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RINEX: The Receiver Independent Exchange Format Version 2.10

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0. REVISION HISTORY

0.1 Revision Summary

First Revision, April 1993
Clarification December 1993
Doppler Definition: January 1994
PR Clarification: October 1994
Wlfact Clarification: February 1995
Event Time Frame Clarification: May 1996
Minor errors in the examples A7/A8: May 1996
Naming convention for compressed met files; January 1997
Continuation line clarifications: April 1997
GLONASS Extensions: April 1997
Met sensor description and position records: April 1997
Wavelength factor clarifications: April 1997
Error in example A12: CORR TO SYSTEM TIME, April 1997
Redefinition of sv clock params in GLONASS Nav Mess Files: March 1998
Naming conventions for compressed RINEX obs files: March 1998
GPS week: No roll-over, continuous number: March 1998
Error in compressed DOS file naming convention: July 1998
Table A13 contained blank satellite identifiers: Sept 1998
Discrepancy between Tables A5 and A9 removed: Sept 1998
Phase data format overflow: Clarification: Oct 1998
Message frame time Table A11: Clarification: Oct 1998
RINEX Version 2.10 Modifications: July 1999
Typo in paragraph 0.4 (epoch flag >1): Nov 1999
Clarification regarding trailing blanks: Dec 1999
Clarification regarding units of ZD,ZT, URA(GEO)
Clarification regarding time system identifier of GEO obs files
Clarification regarding time system identifier in TIME OF LAST record: Feb 2000
Addition of GEO examples: February 2000
Clarification of epoch field for event flag records: May 2000
Table A6: Typos in format definition of epoch: May 2000
Clarification of the GLONASS satellite identifier: June 2001
Clarification of the floating point exponent format: January 2002
Glonass frequency numbers -7 ... +13: December 2007

0.2 First Revision

The first documentation of the RINEX Version 2 Format was published by
W. Gurtner and G. Mader in the CSTG GPS Bulletin of September/October 1990.

The main reason for a revision is the new treatment of antispoofing data by the RINEX format (see chapter 7). Chapter 4 gives a recommendation for data compression procedures, especially useful when large amounts of data are exchanged through computer networks. In Table A3 in the original paper the definition of the "PGM / RUN BY / DATE" navigation header record was missing, although the example showed it. The redefinition of AODE/AODC to IODE/IODC also asked for an update of the format description. For consistency reasons we also defined a Version 2 format for the Meteorological Data files (inclusion of a END OF HEADER record and an optional MARKER NUMBER record).

The slight modification (or rather the definition of a bit in the Loss of Lock Indicator unused so far) to flag AS data is so small a change that we decided to NOT increase the version number!

0.3 Later Revisions

* URA Clarification (10-Dec-93):

The user range accuracy in the Navigation Message File did not contain a definition of the units: There existed two ways of interpretation: Either the 4 bit value from the original message or the converted value in meters according to GPS ICD-200. In order to simplify the interpretation for the user of the RINEX files I propose the bits to be converted into meters prior to RINEX file creation.

* GLONASS Extensions:

In March 1997 a proposal for extensions to the current RINEX definitions based on experiences collected with GLONASS only and mixed GPS/GLONASS data files was circulated among several instrument manufacturers and software developers.

The results of the call for comments have been worked into this document. A separate document (glonass.txt) summarizes just the necessary extensions.

- * A blank satellite identifier is allowed in pure GPS files only
- * Met sensor description and position records were added to facilitate the precise use of met values.
- * Description and examples for wavelength factors and their temporary changes (bit 1 of LLI) clarified.
- * The RINEX documentation distributed in spring 1997 contained definitions for the GLONASS satellite clock offset and drift with the intention to have them defined identically to the GPS values. Unfortunately the GLONASS Interface Document consulted had a sign error in one of the formulae.

The values should be stored into the RINEX file as $-\tau_N$, $+\gamma_N$, $-\tau_C$. The original definition asked for $-\tau_N$, $-\gamma_N$, $+\tau_C$. See paragraph 8.2.

To avoid problems with files created with the original definitions a real valued version number (2.01) has been introduced for GLONASS nav mess files.

- * IGS decided to use the Hatanaka compression scheme for RINEX observation files. Below the corresponding RINEX file name conventions are included as recommendations. The DOS naming (extension .yyE) was wrongly set to .yyY in the March 1998 version of the document.
- * GPS week: The GPS week number in all RINEX files is a continuous number not affected by the 1024 roll-over, it runs from 1023 over 1024 to 1025 etc.

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- * A discrepancy between the definition of the header line fields of met sensor description and position in Table A5 and the example in Table A9 was removed. The latter was correct.
- * Clarification for phase data format overflows: Add or subtract a suitable number of cycles, set LLI flag.
- * Clarification for the GLONASS satellite identifier: "Almanac number" was somewhat ambiguous. It has been replaced by "slot number" within the satellite constellation.

0.4 Version 2.10 Modifications

The modifications leading to Version 2.10 include:

- Fractional version number
- Zero padding of 2-digit year values (years 2000-2009 --> 00-09)
- Field length of time of first obs (1/10 microsecond resolution)
- Non-integer sampling rate (INTERVAL header record)
- Header records now allowed after all epoch flags >1
- Additional obs types in obs files: S1, S2 (raw signal strength values)
- Receiver clock offset header line to clarify applied corrections
- Default wavelength factor header line mandatory
- Inmarsat GPS payloads: New satellite system definition, new nav mess files
- Curve fit interval in GPS nav mess file
- Redefinition of SV health value in GPS nav mess file
- Additional obs types in met files (ZD, ZT)

0.5 Version 2.10 Revisions

- * "Header records now allowed after all epoch flags >2" in paragraph 0.4 should read ">1"
- * The original intention of the RINEX format was to allow for variable record lengths of the ASCII files to minimize the file size. Empty fields or unknown values can either be represented by zeroes or blank space. Most RINEX converters removed trailing blank to further reduce the file size. The documentation was not clear enough to explicitly allow for this practice (paragraphs 2, 5.3, 9.1).
- * The time system identifier of GPS observations generated by GEO payloads defaults to GPS (explicitly stated now in paragraph 9.1)
- * The time system identifier in the TIME OF LAST OBS header record has to be identical to the one in the TIME OF FIRST OBS record
- * Clarification of Table A2 to be compatible with examples of Table A7:
For event flags without significant epoch the epoch fields can be left blank.
Table A6: Format for epoch contained obvious errors
- * Clarification of the floating point exponent format in navigation message files (two digits, E,e,D,d letters)
- * The newer GLONASS satellites started using frequency numbers in the 0 to -7 range. Table A11 BROADCAST ORBIT - 2 was modified accordingly.

1. THE PHILOSOPHY OF RINEX

The first proposal for the "Receiver Independent Exchange Format" RINEX has been developed by the Astronomical Institute of the University of Berne for the easy exchange of the GPS data to be collected during the large European

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GPS campaign EUREF 89, which involved more than 60 GPS receivers of 4 different manufacturers. The governing aspect during the development was the following fact:

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

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

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

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

2. GENERAL FORMAT DESCRIPTION

Currently the format consists of six ASCII file types:

1. Observation Data File
2. Navigation Message File
3. Meteorological Data File
4. GLONASS Navigation Message File
5. GEO Navigation Message File
6. Satellite and Receiver Clock Date File

(The format definition of the clock files has been published in 1998 in a separate document by Jim Ray and Werner Gurtner, available at the IGS Central Bureau Information System: ftp://igs.cb.jpl.nasa.gov/igs.cb/data/format/rinex_clock.txt).

