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RINEX: The Receiver Independent Exchange Format Version 2.10

Werner Gurtner
Astronomical Institute
University of Berne

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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
definiton 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 -TauN, +GammaN, -TauC.
  The original definition asked for -TauN, -GammaN, +TauC. 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.

* A descrepancy 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 explicitely 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
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://igscb.jpl.nasa.gov/igscb/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 mimimum 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 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):

```
    PR  =  distance +
           c * (receiver clock offset - satellite clock offset +
                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 sqaring-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 receiver clock correction should be applied to all 3 observables:

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

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 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 * 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.

"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).

Filenaming 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:

```
  GEO    : Tutc = Tsv - aGf0  -  aGf1 *(Tsv-Toe) -  W0  - 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!             *
```

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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) - Satellite System: blank or 'G': GPS 'R': GLONASS 'S': Geostationary signal payload 'T': NNSS Transit '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 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	2I6,
	- zero or blank	I6
	The default wavelength factor line is required and must preceed satellite-specific lines.	
* 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	2I6,
	- Number of satellites to follow in list for which these factors are valid.	I6,
	- List of PRNs (satellite numbers with system identifier)	7(3X,A1,I2)
	These opional satellite specific lines may follow, if they identify a state different from the default values. Repeat record if necessary.	
# / TYPES OF OBSERV	- Number of different observation types stored in the file	I6,
	- Observation types	9(4X,A2)
	If more than 9 observation types: Use continuation line(s)	6X,9(4X,A2)
	The following observation types are defined in RINEX Version 2.10: 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 Observations collected under Antispoofing are converted to "L2" or "P2" and flagged with bit 2 of loss of lock indicator (see Table A2). Units : Phase : full cycles Pseudorange : meters Doppler : Hz Transit : cycles SNR etc : receiver-dependent The sequence of the types in this record	

	has to correspond to the sequence of the observations in the observation records		
*|INTERVAL	Observation interval in seconds	F10.3	*
|TIME OF FIRST OBS	- 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	5I6,F13.7, 5X,A3	
*|TIME OF LAST OBS	- Time of last observation record (4-digit-year, month,day,hour,min,sec) - Time system: Same value as in TIME OF FIRST OBS record	5I6,F13.7, 5X,A3	*
*|RCV CLOCK OFFS APPL	Epoch, code, and phase are corrected by applying the realtime-derived receiver clock offset: 1=yes, 0=no; default: 0=no Record required if clock offsets are reported in the EPOCH/SAT records	I6	*
*|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	PRN (sat.number), number of observations for each observation type indicated in the "# / TYPES OF OBSERV" - record. If more than 9 observation types: Use continuation line(s) This record is (these records are) repeated for each satellite present in the data file	3X,A1,I2,9I6 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	- Epoch : - year (2 digits, padded with 0 if necessary) - month,day,hour,min, - sec	1X,I2.2, 4(1X,I2), F11.7,
	- Epoch flag 0: OK 1: power failure between previous and current epoch >1: Event flag	2X,I1,
	- Number of satellites in current epoch	I3,
	- List of PRNs (sat.numbers with system identifier, see 5.1) in current epoch	12(A1,I2),
	- receiver clock offset (seconds, optional)	F12.9
	If more than 12 satellites: Use continuation line(s)	32X, 12(A1,I2)

	If epoch flag 2-5:		
	- Event flag:	[2X,I1,]	
	2: start moving antenna		
	3: new site occupation (end of kinem. data)		
	(at least MARKER NAME record follows)		
	4: header information follows		
	5: external event (epoch is significant,		
	same time frame as observation time tags)		
	- "Number of satellites" contains number of	[I3]	
	special records to follow.		
	Maximum number of records: 999		
	- For events without significant epoch the		
	epoch fields can be left blank		
	If epoch flag = 6:		
	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)		
OBSERVATIONS	- Observation	rep. within record for	m(F14.3,
	- LLI	each obs.type (same seq	I1,
	- Signal strength	as given in header)	I1)
	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 W : UTC reference week number. Continuous number, not mod(1024)!	3X,2D19.12, 2I9 *)
* LEAP SECONDS	Delta time due to leap seconds	I6 *
