RINEX

The Receiver Independent Exchange Format

Version 3.05

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Acronyms

AODC	Age of Data Clock
AODE	Age of Data Ephemerides
ARP	Antenna Reference Point
AS	Anti-Spoofing (of GPS)
BDS	BeiDou System
BDT	BeiDou Time
BIPM	International Bureau of Weights and Measures (from French)
BNK	Blank
BOC	Binary Offset Carrier
CNAV	Civil Navigation (message)
DCB	Differential Code Bias
DVS	Data Validity Status
FNAV	Free Navigation (message, of Galileo)
GEO	Geostationary Earth Orbit
GLONASS	Globalnaja Nawigazionnaja Sputnikowaja Sistema
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GST	Galileo System Time
ICD	Interface Control Document
INAV	Integrity Navigation (message, of Galileo)
IOD	Issue of Data
IODC	Issue of Data, Clock
IODE	Issue of Data, Ephemerides
NavIC/IRNSS	Navigation Indian Constellation/Indian Regional Navigation System
LLI	Loss-of-Lock Indicator
LNAV	Legacy Navigation (message)
MBOC	Multiplexed BOC
MEO	Medium Earth Orbit
PCV	Phase Center Variation
PR	Pseudorange
PRN	Pseudo-Random Noise
QZSS	Quasi-Zenith Satellite System
RCV	Receiver
RINEX	Receiver INdependent EXchange format
SA	Selective Availability (of GPS)
SAASM	Selective Availability Anti-Spoofing Module
SBAS	Satellite Based Augmentation System
SSI	Signal Strength Indicator
SNR	Signal to Noise Ratio
SU	Soviet Union
SV	Space Vehicle
TOE	Time of Ephemerides
TOW	Time of Week
URA	User Range Accuracy
URAI	User Range Accuracy Index
USNO	United States Naval Observatory
UTC	Universal Time Coordinated

1 RINEX 3.04 TO 3.05 REVISION HISTORY

23-Nov-2018	**RINEX 3.04 Released**
25-Apr-2019	- Improved the description of BeiDou Frequency Band / Frequency in Table 19 - Added GLONASS Band 3 to **`SYS/#/OBS TYPES`** in Table A2 - Added parentheses: "(nd*86400)" in Table A10 - Reformatted NAV. RECORD column of Table A14 - Added types B1A and B3A to the BDS section in Table A23
31-Jul-2020	- Improved Revision History Table and added all correct release dates for each version. - Changed 3.04 to 3.05 as needed throughout the document - Corrected minor format issues, corrected all figures and tables names, corrected all numbered headings to simplify document update - Updated the acknowledgements
3-Aug-2020	- Deleted "Note 2" from the **`LEAP SECONDS`** line definition in Table A2 "GNSS Observation data file header section" and Table A5 "GNSS Navigation Message File Header". GPS Leap Seconds line is always allowed. BDS Leap Seconds line are allowed and should not be limited to a specific set of navigation files.
10-Aug-2020	- Moved the RINEX 3.04 Section 4 "The Exchange of RINEX Files", on detailed file naming, to the Annex A1 with the rest of the long filename information. - Added a small section on the RINEX 3 long filenames to the new Section 5.1.
12-Aug-2020	- Removed the RINEX 3.04 Section 5.16 "Navigation message files" since it contained only differences to RINEX 2 Navigation files already defined elsewhere. - Changed the RINEX 3.04 Section 6 title, "Additional Hints and Tips" to "RINEX Line Formatting Specifications". - Removed the RINEX 3.04 Section 6.10 "Two-digit years" since this does not apply to RINEX 3 files.
16-Aug-2020	- Removed the RINEX 3.04 Section 6.11 "Fit Interval (GPS Navigation message file)", section 6.12 "Satellite health (GPS Navigation message file)" and section 6.13 "Transmission time of message (GPS Navigation message file) since this is explained in the GPS navigation file definition section. - Removed the RINEX 3.04 Section 7 "RINEX under Antispoofing (AS)" since RINEX 3 has ways to indicate the observable type than using the LLI as was done in RINEX 2.

18-Aug-2020	- Created a new section 5.2 “Observation File Header” to describe and explain different header elements in a consolidated location, this section collects the RINEX 3.04 version sections; Section 5.1 “Observation Codes” Section 5.2 “Satellite system dependent list of observables” Section 5.3 “Marker type” Section 5.4 “Half-wavelength observations, half-cycle ambiguities” Section 5.5 “Scale factor” Section 5.6 “Information about receivers on a vehicle” Section 5.8 “Date/Time format in the header record” Section 5.14 “Corrections of DCBs” Section 5.15 “Corrections of antenna PCVs” Section 6.5 “Order of the header records…” Section 6.9 “Receiver clock offset” Section 6.14 “Antenna references, phase centers”
19-Aug-2020	- Added Table of Tables as part of the Index and numbered all Tables automatically. - Updated BDS signal mapping in Table 19 to properly include BDS-3 Signals B1A and B3A - Moved RINEX 3.04 section 8.1 “Time system identifier” to section 4.1 “Time” - Moved RINEX 3.04 section 8.2 “Pseudorange definition” to section 0 “Pseudorange” since the explanations and definitions are more useful together.
21-Aug-2020	- Created section 5.3 “Observation Data Records” to explain different observation data record elements in a consolidated location, this section collects the RINEX 3.04 sections; Section 5.7 “Signal strength” Section 5.11 “Observation data records” Section 6.5 “… order of data records” Section 6.8 “Event flag records” Section 8.4 “RINEX observation files for GEO satellites” (part)
24-Aug-2020	- Created section 5.4 “Navigation Message Files” to explain different navigation message elements in a consolidated location, this section collects the RINEX 3.04 version sections; Section 8.3 “RINEX navigation message files” Section 8.4 “RINEX observation files for GEO satellites” (part) - Removed RINEX 3.04 section 9 “Modifications for Version …” as redundant with this revision history timeline. Additionally, the RINEX format version documents should describe the current format and some background details but not all historical format changes since those decisions are mostly not relevant to implementing and understanding the current agreed format.

26-Aug-2020	- Removed RINEX 3.04 section 5.12 "Ionosphere delay as pseudo-observables" since these are not receiver-based observations but rather they are a 'product' of line-of-sight ionosphere delays to each of the visible satellites, which does not belong with receiver satellite observations from signal tracking. This was removed after consultation with the IGS Ionosphere Working Group. - Changed all RINEX files examples in the Appendix to indicate 3.05.
1-Sep-2020	- Added a 5th line to the GLONASS navigation message (Table A10) to include missing GLONASS navigation message information; Status flags, L1/L2 group delay difference, accuracy index, and health flags. A few of the new navigation message elements are only for GLO-M/K satellites.
10-Sep-2020	- Added the list of Acronyms for the document. - Added section 6.7 to clarify the Observation data record format and added examples. - Added section 6.8 to clarify the Navigation data record format and added examples. - Added section 6.9 to clarify the Navigation data stored bitwise and added more examples. - Sorted and updated the references (section 7) as needed (date and document versions, and on-line links).
14-Sep-2020	- Re-inserted the RINEX 3.04 section 9.1 "Phase Cycle Shifts" as section 5.2.12 to clarify the "**SYS / PHASE SHIFT**" observation file header record from Table A3. - Removed from Table A2 Band value "**0**" of allowable satellite observation band values, this value is not allowed. - Added the "L1Sb" to the QZSS signal Table 18. This corresponds to the QZSS GEO satellite signal. - Updated the "**TIME SYSTEM CORR**" description in Table A5 for Week number and UTC to clarify the readability of the text.
13-Oct-2020	- Added default values for the 5th line of the GLONASS Navigation message (Table A10). - Added clarification that in the new Health Flag that the bit 0 is to be ignored if the bit 1 is set to zero (Table A10). - Added units (seconds) to the group delay difference value in the 5th line of the GLONASS Navigation message (Table A10).
28-Oct-2020	- Removed old revision histories and updated latest internal revision references - Simplified the Note for the **TIME SYSTEM CORR** on Table A5.
12-Nov-2020	- In Table A15, BDS Navigation Message Example, for consistency made the Spare fields blanks in **BROADCAST ORBIT- 5**, like the **BROADCAST ORBIT-7** Spare fields. A Blank/Spare field is to be skipped; thus, no value should be used (Section 6.4). - In Table A18, NavIC/IRNSS Navigation Message Description, changed "Blank' to Spare for consistency with the other navigation message descriptions. - Clarified in Section 6.4 that Blank/Spare fields shall be left blank and skipped when reading/writing since they hold no defined content

	- Changed Frequency Band & Code name in Table 18 from L5D to L5S(I), L5P to L5S(Q) and L5(D+P) to L5S(I+Q) to be consistent with the QZSS ICD and consistent with the naming in Table A23. - Added Attribute **E** to Table A2 for consistency with QZSS signal **L6E** in Table 18. - Inserted section 5.2.16 (the old RINEX 3.04 section 9.9) explaining the **GLONASS COD/PHS/BIS** mandatory observation file header element, and added the reference in Table A2 back to section 5.2.16 - Added for clarity the explicit field descriptors for LLI & SSI for the Observation records in Table A3, and reference to section 6.7 for further information and examples - Clarified in the Table A5, Navigation file header description, in the **TIME SYSTEM CORR** optional header label the satellite ID issue to remove possible confusion of only SBAS PRNs allowed. - Removed from Table A5, Navigation file header description, in the **TIME SYSTEM CORR** optional header label the line; "**S** and **U** fields to be used for **SBUT** only" since it is no longer applicable - Added clarification to Table A5, Navigation file header description, in the **LEAP SECONDS** optional header label to indicate that all data fields must come from the indicated Time System Identifier. Also added a clarification Note 3 that GLO only navigation files should not have this optional header line. Added clarification Note 2 of where the BDT leap seconds are from and updated the BDS ICD reference.
13-Nov-2020	- Updated Table A23 to indicate that GLO G3 L3Q must be aligned to L3I since the alignment direction is not known. - Updated Table A23 to indicate that BDS B1C & B2A must be aligned to L1D & L5D respectively since the ¼ cycle alignment direction is implementation dependent. - Updated Table A23 to indicate that BDS B2b & B2a+B2b must be aligned to L7D & L8D respectively since alignment direction is not known.
20-Nov-2020	- Remove 'B2' from Table A2 Band **5** signals to maintain consistency with what is defined in Table 19 : RINEX Version 3.05 BDS Observation Codes.
23-Nov-2020	- Inserted NavIC/IRNSS where previously only IRNSS had been written since India has renamed their navigation system, and to remain aligned to the designation in use across the RTCM-SC104.
27-Nov-2020	- Introduced in section 4.1.7 a statement about referring all observations to one receiver clock bias in multi-GNSS receiver, to remain consistent with section 4.2 - Updated the references of the GPS ICDs to the 14 May 2020 versions in section 7. - Introduced the reference BDS ICDs for open signals B2b and B3I in section 7. - Clarified the reference to the RTCA DO-229 SBAS Minimum Operational Performance Standard in section 7.