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

The format has been optimized for minimum space requirements independent from the number of different observation types of a specific receiver by indicating in the header the types of observations to be stored. 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. The maximum record length is 80 bytes per record.

Each Observation file and each Meteorological Data file basically contain the data from one site and one session. RINEX Version 2 also allows to include observation data from more than one site subsequently occupied by a roving receiver in rapid static or kinematic applications. Although Version 2 allows to insert header records into the data field we do not recommend to

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concatenate data of 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 has to be exchanged it would not be economical to include the identical satellite messages collected by the different receivers several times. Therefore the Navigation Message File from one receiver may be exchanged or a composite Navigation Message File created containing non-redundant information from several receivers in order to make the most complete file.

The format of the data records of the RINEX Version 1 Navigation Message file is identical to the former NGS exchange format.

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

3. DEFINITION OF THE OBSERVABLES

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

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. It is expressed in GPS time (not Universal Time).

PSEUDO-RANGE:

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

$$\text{PR} = \text{distance} + c * (\text{receiver clock offset} - \text{satellite clock offset} + \text{other biases})$$

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

See also clarifications for pseudoranges in mixed GPS/GLONASS files in chapter 8.1.

PHASE:

The phase is the carrier-phase measured in whole cycles at both L1 and L2. The half-cycles measured by squaring-type receivers must be converted to whole cycles and flagged by the wavelength factor in the header section.

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 phase observations will not contain any systematic drifts from intentional offsets of the reference oscillators.

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

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

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receiver clock correction should be applied to all 3 observables:

$$\begin{aligned}
\text{Time(corr)} &= \text{Time}(r) - dT(r) \\
\text{PR(corr)} &= \text{PR}(r) - dT(r)*c \\
\text{phase(corr)} &= \text{phase}(r) - dT(r)*\text{freq}
\end{aligned}$$

DOPPLER:

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

4. THE EXCHANGE OF RINEX FILES:

We recommend using the following naming convention for RINEX files:

```

ssssdddf.yyt      ssss:  4-character station name designator
                   ddd:   day of the year of first record
                   f:    file sequence number within day
                   0:    file contains all the existing
                        data of the current day
                   yy:   year
                   t:   file type:
                       O: Observation file
                       N: Navigation file
                       M: Meteorological data file
                       G: GLONASS Navigation file
                       H: Geostationary GPS payload nav mess file
                       B: Geostationary GPS payload broadcast data
                       C: Clock files (see separate documentation)

```

When data transmission times or storage volumes are critical we recommend compressing the files prior to storage or transmission using the UNIX "compress" und "uncompress" programs. Compatible routines are available on VAX/VMS and PC/DOS systems, as well.

Proposed naming conventions for the compressed files:

| File Types | UNIX | VMS | DOS |
|----------------------------|----------------|----------------|--------------|
| Obs Files | ssssdddf.yyO.Z | ssssdddf.yyO_Z | ssssdddf.yyY |
| Obs Files (Hatanaka compr) | ssssdddf.yyD.Z | ssssdddf.yyD_Z | ssssdddf.yyE |
| GPS Nav Files | ssssdddf.yyN.Z | ssssdddf.yyN_Z | ssssdddf.yyX |
| GLONASS Nav File | ssssdddf.yyG.Z | ssssdddf.yyG_Z | ssssdddf.yyV |
| GEO Nav Files | ssssdddf.yyH.Z | ssssdddf.yyH_Z | ssssdddf.yyU |
| GEO Broadcast Files | ssssdddf.yyB.Z | ssssdddf.yyB_Z | |
| Met Data Files | ssssdddf.yyM.Z | ssssdddf.yyM_Z | ssssdddf.yyW |
| Clock Files (see sep.doc.) | ssssdddf.yyC.Z | ssssdddf.yyC_Z | |

References for the Hatanaka compression scheme: See e.g.

<ftp://igscb.jpl.nasa.gov/igscb/software/rnxcmp/docs/>

IGSMails 1525,1686,1726,1763,1785

5. RINEX VERSION 2 FEATURES

The following section contains features that have been introduced for RINEX Version 2:

5.1 Satellite Numbers:

Version 2 has been prepared to contain GLONASS or other satellite systems' observations. Therefore we have to be able to distinguish the satellites of the different systems: We precede the 2-digit satellite number with a system identifier.

```

snn          s:   satellite system identifier
              G or blank : GPS
              R           : GLONASS
              S           : Geostationary signal payload
              T           : Transit

              nn:   - PRN (GPS), slot number (GLONASS)
                   - PRN-100 (GEO)
                   - two-digit Transit satellite number

```

Note: G is mandatory in mixed GPS/GLONASS files

(blank default modified in April 1997)

5.2 Order of the Header Records:

As the record descriptors in columns 61-80 are mandatory, the programs reading a RINEX Version 2 header are able to decode the header records with formats according to the record descriptor, provided the records have been first read into an internal buffer.

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

- The "RINEX VERSION / TYPE" record must be the first record in a file
- The default "WAVELENGTH FACT L1/2" record must precede all records defining wavelength factors for individual satellites
- 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.

5.3 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 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.

5.4 Event Flag Records

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

5.5 Receiver Clock Offset

A large number of users asked to optionally include a receiver-derived

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clock offset into the RINEX format. In order to remove uncertainties if the data (epoch, pseudorange, phase) have been previously corrected or not by the reported clock offset, RINEX Version 2.10 requests a clarifying (new) header record.

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

As the output format for the receiver-derived clock offset is limited to nanoseconds the offset should be rounded to the nearest nanosecond before it is used to correct the observables in order to guarantee correct reconstruction.

6. ADDITIONAL HINTS AND TIPS

6.1 Version 1 / Version 2

Programs developed to read RINEX Version 1 files have to verify the version number. Version 2 files may look different (version number, END OF HEADER record, receiver and antenna serial number alphanumeric) even if they do not use any of the new features

6.2 Leading Blanks in CHARACTER fields

We propose that routines to read RINEX Version 2 files automatically delete leading blanks in any CHARACTER input field. Routines creating RINEX Version 2 files should also left-justify all variables in the CHARACTER fields.

6.3 Variable-length Records

DOS, and other, files may have variable record lengths, so we recommend to first read each observation record into a 80-character blank string and decode the data afterwards. In variable length records, empty data fields at the end of a record may be missing, especially in the case of the optional receiver clock offset.

6.4 Blank Fields

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

6.5 2-Digit Years

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

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

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

Full 4-digit year fields could then be defined by a future RINEX version 3.

6.6 Fit Interval

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

0 = 4 hours
1 = greater than 4 hours.

Together with the IODC values and Table 20-XII the actual fit interval can be determined. The second value in the last record of each message shall contain the fit interval in hours determined using IODC, fit flag, and Table 20-XII, according to the Interface Document ICD-GPS-200.