END OF HEADER	Last record in the header section.	60X

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	I2,
	- Epoch: Toc - Time of Clock	
	year (2 digits, padded with 0 if necessary)	1X,I2.2,
	month	1X,I2,
	day	1X,I2,
	hour	1X,I2,
	minute	1X,I2,
	second	F5.1,
	- SV clock bias (seconds)	3D19.12
	- SV clock drift (sec/sec)	
	- SV clock drift rate (sec/sec2)	*)
BROADCAST ORBIT - 1	- IODE Issue of Data, Ephemeris	3X,4D19.12
	- Crs (meters)	
	- Delta n (radians/sec)	
	- M0 (radians)	
BROADCAST ORBIT - 2	- Cuc (radians)	3X,4D19.12
	- e Eccentricity	
	- Cus (radians)	
	- sqrt(A) (sqrt(m))	
BROADCAST ORBIT - 3	- Toe Time of Ephemeris	3X,4D19.12
	(sec of GPS week)	
	- Cic (radians)	
	- OMEGA (radians)	
	- CIS (radians)	
BROADCAST ORBIT - 4	- i0 (radians)	3X,4D19.12
	- Crc (meters)	
	- omega (radians)	

	- OMEGA DOT (radians/sec)	
BROADCAST ORBIT - 5	- IDOT (radians/sec)	3X,4D19.12
	- Codes on L2 channel	
	- GPS Week # (to go with TOE)	
	Continuous number, not mod(1024)!	
	- L2 P data flag	
BROADCAST ORBIT - 6	- SV accuracy (meters)	3X,4D19.12
	- SV health (bits 17-22 w 3 sf 1)	
	- TGD (seconds)	
	- IODC Issue of Data, Clock	
BROADCAST ORBIT - 7	- Transmission time of message **)	3X,4D19.12
	(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

METEOROLOCICAL DATA FILE - HEADER SECTION DESCRIPTION

HEADER LABEL (Columns 61-80)	DESCRIPTION	FORMAT
RINEX VERSION / TYPE	- Format version (2.10)	F9.2,11X,
	- File type ('M' for Meteorological Data)	A1,39X
PGM / RUN BY / DATE	- Name of program creating current file	A20,
	- Name of agency creating current file	A20,
	- Date of file creation	A20
* COMMENT	Comment line(s)	A60 *
MARKER NAME	Station Name	A60
	(preferably identical to MARKER NAME in	
	the associated Observation File)	
* MARKER NUMBER	Station Number	A20 *
	(preferably identical to MARKER NUMBER in	
	the associated Observation File)	
# / TYPES OF OBSERV	- Number of different observation types	I6,
	stored in the file	
	- Observation types	9(4X,A2)
	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 If more than 9 observation types are being used, use continuation lines with format (6X,9(4X,A2))	
SENSOR MOD/TYPE/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 met data 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
```

```
BILL SMITH          ABC INSTITUTE                           OBSERVER / AGENCY
X1234A123           XX                  ZZZ                 REC # / TYPE / VERS
234                 YY                                      ANT # / TYPE
  4375274.       587466.      4589095.                       APPROX POSITION XYZ
         .9030         .0000         .0000                  ANTENNA: DELTA H/E/N
     1     1                                                 WAVELENGTH FACT L1/2
     1     2     6   G14   G15   G16   G17   G18   G19      WAVELENGTH FACT L1/2
     0                                                       RCV CLOCK OFFS APPL
     4    P1    L1    L2    P2                               # / TYPES OF OBSERV
    18.000                                                   INTERVAL
  2001     3    24    13    10   36.0000000                 TIME OF FIRST OBS
                                                            END OF HEADER
 01  3 24 13 10 36.0000000  0  3G12G 9G 6                            -.123456789
  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 FACT L1/2
  *** WAVELENGTH FACTOR CHANGED FOR 2 SATELLITES ***         COMMENT
      NOW 8 SATELLITES HAVE WL FACT 1 AND 2!                 COMMENT
                                                             COMMENT
 01  3 24 13 10 54.0000000  0  5G12G 9G 6R21R22                      -.123456789
  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! ***               COMMENT
 01  3 24 13 11 48.0000000  0  4G16G12G 9G 6                      -.123456789
  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                                                       MARKER NAME
9080.1.34                                                    MARKER NUMBER
         .9030         .0000         .0000                  ANTENNA: DELTA H/E/N
          --> THIS IS THE START OF A NEW SITE <--            COMMENT
 01  3 24 13 12  6.0000000  0  4G16G12G 6G 9                      -.123456987
  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)                COMMENT
 01  3 24 13 14 12.0000000  0  4G16G12G 9G 6                      -.123456012
  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             COMMENT
 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         COMMENT
               THE OBSERVATIONS                              COMMENT
 01  3 24 13 14 48.0000000  0  4G16G12G 9G 6                      -.123456234
  21128884.159      110143.144 7     85825.18545  21128890.7764
  23487131.045     -318463.297 7   -248152.72824  23487146.149
  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/TYPE/ACC
HAENNI                                           0.1    TD SENSOR MOD/TYPE/ACC
ROTRONIC            I-240W                       5.0    HR SENSOR MOD/TYPE/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
 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    |               DESCRIPTION               |   FORMAT    |
 |  (Columns 61-80)   |                                         |             |
 +--------------------+-----------------------------------------+-------------+
```