30-Nov-2020	- Updated all ftp references in section 7 to the IGS to https links since ftp is being phased out at the IGS from December 2020. - In section 6.7.1 clarified the LLI index and allowed the LLI bit 2 to be set for more than just Galileo. - Removed the spaces after the "*****" for optional header lines in column **HEADER LABEL** and standardized the use of commas in column **FORMAT** in Table A2 and Table A5 - Added line continuation symbols → to Table 22 to clearly indicate the long line of observables per satellite are wrapped due to the table width.
01-Dec-2020	**RINEX 3.05 Released**

2 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 geodetic processing 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, antenna model, etc.

Three major format versions of RINEX have been developed and published to date:

- 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]
- RINEX Version 3 developed in the early 2000s to support multi-GNSS and to clearly identified the tracking modes of each of the observations by introducing and defining 3-character observation codes for all GNSS constellations.

As spin-offs of the idea of a receiver-independent data exchange format, other RINEX-like exchange file formats have been defined over time, 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 **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]

Several subversions of RINEX Version 2 were defined over time:

- 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] - ***<u>This is the last official RINEX Version 2</u>***
- 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]

In the early 2000s when new GNSS constellations were being planned, and soon thereafter started transmitting their new navigation signals, it was clear that RINEX 2 was not capable of fully supporting the new signals, tracking modes and satellites efficiently. The new Beidou, Galileo, QZSS, etc and the modernized GPS and GLONASS with new frequencies and observation types needed a leap in the RINEX format.

Especially the possibility to track frequencies on different channels, required a more flexible and more detailed definition of the observation codes.

Several versions of RINEX 3 have been defined:

- RINEX 3.00 (2007) fully supports multi-GNSS observation data storage. The initial RINEX Version 3 also incorporates the version 2.20 definitions for space-borne receivers.
- RINEX 3.01 (2009) introduced 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 (2013) 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 (2015) adds support for the NavIC/IRNSS and clarifies several implementation issues in 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. The Galileo Navigation section was updated to clarify the Issue of Data (IOD). RINEX 3.03 was also modified to specify that only known observation tracking modes can be encoded in the standard.
- RINEX 3.04 (2018) adds clarifications for signal tables for GLONASS, QZSS and BeiDou, and a small number of edits and corrections needed from the previous version.
- RINEX 3.05 (2020) is a major restructure and revision of the format document to make it clearer and easier to read, it adds BeiDou signals and tracking codes to fully support BDS-2 and BDS-3, and it also adds missing flags and values to the GLONASS navigation messages.

3 GENERAL FORMAT DESCRIPTION

The RINEX 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. These labels are mandatory and must appear exactly as given in these descriptions and examples. The header does not have a fixed length and many of the labels are optional depending on the application. Comments can be added freely in the header.

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 observation session, 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. Although the format allows for the 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.

RINEX 3 mixed navigation message files are allowed to contain navigation messages of more than one satellite system to make their exchange and the processing more efficient.

The header and data record format descriptions as well as examples for each file type are given in the Appendix Tables at the end of the document.

4 BASIC DEFINITIONS

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

4.1 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. The details of each GNSS Time and their use in RINEX is defined below.

4.1.1 GPS Time

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 UTC (midnight) on January 6, 1980.

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.

4.1.2 GLONASS 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.

4.1.3 Galileo System 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.

4.1.4 BeiDou 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.

4.1.5 QZSS 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.

4.1.6 NavIC/IRNSS System Time

NavIC/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 NavIC/IRNSS time.

4.1.7 GNSS Time Relationships

Apart from the small, sub-microsecond differences, in the realizations of the different time systems, the GNSS time scales differ from UTC and each other by integer seconds. The relations between the various systems are summarized in Table 1 and Table 2.

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.

In a multi-GNSS receiver (GPS/GLONASS/Galileo/QZSS/BDS) all pseudorange observations must refer to one receiver clock only.

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

Table 1 : Constellation Time Relationships

ΔtLS	=	Delta time between GPS and UTC due to leap seconds, as transmitted by the GPS satellites in the almanac (1999-01-01 - 2006-01-01: ΔtLS = 13, 2006-01-01 - 2009-01-01: ΔtLS = 14, 2009-01-01 - 2012-07-01: ΔtLS = 15, 2012-07-01 - 2015-07-01: ΔtLS = 16, 2015-07-01 - 2017-01-01: ΔtLS = 17 and 2017-01-01 - ????-??-??: ΔtLS = 18).
ΔtLS_{BDS}	=	Delta time between BDT and UTC due to leap seconds, as transmitted by the BDS satellites in the almanac (2006-01-01 - 2009-01-01: ΔtLS_{BDS} = 0, 2009-01-01 - 2012-07-01: ΔtLS_{BDS} = 1, 2012-07-01 - 2015-07-01: ΔtLS_{BDS} = 2, 2015-07-01 - 2017-00-01: ΔtLS_{BDS} = 3 and 2017-01-01 - ????-??-??: ΔtLS = 4). See BDS-SIS-ICD-2.0 Section 5.2.4.17

Table 2 : GPS and BeiDou UTC Leap Second Relationship

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.

4.1.8 GNSS Week numbers

The use of the week number from the start of a GNSS service is a common time reference. The relationships between the different GNSS week numbers are as shown in Table 3.

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
NavIC/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 3 : Week Numbers between RINEX and GPS, QZSS, IRN, GST, GAL, BDS

4.2 Pseudorange

The pseudorange (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 pseudorange reflects the actual behavior of the receiver and satellite clocks. The pseudorange is stored in units of meters. In the above relation, *c* = 299 792 458 m/s denotes the speed of light.

In a mixed-mode GPS/GLONASS/Galileo/QZSS/BDS receiver all pseudorange observations must refer 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 pseudoranges must be corrected in this case as shown in Table 4 to remove the contributions of the leap seconds from the pseudo-ranges.

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 4 : Constellation Pseudorange Corrections

ΔtLS is the actual number of leap seconds between GPS/GAL and GLO time, as broadcast in the respective navigation messages 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 BeiDou navigation message.

4.3 Phase

The phase observable provided in a RINEX file is the carrier-phase range from the antenna to a satellite measured in whole cycles. Half-cycle phase measurements by squaring-type receivers must be converted to whole cycles and flagged by the respective observation code (see section 5.2.13 for further clarification).

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 as indicated by the header lines **SYS/PHASE SHIFT** (see section 5.2.12). This is needed to guarantee consistency between phases of the same frequency and satellite system based on different signal channels (See 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 / pseudorange / epoch must be maintained, i.e. the receiver clock correction shall be applied to all 3 observables as specified in Table 5.

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

Table 5: Observation Corrections for Receiver Clock Offset

*) For detailed definition of QZSS, please refer to section 4.5.

4.4 Doppler

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

4.5 Satellite numbers

For clear unambiguous identification, individual satellites are identified in RINEX files by a two-digit number indicating the PRN code or the slot number. This number is preceded by a one-character system identifier **s** as shown in Figure 1.

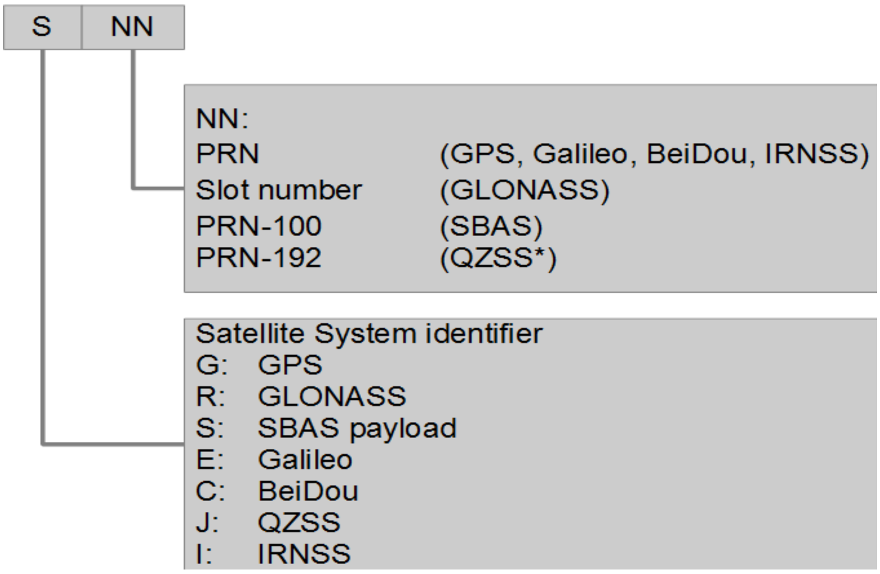

Figure 1: Satellite numbers and Constellation Identifiers

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

QZSS satellites are fully identified the using the standard PRN numbering conventions; J01-J09 as shown in Table 6.