6.7 Satellite Health

The health of the signal components (bits 18 to 22 of word three in subframe one) are now (Version 2.10) included into the health value reported in the second field of the sixth nav mess records.

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

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

6.8 Transmission Time of Message (Navigation message file)

The transmission time of message can be shortly before midnight Saturday/Sunday, the TOE and TOC of the message already in the next week. As the reported week in the RINEX nav message (BROADCAST ORBIT - 5 record) goes with ToE (this is different from the GPS week in the original satellite message!), the transmission time of message should be reduced by 604800 (i.e., will become negative) to also refer to the same week.

7. RINEX UNDER ANTISPOOFING (AS)

Some receivers generate code delay differences between the first and second frequency using cross-correlation techniques when AS is on and may recover the phase observations on L2 in full cycles. Using the C/A code delay on L1 and the observed difference it is possible to generate a code delay observation for the second frequency.

Other receivers recover P code observations by breaking down the Y code into P and W code.

Most of these observations may suffer from an increased noise level. In order to enable the postprocessing programs to take special actions, such AS-infected observations are flagged using bit number 2 of the Loss of Lock Indicators (i.e. their current values are increased by 4).

8. GLONASS Extensions

8.1 RINEX Observation File

8.1.1 Time System Identifier

The original RINEX Version 2 needed one major supplement, the explicit definition of the time system:

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. In order to remove possible misunderstandings and ambiguities, the header records "TIME OF FIRST OBS" and (if present) "TIME OF LAST OBS" in GLONASS and GPS observation files `_can_`, in mixed GLONASS/GPS observation files `_must_` contain a 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. Pure GPS files default to GPS and pure GLONASS files default to GLO.

Format definitions see Table A1.

Hence, the two possible time tags differ by the current number of leap seconds.

In order to have the current number of leap seconds available we recommend to include a LEAP SECOND line into the RINEX header.

If there are known non-integer biases between the "GPS receiver clock" and "GLONASS receiver clock" in the same receiver, they should be applied. In this case the respective code and phase observations have to be corrected, too ($c * \text{bias}$ if expressed in meters).

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

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

8.1.2 Pseudorange Definition

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

If a mixed-mode GPS/GLONASS receiver refers all pseudorange observations to one receiver clock only,

- the raw GLONASS pseudoranges will show the current number of leap seconds between GPS time and GLONASS time if the receiver clock is running in the GPS time frame
- the raw GPS pseudoranges will show the negative number of leap seconds between GPS 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 follows:

```
PR(GPS) := PR(GPS) + c * leap_seconds    if generated with a receiver clock
                                             running in the GLONASS time frame

PR(GLO) := PR(GLO) - c * leap_seconds    if generated with a receiver clock
                                             running in the GPS time frame
```

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

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"leap_seconds" is the actual number of leap seconds between GPS and GLONASS (UTC) time, as broadcast in the GPS almanac and distributed in Circular T of BIPM.

8.1.3 More Than 12 Satellites per Epoch

The format of the epoch / satellite line in the observation record part of the RINEX Observation files has only been defined for up to 12 satellites per epoch. We explicitly define now the format of the continuation lines, see Table A2.

8.2 RINEX Navigation Files for GLONASS

As the GLONASS navigation message differs in contents from the GPS message too much, a special GLONASS navigation message file format has been defined.

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

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

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

*** In order to use the same sign conventions for the GLONASS corrections as in the GPS navigation files, the broadcast GLONASS values are stored as:

-TauN, +GammaN, -TauC.

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

File naming convention: See above.

9. RINEX Extensions for Geostationary Satellites (GPS Signal Payloads)

With the implementation of GNSS programs, GPS-like ranging measurements can be performed on geostationary navigation payloads.

RINEX Version 2.10 defines the necessary extensions to handle such data in RINEX files for data exchange and postprocessing purposes.

9.1 RINEX Observation Files for GEO Satellites

A new satellite system identifier has been defined for the geostationary GPS signal payloads: "S", to be used in the RINEX VERSION / TYPE header line and in the satellite identifier 'snn', nn being the GEO PRN number minus 100.

e.g.: PRN = 120 --> 'snn' = "S20"

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

The time system identifier of GEO satellites generating GPS signals defaults to GPS time.

9.2 RINEX Navigation Message Files for GEO Satellites

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

The header section contains informations 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 such as health, age of the data, etc.

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

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

$$\text{GEO} \quad : \text{Tutc} = \text{Tsv} - \text{aGf0} - \text{aGf1} * (\text{Tsv} - \text{Toe}) - \text{W0} - \text{leap_sec}$$

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

* References for the definition of the accuracy and health codes still have *
 * to be defined. *
 * Help is needed here by colleagues working with such GEO data! *

10. REFERENCES

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11. RINEX VERSION 2.10 FORMAT DEFINITIONS AND EXAMPLES

| TABLE A1 GPS OBSERVATION DATA FILE - HEADER SECTION DESCRIPTION | | |
|--|---|----------------------|
| HEADER LABEL (Columns 61-80) | DESCRIPTION | FORMAT |
| RINEX VERSION / TYPE | - Format version (2.10) - File type ('O' for Observation Data) | F9.2,11X, A1,19X, |

| rinex210 | | | |
|------------------------|---|--------------------------------|---|
| | - Satellite System: blank or 'G': GPS 'R': GLONASS 'S': Geostationary signal payload 'T': NNSS Transit 'M': Mixed | A1,19X | |
| PGM / RUN BY / DATE | - Name of program creating current file - Name of agency creating current file - Date of file creation | A20, A20, A20 | |
| * COMMENT | Comment line(s) | A60 | * |
| MARKER NAME | Name of antenna marker | A60 | |
| * MARKER NUMBER | Number of antenna marker | A20 | * |
| 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 | Approximate marker position (WGS84) | 3F14.4 | |
| ANTENNA: DELTA H/E/N | - Antenna height: Height of bottom surface of antenna above marker - Eccentricities of antenna center relative to marker to the east and north (all units in meters) | 3F14.4 | |
| WAVELENGTH FACT L1/2 | - Default wavelength factors for L1 and L2 1: Full cycle ambiguities 2: Half cycle ambiguities (squaring) 0 (in L2): Single frequency instrument - zero or blank The default wavelength factor line is required and must precede satellite- specific lines. | 2I6, I6 | |
| * WAVELENGTH FACT L1/2 | - Wavelength factors for L1 and L2 1: Full cycle ambiguities 2: Half cycle ambiguities (squaring) 0 (in L2): Single frequency instrument - Number of satellites to follow in list for which these factors are valid. - List of PRNs (satellite numbers with system identifier) These optional satellite specific lines may follow, if they identify a state different from the default values. Repeat record if necessary. | 2I6, I6, 7(3X,A1,I2) | * |
| # / TYPES OF OBSERV | - Number of different observation types stored in the file - Observation types | I6, 9(4X,A2) | |

