DGPS Data Formats 2.0

by

Andreas Bagge
Geo++® Gesellschaft für satellitengestützte geodätische und navigatorische Technologien mbH
Steinriede 8, D − 30827 Garbsen, Germany, Tel. +49 − 5131 − 4689−0
http://www.geopp.de
andreas.bagge@geopp.de

Version 2.01 from 20. November 2001

Summary: The various correction data formats used for Differential GPS are explained in this report. The formats standardized by the RTCM Committee, as well as the necessary extensions are explained, as long as they are required for the understanding of the operation of reference stations and reference station networks, especially the Satellite Positioning Service SAPOS® of the German state survey authorities. The RINEX format for post processing applications is also discussed.

1 Introduction

Since the emergence of differential GPS applications it has been essential to transmit the information needed for DGPS computation from the reference station to the mobile station. With its Special Committee 104 (SC104), the US Radio Technical Commission for Maritime Services (RTCM) set up a team composed of representatives of US federal authorities, GPS manufacturers and users. Already in the early 1990s, they adopted a first standard for the transmission format and contents for DGPS applications which has been modified, in the following years, to match current developments.

Because these RTCM standards have been supported by leading manufacturers and users, they also spread widely outside the USA and thus developed into an internationally recognized standard. Version 2.1 is the current standard. Version 2.2 with enhancements so as to include GLONASS will be adopted shortly.

The current version of the RTCM standard can be obtained from the

Radio Technical Commission for Marine Services
Special Committee 104
Post Office Box 19037
Washington, D.C. 20036
USA
http://www.rtcm.org

and costs about US$70 in hard copy.

Experience shows that, because of the need for agreement among all the institutions and interested parties involved, standards develop only very slowly. Thus there have always been, and remain, a large number of proprietary solutions (e.g. from Trimble and others) which are not compatible with the RTCM standard. However, from the beginning, Geo++® GmbH has backed the available standards and has implemented any necessary enhancements in a way which is compatible with them. Today Geo++® participates in the consultations of the RTCM Committee.

2 Raw data / correction data

In principle, there are two different ways to transmit the necessary information from the reference station to the mobile stations.

The most obvious possibility is the transmission of the raw data in its original form generated by the receiver at the reference station (original observation data). Apart from the obvious advantage that little or no calculation is needed at the reference station, with this form of data it is also relatively easy to use the existing algorithms and GPS post-processing programs for real-time processing, because only slight modifications are needed. However, much additional information, from precise reference station coordinates to the antenna types used, must be supplied to the mobile station.

The other possibility is to supply the necessary information by transmitting only the corrections compared with a theoretical value rather than the original observations. With knowledge of the reference station coordinates and the satellite positions, ranges can be calculated for each of the satellites (neglecting orbit, clock and propagation errors, SA effects, etc.). The differences from the actually measured distances yield, in simplified terms, the correction values which can then be transmitted to the mobile station.

However, this second method generates increased computation workload at the reference station and demands appropriate algorithms able to handle the correction data at the mobile station. Nevertheless, correction data has numerous advantages compared with raw data. On the one hand, correction data formats call for significantly less space than raw data because the number of significant digits needed is less. On the other hand, the correction data is independent of specific reference station parameters, which means that there is no need for the mobile station to know the exact reference station coordinates or antenna parameters. Another advantage is that individual corrections at the reference station, e.g. for azimuth- and elevation-dependent antenna phase centers or for multi-path effects, can be very easily incorporated. More sophisticated models, such as the concept of networked reference stations, cannot be employed at all without correction data.

For DGPS applications, the use of correction data has generally gained acceptance. Probably because it was easier for them to implement, most GPS manufacturers at first adopted the raw data format for PDGPS applications. For its PDGPS solution, Geo++® GmbH recognized the advantages of correction data early on, and since 1994 has implemented the correction data format even for carrier phase operations. In the meantime, other manufacturers also appear to have seen its advantages so that an increasing number of implementations using correction data format are coming onto the market.

3 The RTCM Data Format

RTCM data is transmitted as a continuous binary data stream. Typically, a complete RTCM data record is transmitted within one second. RTCM compresses the various contents of a data record in several message types.

Message 1
Message 2
...
Message n

Table 1 RTCM record, divided into multiple Messages

Every message within a data record comprises a message header and a message body.