RINEX Satellite ID	Standard PNT Signals and Centimeter Level Augmentation (LEX/L6D) (PRN-192)	Sub-meter Level Augmentation (L1-SAIF/L1S) (PRN-182)	Centimeter Level Augmentation for Experiments (L6E) (PRN-202)	Positioning Technology Verification Service (L5S) (PRN Code)
J01	193	183		
J02	194	184	204	196
J03	195	185	205	200
J04	196	186	206	
J05	197	187	207	
J06	198	188	208	
J07	199	189	209	197
J08	200	190	210	
J09	201	191	211	

Table 6: QZSS PRN to RINEX Satellite Identifier

5 RINEX VERSION 3 FEATURES

This chapter contains description and explanations of the RINEX 3 main features; recommended filenames, the main header elements including the observation codes for each GNSS Constellation, the observation data records, and the navigation files.

5.1 Long Filenames

From RINEX 3.02 onwards the data filenames are recommended to use the proposed long filenames to be more descriptive, flexible and extensible than the previous short file naming convention.

Table 7 lists example filenames for GNSS observation and navigation files, please note that the source of the data, the start time, the duration, the cadence and the data type are now easily visible. This allows files from the same station over the same time period, different sources, different cadences and with different observation types to be stored together easily.

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_01D_30S_MO.rnx	Mixed RINEX GNSS observation file containing 1 day of data, with an observation every 30 seconds
ALGO00CAN_R_20121600000_01D_MN.rnx	RINEX mixed navigation file, containing one day's data

Table 7: Examples of long filenames for RINEX 3 data files

See Appendix A1 for the full description of the file naming convention.

5.2 Observation File Header

See the Appendix A2 for a detailed specification of the RINEX 3 observation file header. This section provides general descriptions and clarifications for the observation file header.

5.2.1 Order of the header records

As the header record descriptors in columns 61-80 are mandatory, the software reading a RINEX 3.XX header must decode the header records with formats according to the record descriptor in Appendix A2.
RINEX allows the 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 the whole raw data file, we define them to be optional
- The **END OF HEADER** of course is the last record in the header

5.2.2 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 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.

5.2.3 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 8.

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. However, Event flags ‘2’ and ‘3’ (See Appendix A3) are necessary to flag alternating kinematic and static phases of a receiver visiting multiple earth-fixed monuments. Users may define other project-dependent keywords.

Marker Type	Description
`GEODETIC`	Earth-fixed high-precision monument
`NON_GEODETIC`	Earth-fixed low-precision monument
`NON_PHYSICAL`	Generated from network processing
`SPACEBORNE`	Orbiting space vehicle
`AIRBORNE`	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 8: Proposed Marker Type Keywords

5.2.4 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 with respect 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.
- The ***Orientation*** of the antenna: The "zero direction" should be 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.

In order to interpret the various positions correctly, it is important that the **MARKER TYPE** record be included in the RINEX header.

5.2.5 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 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 section 5.2.4.

See section 5.2.10 regarding the use of phase center variation corrections.

5.2.6 Antenna orientation

Dedicated header records have been defined to report the orientation of the antenna zero-direction; **ANTENNA: ZERODIR**, as well as the direction of its vertical axis (bore-sight) if mounted tilted on a fixed station; **ANTENNA: B.SIGHT**.

The header records can also be used for antennas on vehicles.

5.2.7 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 5.2.4): **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 5.2.5)

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.

5.2.8 Time of First/Last Observations

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** 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 NavIC/IRNSS time

Pure GPS observation files default to **GPS**, pure GLONASS files default to **GLO**, pure Galileo files default to **GAL**, pure BDS observation files default to **BDT**, etc.

Multi-GNSS observation files **must** contain the system time identifier (one of the above) that all time tags refer to.

5.2.9 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.

This can be reported by special header records **SYS / DCBS APPLIED** pointing to the file containing the applied corrections.

5.2.10 Corrections of antenna phase center variations (PCVs)

For precise applications it is recommended that elevation-dependent, or elevation and azimuth-dependent Phase Center Variation (PCV) model for the antenna (referring to the agreed-upon ARP) be used during the processing.

For special applications, it might be useful to generate RINEX files with these PCV corrections already applied. This can be reported by special header records **SYS / PCVS APPLIED** pointing to the file containing the PCV correction models.

5.2.11 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.

5.2.12 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 by other fractional parts of a cycle. Appendix Table A23 specifies the reference signal and the phase shifts that are specified by the ICDs of each constellation.

All phase observations **must** be aligned from RINEX 3.01 onwards and the new **SYS / PHASE SHIFT** header is mandatory. See Appendix A2 for the message definition, and the example in Table 10. If the phase alignment is not known, then the observation data **should not** be published in a RINEX 3 observation 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 file:

- All phase observations must be aligned to the designated constellation and frequency reference signal as specified in Appendix 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 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 A23 specifies the reference signal that should be used by each constellation and frequency band. Additionally, it 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 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), then 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, then the header record allows for the affected satellites to be indicated.
- If the applied phase corrections or the phase alignment is unknown, then 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 9: RINEX Phase Alignment Correction Convention

Example (for definition see Appendix A2):

```
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
G L2S -0.25000                                              SYS / PHASE SHIFT
G L2X -0.25000                                              SYS / PHASE SHIFT
R L2P  0.25000                                              SYS / PHASE SHIFT
E L8Q -0.25000                                              SYS / PHASE SHIFT
```

Table 10 : Example **SYS / PHASE SHIFT** Record

5.2.13 Half-wavelength observations, half-cycle ambiguities

Half-wavelength observations of encrypted GPS P(Y)-code signals collected by **codeless** squaring techniques get their own observation codes, see section 5.2.17. 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 A3). ***Note***: The loss of lock bit is the least significant bit.

5.2.14 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, use the header record: **RCV CLOCK OFFS APPL**.

It would then be possible to reconstruct the original observations, if necessary.

5.2.15 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 3 requests system-dependent observation code lists (header record type **SYS / # / OBS TYPES**), see a full description of all observation types in section 5.2.17.

5.2.16 GLONASS Mandatory Code-Phase Alignment Header Record

Analysis has revealed that some GNSS receivers produce biased GLONASS observations. The code-phase bias results in the code and phase observations are not being measured at the same time. To remedy this problem, a mandatory GLONASS Code-Phase header bias record is required (see Table A2).

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**) example in Table 11. The GLONASS code-phase alignment message contains: L1C, L1P, L2C and L2P corrections. Phase data from GNSS receivers that issue biased data must 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 11 : Example of GLONASS Code Phase Bias Correction Record

If the GLONASS code phase alignment is unknown, then all fields within GLONASS COD/PHS/BIS header record are left blank (see Table 12). 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 12 : Example of Unknown GLONASS Code Phase Bias Record

5.2.17 Observation codes

Dedicated observation codes are used in RINEX to distinguish individual signals and tracking modes. In order to keep the observation codes short, but still allow for a detailed characterization of the actual signal generation, the observation codes are composed of three characters/digits "**tna**" as detailed in Table 13.

t : observation type	**C** = pseudo-range	**L** = carrier phase	**D** = doppler	**S** = signal strength	**X** = channel number
n : band / frequency	1, 2,...,9				
a : attribute	tracking mode or channel, e.g., **I, Q, C, P,** etc.				

Table 13 : 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)

Blank (unknown) observation attributes (tracking modes or channels) are not supported from RINEX 3.02 onwards. Except for the '**X**' pseudo-observations (see section 5.3.4) which indicate the receiver channel number(s) tracking the specific satellite, and have blank a 'attribute' value.

For satellite observations only the complete specification of all signals is allowed i.e. all three fields must be specified. RINEX observation codes for all supported frequencies, signals and tracking modes for all GNSS constellations are detailed in Table 14 to Table 20.

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 14 : RINEX Version 3.05 GPS Observation Codes

Antispoofing (AS) of GPS: Various techniques may be used by GPS receivers to track the encrypted GPS P(Y)-Code during Antispoofing (AS). In view of different properties of the resulting observations, which need to be considered in the observation modelling, RINEX offers multiple attributes to unambiguously distinguish the respective observations. 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**.

