



GNSS DATA FORMATS

GNSS Under Attack course

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BME



FACULTY OF
CIVIL ENGINEERING



DEPARTMENT OF GEODESY AND
SURVEYING

GNSS DATA AND OBSERVATIONS

Constellations

Frequencies

- Pseudorange
- Carrier phase
- Doppler shift
- Signal-to-Noise Ratio

Observations

Constellations

- Orbit parameters
- Satellite clock model
- Satellite health
- Leap seconds
- Ionosphere parameters

Data

GNSS DATA FORMATS

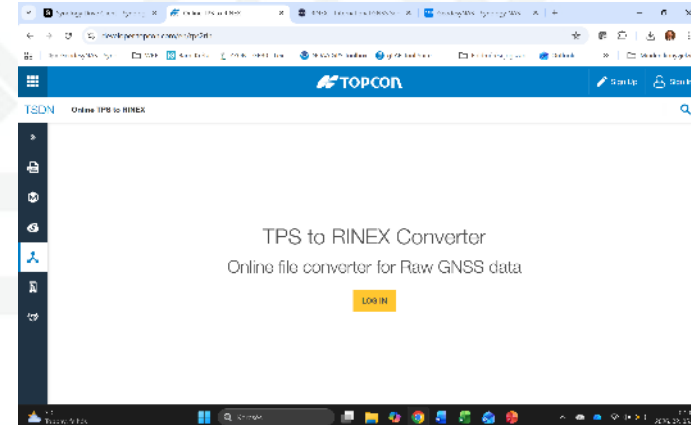
Observation:

Post processing:

- Proprietary: e.g. Trimble .DAT, .T00, .T01, Leica .m00, etc.
- Non-proprietary: RINEX (**R**eceiver **I**ndependent **EX**change format)

Data:

- Proprietary: vendor dependent
- Non-proprietary: RINEX, SP3



GNSS DATA FORMATS

Observation and Data:

Realtime:

- Proprietary: e.g. Trimble CMR, CMR+, u-blox .ubx, etc.
- Non-proprietary: RTCM 2.3, 3.1, 3.2, etc.

Results (coordinates, time, etc):

- Proprietary: e.g. u-blox .ubx
- Non-proprietary: NMEA 0183



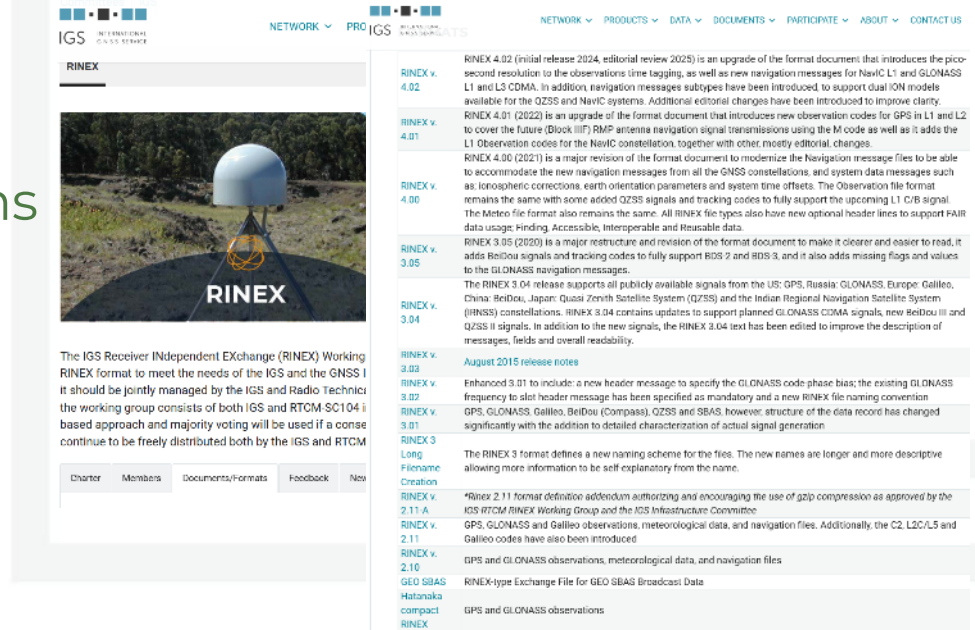
GNSS DATA FORMATS

Receiver **IN**dependent **EX**change Format (RINEX)

- Observations
- Navigation messages
- Meteorological observations
- Satellite Clock Data files

Structure:

- Header + Body
- ASCII



The screenshot displays the IGS RINEX website. The header includes the IGS logo and navigation links: NETWORK, PRODUCTS, DATA, DOCUMENTS, PARTICIPATE, ABOUT, and CONTACT US. The main content area features a large image of a GNSS antenna with the word "RINEX" overlaid. Below the image, a paragraph states: "The IGS Receiver INdependent EXchange (RINEX) Working Group format to meet the needs of the IGS and the GNSS I should be jointly managed by the IGS and Radio Technical Commission for Space (RTCM). The working group consists of both IGS and RTCM-SC104 based approach and majority voting will be used if a consensus cannot be reached. The format will be freely distributed both by the IGS and RTCM." Below this text is a navigation bar with links: Charter, Members, Documents/Formats, Feedback, and News. The right sidebar lists various RINEX versions and their release dates, with the most recent being RINEX v. 4.02 (initial release 2024, editorial review 2025). The release notes for RINEX v. 4.02 describe an upgrade of the format document that introduces the pico-second resolution to the observations time tagging, as well as new navigation messages for NavIC L1 and GLONASS L1 and L3 CDMA. In addition, navigation messages subtypes have been introduced, to support dual ION models available for the QZSS and NavIC systems. Additional editorial changes have been introduced to improve clarity. RINEX 4.01 (2022) is an upgrade of the format document that introduces new observation codes for GPS in L1 and L2 to cover the future (Block III/F) RMP antenna navigation signal transmissions using the M code as well as it adds the L1 Observation codes for the NavIC constellation, together with other, mostly editorial, changes. RINEX 4.00 (2021) is a major revision of the format document to modernize the Navigation message files to be able to accommodate the new navigation messages from all the GNSS constellations, and system data messages such as: ionospheric corrections, earth orientation parameters and system time offsets. The Observation file format remains the same with some added QZSS signals and tracking codes to fully support the upcoming L1 C/B signal. The Meteor file format also remains the same. All RINEX file types also have new optional header lines to support FAIR data usage: Finding, Accessible, Interoperable and Reusable data. RINEX 3.05 (2020) is a major restructure and revision of the format document to make it clearer and easier to read, it adds BeiDou signals and tracking codes to fully support BDS 2 and BDS 3, and it also adds missing flags and values to the GLONASS navigation messages. The RINEX 3.04 release supports all publicly available signals from the US: GPS, Russia: GLONASS, Europe: Galileo, China: BeiDou, Japan: Quasi-Zenith Satellite System (QZSS) and the Indian Regional Navigation Satellite System (IRNSS) constellations. RINEX 3.04 contains updates to support planned GLONASS CDMA signals, new BeiDou III and QZSS II signals. In addition to the new signals, the RINEX 3.04 text has been edited to improve the description of messages, fields and overall readability. RINEX v. 3.03 (2015) release notes: Enhanced 3.01 to include: a new header message to specify the GLONASS code-phase bias; the existing GLONASS frequency to dist header message has been specified as mandatory and a new RINEX file naming convention GPS, GLONASS, Galileo, BeiDou (Compass), QZSS and SBAS. However, structure of the data record has changed significantly with the addition to detailed characterization of actual signal generation. RINEX 3.02 (2011) release notes: The RINEX 3 format defines a new naming scheme for the files. The new names are longer and more descriptive allowing more information to be self explanatory from the name. RINEX v. 2.11 (2011) release notes: *Rinex 2.11 format definition addendum authorizing and encouraging the use of gzip compression as approved by the IGS RTCM RINEX Working Group and the IGS Infrastructure Committee. GPS, GLONASS and Galileo observations, meteorological data, and navigation files. Additionally, the C2, L2C/L5 and Galileo codes have also been introduced. RINEX v. 2.10 (2010) release notes: GPS and GLONASS observations, meteorological data, and navigation files. RINEX-type Exchange File for GEO SBAS Broadcast Data. RINEX v. 2.05 (2005) release notes: GPS and GLONASS observations.

<https://igs.org/wg/rinex/#documents-formats>

GNSS DATA FORMATS

Receiver **IN**dependent **EX**change Format (RINEX)

```
2 NAVIGATION DATA RINEX VERSION / TYPE
ASRINEXN V2.4.7 LH RIGTC - GO Pecny 02-MAY-00 00:21 PGM / RUN BY / DATE
GPS NAV DATA FROM SITE GOPE - 11502M002 (Pecny, Ondrejov CZ) COMMENT
0.2794E-07 0.1490E-07 -0.1788E-06 -0.5960E-07 ION ALPHA
0.1331E+06 0.8192E+05 -0.2621E+06 0.1966E+06 ION BETA
0.186264514923E-08 0.115463194561E-13 147456 1060 DELTA-UTC: A0,A1,T,W
13 LEAP SECONDS
END OF HEADER
8 00 5 1 0 0 0.0 0.704237259924E-03-0.454747350886E-11 0.000000000000E+00
0.191000000000E+03-0.465000000000E+02 0.436732477375E-08-0.220503049797E+00
-0.249966979027E-05 0.753784261178E-02 0.115483999252E-04 0.515372127151E+04
0.864000000000E+05-0.201165676117E-06-0.781976046910E+00-0.540167093277E-07
0.957918941169E+00 0.158187500000E+03 0.185776944847E+01-0.799354724904E-08
-0.312155859687E-09 0.000000000000E+00 0.106000000000E+04 0.000000000000E+00
0.700000000000E+01 0.000000000000E+00-0.465661287308E-08 0.191000000000E+03
0.860700000000E+05 0.000000000000E+00 0.000000000000E+00 0.000000000000E+00
```

PRN YY MM DD HH mm ss.s	clock bias,a0(s)	cl. drift	a1(s/s)	drift rate a2(s/s2)
Eph ID	Crs (méter)	Δn (rad/s)	M0 (rad)	
Cuc (rad)	e (eccentr.)	Cus (rad)	sqrt(a) (sqrt(m))	
ToE(sec on GPS Week)	Cic (rad)	OMEGA (rad)	Cis (rad)	
i0 (rad)	Crc (méter)	omega (rad)	OMEGA DOT (rad/sec)	
IDOT (rad/sec)	L2 codes	GPS Week	L2 P data	
SV accuracy (m)	SV health	TGD (sec)	IODC	
Transm. Time of Msg.				