Message-Header
Message-Body

Table 2 RTCM message, divided into header and body

The message type, time information (albeit ambiguous), the reference station ID, the length of the message and further information such as the monitoring status, are all coded in the header. The body comprises the relevant operational data for every data type. The length of a message depends on the data type.

Header and body are protected by parity bits, permitting the relatively reliable recognition of transmission errors.

An RTCM data record does not necessarily have to include every message type. Some message types must be sent every second, others are automatically sent at defined times or at any desired interval. If a complete RTCM data record is shorter than the sending interval, no data will normally be sent during the remainder of the inter−val.

Because of the real−time requirement, and in case of restricted bandwidth of the transmission channel, there is normally no point in repeating incomplete or defective data records. Instead, it is better to wait for the next data record.

4 Update Rate

An important criterion for the choice of transmission channels is the required update rate with which a complete RTCM data record must be transmitted. For static applications (point positioning), update rates of several sec−onds are permissible although they should be as short as possible to ensure rapid progress of the work. For kinematic applications with a mobile antenna (sea, air and land navigation as well as setting out), an update rate of at least one data record per second is necessary because of the dynamic behavior involved. A slower update rate will yield a poorer accuracy.

5 RTCM−2.0

Version 2.0, which is important for DGPS applications, was adopted by the RTCM committee in 1990. It com−prises all necessary information to provide correction data and some additional information for DGPS applica−tions.

Amongst the message types defined in RTCM 2.0, the following are important for the SAPOS service:

Type	Content	Frequency
1	Differential corrections for code observations	in every record, typically once per second
2	Delta corrections, describe differences in the correction data on transition be−tween ephemeris records, because reference station and mobile station may make the transfer with a gap of some seconds	automatically with each ephemeris shift, e.g. for each change of hour
3	coordinates of the reference station	as required, typically at intervals of about 1 minute
16	any desired alphanumeric text, e.g. name and tel. no. of the reference station	as required, e.g. every 10 minutes
59	user−defined message type, any further data,packed in a user−defined format, e.g. to provide additional information or a higher accuracy	as required

Table 3 RTCM−2.0 message types, relevant to DGPS

RTCM Version 2.0 includes numerous other message types which are important chiefly for special (e.g. mari−time) applications.

The DGPS accuracy achievable with RTCM Version 2.0 is about 1 meter. RTCM 2.0 does not contain any car−rier phase information so no RTK applications are possible with this version. Thus, RTCM 2.0 is mainly of in−terest for navigation applications.

If the corrections for all available satellites are to be transmitted, a complete RTCM 2.0 data record will take about 1200 Bits.

Under the SAPOS concept of the AdV (Association of German State Survey Departments), RTCM 2.0 is trans−mitted within the framework of the EPS service indirectly via the RASANT format (see below) through RDS and through VHF radio transmission as part of the RTCM−AdV format.

6 RTCM−2.1

With the emergence of the first PDGPS applications based on centimeter accuracy carrier phase solutions, in 1993 the RTCM committee developed version 2.1 of the RTCM standard. The full content of RTCM 2.0 was retained in RTCM 2.1. The important enhancements consisted of some new message types permitting the transmission of the information needed for PDGPS carrier phase solutions.

Type	Content	Frequency
1	as in RTCM 2.0	as in RTCM 2.0
2	as in RTCM 2.0	as in RTCM 2.0
3	as in RTCM 2.0	as in RTCM 2.0
16	as in RTCM 2.0	as in RTCM 2.0
18	carrier phase raw data for PDGPS applications	in every record, typically once per second (where type 20 is not used)
19	code phase raw data for PDGPS applications	in every record, typically once per second (where type 21 is not used)
20	carrier phase corrections for PDGPS applications	in every record, typically once per second (where type 18 is not used)
21	code phase corrections for PDGPS applications	in every record, typically once per second (where type 19 is not used)
59	as in RTCM 2.0	as in RTCM 2.0

Table 4 RTCM−2.1 message types, relevant to PDGPS

For PDGPS applications, either message type 18 (carrier phase raw data)or, preferably, message type 20 (carrier phase corrections) must be transmitted. The advantages of correction data over raw data have already been described above.

The information about the code phases (message types 19 and 21) improves the accuracy of the information transmitted in message type 1 and is especially useful for rapid mobile PDGPS solutions. This should therefore also be transmitted, at least for the L1 code observations.