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| | | | |
|-----------------------|--|---------------------|---|
| | <p>If more than 9 observation types: Use continuation line(s)</p> <p>The following observation types are defined in RINEX Version 2.10:</p> <p>L1, L2: Phase measurements on L1 and L2 C1 : Pseudorange using C/A-Code on L1 P1, P2: Pseudorange using P-Code on L1,L2 D1, D2: Doppler frequency on L1 and L2 T1, T2: Transit Integrated Doppler on 150 (T1) and 400 MHz (T2) S1, S2: Raw signal strengths or SNR values as given by the receiver for the L1,L2 phase observations</p> <p>Observations collected under Antispoofing are converted to "L2" or "P2" and flagged with bit 2 of loss of lock indicator (see Table A2).</p> <p>Units : Phase : full cycles Pseudorange : meters Doppler : Hz Transit : cycles SNR etc : receiver-dependent</p> <p>The sequence of the types in this record has to correspond to the sequence of the observations in the observation records</p> | 6X,9(4X,A2) | |
| * INTERVAL | Observation interval in seconds | F10.3 | * |
| TIME OF FIRST OBS | <p>- Time of first observation record (4-digit-year, month,day,hour,min,sec) - Time system: GPS (=GPS time system) GLO (=UTC time system) Compulsory in mixed GPS/GLONASS files Defaults: GPS for pure GPS files GLO for pure GLONASS files</p> | 5I6,F13.7, 5X,A3 | |
| * TIME OF LAST OBS | <p>- Time of last observation record (4-digit-year, month,day,hour,min,sec) - Time system: Same value as in TIME OF FIRST OBS record</p> | 5I6,F13.7, 5X,A3 | * |
| * RCV CLOCK OFFS APPL | Epoch, code, and phase are corrected by applying the realtime-derived receiver clock offset: 1=yes, 0=no; default: 0=no Record required if clock offsets are reported in the EPOCH/SAT records | I6 | * |
| * LEAP SECONDS | Number of leap seconds since 6-Jan-1980 Recommended for mixed GPS/GLONASS files | I6 | * |
| * # OF SATELLITES | Number of satellites, for which observations are stored in the file | I6 | * |
| * PRN / # OF OBS | <p>PRN (sat.number), number of observations for each observation type indicated in the "# / TYPES OF OBSERV" - record.</p> <p>If more than 9 observation types:</p> | 3X,A1,I2,9I6 | * |

| | | |
|---------------|---|--------|
| | rinex210 Use continuation line(s) This record is (these records are) repeated for each satellite present in the data file | 6X,9I6 |
| END OF HEADER | Last record in the header section. | 60X |

Records marked with * are optional

| TABLE A2 GPS OBSERVATION DATA FILE - DATA RECORD DESCRIPTION | | |
|---|---|---|
| OBS. RECORD | DESCRIPTION | FORMAT |
| EPOCH/SAT or EVENT FLAG | <ul style="list-style-type: none"> - Epoch : <li style="padding-left: 20px;">- year (2 digits, padded with 0 if necessary) <li style="padding-left: 20px;">- month, day, hour, min, <li style="padding-left: 20px;">- sec - Epoch flag 0: OK <li style="padding-left: 20px;">1: power failure between previous and current epoch <li style="padding-left: 20px;">>1: Event flag - Number of satellites in current epoch - List of PRNs (sat.numbers with system identifier, see 5.1) in current epoch - receiver clock offset (seconds, optional) <p>If more than 12 satellites: Use continuation line(s)</p> <p>If epoch flag 2-5:</p> <ul style="list-style-type: none"> - Event flag: <li style="padding-left: 20px;">2: start moving antenna <li style="padding-left: 20px;">3: new site occupation (end of kinem. data) (at least MARKER NAME record follows) <li style="padding-left: 20px;">4: header information follows <li style="padding-left: 20px;">5: external event (epoch is significant, same time frame as observation time tags) - "Number of satellites" contains number of special records to follow. Maximum number of records: 999 - For events without significant epoch the epoch fields can be left blank <p>If epoch flag = 6:</p> <ul style="list-style-type: none"> 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) | <p>1X,I2.2, 4(1X,I2), F11.7,</p> <p>2X,I1,</p> <p>I3, 12(A1,I2),</p> <p>F12.9</p> <p>32X, 12(A1,I2)</p> <p>[2X,I1,]</p> <p>[I3]</p> |
| OBSERVATIONS | <ul style="list-style-type: none"> - Observation - LLI - Signal strength | <p>rep. within record for each obs.type (same seq as given in header)</p> <p>m(F14.3, I1, I1)</p> |

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If more than 5 observation types (=80 char):
continue observations in next record.

This record is (these records are) repeated for
each satellite given in EPOCH/SAT - record.

Observations:

Phase : Units in whole cycles of carrier
Code : Units in meters
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 LLI indicator.

Loss of lock indicator (LLI). Range: 0-7

0 or blank: OK or not known
Bit 0 set : Lost lock between previous and
current observation: cycle slip
possible
Bit 1 set : Opposite wavelength factor to the
one defined for the satellite by a
previous WAVELENGTH FACT L1/2 line.
Valid for the current epoch only.
Bit 2 set : Observation under Antispoofing
(may suffer from increased noise)

Bits 0 and 1 for phase only.

Signal strength projected into interval 1-9:

1: minimum possible signal strength
5: threshold for good S/N ratio
9: maximum possible signal strength
0 or blank: not known, don't care

TABLE A3
GPS NAVIGATION MESSAGE FILE - HEADER SECTION DESCRIPTION

| HEADER LABEL (Columns 61-80) | DESCRIPTION | FORMAT |
|---------------------------------|---|--------------------------|
| RINEX VERSION / TYPE | - Format version (2.10) - File type ('N' for Navigation data) | F9.2,11X, A1,19X |
| PGM / RUN BY / DATE | - Name of program creating current file - Name of agency creating current file - Date of file creation | A20, A20, A20 |
| * COMMENT | Comment line(s) | A60 |
| * ION ALPHA | Ionosphere parameters A0-A3 of almanac (page 18 of subframe 4) | 2X,4D12.4 |
| * ION BETA | Ionosphere parameters B0-B3 of almanac | 2X,4D12.4 |
| * DELTA-UTC: A0,A1,T,W | Almanac parameters to compute time in UTC (page 18 of subframe 4) A0,A1: terms of polynomial T : reference time for UTC data | 3X,2D19.12, 2I9 *) |

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| | | |
|----------------|---|-----|
| | W : UTC reference week number. Continuous number, not mod(1024)! | |
| * LEAP SECONDS | Delta time due to leap seconds | I6 |
| END OF HEADER | Last record in the header section. | 60X |