GNSS DATA FORMATS

Receiver **IN**dependent **EX**change Format (RINEX)

```
2.11      OBSERVATION DATA      M (MIXED)      RINEX VERSION / TYPE
teqc      2007Jun25                20081114 03:12:00UTCPGM / RUN BY / DATE
BUTE                                MARKER NAME
11209M001                            MARKER NUMBER
BUTE/DGS                            OBSERVER / AGENCY
4722K06130      TRIMBLE NETR5      3.32      REC # / TYPE / VERS
0                                RCV CLOCK OFFS APPL
30436720                                ANT # / TYPE
4081882.3740  1410011.1390  4678199.3890  APPROX POSITION XYZ
0.0000      0.0000      0.0000  ANTENNA: DELTA H/E/N
1      1                                WAVELENGTH FACT L1/2
10      C1      P1      P2      C2      L1      L2      S1      S2  D1# / TYPES OF OBSERV
D2                                # / TYPES OF OBSERV
30.0000  INTERVAL
2008      11      13      0      0      0.0000000  GPS  TIME OF FIRST OBS
Linux 2.4.20-8|Pentium IV|gcc -static|Linux|486/DX+  COMMENT
GPSBase 2.51 2653      13-Nov-08 01:07:39  COMMENT
END OF HEADER

08 11 13  0  0  0.0000000  0 17R13G25G 7G 8R11G10R14G13R 4G23G20G16
G 4R20G27G 2R19
19966178.813  19966177.781  19966182.926  -25464853.652  8
-19783378.78848  53.000  46.000
20567958.281  20567953.914  -26126266.185  7
-19683420.37247  48.000  41.000
20492914.938  20492910.660  20492910.586  -27457060.159  6
-21364847.51347  46.000  42.000
22829218.820  22829215.922  -17132875.193  6
-13298081.41847  45.000  32.000
23827799.078  23827798.164  23827802.672  -3942997.260  6
-3035746.07147  44.000  34.000
23737277.992  23737275.266  -6469002.526  4
-4704521.29046  39.000  23.000
23894782.773  23894781.508  23894790.012  -4129265.329  4
-3163775.00247  38.000  36.000
```

Interactive RINEX explanation:

https://server.gage.upc.edu/gLAB/HTML/Observation_Rinex_v3.01.html

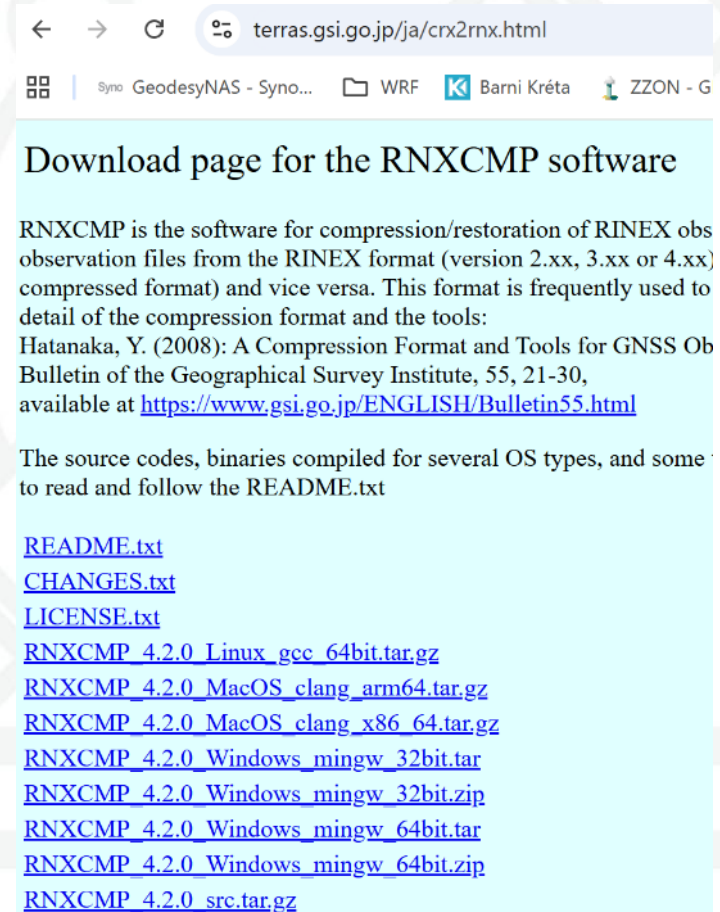
GNSS DATA FORMATS

Compact RINEX (Hatanaka)

Problem of RINEX: similar, but large numbers repeating in every epoch (pseudoranges, phase cycles, etc.) → large ASCII files

Principle: use a differential operator on the data sequence of the same type (e.g. continuous pseudorange observations of the same satellite)

<https://www.gsi.go.jp/common/000045517.pdf>



GNSS DATA REPOSITORIES

IGS / EUREF PN / National / Other

The screenshot shows a web browser window displaying the IGS Data & Products Repository. The browser's address bar shows the URL `igs.bkg.bund.de/browseFiles`. The page has a blue header with the BKG logo and navigation links: Home, Data & Products, Tools, and Links. Below the header, the page is titled "Data & Products Repository". On the left, a tree view shows the directory structure: BfGNet, EPNrepro1, EPNrepro2, EUREF (expanded), BRDC, BRDC_v3, highrate, highrate_v4, nrt, nrt_v3, obs, 2026 (expanded), CHECK_IMPORT_RNX3.BKG, CHECK_IMPORT.BKG, 036, 035, and a highlighted file `AAER00FRA_R_20260350000_01D_30S_MO.crx.gz`. On the right, a table displays the file's metadata:

Filename:	AAER00FRA_R_20260350000_01D_30S_MO.crx.gz
Filepath:	/root_ftp/EUREF/obs/2026/035/
Filesize:	4804.31 KB
Received:	2026-02-05T01:30:09.711Z
Last Update:	2026-02-05T01:20:08Z
Data Source:	Receiver
RINEX Vers.:	3.04

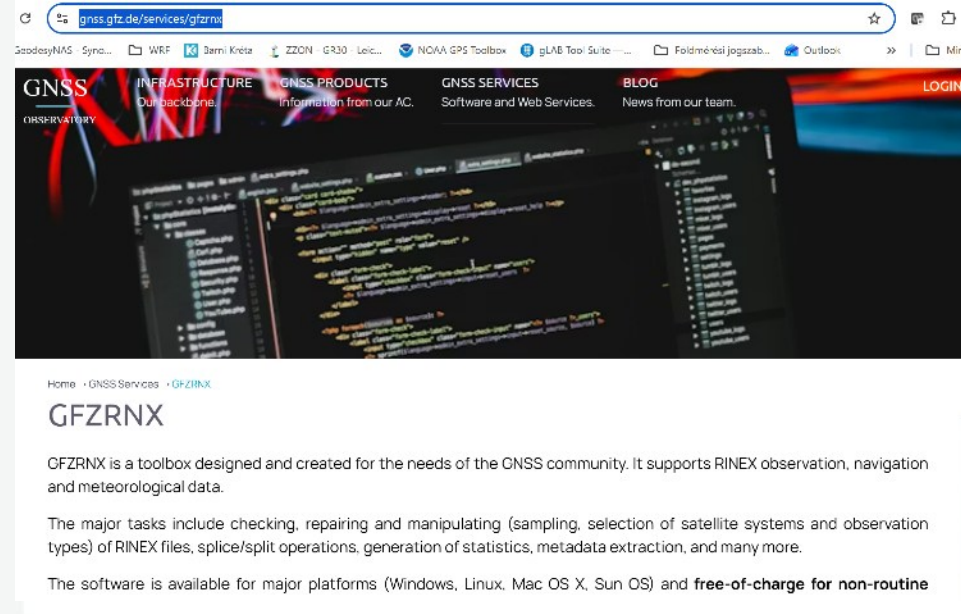
Below the table, there are download and view icons.

WORKING WITH RINEX DATA

RINEX Manipulation

- data checking/repairing
- data selection/filtering
- quality control (e.g. MP), statistics
- metadata extraction
- decimation
- concatenation/splitting
- update header information

<https://gnss.gfz.de/services/gfzrxn>



GNSS DATA FORMATS

SP3 Ephemerides

```
#cP2026 2 1 0 0 0.00000000 96 ORBIT IGc20 HLM IGS
## 2404 0.00000000 900.00000000 61072 0.00000000000000
+ 31 G01G02G03G04G05G06G07G08G09G10G11G12G13G14G15G16G17
+ G18G19G21G22G23G24G25G26G27G28G29G30G31G32 0 0 0
+ 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
+ 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
++ 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
++ 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2 0 0 0 0 0 0
++ 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
++ 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
++ 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
% C G cc GPS ccc cccc cccc cccc cccc ccccc ccccc ccccc ccccc
% C cc cc ccc ccc cccc cccc cccc cccc ccccc ccccc ccccc ccccc
%f 1.2500000 1.025000000 0.000000000000 0.0000000000000000
%f 0.0000000 0.000000000 0.00000000000 0.0000000000000000
%i 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
%i 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
/* RAPID ORBIT COMBINATION FROM WEIGHTED AVERAGE OF:
/* cod emr esa gfz grg jgx jpl ngs sio usn whu
/* REFERENCED TO IGS TIME (IGST) AND TO WEIGHTED MEAN POLE:
/* PCV:IGS20 OL/AL:FES2014b NONE Y ORB:CMB CLK:CMB
```

```
• 2026 2 1 0 0 0.00000000
• PG01 21397.352409 15169.909456 -4413.752085 337.822063 9 7 8 172
• PG02 15356.516791 16053.103134 -14546.821691 28.794659 5 8 6 146
PG03 11901.993151 17567.664346 15853.997340 582.806980 5 6 3 127
PG04 14864.785096 7260.565527 20846.769378 41.555103 7 5 6 160
PG05 -5096.758401 -25988.263320 -1894.182070 -228.212043 7 5 7 152
PG06 13543.594226 -8958.578536 21120.855592 -607.341221 7 7 7 168
PG07 24899.613163 5118.575098 -7775.516748 -142.912421 8 6 6 151
PG08 5118.686200 15445.570745 -21101.962536 497.542818 6 4 3 116
PG09 21177.207459 -2325.940461 15812.175652 770.368982 6 3 5 132
PG10 -11104.162458 14484.051970 -18897.726310 -586.060740 8 7 5 137
PG11 -1835.516204 -16864.216229 20507.886983 -454.565425 6 6 6 128
PG12 -9333.554384 -21407.491377 12368.080208 -607.113511 5 2 5 109
PG13 3969.502817 -17241.394226 -19994.357829 688.071486 14 11 7 140
```

↑
X

↑
Y

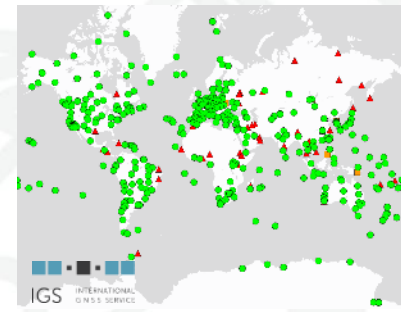
↑
Z

↑
 δt^S

Position, satellite clock
(+ velocity vector)