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
	G1a/ 1600.995	L1OCd	C4A	L4A	D4A	S4A
		L1OCp	C4B	L4B	D4B	S4B
		L1OCd+ L1OCp	C4X	L4X	D4X	S4X
	G2/ 1246+k*7/16	C/A	C2C	L2C	D2C	S2C
		P	C2P	L2P	D2P	S2P
	G2a/ 1248.06	L2CSI	C6A	L6A	D6A	S6A
		L2OCp	C6B	L6B	D6B	S6B
		L2CSI+ L2OCp	C6X	L6X	D6X	S6X
	G3 / 1202.025	I	C3I	L3I	D3I	S3I
		Q	C3Q	L3Q	D3Q	S3Q
		I+Q	C3X	L3X	D3X	S3X

Table 15 : RINEX Version 3.05 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 OS data	C1B	L1B	D1B	S1B
		C OS pilot	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 16 : RINEX Version 3.05 Galileo Observation Codes

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 17 : RINEX Version 3.05 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
		L1S/L1-SAIF	C1Z	L1Z	D1Z	S1Z
		L1Sb	C1B	L1B	D1B	S1B
	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 *(Block I+II Signals) **(Block II L5S Signals)	I *	C5I	L5I	D5I	S5I
		Q *	C5Q	L5Q	D5Q	S5Q
		I+Q *	C5X	L5X	D5X	S5X
		L5S(I) **	C5D	L5D	D5D	S5D
		L5S(Q) **	C5P	L5P	D5P	S5P
		L5S(I+Q) **	C5Z	L5Z	D5Z	S5Z
	L6 / 1278.75 *(Block I LEX Signals) **(Block II Signals)	L6D *,**	C6S	L6S	D6S	S6S
		L6P *	C6L	L6L	D6L	S6L
		L6(D+P) *	C6X	L6X	D6X	S6X
		L6E **	C6E	L6E	D6E	S6E
		L6(D+E) **	C6Z	L6Z	D6Z	S6Z

Table 18 : RINEX Version 3.05 QZSS Observation Codes

Note: The RINEX 1Z signal code is used for both the initial Block I L1-SAIF signal and the updated L1S signal. L6D is the "code 1" of the L61(Block I) and L62 (Block II) signals, L6P is the "code 2" (or pilot) signal of the L61(Block I) signal and L6E is the "code 2" of the L62 (Block II) signal as specified in IS-QZSS-L6. See section 4.5 and Table 6 for QZSS PRN to RINEX identifier coding.

GNSS System	Freq. Band / Frequency	Channel or Code	Observation Codes			
			Pseudo Range	Carrier Phase	Doppler	Signal Strength
BDS	B1 / 1561.098 (BDS-2/3 Signals)	I (B1I signal)	C2I	L2I	D2I	S2I
		Q	C2Q	L2Q	D2Q	S2Q
		I+Q	C2X	L2X	D2X	S2X
	B1C / 1575.42 (BDS-3 Signals)	Data	C1D	L1D	D1D	S1D
		Pilot	C1P	L1P	D1P	S1P
		Data+Pilot	C1X	L1X	D1X	S1X
	B1A / 1575.42 (BDS-3 Signals)	Data	C1S	L1S	D1S	S1S
		Pilot	C1L	L1L	D1L	S1L
		Data+Pilot	C1Z	L1Z	D1Z	S1Z
	B2a / 1176.45 (BDS-3 Signals)	Data	C5D	L5D	D5D	S5D
		Pilot	C5P	L5P	D5P	S5P
		Data+Pilot	C5X	L5X	D5X	S5X
	B2 / 1207.140 (BDS-2 Signals)	I (B2I signal)	C7I	L7I	D7I	S7I
		Q	C7Q	L7Q	D7Q	S7Q
		I+Q	C7X	L7X	D7X	S7X
	B2b / 1207.140 (BDS-3 Signals)	Data	C7D	L7D	D7D	S7D
		Pilot	C7P	L7P	D7P	S7P
		Data+Pilot	C7Z	L7Z	D7Z	S7Z
	B2(B2a+B2b)/1191.795 (BDS-3 Signals)	Data	C8D	L8D	D8D	S8D
		Pilot	C8P	L8P	D8P	S8P
		Data+Pilot	C8X	L8X	D8X	S8X
	B3/1268.52 (BDS-2/3 Signals)	I	C6I	L6I	D6I	S6I
		Q	C6Q	L6Q	D6Q	S6Q
		I+Q	C6X	L6X	D6X	S6X
	B3A / 1268.52 (BDS-3 Signals)	Data	C6D	L6D	D6D	S6D
		Pilot	C6P	L6P	D6P	S6P
		Data+Pilot	C6Z	L6Z	D6Z	S6Z

Table 19 : RINEX Version 3.05 BDS Observation Codes

Note: When reading a RINEX 3.02 file, both 1I/Q/X and 2I/Q/X observation codes should be accepted and treated the same as 2I/Q/X in the current RINEX standard.

GNSS System	Freq. Band / Frequency	Channel or Code	Observation Codes			
			Pseudo Range	Carrier Phase	Doppler	Signal Strength
NavIC/ 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 20 : RINEX Version 3.05 NavIC/IRNSS Observation Codes

5.3 Observation Data Records

See Appendix A3 for a detailed specification of the RINEX 3 data record description. Below are some descriptions and clarifications for some of the data records elements.

Each observation record begins with the satellite identifier **snn** (see section 4.5), 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.

There is no data record length limitation as it depends on the declared constellation observation list and the available observables per satellite per epoch.

Table 21 shows a sample list of observation types for six satellite systems **G,E,S,R,C,J**.

```
G   22 C1C L1C D1C S1C C1W S1W C2W L2W D2W S2W C2L L2L D2L  SYS / # / OBS TYPES
       S2L C5Q L5Q D5Q S5Q C1L L1L D1L S1L                  SYS / # / OBS TYPES
E   20 C1C L1C D1C S1C C6C L6C D6C S6C C5Q L5Q D5Q S5Q C7Q  SYS / # / OBS TYPES
       L7Q D7Q S7Q C8Q L8Q D8Q S8Q                          SYS / # / OBS TYPES
S    8 C1C L1C D1C S1C C5I L5I D5I S5I                      SYS / # / OBS TYPES
R   20 C1C L1C D1C S1C C1P L1P D1P S1P C2P L2P D2P S2P C2C  SYS / # / OBS TYPES
       L2C D2C S2C C3Q L3Q D3Q S3Q                          SYS / # / OBS TYPES
C   20 C1P L1P D1P S1P C5P L5P D5P S5P C2I L2I D2I S2I C7I  SYS / # / OBS TYPES
       L7I D7I S7I C6I L6I D6I S6I                          SYS / # / OBS TYPES
J   20 C1C L1C D1C S1C C2L L2L D2L S2L C5Q L5Q D5Q S5Q C1L  SYS / # / OBS TYPES
       L1L D1L S1L C1Z L1Z D1Z S1Z                          SYS / # / OBS TYPES
```

Table 21 : Example Observation Type Records

RINEX observation measures are written as detailed in section 6.7. An epoch and partial observation records example is provided in Table 22. The long observation lines per satellite are wrapped to fit the table width, each new line starts with a PRN and continues (indicated by →) until the next PRN.

```
> 2020 01 28 00 00  0.0000000  0 48
C19  24654392.553 7 129559707.78007     -2902.686 7        44.750    24654395.451
→7  96749126.04807     -2167.576 7       44.500    24654390.675 7 128381880.85807
→-2876.245       7                                                         46.250
→24654391.375 7 104320752.71507     -2337.249 7        45.250
E04  23840346.329 7 125281891.86507      1327.432 7        47.250    23840348.158
→8 101689874.47708       1077.475 8       50.500    23840349.531 8  93554698.18708
→991.252  8          50.500     23840347.337  8  95995235.59308         1017.092  8
→50.750    23840348.470 8  94774971.96308       1004.174 8        53.750
G02  22187868.655 7 116598092.03507      1322.609 7        46.750    22187867.444
→5          34.750    22187866.324 5  90855658.54005       1030.607 5        34.750
J02  39360055.791 6 206838418.87206     -2309.902 6        41.500    39360060.423
→6 161172711.84406     -1799.765 6       38.750    39360062.564 7 154457226.33407
→-1724.901  7          44.250     39360056.067 7 206838395.87407      -2309.921  7
→42.000    39360052.638 6 206838394.23206     -2309.937  6        41.500
R02  20785793.428 8 110917264.66308     -3161.955 8        50.000    20785793.589
→8 110917013.67108     -3161.968 8       50.500    20785800.249 7  86268837.39807
→-2459.221  7          46.250     20785800.084  7   86268905.40407      -2459.355  7
→45.750
S29  40051393.288 5 210471465.60005         2.190 5        35.750
S38  37925915.028 7 199302015.88507        -3.269 7        45.750    37925889.993
→8 148829334.35608         -2.392 8       49.250
```

Table 22 : Example RINEX Observation Epoch

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.

5.3.1 Order of Data records

Multiple epoch observation data records with identical time tags are not allowed (exception: Event records).

Epochs in a RINEX file have to be listed ordered in time.

5.3.2 Event flag records

Special occurrences during the tracking can be indicated in the **EPOCH** event flag in a RINEX file. The event flag is the integer after the number of seconds in the epoch, different such events can be indicated using integers;

- 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)

The “number of satellites” field if the event field is ≥2 then corresponds to the number of records of the same epoch following the **EPOCH** record. Therefore, the “number of satellites” in the **EPOCH** may be used to skip the appropriate number of data records if certain event flags are not to be evaluated in detail.

5.3.3 RINEX observation data records for GEO & SBAS satellites

Satellite-Based Augmentation System (SBAS) payloads on GEO satellites transmitting navigation signals. The satellite identifier ‘**S**’ is to be used, as shown in Figure 1, in the **RINEX VERSION / TYPE** header line and to identify the satellite. The PRN ‘**nn**’ is defined as being the GEO PRN number minus 100;

e.g.: PRN = 120 ⇒ **Snn** = **S20**

For GNSS constellations with mixed multi-frequency MEO satellites and single-frequency GEO payload observations, the fields for the second frequency observations of GEO satellites remain blank, are set to zero values, or (if last in the record) can be truncated.

5.3.4 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 and band/frequency. We may include this information as a pseudo-observable in each epoch data record line per satellite:

t : observation type:	**X** = Receiver channel number
n : band / frequency :	**1,2,…,9**
a : attribute:	blank

The lowest channel number allowed is 1 (re-number channels beforehand, if necessary). In the 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. Using a Fortran float number 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

5.4 Navigation Message Files

The navigation file headers are generic for all satellite systems: GPS, GLONASS, Galileo, SBAS, QZSS and NavIC/IRNSS, except for the constellations specific "**IONOSPHERIC CORR**" records (See Appendix A5).

