust the *Transmission time of message* by + or -604800 to refer to the reported week in ***BROADCAST ORBIT 5*, if necessary. Set value to 0.9999E9 if not known.

A 19 IRNSS Navigation Message File – Example

```
+------------------------------------------------------------------------------+
|                                TABLE A19                                     |
|                   IRNSS NAVIGATION MESSAGE FILE - EXAMPLE                    |
+------------------------------------------------------------------------------+

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

     3.03           NAVIGATION DATA     I (IRNSS)           RINEX VERSION / TYPE
DecodIRNSS          montenbruck         20141004 164512 GMT PGM / RUN BY / DATE
Source: IRNSS-1A Navbits                                    COMMENT
                                                            END OF HEADER
I01 2014 04 01 00 00 00-9.473115205765e-04 1.250555214938e-12 0.000000000000e+00
     0.000000000000e+00-5.820625000000e+02 4.720196615135e-09-1.396094758025e+00
    -1.898035407066e-05 2.257102518342e-03-1.068413257599e-05 6.493487739563e+03
     1.728000000000e+05 6.705522537231e-08-8.912102146884e-01-5.215406417847e-08
     4.758105460020e-01 4.009375000000e+02-2.999907424014e+00-4.414469594664e-09
    -4.839487298357e-10                    1.786000000000e+03
     1.130000000000e+01 0.000000000000e+00-4.190951585770e-09
     1.728000000000e+05
I01 2014 04 01 02 00 00-9.473022073507e-04 1.250555214938e-12 0.000000000000e+00
     1.000000000000e+00-5.101875000000e+02 4.945920303147e-09-8.741766987741e-01
    -1.684948801994e-05 2.254169434309e-03-1.182407140732e-05 6.493469217300e+03
     1.800000000000e+05 2.346932888031e-07-8.912408598963e-01-1.117587089539e-08
     4.758065024964e-01 4.403750000000e+02-2.996779607145e+00-4.508759236491e-09
    -5.464513333200e-10                    1.786000000000e+03
     1.130000000000e+01 0.000000000000e+00-4.190951585770e-09
     1.800000000000e+05
I01 2014 04 01 04 00 00-9.472924284637e-04 1.250555214938e-12 0.000000000000e+00
     2.000000000000e+00-5.100000000000e+02 5.217360181136e-09-3.491339518362e-01
    -1.697987318039e-05 2.254509832710e-03-1.212581992149e-05 6.493469842911e+03
     1.872000000000e+05 1.378357410431e-07-8.912725364615e-01 2.942979335785e-07
     4.758010370344e-01 4.460625000000e+02-2.996772972812e+00-4.790199531038e-09
    -6.039537285256e-10                    1.786000000000e+03
     1.130000000000e+01 0.000000000000e+00-4.190951585770e-09
     1.872000000000e+05
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
```

A 20 Meteorological Data File -Header Section Description

TABLE A20 METEOROLOGICAL DATA FILE - HEADER SECTION DESCRIPTION		
HEADER LABEL (Columns 61-80)	**DESCRIPTION**	**FORMAT**
RINEX VERSION / TYPE	- Format version : **3.03** - File type: **M** for Meteorological 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 (See section 5.8)	A20, A20, A20
*** COMMENT**	- Comment line(s)	A60
MARKER NAME	- Station Name (preferably identical to **MARKER NAME** in the associated Observation File)	A60
*** MARKER NUMBER**	- Station Number (preferably identical to **MARKER NUMBER** in the associated Observation File)	A20
# / TYPES OF OBSERV	- Number of different observation types stored in the file - Observation types The following meteorological observation types are defined in RINEX Version 3: **PR** : Pressure (mbar) **TD** : Dry temperature (deg Celsius) **HR** : Relative humidity (percent) **ZW** : Wet zenith path delay (mm), (for WVR data) **ZD** : Dry component of zen.path delay (mm) **ZT** : Total zenith path delay (mm) **WD** : Wind azimuth (deg) from where the wind blows **WS** : Wind speed (m/s) **RI** : "Rain increment" (1/10 mm): Rain accumulation since last measurement **HI** : Hail indicator non-zero: Hail detected since last measurement The sequence of the types in this record must correspond to the sequence of the measurements in the data records. - If more than 9 observation types are being used, use continuation lines with format	I6, 9(4X,A2) (6X,9(4X,A2))
SENSOR MOD/TYPE/ACC	Description of the met sensor - Model (manufacturer)	 A20,