GNSS DATA FORMATS

IGS Orbit Products

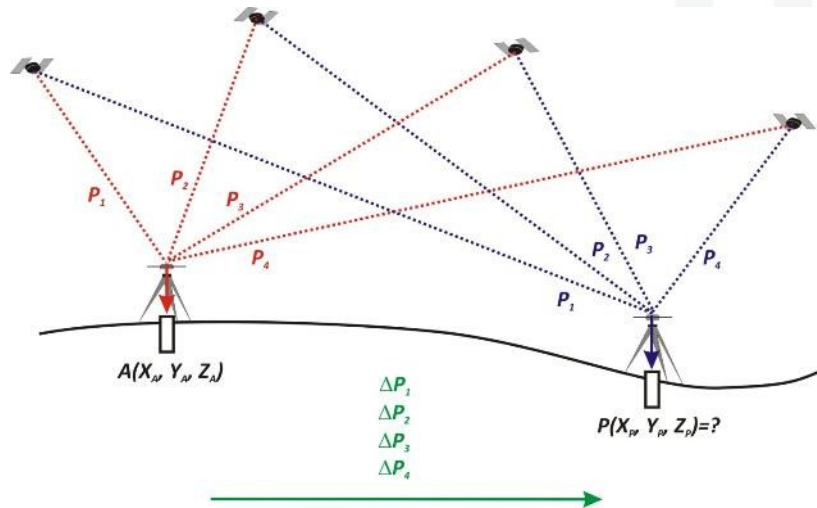


Type		Accuracy	Latency	Updates	Sample Interval
Broadcast	orbits	~100 cm	real time	—	daily
	Sat. clocks	~5 ns RMS ~2.5 ns SDev			
Ultra-Rapid (predicted half)	orbits	~5 cm	real time	at 03, 09, 15, 21 UTC	15 min
	Sat. clocks	~3 ns RMS ~1.5 ns SDev			
Ultra-Rapid (observed half)	orbits	~3 cm	3 – 9 hours	at 03, 09, 15, 21 UTC	15 min
	Sat. clocks	~150 ps RMS ~50 ps SDev			
Rapid	orbits	~2.5 cm	17 – 41 hours	at 17 UTC daily	15 min
	Sat. & Stn. clocks	~75 ps RMS ~25 ps SDev			5 min
Final	orbits	~2.5 cm	12 – 19 days	every Friday	15 min
	Sat. & Stn. clocks	~75 ps RMS ~20 ps SDev			Sat.: 30s Stn.: 5 min

REALTIME GNSS DATA FORMATS

RTCM 10402.3 – Radio Technical Commission of Maritime Services 2.3

Standardized data format for **differential GNSS** positioning



Principle of DGNSS Positioning



REALTIME GNSS DATA FORMATS

RTCM 10402.3 – Radio Technical Commission of Maritime Services 2.3

Standardized data format for **differential GNSS** positioning

```
RTCM23 01 00 01 17 6 76.0 Satnum=10
ID= 6 UDER = 0 IOD = 25 Range = -11.060 Range rate = 0.000
ID= 11 UDER = 0 IOD = 79 Range = -34.540 Range rate = 0.004
ID= 12 UDER = 0 IOD = 69 Range = -1.460 Range rate = 0.000
ID= 15 UDER = 0 IOD = 51 Range = -30.860 Range rate = -0.006
ID= 17 UDER = 0 IOD = 40 Range = -8.440 Range rate = -0.004
ID= 19 UDER = 0 IOD = 55 Range = -3.820 Range rate = 0.000
ID= 22 UDER = 0 IOD = 70 Range = -35.620 Range rate = -0.022
ID= 24 UDER = 0 IOD = 4 Range = -1.260 Range rate = 0.000
ID= 25 UDER = 0 IOD = 49 Range = -6.980 Range rate = 0.002
ID= 0 UDER = 0 IOD = 48 Range = -6.420 Range rate = -0.002
RTCM23 31 00 02 17 6 58.0 Satnum=10
ID= 3 UDER = 0 Tk = 47 Range = -46.600 Range rate = -0.020 0
ID= 4 UDER = 0 Tk = 47 Range = -7.420 Range rate = 0.012 0
ID= 5 UDER = 0 Tk = 47 Range = -0.980 Range rate = -0.008 0
ID= 6 UDER = 0 Tk = 47 Range = -13.880 Range rate = 0.028 0
ID= 13 UDER = 0 Tk = 47 Range = -4.820 Range rate = 0.002 0
ID= 14 UDER = 0 Tk = 47 Range = 2.280 Range rate = -0.002 0
ID= 15 UDER = 0 Tk = 47 Range = -2.900 Range rate = 0.000 0
ID= 22 UDER = 0 Tk = 47 Range = -9.660 Range rate = 0.000 0
ID= 23 UDER = 0 Tk = 47 Range = -0.640 Range rate = 0.002 0
ID= 24 UDER = 0 Tk = 47 Range = -8.720 Range rate = 0.006 0
```

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$$PRC = PRC(t_0) + RRC(t - t_0)$$