The data portion of the navigation message files contain the broadcast navigation data records with floating point numbers. The navigation message format is similar for all satellite systems. The number of records per message and the contents, however, are satellite system-dependent as detailed in the Appendices A6 - A19.

It is encouraged 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 following the convention described in section 4.1.

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

5.4.1 RINEX navigation data for GPS (LNAV)

The specifications for the GPS (LNAV) satellite navigation message are in Appendix A6. The first data record contains the epoch, and satellite clock information. The following six records contains the orbit parameters for the satellite, the time and period of applicability of the navigation message, the URA index of the satellite corresponding to the maximum URA expected over the fit interval, the GPS week number, the transmission time of message, the fit interval, the satellite health flag, and some other flags.

With the navigation message parameters, the corrections of the satellite time to UTC is as follows:

GPS: Tutc = Tsv –af0 –af1 *(Tsv-Toc) -... –A0 -... –ΔtLS

5.4.2 RINEX navigation data for GLONASS (FDMA)

The specifications for the GLONASS (FDMA) satellite navigation message are in Appendix A10. The first data record contains the epoch, and satellite clock information. 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 last record includes Status and Health flags, the signal group delay difference and the accuracy index, but some of the values in the last record only apply to GLO-M/K satellites.

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

GLONASS: Tutc = Tsv + TauN –GammaN*(Tsv-Tb) + TauC

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

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

5.4.3 RINEX navigation data for Galileo

The specifications for the Galileo satellite navigation message are in Appendix A8. 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 (LNAV) 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) indicates the frequency pair the stored clock corrections are valid for.

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 decoded, then the relevant bit fields must be set in the RINEX message and both should be written in separate messages. The Galileo ICD 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. To ensure 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 Section 5.1.9.2 Issue of Data).
As mentioned in section 4.1.8 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.

5.4.4 RINEX navigation data for SBAS satellites

The specifications for SBAS satellite navigation message are in Appendix A16. Navigation data records for SBAS satellites are mainly based on the contents of the MT 9 "GEO Navigation Message" with optional health information from the MT 17 "GEO Almanacs" message.

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 data are given in the GPS time frame, i.e. **not** UTC.

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

GEO: $Tutc = Tsv - aGf0 - aGf1 * (Tsv-Toe) - W0 - \Delta tLS$

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* (**SV / 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*. If necessary, the *Transmission Time of Message* may have to be adjusted by - or + 604800 seconds (which would make it lower than zero or larger than 604800, respectively and then further corrected to correspond to the *Epoch of Ephemeris*) so that it is referenced to the GPS week of the *Epoch of Ephemeris*.

Health is 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

The time system identifier of SBAS 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.

5.4.5 RINEX navigation data for BDS

The BDS Open Service broadcast navigation message is defined in Appendix A14. As with all other message the first data record contains epoch and satellite clock information, followed by the orbit parameters, several time parameters, and health and accuracy flags.

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.

5.4.6 RINEX navigation data for NavIC/IRNSS

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

See Appendix A18 and A19 for a description and example of each field.

6 RINEX FORMATTING CLARIFICATIONS

6.1 Versions

Programs developed to read RINEX files have to verify the version number, and take proper action if it cannot deal with it.

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 should 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[1] 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/Spare Fields

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

Blank or Spare fields are recommended to be left blank so as to avoid confusion.

6.5 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.

6.6 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.

[1] Record is defined by the satellite system with the largest number of possible observables. The length limitation to 80 characters of the observation data records has been removed.

6.7 Floating point numbers in Observation data records

RINEX observation measures are written as floating point values with three decimals and a total field width of 14 characters (e.g. Fortran F14.3 format). Following each observation, a two-digit field for optional loss-of-lock indicator (LLI) (only for phase observation) and signal strength indicators (SSI) is provided.

Example:

```
PRN    code(m)        phase(cycles)
---  ------------   -------------
G02  22187868.655 7 116598092.03507
R09  22677458.268 6 121096420.07006
```

SSI (arrow to the "6" after the code value); LLI and SSI (arrows to the last two digits "0" and "6" of the phase value)

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.

6.7.1 Loss of lock indicator (LLI)

For phase observations only. The LLI values are three-bit codes (binary 000-111) stored as decimals 0-7. Each bit has a special meaning;

`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: BOC-tracking of an MBOC-modulated signal (may suffer from increased noise).

6.7.2 Signal Strength Indicator (SSI)

Signal strength indicators are part of the code and phase observations to offer a compact quality indicator. 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 **`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 (Observations)
N/A	0 or blank (not known, don't care)
< 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 23 : Standardized SNR Indicators

Additionally, observation codes per signal are specified to store detailed signal strength observations '**Sna**' (see Table 14 - Table 20). The **SIGNAL STRENGTH UNIT** header record can be used to indicate the units of these observations.

6.8 Floating point numbers in Navigation data records

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

Examples, from different station navigation files:

```
 1.175282523036D-05 4.381518345326D-03 8.882023394108D-06 6.493065311432D+03
 1.266124167725E-09 2.000000000000E+00 2.069000000000E+03 1.000000000000E+00
-4.411928222656e+03-3.539047241211e+00 9.313225746155e-10 0.000000000000e+00
```

The same exponent indicator will be used throughout a station navigation file.

6.9 Navigation data stored bitwise

Some Navigation parameters contain the data 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

Examples:

0.170000000000D+02 → 17 → 10001 ; Bits 4,0 are set, all others are zero
1.790000000000E+02 → 179 →10110011 ; Bits 7,5,4,1,0 are set, all others are zero
6.300000000000e+02 → 63 →111111 ; all six bits are set
5.130000000000D+02 → 513 →1000000001 ; Bits 9,0 are set , all others are zero
4.800000000000e+01 → 48 →110000 ; Bits 5,4 are set , all others are zero

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8 APPENDIX: RINEX FORMAT DEFINITIONS AND EXAMPLES

A1 RINEX Long Filenames

Modern operating systems support 255-character file names and thus RINEX has evolved to a file naming convention that is more descriptive, flexible and extensible.

Figure 2 lists the filename elements from the RINEX 3.02 onwards;

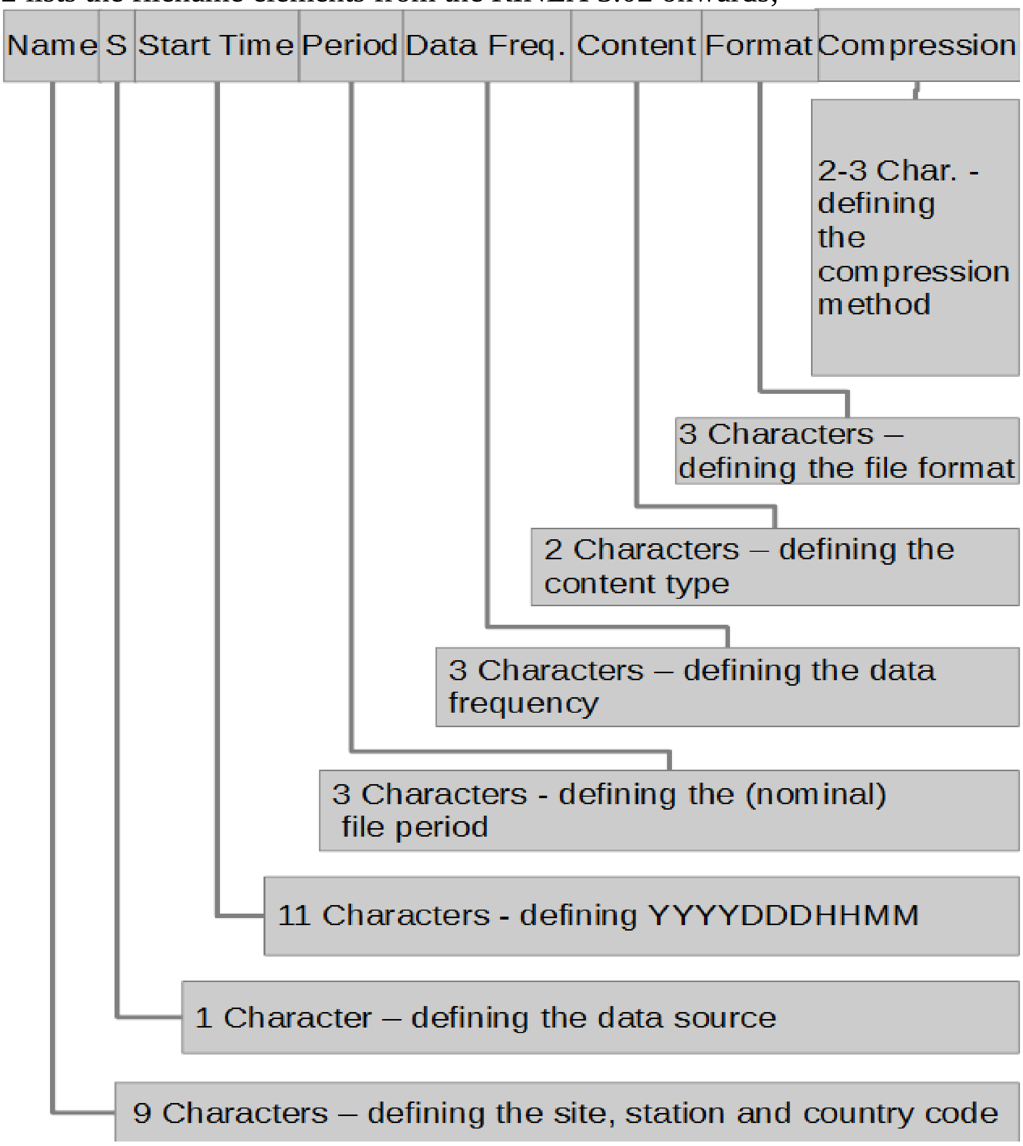

Figure 2: RINEX Long filename parameters.