Records marked with * are optional

TABLE A4
GPS NAVIGATION MESSAGE FILE - DATA RECORD DESCRIPTION

| OBS. RECORD | DESCRIPTION | FORMAT |
|----------------------|---|---|
| PRN / EPOCH / SV CLK | - Satellite PRN number - Epoch: Toc - Time of Clock year (2 digits, padded with 0 if necessary) month day hour minute second - SV clock bias (seconds) - SV clock drift (sec/sec) - SV clock drift rate (sec/sec2) | I2, 1X,I2.2, 1X,I2, 1X,I2, 1X,I2, 1X,I2, F5.1, 3D19.12 *) |
| BROADCAST ORBIT - 1 | - IODE Issue of Data, Ephemeris - Crs (meters) - Delta n (radians/sec) - M0 (radians) | 3X,4D19.12 |
| BROADCAST ORBIT - 2 | - Cuc (radians) - e Eccentricity - Cus (radians) - sqrt(A) (sqrt(m)) | 3X,4D19.12 |
| BROADCAST ORBIT - 3 | - Toe Time of Ephemeris (sec of GPS week) - Cic (radians) - OMEGA (radians) - CIS (radians) | 3X,4D19.12 |
| BROADCAST ORBIT - 4 | - i0 (radians) - Crs (meters) - omega (radians) - OMEGA DOT (radians/sec) | 3X,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 | 3X,4D19.12 |
| BROADCAST ORBIT - 6 | - SV accuracy (meters) - SV health (bits 17-22 w 3 sf 1) - TGD (seconds) - IODC Issue of Data, Clock | 3X,4D19.12 |
| BROADCAST ORBIT - 7 | - Transmission time of message (**) | 3X,4D19.12 |

| | | |
|--|--|--|
| | rinex210 (sec of GPS week, derived e.g. from Z-count in Hand Over Word (HOW) - Fit interval (hours) (see ICD-GPS-200, 20.3.4.4) Zero if not known - spare - spare | |
|--|--|--|

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

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

| TABLE A5 METEOROLOGICAL DATA FILE - HEADER SECTION DESCRIPTION | | | |
|---|--|---------------------|---|
| HEADER LABEL (Columns 61-80) | DESCRIPTION | FORMAT | |
| RINEX VERSION / TYPE | - Format version (2.10) - 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 | 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 2: PR : Pressure (mbar) TD : Dry temperature (deg Celsius) HR : Relative Humidity (percent) ZW : Wet zenith path delay (millimeters) (for WVR data) ZD : Dry component of zenith path delay (millimeters) ZT : Total zenith path delay (millimeters) The sequence of the types in this record must correspond to the sequence of the measurements in the data records | I6, 9(4X,A2) | |

| rinex210 | | |
|--------------------|--|--------------------------------------|
| | If more than 9 observation types are being used, use continuation lines with format (6X,9(4X,A2)) | |
| SENSOR MOD/TYP/ACC | Description of the met sensor - Model (manufacturer) - Type - Accuracy (same units as obs values) - Observation type Record is repeated for each observation type found in # / TYPES OF OBSERV record | A20, A20,6X, F7.1,4X, A2,1X |
| SENSOR POS XYZ/H | Approximate position of the met sensor - Geocentric coordinates X,Y,Z (ITRF) - Ellipsoidal height H or WGS-84) - Observation type Set X,Y,Z to zero if not known. 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

| TABLE A6 METEOROLOGICAL DATA FILE - DATA RECORD DESCRIPTION | | |
|--|---|---|
| OBS. RECORD | DESCRIPTION | FORMAT |
| EPOCH / MET | - Epoch in GPS time (not local time!) year (2 digits, padded with 0 if necessary) month,day,hour,min,sec The 2-digit years in RINEX Version 1 and 2.xx files are understood to represent 80-99: 1980-1999 and 00-79: 2000-2079 - Met data in the same sequence as given in the header More than 8 metdata types: Use continuation lines | 1X,I2.2, 5(1X,I2), mF7.1 4X,10F7.1,3X |

| TABLE A7 GPS OBSERVATION DATA FILE - EXAMPLE | | |
|---|--|--|
|---|--|--|

```

----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
2.10      OBSERVATION DATA      M (MIXED)      RINEX VERSION / TYPE
BLANK OR G = GPS,  R = GLONASS,  T = TRANSIT,  M = MIXED  COMMENT
XXRINEXO V9.9      AIUB          24-MAR-01 14:43  PGM / RUN BY / DATE
EXAMPLE OF A MIXED RINEX FILE  COMMENT
A 9080          MARKER NAME
9080.1.34      MARKER NUMBER