The required data volume for a complete RTCM 2.1 data record with twelve GPS satellites available simultaneously is more than 4800 bits. Unfortunately, correction data types 20 and 21 have been defined with the same internal structure as the raw data types 18 and 19, so the advantage of the smaller data volume of correction data has not been exploited in the RTCM 2.1 format.

With RTCM 2.1 correction data, an accuracy of one centimeter or better can be achieved. However, the achievable accuracy depends strongly on the distance, such that the accuracy decreases by a factor of about 1ppm of the distance from the reference station.

With RTCM 2.1 raw data, the accuracy is slightly lower because the additional information necessary for the processing of raw data cannot be transmitted in RTCM 2.1 with the required accuracy. The number of digits for reference station coordinates in RTCM message type 3 restricts the resolution to 1 cm, so an error of up to 5 mm may occur in each coordinate direction. With the concept of correction data, this error effect is eliminated because correction data is invariant in relation to reference station coordinates.

A required update rate of one data record per second demands a transmission rate of 9600 bits per second. Often, baud rates of only 2400 bits per second are available (e.g. with VHF radio transmission), so the RTCM 2.1 format is not operable everywhere without restriction. However, it is the only internationally recognized standard for PDGPS real−time applications.

RTCM 2.1 is made available to mobile PDGPS users by the AdV through its SAPOS program, within the HEPS service, by means of the SAPOS decoder box or SMARTgate communication device (see below).

7 RTCM−2.2

Version 2.2 of the RTCM standard was published at January 15th, 1998 by the RTCM committee. Compared with RTCM 2.1, this version will include some enhancements and allows the exploitation of satellites of the Russian GLONASS satellite navigation system.

Differential GLONASS corrections are stored in message type 31, which is construced similar to message type 1 for DGPS. More precise GLONASS observations and corrections are transmitted like their GPS pendants in the message types 18/19 rsp. 20/21. To differentiate against GPS there is a special flag in each of these messages. Additionally, RTCM−2.2 defines with the message types 32 to 36 some more message types special for GLONASS, which are of no importance for geodetic applications.

Unfortunately the message types 18 to 21 are not fully compatible to version 2.1, therefore there may under circumstances arise problems in the combination of RTCM−2.1 and RTCM−2.2 reference stations and rover.

In principle, the intended consideration of datum parameters in RTCM 2.2 is welcome from the point of view of geodetic applications. Unfortunately, it apparently fails to provide the resolution needed to achieve centimetre accuracy.

All in all, RTCM 2.2 will not immediately affect the AdV SAPOS concept. As soon as developments (e.g. GLONASS) demand it, the features of RTCM 2.2 will be used.

8 RTCM−2.3

In spring 2001 the final version 2.3 of the RTCM standard has been published.

For geodetic applications the definition of antenna types (message type 23) and of the antenna reference point ARP (message type 24) may become interesting.

The message types 18−21 are mostly compatible to RTCM−2.2, there are some clarifications that should for the future a better compatibility between implementations of different manufacturers.

9 RTCM−3.0

The next RTCM version 3.0 will probably bring the possibility to transmit the results of networking reference stations in well defined message types. Since RTCM is designed exclusively for broadcast distribution of correction data, only broadcast capable data formats can be considered. This could be e.g.:

- representation models (like e.g. Geo++® FKP "Flächenkorrekturparameter")
- complete system state of a Geo++® GNSMART network solution
- grid models for virtual reference stations along a fixed raster.

Which model will be included in the RTCM standard is currently under discussion.

10 RTCM++

The RTCM++ format was developed in 1993 by Geo++® GmbH to overcome the shortcomings of RTCM 2.1, especially with regard to accuracy and to the data volume of the information transmitted.

RTCM++ makes use of the existing redundancy in the correction data under RTCM 2.1 as well as special algorithms to reduce and compress the data. Thus, the data content of message types 20 and 21 is reduced to a fraction of its original size without any loss of information. The compressed data is packed in conformance with the RTCM standard in message type 59, which is reserved for user−specific information. The remaining message types are already packed almost optimally and are therefore included in RTCM++ unchanged in comparison with RTCM 2.0 and RTCM 2.1.