All elements of the main body of the file name must contain capital ASCII letters or numbers and all elements are fixed length and are separated by an underscore "_". The file type and compression fields (extension) use a period "." as a separator and must be ASCII characters and lower case. Fields must be padded with zeros to fill the field width. The file compression field is optional.

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.

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 DD – data frequency	05Z	Mandatory for RINEX Obs. Data.	XXC – 100 Hertz XXZ – Hertz, XXS – Seconds,

Table A1 RINEX File name description				
Field	**Field Description**	**Example**	**Required**	**Comment/Example**
	U – units of data rate (3 characters)		NOT required for Navigation Files.	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 – NavIC/IRNSS Obs. SO - SBAS Obs. MO - Mixed Obs. GN - Nav. GPS RN - GLONASS Nav. EN - Galileo Nav. JN - QZSS Nav. CN - BDS Nav. IN – NavIC/IRNSS Nav. SN - SBAS Nav. MN – Mixed Nav. (All GNSS Constellations) MM-Meteorological Observation
<**FORMAT**>	FFF FFF – File format (3 characters)	rnx	Yes	Three character indicating the data format: rnx - RINEX, Hatanaka Compressed RINEX
<**COMPRESSION**>	(2-3 Characters)	gz	No	gz
Sub Total	34 or 35			Fields
Separators	(7 characters –Obs. File) (6 characters –Eph. File)			_ underscore 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 and 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

Meteorological filename example:

ALGO00CAN_R_20121600000_01D_30M_MM.rnx.gz //RINEX Met.

<COMPRESSION>:

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

Note: The main body of the file name should contain only ASCII capital letters and numbers. The file extension “.rnx.gz” should be lowercase.

A2 GNSS Observation Data File - Header Description

TABLE A2 GNSS OBSERVATION DATA FILE - HEADER SECTION DESCRIPTION		
HEADER LABEL (Columns 61-80)	**DESCRIPTION**	**FORMAT**
`RINEX VERSION / TYPE`	– Format version: `3.05` – File type: `O` for Observation Data – Satellite System: `G`: GPS `R`: GLONASS `E`: Galileo `J`: QZSS `C`: BDS `I`: NavIC/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 (also see 5.2.3): `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 (see section 5.2.4)	F14.4 2F14.4
*ANTENNA: DELTA X/Y/Z	- Position of antenna reference point for antenna on vehicle (m): XYZ vector in body-fixed coordinate system (see section 5.2.7)	3F14.4
*ANTENNA: PHASECENTER	Average phase center position with respect to antenna reference point (m) (see section 5.2.5) – 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. (see section 5.2.7)	3F14.4
SYS / # / OBS TYPES	– Satellite system code (G/R/E/J/C/I/S) – Number of different observation types for the specified satellite system Observation descriptors: Type, Band, Attribute	A1 2X,I3 13(1X,A3)

TABLE A2 GNSS OBSERVATION DATA FILE - HEADER SECTION DESCRIPTION		
	– 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) **X** = Receiver channel numbers Band: **1** = L1 (GPS, QZSS, SBAS, BDS) G1 (GLO) E1 (GAL) B1C/B1A (BDS) **2** = L2 (GPS, QZSS) G2 (GLO) B1 (BDS) **3** = G3 (GLO) **4** = G1a (GLO) **5** = L5 (GPS, QZSS, SBAS, NavIC/IRNSS) E5a (GAL) B2a (BDS) **6** = E6 (GAL) L6 (QZSS) B3/B3A (BDS) G2a (GLO) **7** = E5b (GAL) B2/B2b (BDS) **8** = E5a+b (GAL) B2a+b (BDS) **9** = S (NavIC/IRNSS) Attribute: **A** = A channel (GAL, NavIC/IRNSS, GLO) **B** = B channel (GAL, NavIC/IRNSS, GLO) **C** = C channel (GAL, NavIC/IRNSS) C code-based (SBAS,GPS,GLO,QZSS) **D** = Semi-codeless (GPS, QZSS) Data Channel (BDS)	6X, 13(1X,A3)

TABLE A2 GNSS OBSERVATION DATA FILE - HEADER SECTION DESCRIPTION		
	E = E Channel (QZSS) **I** = I channel (GPS,GAL, QZSS, BDS) **L** = L channel (L2C GPS, QZSS) P channel (GPS, QZSS) **M** = M code-based (GPS) **N** = Codeless (GPS) **P** = P code-based (GPS,GLO) Pilot Channel (BDS) **Q** = Q channel (GPS,GAL,QZSS,BDS) **S** = D channel (GPS, QZSS) M channel (L2C GPS, QZSS) **W** = Based on Z-tracking (GPS)(see text) **X** = B+C channels (GAL, NavIC/IRNSS) I+Q channels (GPS,GAL, QZSS,BDS) M+L channels (GPS, QZSS) D+P channels (GPS, QZSS, BDS) **Y** = Y code-based (GPS) **Z** = A+B+C channels (GAL) D+P channels (BDS) I+Q channels. (QZSS) D+E channels. (QZSS) All characters in uppercase only! Units; Phase; full cycles Pseudorange; meters Doppler; Hz SNR etc.; receiver-dependent Channel #; See 5.3.4 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. (see section 5.3) **Note: In RINEX 3.XX, all fields (Type, Band and Attribute) must be defined, only known tracking mode attributes are allowed (except for observation Type 'X' which has attribute of blank, see section 5.3.4).**	
`*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 (see section 5.2.8): **GPS** (=GPS time system) **GLO** (=UTC time system) **GAL** (=Galileo time system) **QZS** (= QZSS time system) **BDT** (= BDS time system) **IRN** (=NavIC/IRNSS time system) Compulsory in mixed GNSS files Default values for single system GNSS files (not compulsory): **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 NavIC/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 (see section 5.2.8).	5I6,F13.7 5X,A3
***RCV CLOCK OFFS APPL**	– Epoch, code, and phase are corrected by applying the real-time-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. (see section 5.2.11)	2X,I2 12(1X,A3) 10X 12(1X,A3)
`SYS / PHASE SHIFT`	Phase shift correction used to generate phases consistent with respect 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 section 5.2.12 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, 1X)
`GLONASS COD/PHS/BIS`	– GLONASS Phase bias correction used to align code and phase observations. • GLONASS signal identifier: C1C and Code Phase bias correction (meters) • GLONASS signal identifier: C1P and Code Phase bias correction (meters) • GLONASS signal identifier: C2C and Code Phase bias correction (meters) • GLONASS signal identifier: C2P and Code Phase bias correction (meters)	4(X1,A3,X 1,F8.3)

TABLE A2 GNSS OBSERVATION DATA FILE - HEADER SECTION DESCRIPTION		
	Note: See section 5.2.16 for further details. If the GLONASS code phase bias values are unknown then all fields in the record are left blank 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 BDT are valid identifiers. Blank defaults to GPS, see Notes section below. **Notes**: 1. GPS, GAL, QZS and IRN time systems are aligned and equivalent with respect to leap seconds (Leap seconds since 6-Jan-1980). See the GPS almanac, and DN reference IS-GPS-200L 20.3.3.5.2.4.	I6 I6 I6 I6 A3
`*# OF SATELLITES`	– Number of satellites, for which observations are stored in the file	I6
`*PRN / # OF OBS`	– Satellite IDs, 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. These records are repeated for each satellite in the data file.	3X A1,I2.2 9I6 6X,9I6
`END OF HEADER`	Last record in the header section.	60X

Records marked with * are optional

A3 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
– *m* fields of observation data (in the same sequence as given in the respective **SYS / # / OBS TYPES** record), each containing the specified observations for example: pseudorange, phase, Doppler and SNR.	*m*(F14.3,
– Loss of Lock Indicator - LLI (see Notes, below)	I1,
– Signal Strength Indicator - SSI (see Notes, below)	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. For observations formatting see section 6.7. **Notes** (see also section 6.7): 1. Loss of Lock Indicator (LLI) should only be associated with the phase observation. 2. Signal Strength Indicator (SSI) should be deprecated and replaced by a defined SNR field for each signal. However, if this is not possible/practical then SSI should be specified for each phase signal type for example. GPS: L1C, L1W, L2W, L2X and L5X. 3. If only the pseudorange measurements are observed then the SSI should be associated with the code measurements.	
Epoch flag 2-5: ***EVENT***: *Special records* may follow	
– Epoch flag; (additionally see section 5.3.2) • 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	2X,I1

TABLE A3 GNSS OBSERVATION DATA FILE – DATA RECORD DESCRIPTION	
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	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

A4 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|

     3.05           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
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|
```

A4 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|
     3.05           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|
```