```

```

                                rinex210
BILL SMITH                    ABC INSTITUTE                    OBSERVER / AGENCY
X1234A123                    XX                                REC # / TYPE / VERS
234                            YY                                ANT # / TYPE
    4375274.                  587466.                4589095.
        .9030                    .0000                    .0000
    1      1
    1      2      6      G14      G15      G16      G17      G18      G19
    0
    4      P1      L1      L2      P2
    18.000
    2001      3      24      13      10      36.0000000
01  3  24  13  10  36.0000000  0  3G12G  9G  6
23629347.915                    .300  8                    -.353      23629364.158
20891534.648                    -.120  9                    -.358      20891541.292
20607600.189                    -.430  9                    .394      20607605.848
01  3  24  13  10  50.0000000  4  4
    1      2      2      G 9      G12
*** WAVELENGTH FACTOR CHANGED FOR 2 SATELLITES ***
    NOW 8 SATELLITES HAVE WL FACT 1 AND 2!
01  3  24  13  10  54.0000000  0  5G12G  9G  6R21R22
23619095.450                    -53875.632  8                    -41981.375      23619112.008
20886075.667                    -28688.027  9                    -22354.535      20886082.101
20611072.689                    18247.789  9                    14219.770      20611078.410
21345678.576                    12345.567  5
22123456.789                    23456.789  5
01  3  24  13  11  0.0000000  2  1
*** FROM NOW ON KINEMATIC DATA! ***
01  3  24  13  11  48.0000000  0  4G16G12G  9G  6
21110991.756                    16119.980  7                    12560.510      21110998.441
23588424.398                    -215050.557  6                    -167571.734      23588439.570
20869878.790                    -113803.187  8                    -88677.926      20869884.938
20621643.727                    73797.462  7                    57505.177      20621649.276
                                3  4
A 9080
9080.1.34
    .9030                    .0000                    .0000
--> THIS IS THE START OF A NEW SITE <--
01  3  24  13  12  6.0000000  0  4G16G12G  6G  9
21112589.384                    24515.877  6                    19102.763  3      21112596.187
23578228.338                    -268624.234  7                    -209317.284  4      23578244.398
20625218.088                    92581.207  7                    72141.846  4      20625223.795
20864539.693                    -141858.836  8                    -110539.435  5      20864545.943
01  3  24  13  13  1.2345678  5  0
                                4  1
    (AN EVENT FLAG WITH SIGNIFICANT EPOCH)
01  3  24  13  14  12.0000000  0  4G16G12G  9G  6
21124965.133                    89551.30216      69779.62654      21124972.2754
23507272.372                    -212616.150  7                    -165674.789  5      23507288.421
20828010.354                    -333820.093  6                    -260119.395  5      20828017.129
20650944.902                    227775.130  7                    177487.651  4      20650950.363
                                4  1
*** ANTISPOOFING ON G 16 AND LOST LOCK
01  3  24  13  14  12.0000000  6  2G16G  9
                                123456789.0      -9876543.5
                                0.0                    -0.5
                                4  2
--> CYCLE SLIPS THAT HAVE BEEN APPLIED TO
    THE OBSERVATIONS
01  3  24  13  14  48.0000000  0  4G16G12G  9G  6
21128884.159                    110143.144  7                    85825.18545      21128890.7764
23487131.045                    -318463.297  7                    -248152.72824      23487146.149

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20817844.743 -387242.571 6 -301747.22925 20817851.322
20658519.895 267583.67817 208507.26234 20658525.869

4 4
*** SATELLITE G 9 THIS EPOCH ON WLFACT 1 (L2) COMMENT
*** G 6 LOST LOCK AND THIS EPOCH ON WLFACT 2 (L2) COMMENT
(OPPOSITE TO PREVIOUS SETTINGS) COMMENT

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

-----+-----
| TABLE A8 |
| GPS NAVIGATION MESSAGE FILE - EXAMPLE |
-----+-----

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

2.10 N: GPS NAV DATA RINEX VERSION / TYPE
XXRINEXN V2.10 AIUB 3-SEP-99 15:22 PGM / RUN BY / DATE
EXAMPLE OF VERSION 2.10 FORMAT COMMENT
.1676D-07 .2235D-07 -.1192D-06 -.1192D-06 ION ALPHA
.1208D+06 .1310D+06 -.1310D+06 -.1966D+06 ION BETA
.133179128170D-06 .107469588780D-12 552960 1025 DELTA-UTC: A0,A1,T,W
13 LEAP SECONDS
END OF HEADER

6 99 9 2 17 51 44.0 -.839701388031D-03 -.165982783074D-10 .000000000000D+00
.910000000000D+02 .934062500000D+02 .116040547840D-08 .162092304801D+00
.484101474285D-05 .626740418375D-02 .652112066746D-05 .515365489006D+04
.409904000000D+06 -.242143869400D-07 .329237003460D+00 -.596046447754D-07
.111541663136D+01 .326593750000D+03 .206958726335D+01 -.638312302555D-08
.307155651409D-09 .000000000000D+00 .102500000000D+04 .000000000000D+00
.000000000000D+00 .000000000000D+00 .000000000000D+00 .910000000000D+02
.406800000000D+06 .000000000000D+00
13 99 9 2 19 0 0.0 .490025617182D-03 .204636307899D-11 .000000000000D+00
.133000000000D+03 -.963125000000D+02 .146970407622D-08 .292961152146D+01
-.498816370964D-05 .200239347760D-02 .928156077862D-05 .515328476143D+04
.414000000000D+06 -.279396772385D-07 .243031939942D+01 -.558793544769D-07
.110192796930D+01 .271187500000D+03 -.232757915425D+01 -.619632953057D-08
-.785747015231D-11 .000000000000D+00 .102500000000D+04 .000000000000D+00
.000000000000D+00 .000000000000D+00 .000000000000D+00 .389000000000D+03
.410400000000D+06 .000000000000D+00

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

-----+-----
| TABLE A9 |
| METEOROLOGICAL DATA FILE - EXAMPLE |
-----+-----

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

2.10 METEOROLOGICAL DATA RINEX VERSION / TYPE
XXRINEXM V9.9 AIUB 3-APR-96 00:10 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/TYPER/ACC
HAENNI 0.1 TD SENSOR MOD/TYPER/ACC
ROTRONIC I-240W 5.0 HR SENSOR MOD/TYPER/ACC
0.0 0.0 0.0 1234.5678 PR SENSOR POS XYZ/H
END OF HEADER

96 4 1 0 0 15 987.1 10.6 89.5

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96 4 1 0 0 30 987.2 10.9 90.0
 96 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|

| TABLE A10 GLONASS NAVIGATION MESSAGE FILE - HEADER SECTION DESCRIPTION | | | |
|---|---|-------------------------|---|
| HEADER LABEL (Columns 61-80) | DESCRIPTION | FORMAT | |
| RINEX VERSION / TYPE | - Format version (2.10) - File type ('G' = GLONASS nav mess data) | F9.2,11X, A1,39X | # |
| PGM / RUN BY / DATE | - Name of program creating current file - Name of agency creating current file - Date of file creation (dd-mmm-yy hh:mm) | A20, A20, A20 | |
| * COMMENT | Comment line(s) | A60 | * |
| * CORR TO SYSTEM TIME | - Time of reference for system time corr (year, month, day) - Correction to system time scale (sec) to correct GLONASS system time to UTC(SU) (-TauC) | 3I6, 3X,D19.12 *) | * |
| * LEAP SECONDS | Number of leap seconds since 6-Jan-1980 | I6 | * |
| END OF HEADER | Last record in the header section. | 60X | |

Records marked with * are optional

| TABLE A11 GLONASS NAVIGATION MESSAGE FILE - DATA RECORD DESCRIPTION | | | |
|--|--|---|--|
| OBS. RECORD | DESCRIPTION | FORMAT | |
| PRN / EPOCH / SV CLK | - Satellite number: Slot number in sat. constellation - Epoch of ephemerides (UTC) - year (2 digits, padded with 0, if necessary) - month, day, hour, minute, - second - SV clock bias (sec) (-TauN) - SV relative frequency bias (+GammaN) - message frame time (tk) (0 .le. tk .lt. 86400 sec of day UTC) The 2-digit years in RINEX 1 and 2.xx files are understood to represent 80-99: 1980-1999 and 00-79: 2000-2079 | I2, 1X,I2.2, 4(1X,I2), F5.1, D19.12, D19.12, D19.12 *) | |
| BROADCAST ORBIT - 1 | - Satellite position X (km) - velocity X dot (km/sec) - X acceleration (km/sec2) - health (0=OK) (Bn) | 3X,4D19.12 | |

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| | | |
|---------------------|---------------------------------------|------------|
| BROADCAST ORBIT - 2 | - Satellite position Y (km) | 3X,4D19.12 |
| | - velocity Y dot (km/sec) | |
| | - Y acceleration (km/sec2) | |
| | - frequency number (-7 ... +13) | |
| BROADCAST ORBIT - 3 | - Satellite position Z (km) | 3X,4D19.12 |
| | - velocity Z dot (km/sec) | |
| | - Z acceleration (km/sec2) | |
| | - Age of oper. information (days) (E) | |

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

TABLE A12
GLONASS NAVIGATION MESSAGE FILE - EXAMPLE

```

----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
      2.10          GLONASS NAV DATA          RINEX VERSION / TYPE
ASRINEXG V1.1.0 VM AIUB          19-FEB-98 10:42 PGM / RUN BY / DATE
STATION ZIMMERWALD          COMMENT
 1998   2   16   0.379979610443D-06 CORR TO SYSTEM TIME
                                     END OF HEADER
3 98  2 15  0 15  0.0 0.163525342941D-03 0.363797880709D-11 0.108000000000D+05
   0.106275903320D+05-0.348924636841D+00 0.931322574615D-09 0.000000000000D+00
  -0.944422070313D+04 0.288163375854D+01 0.931322574615D-09 0.210000000000D+02
   0.212257280273D+05 0.144599342346D+01-0.186264514923D-08 0.300000000000D+01
4 98  2 15  0 15  0.0 0.179599039257D-03 0.636646291241D-11 0.122400000000D+05
   0.562136621094D+04-0.289074897766D+00-0.931322574615D-09 0.000000000000D+00
  -0.236819248047D+05 0.102263259888D+01 0.931322574615D-09 0.120000000000D+02
   0.762532910156D+04 0.339257907867D+01 0.000000000000D+00 0.300000000000D+01
11 98  2 15  0 15  0.0-0.559808686376D-04-0.272848410532D-11 0.108600000000D+05
  -0.350348437500D+04-0.255325126648D+01 0.931322574615D-09 0.000000000000D+00
   0.106803754883D+05-0.182923507690D+01 0.000000000000D+00 0.400000000000D+01
   0.228762856445D+05 0.447064399719D+00-0.186264514923D-08 0.300000000000D+01
12 98  2 15  0 15  0.0 0.199414789677D-04-0.181898940355D-11 0.108900000000D+05
   0.131731816406D+05-0.143945598602D+01 0.372529029846D-08 0.000000000000D+00
   0.171148715820D+05-0.118937969208D+01 0.931322574615D-09 0.220000000000D+02
   0.135737919922D+05 0.288976097107D+01-0.931322574615D-09 0.300000000000D+01

```

TABLE A13
GLONASS OBSERVATION FILE - EXAMPLE