TABLE A20 METEOROLOGICAL DATA FILE - HEADER SECTION DESCRIPTION		
HEADER LABEL (Columns 61-80)	**DESCRIPTION**	**FORMAT**
	- Type - Accuracy (same units as obs values) - Observation type Record is repeated for each observation type found in **# / TYPES OF OBSERV** record	A20,6X, F7.1,4X, A2,1X
SENSOR POS XYZ/H	- Approximate position of the met sensor - Geocentric coordinates X,Y,Z (ITRF - Ellipsoidal height H or WGS-84) - Observation type Set X, Y, Z to (BNK). Make sure H refers to ITRF or WGS-84! Record required for barometer, recommended for other sensors.	3F14.4, 1F14.4, 1X,A2,1X
END OF HEADER	Last record in the header section.	60X

Records marked with * are optional

A 21 Meteorological Data File -Data Record Description

TABLE A21 METEOROLOGICAL DATA FILE - DATA RECORD DESCRIPTION		
OBS. RECORD	**DESCRIPTION**	**FORMAT**
EPOCH / MET	- Epoch in GPS time (not local time!) year (4 digits, padded with 0 if necessary) - month, day, hour, min, sec - Met data in the same sequence as given in the header - More than 8 met data types: Use continuation lines	1X,I4.4, 5(1X,I2), mF7.1 4X,10F7.1