REALTIME GNSS DATA FORMATS

RTCM 10403.3 – RTCM 3.x

Standardized data format for **differential + relative GNSS** positioning

Multi GNSS, multi frequency correction/observation data format

```
C29 22808281.914 118768857.535 6422528 52.1 -2417.723 22808279.139 96509
C30 22541037.445 117377194.513 11534336 53.1 578.292 22541036.953 95378
C36 22206148.413 115633252.990 19398656 52.9 1505.206 22206151.047 93961
C40 40737804.119 212132360.351 24641536 33.9 1174.740 40737801.088 955.1
C42 26115368.688 135989560.808 5373952 46.9 350.666 26115375.766 110502
C45 22115823.474 115162925.550 9699328 52.1 -1159.769 22115814.533 93579
C56 38380693.171 199858296.966 27787264 46.9 804.385 38380693.097 162401
C60 40653799.384 211694982.833 67108864 44.2 -63.093 40653789.101 172019
RTCM3 1077 0207 00 381729.000 SatelliteNum=10 SignaNum=04 GPS[ L1C L2W L2S L
G03 25435262.312 133663206.959 49152 37.2 -312.544 25435266.244 1041531
G06 23067535.987 121220910.662 7471104 48.7 344.645 23067540.191 944571
G11 22956355.109 120636638.123 4456448 49.8 -2258.349 22956358.890 94002
G12 20273999.465 106540593.604 13893632 53.7 566.917 20273998.594 83018
G19 23720084.441 124649886.722 16777216 46.4 3286.190 23720085.064 97121
G24 21920597.785 115193479.303 17825792 50.6 3173.699 21920602.178 89761
G25 20737123.415 108974362.683 7995392 50.7 -1982.010 20737126.286 84915
G28 24794696.494 130297018.337 819200 45.2 -3527.603 24794697.730 101530
G29 23470353.456 123337679.956 3473408 48.8 -3495.937 23470357.944 96107
G32 22844579.776 120049053.321 7602176 50.0 -34.554 22844582.652 935447
RTCM3 1087 0207 04 46911.000 SatelliteNum=09 SignaNum=03 GLO[ L1C L2C L2P ]
R04 23891628.306 127938438.675 15204352 45.7 4243.947 23891642.316 99501
R05 21975657.640 117472454.527 9699328 52.7 2522.889 21975661.413 91367
R06 22535448.520 120253458.131 4456448 48.9 -930.169 22535453.157 935301
R13 23824836.938 127223155.952 21495808 41.4 3383.234 GLOFreq -2
R14 19771277.745 105392041.065 14942208 53.7 1161.605 19771282.014 81971
R15 20287976.395 108412838.788 7864320 53.6 -2124.945 20287979.384 84321
R17 22076897.766 118138002.288 2752512 49.4 -4298.330 22076905.630 81885
```



Version	Messages Defined	Change Description
3.0	1001-1013	RTK messages for single or dual-frequency GPS and GLONASS operation.
3.1	1001-1029 4088-4095	GPS Network RTK GPS and GLONASS Ephemeris messages Transformation messages UNICODE message
3.1 A.1	1001-1029 4001-4087	Improved messages descriptions. Addition of proprietary messages
3.1 A.2	1001-1033 4001-4095	Network RTK residual messages Physical reference station position message (for VRS) Receiver and antenna description messages
3.1 A.3	1001-1033 4001-4095	Handling of quarter-cycle phase shifts
3.1 A.4	1001-1039 4001-4095	GPS and GLONASS FKP GLONASS MAC
3.1 A.5	1001-1039 1057-1068 4001-4095	State space representation (SSR; PPP) messages
3.2	1001-1039 1057-1068 1071-1230 4001-4095	Multiple signal messages (MSM) GLONASS bias information message
3.2 A.1	1001-1039 1045 1057-1068 1071-1230 4001-4095	Added Galileo F/NAV Satellite Ephemeris Data (1045) BDS MSM (1121-1127)
3.2 A.2	1001-1039 1044-1045 1057-1068 1071-1230	Added QZSS Ephemeris (1044) QZSS MSM (1111-1117)

Version	Messages Defined	Change Description
3.3 (with Amendment 1 marked by *)	1-100 1001-1039 1041* 1042 1044-1046 1057-1068 1071-1230 4001-4095	Added Experimental messages (1 - 100) NavIC/IRNSS Ephemeris (1041)* BDS Ephemeris (1042) Galileo I/NAV Ephemeris (1046) SBAS MSM (1101-1107), NavIC (1131-1137)*
3.3 (with Amendment 2)		The changes to Version 3 are made to Table 3.5-73, Table 3.5-107 and Table 3.5-108.