```

----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
      2.10          OBSERVATION DATA          R (GLONASS)          RINEX VERSION / TYPE
XXRINEXO V1.1          AIUB          27-AUG-93 07:23 PGM / RUN BY / DATE
TST1          MARKER NAME
VIEWEG          BRAUNSCHWEIG          OBSERVER / AGENCY
100          XX-RECEIVER          1.0          REC # / TYPE / VERS

```



```

                                rinex210
101                XX-ANTENNA
3844808.114        715426.767  5021804.854
      1.2340          .0000          .0000
      1      1
      2      C1      L1
      10.000
1993      8      23      14      24      40.0490000      GLO

93  8 23 14 24 40.0490000  0  3  2R01R21
23986839.824          20520.565  5
23707804.625          19937.231  5
23834065.096          -9334.581  5
93  8 23 14 24 50.0490000  0  3  2R01R21
23992341.033          49856.525  5
23713141.002          48479.290  5
23831189.435          -24821.796  5
93  8 23 14 25 .0490000  0  3  2R01R21
23997824.854          79217.202  5
23718494.110          77092.992  5
23828329.946          -40219.918  5
93  8 23 14 25 10.0490000  0  5  2R05R17R01R21
24003328.910          108602.422  5
24933965.449          -19202.780  5
22203326.578          -2987.327  5
23723851.686          105777.849  5
23825485.526          -55529.205  5
93  8 23 14 25 20.0490010  0  5  2R05R17R01R21
24008828.023          138012.178  5
24927995.616          -51188.500  5
22202547.907          -7213.298  5
23729236.758          134533.636  5
23822662.277          -70749.590  5
93  8 23 14 25 30.0490000  0  5  2R05R17R01R21
24014330.779          167446.477  5
24922041.288          -83151.666  5
22201767.457          -11388.909  5
23734633.024          163360.131  5
23819848.894          -85881.102  5

```

```

ANT # / TYPE
APPROX POSITION XYZ
ANTENNA: DELTA H/E/N
WAVELENGTH FACT L1/2
# / TYPES OF OBSERV
INTERVAL
TIME OF FIRST OBS
END OF HEADER

```

```

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

```

```

+-----+
|                                     TABLE A14                                     |
|                                     MIXED GPS/GLONASS OBSERVATION FILE - EXAMPLE                                     |
+-----+

```

```

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

```

```

      2.10                OBSERVATION DATA      M (MIXED)                RINEX VERSION / TYPE
YRINEXO V2.8.1 VM  AIUB                6-FEB-00 13:59                PGM / RUN BY / DATE
TST2
001-02-A                MARKER NAME
JIM                    MARKER NUMBER
1                      Y-COMPANY                OBSERVER / AGENCY
1                      YY-RECEIVER                REC # / TYPE / VERS
1                      GEODETIC L1                ANT # / TYPE
      3851178.1849        -80151.4072  5066671.1013        APPROX POSITION XYZ
      1.2340          0.0000          0.0000                ANTENNA: DELTA H/E/N
      1      0
      2      C1      L1                WAVELENGTH FACT L1/2
      10.000                # / TYPES OF OBSERV
      11                    INTERVAL
2000      2      6      11      53      0.0000000      GPS                LEAP SECONDS
                                                TIME OF FIRST OBS

```

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END OF HEADER

00 2 6 11 53 0.0000000 0 14G23G07G02G05G26G09G21R20R19R12R02R11
R10R03

22576523.586 -11256947.60212
22360162.704 -16225110.75413
24484865.974 14662682.882 2
21950524.331 -13784707.24912
22507304.252 9846064.848 2
20148742.213 -20988953.712 4
22800149.591 -16650822.70012
19811403.273 -25116169.741 3
23046997.513 -3264701.688 2
22778170.622 -821857836.745 1
22221283.991 -988088156.884 2
19300913.475 -83282658.19013
20309075.579 -672668843.84713
23397403.484 -285457101.34211

00 2 6 11 53 10.0000000 0 14G23G07G02G05G26G09G21R20R19R12R02R11
R10R03

22578985.016 -11244012.910 2
22359738.890 -16227337.841 2
24490324.818 14691368.710 2
21944376.706 -13817012.849 2
22512598.731 9873887.580 2
20147322.111 -20996416.338 4
22798942.949 -16657163.594 2
19812513.509 -25110234.795 3
23053885.702 -3227854.397 2
22770607.029 -821898566.774 1
22222967.297 -988079145.989 2
19297913.736 -83298710.38413
20313087.618 -672647337.04113
23392352.454 -285484291.40311

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

| TABLE A15 GEOSTATIONARY NAVIGATION MESSAGE FILE - HEADER SECTION DESCRIPTION | | | |
|---|--|-------------------------|---|
| HEADER LABEL (Columns 61-80) | DESCRIPTION | FORMAT | |
| RINEX VERSION / TYPE | - Format version (2.10) - File type ('H' = GEO nav mess data) | F9.2,11X, A1,39X | |
| PGM / RUN BY / DATE | - Name of program creating current file - Name of agency creating current file - Date of file creation (dd-mmm-yy hh:mm) | A20, A20, A20 | |
| * COMMENT | Comment line(s) | A60 | * |
| * CORR TO SYSTEM TIME | - Time of reference for system time corr (year, month, day) - Correction to transform the GEO system time to UTC (W0) | 3I6, 3X,D19.12 *) | * |
| * LEAP SECONDS | Number of leap seconds since 6-Jan-1980 | I6 | * |
| END OF HEADER | Last record in the header section. | 60X | |

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Records marked with * are optional

| TABLE A16 GEOSTATIONARY NAVIGATION MESSAGE FILE - DATA RECORD DESCRIPTION | | |
|--|---|--|
| OBS. RECORD | DESCRIPTION | FORMAT |
| PRN / EPOCH / SV CLK | - Satellite number (PRN - 100) - Epoch of ephemerides (GPS) (Toe) - year (2 digits, padded with 0 if necessary) - month, day, hour, minute, second - SV clock bias (sec) (aGf0) - SV relative frequency bias (aGf1) - message frame time (sec of day GPS) | I2, 1X, I2.2, 4 (1X, I2), F5.1, D19.12, D19.12, D19.12 |
| BROADCAST ORBIT - 1 | - Satellite position X (km) - velocity X dot (km/sec) - X acceleration (km/sec2) - health (0=OK) | 3X, 4D19.12 *) |
| BROADCAST ORBIT - 2 | - Satellite position Y (km) - velocity Y dot (km/sec) - Y acceleration (km/sec2) - Accuracy code (URA, meters) | 3X, 4D19.12 |
| BROADCAST ORBIT - 3 | - Satellite position Z (km) - velocity Z dot (km/sec) - Z acceleration (km/sec2) - spare | 3X, 4D19.12 |

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

| TABLE A17 MIXED GPS/GEO OBSERVATION FILE - EXAMPLE | | | |
|---|--|--|--|
|---|--|--|--|