A4 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|
    3.05           OBSERVATION DATA    M: MIXED            RINEX VERSION / TYPE
R25 V3.08                              20140513 072944 UTC PGM / RUN BY / DATE
NR is mapped to RINEX snr flag value [1-9]                 COMMENT
X:      < 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
okio                                                       MARKER NAME
OKI                                                        MARKER NUMBER
J Japan - Leica Geosystems                                 OBSERVER / AGENCY
870023             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
   16 C1C L1C D1C S1C C2S L2S D2S S2S C2W L2W D2W S2W C5Q  SYS / # / OBS TYPES
      L5Q D5Q S5Q                                          SYS / # / OBS TYPES
   12 C1C L1C D1C S1C C2P L2P D2P S2P C2C L2C D2C S2C      SYS / # / OBS TYPES
   16 C1C L1C D1C S1C C5Q L5Q D5Q S5Q C7Q L7Q D7Q S7Q C8Q  SYS / # / OBS TYPES
      L8Q D8Q S8Q                                          SYS / # / OBS TYPES
    8 C2I L2I D2I S2I C7I L7I D7I S7I                      SYS / # / OBS TYPES
   12 C1C L1C D1C S1C C2S L2S D2S S2S C5Q L5Q D5Q S5Q      SYS / # / OBS TYPES
    4 C1C L1C D1C S1C                                      SYS / # / OBS TYPES
BHZ                                                        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
 L1C                                                       SYS / PHASE SHIFT
 L2S -0.25000                                              SYS / PHASE SHIFT
 L2W                                                       SYS / PHASE SHIFT
 L5Q -0.25000                                              SYS / PHASE SHIFT
 L1C                                                       SYS / PHASE SHIFT
 L2P  0.25000                                              SYS / PHASE SHIFT
 L2C                                                       SYS / PHASE SHIFT
 L1C +0.50000                                              SYS / PHASE SHIFT
 L5Q -0.25000                                              SYS / PHASE SHIFT
 L7Q -0.25000                                              SYS / PHASE SHIFT
 L8Q -0.25000                                              SYS / PHASE SHIFT
 L2I                                                       SYS / PHASE SHIFT
 L7I                                                       SYS / PHASE SHIFT
 L1C                                                       SYS / PHASE SHIFT
 L2S                                                       SYS / PHASE SHIFT
 L5Q -0.25000                                              SYS / PHASE SHIFT
 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
ND OF FILE                                                 COMMENT
---|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
```

A5 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: **3.05** – File type ('**N**' for Navigation Data) – Satellite System: **G**: GPS **R**: GLONASS **E**: Galileo **J**: QZSS **C**: BDS **I:** NavIC/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** = NavIC/IRNSS alpha0 - alpha3 **IRNB** = NavIC/IRNSS beta0 - beta3 – Parameters: GAL: ai0, ai1, ai2, Blank GPS: alpha0-alpha3 or beta0-beta3 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: A=BDT 00h-01h;	 A4,1X 4D12.4 1X,A1

TABLE A5 GNSS NAVIGATION MESSAGE FILE - HEADER SECTION DESCRIPTION		
HEADER LABEL (Columns 61-80)	**DESCRIPTION**	**FORMAT**
	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`	Difference between GNSS system time and UTC or other time systems – **Type**: **`GPUT`** = GPS - UTC (a0, a1) **`GLUT`** = GLO - UTC (a0= -TauC, a1=zero) **`GAUT`** = GAL - UTC (a0, a1) **`BDUT`** = BDS - UTC (a0=A_{0UTC}, a1=A_{1UTC}) **`QZUT`** = QZS - UTC (a0, a1) **`IRUT`** = IRN - UTC (a0=A_{0UTC}, a1=A_{1UTC}) **`SBUT`** = SBAS - UTC (a0, a1) **`GLGP`** = GLO - GPS (a0=-TauGPS, a1=zero) **`GAGP`** **=** GAL - GPS **(**See ****Note** Below**)** (a0 = A0G, a1 = A1G for GAL INAV/FNAV; a0 = –$A0_{GGTO}$, a1 = –$A1_{GGTO}$ for GPS CNAV) **`QZGP`** = QZS - GPS (a0, a1) **`IRGP`** =IRN - GPS (a0=A_0, a1=A_1) – **a0, a1 coefficients** of linear polynomial $\Delta t = a0 + a1 \cdot (t-t_{ref})$ for fractional part (excluding leap seconds) of time system difference (a0; sec, a1; sec/sec)	 A4,1X D17.10 D16.9

<table>
<tr><th colspan="3">TABLE A5
GNSS NAVIGATION MESSAGE FILE - HEADER SECTION DESCRIPTION</th></tr>
<tr><th>HEADER LABEL
(Columns 61-80)</th><th>DESCRIPTION</th><th>FORMAT</th></tr>
<tr><td></td><td>– T Reference time for polynomial (Seconds into GPS/GAL/BDS/QZS/IRN/SBAS week)
– W Reference week number;
o GPS/GAL/QZS/IRN/SBAS week aligned to GPS, continuous number from 6-Jan-1980
o GLONASS T and W zero.
o BDS week, continuous from: 1-Jan-2006
– Satellite ID;
System identifier and PRN/slot number ‘snn’ of the GNSS satellite (see section 4.5) broadcasting the time system difference or SBAS satellite broadcasting the MT12. Use EGNOS, WAAS, or MSAS for SBAS time differences from MT17.
– 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.

**Note: From RINEX 3.04 the GPGA label is replaced by GAGP, while the value and sign for the Galileo minus GPS time offset remains unchanged.</td><td>1XI6

1XI4

1X,A5,1X

I2,1X</td></tr>
<tr><td>*LEAP SECONDS</td><td>– 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 BDT</td><td>I6
I6

I6

I6

A3</td></tr>
</table>

TABLE A5 GNSS NAVIGATION MESSAGE FILE - HEADER SECTION DESCRIPTION		
HEADER LABEL (Columns 61-80)	**DESCRIPTION**	**FORMAT**
	are valid identifiers. All data fields **must** match the indicated time system identifier. 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-200L 20.3.3.5.2.4. 2. For BDT Time System Identifier, the Number of leap seconds since 1-Jan-2006 as transmitted by the BDS almanac Δt_{LS} (see BDS-SIS-ICD-OS_B1C section 7.12.1). 3. GLO-only navigation files should not have this optional header written.	
END OF HEADER		

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

A6 GNSS Navigation Message File – GPS Data Record Description

TABLE A6 GNSS NAVIGATION MESSAGE FILE – GPS DATA RECORD DESCRIPTION		
NAV. 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 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; bit 17 w 10 sf 2 + IODC & Table 20-XII of GPS ICD. (BNK if Unknown). - Spare(x2) (see Section 6.4)	4X,4D19.12

*) see section 6.8.

) Adjust the *Transmission time of message* by ±604800 to refer to the reported week in ***BROADCAST ORBIT 5*, if necessary. Set value to **.9999999999E+09** 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.

A7 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|
     3.05           N: GNSS NAV DATA    G: GPS              RINEX VERSION / TYPE
XXRINEXN V3         AIUB                19990903 152236 UTC PGM / RUN BY / DATE
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   G12  2 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|
```

A8 GNSS Navigation Mssg File – GALILEO Data Record Description

TABLE A8 GNSS NAVIGATION MESSAGE FILE - GALILEO DATA RECORD DESCRIPTION		
NAV. 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 (see Section 6.4)	4X,4D19.12 ****) *****)
BROADCAST ORBIT - 6	- SISA Signal in space accuracy (meters) No Accuracy Prediction Available(NAPA) /	4X,4D19.12

TABLE A8 GNSS NAVIGATION MESSAGE FILE - GALILEO DATA RECORD DESCRIPTION		
NAV. RECORD	**DESCRIPTION**	**FORMAT**
	unknown: -1.0 - SV health (FLOAT → 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(x3) (see Section 6.4)	4X,4D19.12

*) see section 6.8.

) Adjust the *Transmission time of message* by + or -604800 to refer to the reported week in ***BROADCAST ORBIT 5*, if necessary. Set value to **.999999999999E+09** 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.

****) For Navigation data fields stored bitwise see section 6.9.

*****) 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).

******) For Navigation data fields stored bitwise see section 6.9. If bit 0 or bit 2 of Data sources (***BROADCAST ORBIT – 5)*** is set then the SV health parameter; 'E1B DVS' & 'E1B HS','E5b DVS' & 'E5b HS' and both 'BGDs' are valid. If bit 1 of Data sources is set then 'E5a DVS' & 'E5a HS' and BGD E5a/E1 are valid. Non-valid parameters are set to 0 and to be ignored.