Type	Content	Frequency
1	as in RTCM 2.0	as in RTCM 2.0
2	as in RTCM 2.0	as in RTCM 2.0
3	as in RTCM 2.0	as in RTCM 2.0

Type	Content	Frequency
16	as in RTCM 2.0	as in RTCM 2.0
59	Code and carrier phase corrections, identical data content to RTCM 2.1 correction data, with its own subtypes: • Subtype 11, type 20 • Subtype 21, type 21 • Subtype n: networking parameters	in every record, typically once per second

Table 5 RTCM++ message types, relevant to PDGPS

Because the content of RTCM++ data is identical with RTCM 2.1 correction data, at least the same accuracy (1 centimetre or better) is achievable. The resolution of the observed quantities in RTCM++ is 1 mm, thus offering scope for improvements in accuracy in the future.

Furthermore, the use of message type 59 allows the transmission of additional information to improve accuracy. This includes especially the parameters which provide the mobile station with the results of networking of the reference stations. Thus the achievable accuracy no longer depends on distance, so that one centimeter accuracy can be guaranteed to be largely homogeneous over the whole area covered by a reference station network.

In principle, the RTCM++ format offers numerous further opportunities for special applications, for example the exploitation of mobile reference stations for the relative positioning of two moving vehicles one to the other (so−called relative DGPS or RDGPS).

The importance of the RTCM++ format for the SAPOS concept arises indirectly from the use of RTCM−AdV which has essentially been developed using RTCM++ (see RTCM−AdV).

11 RTCM−AdV

The RTCM−AdV format is based on the Geo++® GmbH RTCM++ proprietary format. This format has been provided by Geo++® to the member organizations of the Association of German State Survey Departments (AdV − Arbeitsgemeinschaft der Vermessungsverwaltungen der Bundesrepublik Deutschland) for operation within their SAPOS satellite positioning service. Compared with the RTCM++ format, the RTCM−AdV format allows additional data encryption which is controlled exclusively by the operator. These measures guarantee the independence of the RTCM−AdV format from the proprietary RTCM++ format.

By using the SAPOS "decoder box" (AdV box) or a SMARTgate communication device at the mobile station, connected between the VHF radio receiver and the PDGPS computer, correction data which fully conforms to the RTCM 2.1 standard may be reconstructed from the RTCM−AdV format. RTCM−AdV is used only for the radio transmission between reference station and mobile station. The interface to the user is the output of the SAPOS decoder box and is thus in RTCM 2.1. In this approach the information for improving accuracy which RTCM−AdV allows (e.g. networking parameters) may also be transmitted to the mobile station, ready for use by the SAPOS decoder box in generating RTCM 2.1.

12 RTCM−AdV with network corrections

In accordance with their definition already given, the correction data included in RTCM−AdV always refer to one station and contain information on this station only. To improve accuracy, homogeneity and reliability, in−formation on the linking of reference stations (for a multi−station solution) must also be included in the correc−tion data.

This additional information on reference station networking involves the computation of parameters of a two−dimensional model covering both reference and mobile stations (area correction parameters − Flächenkorrek−turparametern (FKP)) and packed in a few free bits of the RTCM−AdV format. The whole format with RTCM−AdV correction data and the additional area correction parameters is called RTCM−AdV FKP, to make it clear that it is essentially the known RTCM−AdV format but that additional information is included.

Geo++® GmbH has developed a provisional specification for this format, which meets the requirements for ac−curacy and currency with as low a data volume as possible.

This format will be especially important with future developments in communication techniques such as Digital Audio Broadcasting (DAB). This will enable a whole country or region to be supplied with one unified correction data set. For this, the locally optimized correction values will be calculated at mobile stations from the unified data set by means of the area correction parameters. Local VHF transmitters may thus perhaps become redundant.

13 RTCM−RSIM

On the basis of the RTCM message structure, some message types have been standardized through the RTCM−RSIM format (RSIM= Reference Station Integrity Monitoring) for transmission of controlling, checking and monitoring information (see for example RTCM Special Committee 104: RTCM Recommended Standards for Differential NAVSTAR GPS Reference Stations and Integrity Monitors, Future Version 1.0, Final Draft, August 10, 1993).

These message types may serve as a basis for communication between reference and monitoring stations. Some additional information, not yet (?) provided in the RTCM−RSIM format but indispensable for the efficient and complete transmission of information, has been defined by Geo++® GmbH in largely format−compatible enhancements, as the so−called RSIM++ format.

14 RASANT

The RASANT correction data format is one realization of RTCM 2.0 correction data for data transmission using the Radio Data System (RDS) for FM broadcasting.

