

## **GNSS High Rate Binary Format (v1.9)**

### **1 Overview**

This document describes a binary GNSS data format intended for storing both low and high rate (>1Hz) tracking data. To accommodate GNSS measurements we use the RINEX3.02 standard as a guide. In order to maintain simple structures, few efforts are made to compress the information as this format is intended for disk storage rather than streaming. In addition each field size is a multiple of 8 bits (one byte).

Each data file consists of an observation section and a Trailer section. The observation section contains a set of Epoch Data Records and optionally High Rate Data Records. Epoch Data Records may be written at up to 1Hz. If a data rate of greater than 1Hz is required, a set of High Rate Data Records follow each Epoch Data Record. The Epoch and High Rate data records are stored sorted first by GNSS type (as specified in the trailer), then by PRN, and finally by time.

The Trailer Record is written at the end of the file and contains metadata. The metadata is written at the end because the data writer accumulates needed information as each file is written and only has all information necessary for the trailer at the end of the process. The low rate and high rate data types for each satellite system are specified once in the trailer. Each Epoch Data Record and High Rate Data Record must contain all valid observation types defined in the trailer. However, the measurements written in a given record may be flagged as invalid by writing them as a NaN or missing value. The trailer also provides byte offsets to each satellite represented in the file in order to enable efficient seeking.

**NOTE:** All numeric data in this format are stored in big-endian byte order (with most-significant bytes first).

## 2 Definitions

These fields are used in multiple places.

Field ID	Field Definition	Description	Notes
N/A	<p>Observation type consists of 16 bits representing the RINEX3 observation code plus metadata</p> <p>3 bits observation type 3 bits frequency band 5 bits tracking attribute 5 bits metadata</p>	<p>Observation type: 0 = C 1 = L 2 = D 3 = S 4-7 = reserved</p> <p>Frequency band: 0-7, add +1 to interpret</p> <p>Tracking attribute: 0, A-Z</p> <p>0 = invalid obs type</p> <p>Metadata: 0,A-Z M = model data 0 = no flag</p>	See RINEX3.02 specification, Section 5.
N/A	char (8 bits)	<p>Satellite system: G = GPS R = GLONASS E = Galileo C = BeiDou S = SBAS Blank = invalid/none</p>	

### 3 Epoch Data Record

Epoch Data Records may be written at up to 1Hz. High Rate Data Records optionally follow a given Epoch Data Record.

Field ID	Field Definition	Description	Notes
1	uint32_t	GPS seconds (epoch 1980-01-06 00:00:00 UTC)	Good for 136 years. Refers to receive time.
2	8 bits	Tracking status flags bit 0 = open/closed loop (1 = open, 0 = closed) bits 1-7 reserved	
3	uint8_t	Receiver antenna ID: 0-255	Typically have 4 antennas for COSMIC.
4	char (8 bits)	Satellite system	See definition in section 2.
5	uint16_t	SVN: 0- 65535	We keep PRN and SVN in case there is an issue with the table used for conversion to SVN.
6	uint8_t	PRN/slot: 0-255	Typically 1-32, but able to handle SBAS.
7	uint16_t	Number of High Rate Data Records to follow: 0-65535	Supports up to 65KHz data
8 -	double (64 bits)	Measurement NaN = invalid	Repeat fields as many times as valid observation types are specified in Trailer Record for this constellation.

#### 4 High Rate Data Record

Field ID	Field Definition	Description	Notes
1	24 bits	Time offset in tenths of microseconds 0-16777215 0-9999999 = valid values	Absolute time = epoch + this value in seconds + high rate data offset (field 33 in section 5.1)
2	Data type specified in field 4 in the High Rate Data Descriptor (8-64 bits)	Measurement NaN = invalid for float or double types max(int) = invalid for integer types	Repeat fields as many times as valid observation types are specified in Trailer Record Data Descriptors for this constellation.

## 5 Trailer Record

The trailer consists of data descriptors for each satellite system stored in this file, followed by a small fixed-length end section specifying which satellite systems are present in the file.

The total length of the trailer record is  $9+340*N$  bytes, where N is the number of satellite systems present. The final 9 bytes of the record are always written and specify N.

### 5.1 Data Descriptors

This portion of the trailer is stored above the trailer and is repeated once for each satellite system in the file, stored in the order they are found in the trailer. We allow up to 16 observation types for the low and high rate data for each satellite system.

Field ID	Field Definition	Description	Notes
1-16	16 bits	Observation type (16 bits)	See definition in section 2. Set invalid for unused observations types.
17-32	24 bits	High Rate Data Record Descriptor	Observation type plus one char, see section 5.2 for details. Set observation type invalid for unused observations types.
33	sint32_t	High rate data offset. The offset in nanoseconds between the integer epoch time and the fractional high rate data time. $-0.5e9$ to $0.5e9$ . This is set to $-0.5$ seconds for JPL RO receivers, can be set to zero for other receivers.	Observation time = epoch time + high rate data offset + 24-bit high rate time offset
34-65	sint64_t * 32	Byte offset from start of file to PRNs 1-32 -1 = not present	
Total: $(16 * 16) + (16 * 24) + 32 + (64 * 32) = 2720$ bits (340 bytes)			

## 5.2 High Rate Data Record Descriptor

This three-byte field describes one high-rate data type.

Field ID	Field Definition	Description	Notes
1	16 bits	Observation type	See definition in section 2.
2	char (8 bits)	Perl 'pack' format data type: S = unsigned short d = double f = float etc.	
Total:	24 bits (3 bytes)		

## 5.3 End Section

The final section of the trailer record specifies the data file version as well as which satellite systems are present in the file.

Field ID	Field Definition	Description	Notes
1	uint8_t	Version ID. 0-255	
2-9	char (8 bits)	List of up to 8 satellite systems found in this file.	See definition in section 2. Set to invalid for constellations not present in the file.
Total:	72 bits (9 bytes)		