REALTIME GNSS DATA FORMATS

RTCM 10403.3 – RTCM 3.x

Standardized data format for **differential + relative GNSS** positioning

Multi GNSS, multi frequency
correction/observation data format

```
C29 22808281.914 118768857.535 6422528 52.1 -2417.723 22808279.139 96509
C30 22541037.445 117377194.513 11534336 53.1 578.292 22541036.953 95378
C36 22206148.413 115633252.990 19398656 52.9 1505.206 22206151.047 93961
C40 40737804.119 212132360.351 24641536 33.9 1174.740 40737801.088 955.1
C42 26115360.680 135909560.000 5373952 46.9 350.666 26115375.766 110502
C45 22115823.474 115162925.550 9699328 52.1 -1159.769 22115814.533 93679
C56 38380693.171 199858296.966 27787264 46.9 804.385 38380693.097 162401
C60 40653799.304 211694902.833 67108064 44.2 -63.093 40653789.101 172019
RTCM3 1077 0207 00 381729.000 SatelliteNum=10 SignaNum=04 GPS[ L1C L2W L2S 1
G03 25435262.312 133663206.959 49152 37.2 -312.544 25435266.244 1041531
G06 23067535.987 121220910.662 7471104 48.7 344.645 23067540.191 944571
G11 22956355.109 120636638.123 4456448 49.8 -2258.349 22956358.890 94002
G12 20273999.465 106540593.604 13893632 53.7 566.917 20273998.594 83018
G19 23720084.441 124649886.722 16777216 46.4 3286.190 23720085.064 97121
G24 21920597.785 115193479.303 17825792 50.6 3173.699 21920602.178 89761
G25 20737123.415 108974362.683 7995392 50.7 -1982.010 20737126.286 04915
G28 24794696.494 130297018.337 819200 45.2 -3527.603 24794697.730 101530
G29 23470353.456 123337679.956 3473408 48.8 -3495.937 23470357.944 96107
G32 22044579.776 120049053.321 7602176 50.0 -34.554 22044582.652 935447
RTCM3 1087 0207 04 46911.000 SatelliteNum=09 SignaNum=03 GLO[ L1C L2C L2P ]
R04 23891628.306 127938438.675 15204352 45.7 4243.947 23891642.316 99501
R05 21975657.640 117472454.527 9699328 52.7 2522.889 21975661.413 91367
R06 22535448.520 120253458.131 4456448 48.9 -930.169 22535453.157 935301
R13 23824836.938 127223155.952 21495808 41.4 3383.234 GLOFreq -2
R14 19771277.745 105392041.065 14942208 53.7 1161.605 19771282.014 81971
R15 20287976.395 108412838.788 7864320 53.6 -2124.945 20287979.384 84321
R17 22076897.766 118118092.288 9759512 48.4 -4988.339 22076898.639 91885
```

```
*****
1006 117
1008 116
1019 11
1020 9
1033 116
1077 1742
1087 1743
1097 1743
1127 3485
Other 1013 0X03f5 174
Other 1042 0X0412 18
Other 1045 0X0415 12
Other 1046 0X0416 16
Other 1230 0X04ce 116
*****
```

DATA FIELD	DF NUMBER	DATA TYPE	NO. OF BITS
Message Number ("1006"-- 0011 1110 1110)	DF002	uint12	12
Reference Station ID	DF003	uint12	12
Reserved for ITRF Realization Year	DF021	uint6	6
GPS Indicator	DF022	bit(1)	1
GLONASS Indicator	DF023	bit(1)	1
Reserved for Galileo Indicator	DF024	bit(1)	1
Reference-Station Indicator	DF141	bit(1)	1
Antenna Reference Point ECEF-X	DF025	int38	38
Single Receiver Oscillator Indicator	DF142	bit(1)	1
Reserved	DF001	bit(1)	1
Antenna Reference Point ECEF-Y	DF026	int38	38
Quarter Cycle Indicator	DF364	bit(2)	2
Antenna Reference Point ECEF-Z	DF027	int38	38
Antenna Height	DF028	uint16	16
TOTAL			168

RTCM3 1006 0207 Year=00 BZ=12 Single_Oscillator_Indicator= 0 Quarter_Indicator= 2
X=4081882.377 Y=1410011.142 Z=4678199.391 Ht=0.000

REALTIME GNSS DATA FORMATS

RTK Streams

1006	117
1008	116
1019	11
1020	9
1033	116
1077	1742
1087	1743
1097	1743
1127	3485
Other 1013 0X03f5	174
Other 1042 0X0412	18
Other 1045 0X0415	12
Other 1046 0X0416	16
Other 1230 0X04ce	116

GNSS MSM7
messages
(GPS, GLO, GAL, BDS)

DATA FIELD	DF NUMBER	DATA TYPE	NO. OF BITS	NOTES
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Table 3.5-21 Contents of GPS Satellite Ephemeris Data, Message Type 1019

DATA FIELD	DF NUMBER	DATA TYPE	NO. OF BITS	NOTES
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Table 3.5-22 Contents of GLONASS Satellite Ephemeris Data, Message Type 1020

DATA FIELD	DF NUMBER	DATA TYPE	NO. OF BITS	NOTES
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Table 3.5-36 Contents of the Type 1033 Message – Receiver and Antenna Descriptors

DATA FIELD	DF NUMBER	DATA TYPE	NO. OF BITS	NOTES
Message Number	DF002	uint12	12	
Reference Station ID	DF003	uint12	12	
Antenna Descriptor Counter N	DF029	uint8	8	
Antenna Descriptor	DF030	char(N)	8*N	$N \leq 31$
Antenna Setup ID	DF031	uint8	8	
Antenna Serial Number Counter M	DF032	uint8	8	
Antenna Serial Number	DF033	char(M)	8*M	$M \leq 31$
Receiver Type Descriptor Counter I	DF227	uint8	8	
Receiver Type Descriptor	DF228	char(I)	8*I	$I \leq 31$
Receiver Firmware Version Counter J	DF229	uint8	8	
Receiver Firmware Version	DF230	char(J)	8*J	$J \leq 31$
Receiver Serial Number Counter K	DF231	uint8	8	
Receiver Serial Number	DF232	char(K)	8*K	$K \leq 31$
TOTAL			72+ 8*(M+N+ I+J+K)	