RASANT is similar to RTCM−AdV. Band width problems occur with transmission through RDS. The RASANT format is generated at the reference station before being passed on to the broadcasting channels. At the mobile station, an RDS decoder (in the same way as a car radio with RDS) makes the conversion back into RTCM 2.0 which may then be fed into a DGPS system. FM radios suitable for RDS are already available as PCMCIA plug−in cards.

RASANT contains additional parity bits for error detection and error correction to reduce the error proneness of the RDS channels. Because the bandwidth of an RDS channel is significantly lower than is required for RTCM 2.0, the update rate for RASANT must be reduced accordingly. Thus transmission of a complete correction data record takes several seconds.

For these reasons, RASANT can achieve an accuracy of only about 2−5 meters, thus it is significantly worse than with RTCM 2.0 using a one second update rate.

The RASANT format was first introduced in the German state "North Rhine−Westphalia" and is now available to all SAPOS operators throughout Germany.

15 RINEX

Already in the 1980s, the RINEX format was defined as a receiver−independent format for GPS raw data, by agreement between various user institutions mainly in research fields. After initially hesitating for commercial reasons, all important GPS vendors now support this format.

Because of its internal structure, the use of RINEX can be recommended only for the archiving of GPS observations. RINEX is not suitable for real−time applications. The most important application area is the post−processing of GPS observations. Static as well as kinematic (from version RINEX−2.0 on) observations can be stored.

RINEX is an ASCII data format with a relatively large number of redundant or superfluous characters. Typically, a RINEX file can be reduced to 50% or less of its original size with simple compression algorithms. Generally, RINEX files are stored on a hard disk at regular intervals of (say) ten minutes or even one hour.

A RINEX file contains one or more multiple−line headers with column−dependent contents. A code word from column 60 on describes the type of header information. The header information itself is contained in columns 1 to 59. The individual data records are stored epoch by epoch in the body of the RINEX file. Each epoch contains an epoch header including the GPS time, the numbers of the observed satellites and further information, followed by the code and carrier phase observations of all satellites for this epoch. For kinematic applications, other elements are added.

Detailed descriptions of the RINEX format are available in, for example:

Werner Gurtner, University of Berne (Switzerland)
Gerald Mader, National Geodetic Survey (USA):
Receiver Independent Exchange Format Version 2.0
Astronomisches Institut der Universität Bern, 1993
http://igscb.jps.nasa.gov/gscb/data/format/

RINEX header ...
epoch header
observations satellite i
observations satellite j
... other satellites ...
epoch header
observations satellite i
observations satellite j
... other satellites ...
... other epochs ...

Table 6 Composition of a RINEX file (simplified)

```
     2                 OBSERVATION DATA                        RINEX 
VERSION / TYPE
DAT2RIN 2.20b          akutsu                12NOV97  2:38:19 GMTPGM / 
RUN BY / DATE
akutsu                 akutsu                                       
OBSERVER / AGENCY
13831                  TRIMBLE 4000SSI       Nav 7.09 Sig 3.03     REC # / 
TYPE / VERS
0                      4000SE INTERNAL                             ANT # / 
TYPE
3831                                                               MARKER 
NAME
3831                                                               MARKER 
NUMBER
 -3959062.0228  3313891.4257  3732479.7078                         APPROX 
POSITION XYZ
        1.6063        0.0000        0.0000                          
ANTENNA: DELTA H/E/N
     1     1     0                                                  
WAVELENGTH FACT L1/2
     4    L1    C1    L2    P2                                     # / 
TYPES OF OBSERV
     1                                                              
INTERVAL
  1997    10    16     1    16   41.000000                         TIME OF 
FIRST OBS
                                                                   END OF 
HEADER
 97 10 16  1 16 41.0000000  0  7  4  6 10 19 24 26 27
     27330.34610  22889087.35200     21295.70550  22889092.02740
     -8360.24710  23804321.80500     -5066.81150  23804326.59840
     -2870.80710  20900767.30500     -2237.66750  20900770.56340
     12187.98710  23342287.63300      9496.93150  23342292.52040
      7696.03410  20361940.66400      5996.35150  20361944.09840
    -26372.91610  22898631.75800    -20550.78050  22898636.96140
    -10317.14310  22350972.40600     -8038.77250  22350975.88740
 97 10 16  1 16 42.0000000  0  7  4  6 10 19 24 26 27
     30365.73500  22889665.05500     23660.94140  22889669.77740
     -9289.07500  23804145.60200     -5790.58240  23804150.00840
     -3191.55600  20900706.30500     -2487.60140  20900709.57440
     13542.07900  23342545.78900     10552.06840  23342550.65240
      8551.24300  20362103.21900      6662.74640  20362106.62940
    -29304.55000  22898073.75000    -22835.16740  22898078.85940
    -11463.81100  22350754.42200     -8932.27840  22350757.99640
```