A9 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|
     3.05           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    E10  5 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
     3.05           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  492   B10  7 TIME SYSTEM CORR
GAUT  3.7252902985e-09 5.329070518e-15 345600 1849   E10  5 TIME SYSTEM CORR
GLGP -3.7252902985e-09 0.000000000e+00 345600 1849   R10  0 TIME SYSTEM CORR
GLUT  1.0710209608e-08 0.000000000e+00 345600 1849   R10  0 TIME SYSTEM CORR
GAGP -2.0081643015e-09-9.769962617e-15 432000 1849   E12  0 TIME SYSTEM CORR
GPUT  4.5110937208e-09 7.105427358e-15 372608 1849   G10  2 TIME SYSTEM CORR
QZUT  1.9557774067e-08 1.598721155e-14  61440 1850   J01  0 TIME SYSTEM CORR
    18                                                      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|
```

A10 GNSS Navigation Mssg File – GLONASS Data Record Description

TABLE A10 GNSS NAVIGATION MESSAGE FILE – GLONASS DATA RECORD DESCRIPTION		
NAV. 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=healthy, 1=unhealthy) (MSB of 3-bit 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
BROADCAST ORBIT - 4	- Status Flags (FLOAT → INTEGER) 9-bit binary number (BNK if Unknown); **M** ; bit 7-8, GLO type indicator (00=GLO, 01=GLO-M/K) **P4** ; bit 6, *GLO-M/K only*, 1=data updated, 0=data not updated **P3** ; bit 5, num of satellites in current frame almanac (0 = 4 sats, 1 = 5 sats) **P2** ; bit 4, indicate even (0) or odd (1) of time interval **P1** ; bit 2-3, update and validity interval (00 = 0 min, 01 = 30 min, 10=45 min, 11=60 min) **P** ; bit 0-1, *GLO-M/K only*, time offset parameters τ_c, τ_{GPS} source (00 =ground, 01 = τ_c ground, τ_{GPS} on-board, 10 = τ_c on-board, τ_{GPS} ground,	4X,4D19.12 **)

TABLE A10 GNSS NAVIGATION MESSAGE FILE – GLONASS DATA RECORD DESCRIPTION		
NAV. RECORD	**DESCRIPTION**	**FORMAT**
	11 = on-board) - L1/L2 group delay difference $\Delta\tau$.(in seconds) ***) - URAI ; *GLO-M/K only* – raw accuracy index F_T. ****) - Health Flags (FLOAT → INTEGER) 3-bit binary number (BNK if Unknown) *****); ***l*(3)** ; bit 2, *GLO-M/K only*, health bit of string 3 **A**C ; bit 1, 1 = almanac health reported in ephemerides record, 0 = not reported **C** ; bit 0, almanac health bit (1 = healthy, 0 = not healthy) *GLO-M/K exclusive flags and values only to be valid when flag M set to "01"*	

*) see section 6.8.

**) For Navigation data fields stored bitwise see section 6.9.

***) `.999999999999E+09` if Unknown

****) `1.500000000000E+01` if Unknown

*****) bit 0 (**C**) is to be ignored if bit 1 (**A**C) is zero

A11 GNSS Navigation Mssg 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|
     3.05           N: GNSS NAV DATA    M: MIXED            RINEX VERSION / TYPE
XXRINEXN V3         AIUB                20061002 000123 UTC PGM / RUN BY / DATE
EXAMPLE OF VERSION 3.05 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   G10  2 TIME SYSTEM CORR
GLUT  0.7823109626E-06 0.000000000E+00      0 1395   R10  0 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
     1.790000000000E+02 8.381903171539E-09 2.000000000000E+00 3.000000000000E+00
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
     5.200000000000E+01 9.456379289034E-09 0.000000000000E+00 0.000000000000E+00
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
```

A12 GNSS Navigation Mssg File – QZSS Data Record Description

TABLE A12 QZSS NAVIGATION MESSAGE FILE – QZSS DATA RECORD DESCRIPTION		
NAV. RECORD (Columns 61-80)	**DESCRIPTION**	**FORMAT**
SV / 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 (fixed to 2, see IS-QZSS-PNT 4.1.2.7) - 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-PNT, Section 5.4.3.1) which refers to: IS-GPS-200 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-PNT 5.4.1) - TGD (seconds) The QZSS ICD specifies a do not use bit pattern	4X,4D19.12

TABLE A12 QZSS NAVIGATION MESSAGE FILE – QZSS DATA RECORD DESCRIPTION		
NAV. RECORD (Columns 61-80)	**DESCRIPTION**	**FORMAT**
	"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-PNT, 4.1.2.4(3) 0 – two hours), 1 – more than 2 hours. Blank if not known. - Spare(x2) (see Section 6.4)	4X,4D19.12

Records marked with * are optional

*) see section 6.8.

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

A13 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|
     3.05           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|
```

A14 GNSS Navigation Message File – BDS Data Record Description

Table A14 GNSS NAVIGATION MESSAGE FILE – BDS DATA RECORD DESCRIPTION		
NAV. 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 (see Section 6.4) - BDT Week # - Spare (see Section 6.4)	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	4X,4D19.12

	- TGD1 B1/B3 (seconds) - TGD2 B2/B3 (seconds)	
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(x2) (see Section 6.4)	4X,4D19.12

*) see section 6.8.

**) 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 **.9999999999E+09** if not known.

A15 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|
     3.05           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                    4.350000000000e+02
     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|
```

A16 GNSS Navigation Mssg File – SBAS Data Record Description

TABLE A16 GNSS NAVIGATION MESSAGE FILE – SBAS DATA RECORD DESCRIPTION		
NAV. 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: SBAS: See section 5.4.4 for: health, health availability and User Range Accuracy.	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, see reference RTCA DO-229, 8 first bits after Message Type if MT9)	4X,4D19.12

*) see section 6.8.

A17 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|
     3.05           N: GNSS NAV DATA    S: SBAS             RINEX VERSION / TYPE
SBAS2RINEX 3.0      CNES                20031018 140100     PGM / RUN BY / DATE
EXAMPLE OF VERSION 3.05 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|
```

A18 GNSS Navigation Mssg File – NavIC/IRNSS Data Record Description

TABLE A18 GNSS NAVIGATION MESSAGE FILE – NavIC/IRNSS DATA RECORD DESCRIPTION		
NAV. RECORD	**DESCRIPTION**	**FORMAT**
SV / EPOCH / SV CLK	- Satellite system (**I**), sat number (PRN) - Epoch: Toc - Time of Clock (NavIC/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 NavIC/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). - Spare (see Section 6.4)	4X,4D19.12
BROADCAST ORBIT - 6	- User Range Accuracy(m), See NavIC/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	4X,4D19.12

TABLE A18 GNSS NAVIGATION MESSAGE FILE – NavIC/IRNSS DATA RECORD DESCRIPTION		
NAV. RECORD	**DESCRIPTION**	**FORMAT**
	and S healthy, 3= both L5 and S unhealthy - TGD (seconds) - Spare (see Section 6.4)	
BROADCAST ORBIT - 7	- Transmission time of message **) (sec of NavIC/IRNSS week) - Spare(x3) (see Section 6.4)	4X,4D19.12

*) see section 6.8.
) Adjust the *Transmission time of message* by + or -604800 to refer to the reported week in ***BROADCAST ORBIT 5*, if necessary. Set value to **.999999999999E+09** if not known.

A19 NavIC/IRNSS Navigation Message File – Example

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

----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
     3.05           NAVIGATION DATA     I (NavIC/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|
```

A20 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: **3.05** - 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 5.2.2)	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) - Type - Accuracy (same units as obs values)	 A20, A20,6X, F7.1,4X,

TABLE A20 METEOROLOGICAL DATA FILE - HEADER SECTION DESCRIPTION		
HEADER LABEL (Columns 61-80)	**DESCRIPTION**	**FORMAT**
	- Observation type Record is repeated for each observation type found in **# / TYPES OF OBSERV** record	A2,1X
SENSOR POS XYZ/H	- Approximate position of the met sensor - Geocentric coordinates **X, Y, Z** (ITRF or WGS84) - Ellipsoidal height **H** - Observation type Set **X, Y, Z** to zero or blank if unknown. 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

A21 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

A22 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|
     3.05           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|
```

A23 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
	G1a	1600.995	L1OCd	L4A	None (Reference Signal)
			L1OCp	L4B	None
			L1OCd+ L1OCd	L4X	None
	G2	1246+k*7/16	C/A	L2C	None (Reference Signal)
			P	L2P	+¼ cycle
	G2a	1248.06	L2CSI	L6A	None (Reference Signal)
			L2OCp	L6B	None
			L2CSI+ L2OCp	L6X	None

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)**
GLONASS	G3	1202.025	I	L3I	None (Reference Signal)
			Q	L3Q	Must be aligned to L3I
			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	+¼ cycle (See Note 5 Below)
			L1C (P)	L1L	+¼ cycle
			L1C-(D+P)	L1X	+¼ cycle
			L1S	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 Signal)
			Q	L5Q	-¼ cycle
			I+Q	L5X	Must be aligned to L5I
	L5S	1176.45	I	L5D	None Reference Signal
			Q	L5P	-¼ cycle
			I+Q	L5Z	None must be aligned to L5D
	L6 (See Note 6 Below)	1278.75	L6D	L6S	None (Reference Signal)
			L6P	L6L	None

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)**
QZSS			L6(D+P)	L6X	None
			L6E	L6E	None
			L6(D+E)	L6Z	None
BDS	B1	1561.098	I	L2I	None (Reference Signal) (See Note 4 Below)
			Q	L2Q	Must be aligned to L2I
			I+Q	L2X	Must be aligned to L2I
	B1C	1575.42	Data (D)	L1D	None (Reference Signal)
			Pilot(P)	L1P	Must be aligned to L1D
			D+P	L1X	Must be aligned to L1D
	B1A	1575.42	Data (D)	L1S	None (Reference Signal)
			Pilot(P)	L1L	Must be aligned to L1S
			D+P	L1Z	Must be aligned to L1S
	B2a	1176.45	Data (D)	L5D	None (Reference Signal)
			Pilot(P)	L5P	Must be aligned to L5D
			D+P	L5X	Must be aligned to L5D
	B2 (BDS-2)	1207.140	I	L7I	None (Reference Signal)
			Q	L7Q	-¼ cycle
			I+Q	L7X	Must be aligned to L7I
	B2b (BDS-3)	1207.140	Data (D)	L7D	None (Reference Signal)
			Pilot(P)	L7P	Must be aligned to L7D
			D+P	L7Z	Must be aligned to L7D
	B2a+B2b (BDS-3)	1191.795	Data (D)	L8D	None Reference Signal
			Pilot(P)	L8P	Must be aligned to L8D
			D+P	L8X	Must be aligned to L8D
	B3	1268.52	I	L6I	None (Reference Signal)
			Q	L6Q	Must be aligned to L6I
			I+Q	L6X	Must be aligned to L6I
	B3A (BDS-3)	1268.52	Data (D)	L6D	None (Reference Signal)
			Pilot (P)	L6P	Must be aligned to L6D
			D+P	L6Z	Must be aligned to L6D

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)**
NavIC/ 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.
5. There has been a phase alignment change between the QZSS Block I and Block II satellites. The table above shows the Block II alignment. Block I corrections: L1S none, L1L +¼.
6. L6D, L6P, L6E are identical to L61/L62(code1), L61(code2), L62(code2) in IS-QZSS-L6 respectively.