RINEX VERSION / TYPE	- Format version (2.10)	F9.2,11X,	#
	- File type ('G' = GLONASS nav mess data)	A1,39X	
PGM / RUN BY / DATE	- Name of program creating current file	A20,	
	- Name of agency creating current file	A20,	
	- Date of file creation (dd-mmm-yy hh:mm)	A20	
* COMMENT	Comment line(s)	A60	*
* CORR TO SYSTEM TIME	- Time of reference for system time corr (year, month, day)	3I6,	*
	- Correction to system time scale (sec) to correct GLONASS system time to UTC(SU) (-TauC)	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	I2,
	- Epoch of ephemerides (UTC)	
	- year (2 digits, padded with 0, if necessary)	1X,I2.2,
	- month,day,hour,minute,	4(1X,I2),
	- second	F5.1,
	- SV clock bias (sec) (-TauN)	D19.12,
	- SV relative frequency bias (+GammaN)	D19.12,
	- message frame time (tk)	D19.12
	(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	
BROADCAST ORBIT - 1	- Satellite position X (km)	3X,4D19.12
	- velocity X dot (km/sec)	
	- X acceleration (km/sec2)	
	- health (0=OK) (Bn)	
BROADCAST ORBIT - 2	- Satellite position Y (km)	3X,4D19.12
	- velocity Y dot (km/sec)	
	- Y acceleration (km/sec2)	
	- frequency number (-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

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


+-----------------------------------------------------------------------------+
|                                 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
101                 XX-ANTENNA                              ANT # / TYPE
  3844808.114    715426.767   5021804.854                  APPROX POSITION XYZ
        1.2340         .0000         .0000                  ANTENNA: DELTA H/E/N
     1     1                                                WAVELENGTH FACT L1/2
     2    C1    L1                                         # / TYPES OF OBSERV
    10.000                                                  INTERVAL
  1993     8    23    14    24   40.0490000     GLO         TIME OF FIRST OBS
                                                            END OF HEADER
 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

----|---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
YYRINEXO V2.8.1 VM  AIUB                 6-FEB-00 13:59     PGM / RUN BY / DATE
TST2                                                        MARKER NAME
001-02-A                                                    MARKER NUMBER
JIM                 Y-COMPANY                               OBSERVER / AGENCY
1                   YY-RECEIVER         2.0.1               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                                                WAVELENGTH FACT L1/2
     2    C1    L1                                         # / TYPES OF OBSERV
    10.000                                                  INTERVAL
    11                                                      LEAP SECONDS
  2000     2     6    11    53    0.0000000     GPS         TIME OF FIRST OBS
                                                            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 (WO)	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 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
                                                            COMMENT
The file contains L1 pseudorange and phase data of the      COMMENT
geostationary AOR-E satellite (PRN 120 = S20)               COMMENT
                                                            COMMENT
TLSE D                                                      MARKER NAME
ESTB                TESTAGENCY                              OBSERVER / AGENCY
SGL98030069         Novatel Millennium  HW3-1 SW 4.45/2.3   REC # / TYPE / VERS
                    ASH701073.1                             ANT # / TYPE
  4629365.0750   112100.1790  4371619.4160                  APPROX POSITION XYZ
        0.0000        0.0000        0.0000                  ANTENNA: DELTA H/E/N
     1     1                                                WAVELENGTH FACT L1/2
     4    C1    L1    L2    P2                             # / TYPES OF OBSERV
     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            04-02-00 10:04   PGM / RUN BY / DATE
                                                         COMMENT
The file contains navigation message data of the         COMMENT
geostationary AOR-E satellite (PRN 120 = S20)            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
    -.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|
```