Tabelle 7 Example of a RINEX file, with header and 2 epochs

16 RTCM−RINEX Converter

The data contents of the RINEX format are more comprehensive than those of the RTCM−AdV format. Never−theless a complete RINEX file can be generated from the contents of RTCM−AdV with a little additional infor−mation (especially satellite ephemeris and station coordinates). Therefore, for long−term data archiving, the storage of the data contained in the RTCM−AdV format together with the additional information for each station on an internal data basis is sufficient.

For the reconstruction of raw data or RINEX data from correction data, the following steps are necessary:

(a) Computation of satellite positions for each epoch from the ephemeris

(b) Computation of range, elevation and azimuth from the satellite positions resulting from (a) and from the coordinates of the reference station

(c) Computation of the corrections taken from RTCM−AdV for the computation at the reference station: satellite clock error, relativity correction and earth rotation correction, with the inclusion of further correction values such as phase center eccentricities as necessary.

(d) In essence, the raw data are reconstructed from the addition of range correction (from RTCM−AdV) + range (from (b)) + satellite clock error + relativity correction + earth rotation correction (from (c) in each case)

The computation of the satellite positions in 1 demands the knowledge of exactly which satellite ephemeris have been used in generating RTCM−AdV corrections at the corresponding reference stations. The ephemeris are identical for all reference stations and for constant time intervals of one hour because they are emitted uniformly from the GPS space segment. For the short time interval needed for the inevitable changeover between two ephemeris records (e.g. at every change of hour), corresponding information is included in all RTCM data thus enabling the reconstruction of unambiguous connections.

If the reconstruction of the RINEX data is to be carried at a central station, the exact coordinates of the reference station, all applied station−dependent corrections and the correct ephemeris must be available at this central station. Normally, the reference station coordinates are constant but are also included in the RTCM−AdV data with high accuracy. Constant coordinates and (normally constant) station−dependent correction values (e.g. phase center eccentricities) can be stored in one central database. The ephemeris can either be collected by a dedicated GPS receiver of the simplest type (with output of ephemeris data) at the central station or they must be brought up via direct line from one or more reference stations at regular intervals. This can be done e.g. using RTCM message type 17, which each holds the ephemeris of one satellite. Each RTCM message include in its header the time information is uniq only within one hour (i.e. modulo 3600 seconds). In order to have a uniq time frame the RTCM message type 14 can be used, which holds the GPS week (unfortunately only modulo 1024) and the full hour within that GPS week.

Some particular corrections which are identical for all satellites at one station (e.g. receiver clock error) can not be re−applied later because this information is lost after generating RTCM−AdV corrections. For this reason, the reconstructed RINEX data will differ slightly from RINEX data generated directly at the reference station. Nevertheless, the information content which is relevant for positioning is the same, thus guaranteeing that computation from either data set will always produce the same coordinates.

Starting from correction data with a given data rate (e.g. 1 Hz = 1 data record per second), higher RINEX data rates (e.g. 2 Hz) may also be derived. This is possible because correction data have lower dynamics in comparison with raw data and reference stations naturally possess static coordinates.

The RINEX format is the file interface for GPPS service users within the SAPOS system. The availability of the RINEX files within a few minutes after the observations is an important requirement for this application area. Furthermore, GPPS users require selected RINEX data whose beginning and end are defined to the nearest minute.This can be achieved if the RINEX files are only generated from the internal data basis after being requested by a user.

The data rate of the outgoing RINEX data must also be selectable. The user requirements for the RINEX data rate range from once per 15 seconds for static point fixation to once per second or even higher for kinematic positioning, for example in aircraft position determination for aerial photography.

Thus the available data should be collected and recorded at the highest possible data rate. Data should be filtered to the required data rate only at the time it is requested. When filtering data, care should be taken to ensure that the flags (e.g. cycle slips) of the filtered−out epochs are correctly taken into account.