REALTIME GNSS DATA FORMATS

Proprietary RTCM Message Types

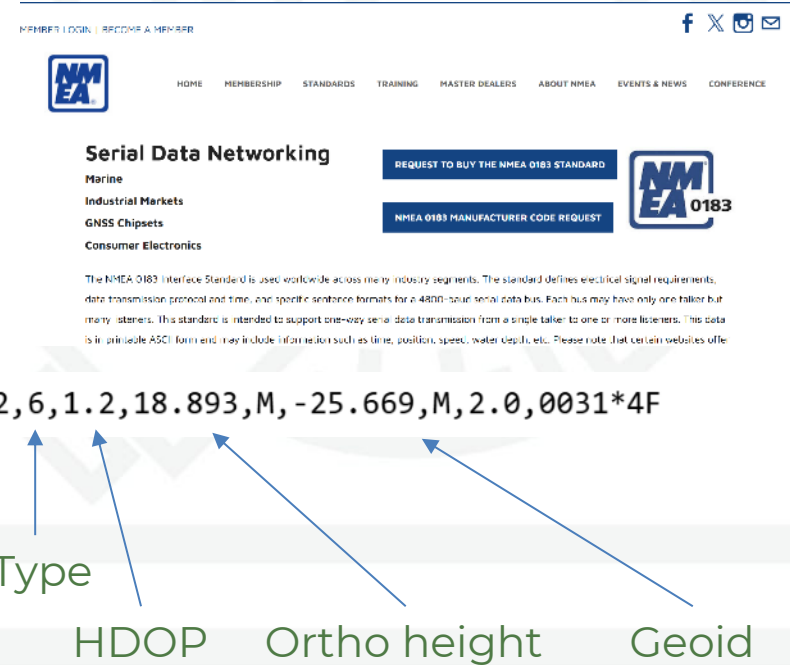
Message Type	Organization	Contact
4095	Ashtech	http://www.ashtech.com
4094	Trimble Navigation Ltd.	http://www.trimble.com
4093	NovAtel Inc.	http://www.novatel.ca
4092	Leica Geosystems	http://www.leica-geosystems.com
4091	Topcon Positioning Systems	http://www.topconpositioning.com
4090	Geo++	http://www.geopp.de/
4089	Septentrio Satellite Navigation	http://www.septentrio.com
4088	IfEN GmbH	http://www.ifen.com
4087	Fugro	http://www.fugro.com
4086	inPosition GmbH	http://www.inposition.ch
4085	European GNSS Supervisory Authority	http://www.gsa.europa.eu
4084	Geodetics, Inc.	http://www.geodetics.com
4083	German Aerospace Center, Institute of Communications and Navigation (DLR)	http://www.dlr.de/kn/en/desktopdefault.aspx/tabid-2204/3257_read-19445/
4082	Cooperative Research Centre for Spatial Information	http://www.crcsi.com.au
4081	Seoul National University GNSS Lab	http://gnss.snu.ac.kr/nav/
4080	NavCom Technology, Inc.	http://navcomtech.com
4079	SubCarrier Systems Corp. (SCSC)	http://www.DGPStools.com

Message Type	Organization	Contact
4078	ComNav Technology Ltd.	http://www.comnavtech.com
4077	Hemisphere GNSS Inc.	http://www.hemispheregnss.com/
4076	International GNSS Service (IGS)	www.igs.org
4075	Alberding GmbH	http://software.rtcntrip.org/wiki/NDF
4074	Unicore Communications Inc.	http://www.unicorecomm.com
4073	Mitsubishi Electric Corp.	http://www.mitsubishielectric.com/
4072	u-blox AG	http://www.u-blox.com
4071	Wuhan Navigation and LBS	http://www.wnlbs.com
4070	Wuhan MengXin Technology	http://www.wh-mx.com
4069	VERIPOS Ltd	http://www.veripos.com
4068	Qianxun Location Networks Co. Ltd	http://www.qxwz.com
4067	China Transport telecommunications & Information Center	http://www.cttic.cn/
4066-4001	RESERVED	

REALTIME GNSS DATA FORMATS

NMEA-0183

ASCII message for serial protocols
for marine navigation
GNSS, sonar, etc.



The screenshot shows the NMEA website's 'Serial Data Networking' section. It lists 'Marine', 'Industrial Markets', 'GNSS Chipsets', and 'Consumer Electronics' as application areas. Two buttons are visible: 'REQUEST TO BUY THE NMEA 0183 STANDARD' and 'NMEA 0183 MANUFACTURER CODE REQUEST'. A paragraph describes the NMEA 0183 Interface Standard as a worldwide used protocol for marine industry segments, defining electrical signal requirements, data transmission protocol, and time, and specifying sentence formats for a 4800-baud serial data bus. It notes that each bus may have only one talker but many listeners, and is intended for one-way serial data transmission from a single talker to one or more listeners. The data is in printable ASCII form and may include information such as time, position, speed, water depth, etc. A note mentions that certain websites offer this data.

\$GPGGA,172814.0,3723.46587704,N,12202.26957864,W,2,6,1.2,18.893,M,-25.669,M,2.0,0031*4F

Diagram illustrating the components of the NMEA 0183 sentence:

- Sol Type (points to the '2' in the sentence)
- HDOP (points to the '6' in the sentence)
- Ortho height (points to the '18.893' in the sentence)
- Geoid (points to the '-25.669' in the sentence)

REALTIME GNSS DATA FORMATS

NMEA-0183

Message	Function
DP	Dynamic positioning
DTM	Datum reference information
GBS	GNSS satellite fault detection (RAIM support)
GGA	Time, position, and fix related data
GLL	Position data: position fix, time of position fix, and status
GNS	GNS Fix data
GRS	GRS range residuals
GSA	GPS DOP and active satellites
GST	Position error statistics
GSV	Number of SVs in view, PRN, elevation, azimuth, and SNR

and many others ...



Thank You for Your Attention!

Contact: rozsa.szabolcs@emk.bme.hu

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SURVEYING