```

----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
2.10      OBSERVATION DATA      M (MIXED)      RINEX VERSION / TYPE
RinExp V.2.0.2  TESTUSER          00-02-04 09:30  PGM / RUN BY / DATE
The file contains L1 pseudorange and phase data of the  COMMENT
geostationary AOR-E satellite (PRN 120 = S20)          COMMENT
TLSE D                                             COMMENT
ESTB          TESTAGENCY          MARKER NAME
SGL98030069   Novatel Millennium HW3-1 SW 4.45/2.3  OBSERVER / AGENCY
4629365.0750  112100.1790  4371619.4160  REC # / TYPE / VERS
0.0000       0.0000       0.0000       ANT # / TYPE
1            1            APPROX POSITION XYZ
4 C1 L1 L2 P2          ANTENNA: DELTA H/E/N
# / TYPES OF OBSERV

```

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| | | | | | | | | |
|------|---|----|----|----|----------|-----|--|---------------------|
| 1 | | | | | | | | INTERVAL |
| 2000 | 1 | 13 | 14 | 45 | 0.000000 | GPS | | TIME OF FIRST OBS |
| 2000 | 1 | 13 | 15 | 0 | 0.000000 | GPS | | TIME OF LAST OBS |
| 0 | | | | | | | | RCV CLOCK OFFS APPL |
| | | | | | | | | END OF HEADER |

| | | | | |
|----------------|-------------|---|---------------------------|---------------|
| 00 01 13 14 45 | 0.0000000 | 0 | 8G25G17G06G05G24G29G30S20 | 0.000535140 |
| 21839900.207 | -236148.877 | 9 | -184047.71049 | 21839901.4384 |
| 25151926.413 | -161002.900 | 9 | -125509.72447 | 25151935.8274 |
| 20531103.515 | 763336.059 | 9 | 594797.53149 | 20531105.0114 |
| 23001624.801 | -432989.642 | 9 | -337436.50348 | 23001628.1684 |
| 23610349.510 | -384890.728 | 9 | -299952.38848 | 23610354.3504 |
| 23954474.398 | -151982.173 | 9 | -118480.96847 | 23954481.1994 |
| 20622367.016 | -332628.466 | 9 | -259214.55249 | 20622367.8754 |
| 38137559.506 | 335849.135 | 9 | | |
| 00 01 13 14 45 | 1.0000000 | 0 | 8G25G17G06G05G24G29G30S20 | 0.000535144 |
| 21839500.278 | -238250.743 | 9 | -185685.52549 | 21839501.4814 |
| 25151246.148 | -164576.503 | 9 | -128294.33947 | 25151256.2614 |
| 20531084.382 | 763235.849 | 9 | 594719.44849 | 20531085.8784 |
| 23002123.430 | -430369.237 | 9 | -335394.62748 | 23002126.7114 |
| 23610670.127 | -383205.864 | 9 | -298639.51048 | 23610674.9834 |
| 23955051.773 | -148948.417 | 9 | -116117.00748 | 23955058.5034 |
| 20622558.579 | -331621.765 | 9 | -258430.11049 | 20622559.4574 |
| 38137558.783 | 335846.284 | 9 | | |
| 00 01 13 14 45 | 2.0000000 | 0 | 8G25G17G06G05G24G29G30S20 | 0.000535144 |
| 21839100.418 | -240352.173 | 9 | -187323.00449 | 21839101.6534 |
| 25150565.890 | -168150.148 | 9 | -131078.97647 | 25150576.2144 |
| 20531065.378 | 763136.116 | 9 | 594641.73549 | 20531066.8984 |
| 23002622.082 | -427748.683 | 9 | -333352.63648 | 23002625.3444 |
| 23610990.819 | -381520.461 | 9 | -297326.20848 | 23610995.8424 |
| 23955629.062 | -145914.531 | 9 | -113752.94748 | 23955636.5544 |
| 20622750.161 | -330614.723 | 9 | -257645.40149 | 20622751.0554 |
| 38137558.365 | 335843.457 | 9 | | |

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

```

+-----+
|                                     |
|               TABLE A18           |
|         GEO NAVIGATION MESSAGE FILE - EXAMPLE         |
|                                     |
+-----+

```

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

| | | |
|------------|---------------------|----------------------|
| 2.10 | H: GEO NAV MSG DATA | RINEX VERSION / TYPE |
| Sup v. 1.4 | TESTUSER | PGM / RUN BY / DATE |
| | 04-02-00 10:04 | COMMENT |
| | | COMMENT |
| | | COMMENT |
| | | COMMENT |
| | | END OF HEADER |

| | | | |
|------------------------|-------------------|--------------------|-------------------|
| 20 00 01 13 14 46 24.0 | .209547579288D-07 | -.545696821064D-11 | .532351280000D+05 |
| .406131052800D+08 | .150625000000D+01 | .875000000000D-04 | .000000000000D+00 |
| -.112454290400D+08 | .308125000000D+01 | -.112500000000D-03 | .400000000000D+01 |
| .781616000000D+05 | .959600000000D+01 | -.437500000000D-03 | .000000000000D+00 |
| 20 00 01 13 14 48 00.0 | .204890966415D-07 | -.545696821064D-11 | .533161280000D+05 |
| .406132503200D+08 | .151500000000D+01 | .875000000000D-04 | .000000000000D+00 |
| -.112451338400D+08 | .307000000000D+01 | -.125000000000D-03 | .400000000000D+01 |
| .790812000000D+05 | .955600000000D+01 | -.437500000000D-03 | .000000000000D+00 |
| 20 00 01 13 14 49 36.0 | .195577740669D-07 | -.545696821064D-11 | .533981280000D+05 |
| .406133961600D+08 | .152375000000D+01 | .875000000000D-04 | .000000000000D+00 |
| -.112448396800D+08 | .305875000000D+01 | -.125000000000D-03 | .400000000000D+01 |
| .799968000000D+05 | .951600000000D+01 | -.437500000000D-03 | .000000000000D+00 |
| 20 00 01 13 14 51 12.0 | .190921127796D-07 | -.545696821064D-11 | .534791280000D+05 |
| .406135428800D+08 | .153250000000D+01 | .875000000000D-04 | .000000000000D+00 |

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-.112445465600D+08 .304687500000D+01 -.125000000000D-03 .400000000000D+01
.809084000000D+05 .947600000000D+01 -.437500000000D-03 .000000000000D+00

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