A 22 Meteorological Data File – Example

```
+--------------------------------------------------------------------------------+
|                                   TABLE A22                                    |
|                     METEOROLOGICAL DATA FILE - EXAMPLE                         |
+--------------------------------------------------------------------------------+
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
     3.03           METEOROLOGICAL DATA                     RINEX VERSION / TYPE
XXRINEXM V9.9       AIUB                19960401 144333 UTC PGM / RUN BY / DATE
EXAMPLE OF A MET DATA FILE                                  COMMENT
A 9080                                                      MARKER NAME
     3    PR    TD    HR                                    # / TYPES OF OBSERV
PAROSCIENTIFIC      740-16B                       0.2    PR SENSOR MOD/TYPE/ACC
HAENNI                                            0.1    TD SENSOR MOD/TYPE/ACC
ROTRONIC            I-240W                        5.0    HR SENSOR MOD/TYPE/ACC
        0.0000        0.0000        0.0000     1234.5678 PR SENSOR POS XYZ/H
                                                            END OF HEADER
 1996  4  1  0  0 15  987.1   10.6   89.5
 1996  4  1  0  0 30  987.2   10.9   90.0
 1996  4  1  0  0 45  987.1   11.6   89.0

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

A 23 Reference Code and Phase Alignment by Constellation and Frequency Band

TABLE A23
Reference Code and Phase Alignment by Frequency Band

System	Frequency Band	Frequency [MHz]	Signal	RINEX Observation Code	Phase Correction applied to each observed phase to obtain aligned phase. (φRINEX = φ original(as issued by the SV) + Δφ)
GPS	L1	1575.42	C/A	L1C	None (Reference Signal)
			L1C-D	L1S	+¼ cycle
			L1C-P	L1L	+¼ cycle
			L1C-(D+P)	L1X	+¼ cycle
			P	L1P	+¼ cycle
			Z-tracking	L1W	+¼ cycle
			Codeless	L1N	+¼ cycle
	L2 See Note 1	1227.60	C/A	L2C	For Block II/IIA/IIR – None; For Block IIR-M/IIF/III -¼ cycle See Note 2
			Semi-codeless	L2D	None
			L2C(M)	L2S	-¼ cycle
			L2C(L)	L2L	-¼ cycle
			L2C(M+L)	L2X	-¼ cycle
			P	L2P	None (Reference Signal)
			Z-tracking	L2W	None
			Codeless	L2N	None
	L5	1176.45	I	L5I	None (Reference Signal)
			Q	L5Q	-¼ cycle
			I+Q	L5X	Must be aligned to L5I
GLONASS	G1	1602+k*9/16	C/A	L1C	None (Reference Signal)
			P	L1P	+¼ cycle
	G2	1246+k*7/16	C/A	L2C	None (Reference Signal)

TABLE A23 Reference Code and Phase Alignment by Frequency Band					
System	**Frequency Band**	**Frequency [MHz]**	**Signal**	**RINEX Observation Code**	**Phase Correction applied to each observed phase to obtain aligned phase.** **(φRINEX = φ original(as issued by the SV) + Δφ)**
			P	L2P	+¼ cycle
	G3	1202.025	I	L3I	None (Reference Signal)
			Q	L3Q	-¼ cycle
			I+Q	L3X	Must be aligned to L3I
Galileo	E1	1575.42	B I/NAV OS/CS/SoL	L1B	None (Reference Signal)
			C no data	L1C	+½ cycle
			B+C	L1X	Must be aligned to L1B
	E5A	1176.45	I	L5I	None(Reference Signal)
			Q	L5Q	-¼ cycle
			I+Q	L5X	Must be aligned to L5I
	E5B	1207.140	I	L7I	None (Reference Signal)
			Q	L7Q	-¼ cycle
			I+Q	L7X	Must be aligned to L7I
	E5(A+B)	1191.795	I	L8I	None (Reference Signal)
			Q	L8Q	-¼ cycle
			I+Q	L8X	Must be aligned to L8I
	E6	1278.75	B	L6B	None (Reference Signal)
			C	L6C	-½ cycle
			B+C	L6X	Must be aligned to L6B
QZSS	L1	1575.42	C/A	L1C	None (Reference Signal)
			L1C (D)	L1S	None
			L1C (P)	L1L	+¼ cycle
			L1C-(D+P)	L1X	+¼ cycle
			L1-SAIF	L1Z	N/A
	L2	1227.60	L2C (M)	L2S	None (Reference Signal)
			L2C (L)	L2L	None
			L2C (M+L)	L2X	None
	L5	1176.45	I	L5I	None (Reference

TABLE A23 Reference Code and Phase Alignment by Frequency Band					
System	**Frequency Band**	**Frequency [MHz]**	**Signal**	**RINEX Observation Code**	**Phase Correction applied to each observed phase to obtain aligned phase.** **(φRINEX = φ original(as issued by the SV) + Δφ)**
					Signal)
			Q	L5Q	-¼ cycle
			I+Q	L5X	Must be aligned to L5I
	LEX(6)	1278.75	S	L6S	None (Reference Signal)
			L	L6L	None
			S+L	L6X	None
BDS	B1	1561.098	I	L2I	None (Reference Signal) (See Note 4 Below)
			Q	L2Q	-¼ cycle
			I+Q	L2X	Must be aligned to L2I
	B2	1207.140	I	L7I	None (Reference Signal)
			Q	L7Q	-¼ cycle
			I+Q	L7X	Must be aligned to L7I
	B3	1268.52	I	L6I	None (Reference Signal)
			Q	L6Q	-¼ cycle
			I+Q	L6X	Must be aligned to L6I
IRNSS	L5	1176.45	A SPS	L5A	None (Reference Signal)
			B RS(D)	L5B	Restricted(See Note 3)
			C RS(P)	L5C	None
			B+C	L5X	Must be aligned to L5A
	S	2492.028	A SPS	L9A	None (Reference Signal)
			B RS(D)	L9B	Restricted(See Note 3)
			C RS(P)	L9C	None
			B+C	L9X	Must be aligned to L9A

NOTES:

1) The GPS L2 phase shift values ignore FlexPower when the phases of the L2W and L2C can be changed on the satellite.

2) The phase of the L2 C/A signal is dependent on the GPS satellite generation.

3) There is no public information available concerning the restricted service signals.

4) Note: Both C1x and C2x (RINEX 3.01 definition) have been used to identify the B1 frequency signals in RINEX 3.02 files. If C2x coding is read in a RINEX 3.02 file treat it as equivalent to C1x.