European Position Determination System

Guidelines For Cross-Border Data Exchange

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Content

1. Introduction

EUPOS services are designed so that homogeneous DGNSS and Network RTK positioning performance can be guaranteed throughout the whole EUPOS coverage area. The cooperation of neighbouring member countries is inevitable in reaching this aim. Relying solely on the reference stations of individual countries the accuracy and reliability of the position services would degrade towards the country borders due to missing external geometrical information. The exchange of raw GNSS measurements of reference stations located close to the borders can help each other's EUPOS National Service Centres (NSC) to extend the homogeneous service coverage areas to the borders. The aim of this paper is to provide guidelines for EUPOS networking stations, enabling them to select appropriate exchange data contents, data formats and transport protocols.

2. Exchange data contents and format

Reference stations of the EUPOS member countries are equipped with various types of GNSS receivers of different manufacturers. Also, different types of reference station and networking software applications can be used to generate standard EUPOS services. It is important therefore to provide real-time GNSS exchange data in the formats that are supported by all national EUPOS network operators.

The international RTCM SC-104 standards are widely accepted and used also for data exchange between reference station networks all over the world. Also EUREF and IGS are considering to use RTCM as a standardised raw data format within their networks.

It is recommended therefore that the EUPOS member countries also use the RTCM standards for cross-border data exchange.

(It has to be noted that even the RTCM standards have some limitations that network operators must be aware of.)

As a result of the evolution of the RTCM standards the contents and format of the streamed GNSS data improved significantly, the suitable Message Types have been refined. RTCM version 2.3 was followed by version 3.0 in 2004 and version 3.1 in 2006. ***It is recommended that EUPOS networking centres exchange data format is RTCM 3.x***.

A great advantage of the RTCM 3.0 and 3.1 formats is that they apply a 70% more effective compression scheme than RTCM 2.3, therefore the use of RTCM 3.x standard Message Types requires significantly lower communications bandwidth. RTCM 2.3 format should not be used for data exchange because it does not contain the CNR values.
It may take some time until all GNSS network software suppliers implement the updated RTCM 3.1 standards into their products, therefore it is temporarily acceptable to use previous versions of the standards (RTCM 3.0).

Proprietary raw data formats are not recommended for EUPOS cross-border data exchange and are only accepted temporarily if RTCM standard data formats are not supported by a networking centre due to software limitations. When proprietary data is used it must be ensured that the receiving networking station is capable of decoding the data streams, i.e. the network processing software installed at the receiving networking centre is able to decode the given data format or the appropriate decoder software is freely available.

A basic rule is that the contents of the selected data formats and Message Types should not reduce the full value of an external station when integrating it into a national EUPOS network.

For post-processing purposes it is recommended to exchange data in the standard format independent from the receiver – RINEX 2.11 or 3.0.

2.1 Exchange data contents

The exchange data streams must contain:

- **raw carrier phase and code observations** on all available GNSS frequencies.

As a result of GNSS modernisation new frequencies and signals will appear in the near future. RTCM standards in their current status do not support the transmission of new observables, it is anticipated however that the standards will be upgraded when this will be necessary. The recommended EUPOS data exchange formats and Message Types will also be revised accordingly.

In addition it is preferable that the exchange data streams contain:

- **ephemeris information**,
- **time information**,
- **signal strength information** (carrier-to-noise = CNR),
- **ETRS 89 coordinates of the Antenna Reference Point (ARP) with height information**,
- **antenna type descriptor and antenna serial number**,

Further requirements on the raw data:

- antenna phase centre corrections are applied. If the data streams are stored into RINEX files for post-processing purposes, this fact must be taken into account,
- unsmoothed pseudoranges should be streamed,
- clock steering should be enabled,
- the recommended update rate for the range measurements, time and CNR is 1 Hz, ephemeris information should be updated upon change,
- the ARP coordinates along with the antenna type information and antenna serial number should be updated once every minute.

Additional information recommended for the exchange:

- individual absolute antenna calibration values in ANTEX format if available (according to the licence agreement) is recommended to exchange between National service centres,
- if whole antenna mounting was used for robot calibration, it is desirable to submit the description of the reference point to which the calibration values relate
- site information documented in site log (according to the IGS)

2.2 Recommended data format and Message Types

For EUPOS cross-border data exchange the recommended data format is RTCM version 3.1, the suitable Message Types are listed in Table 1.

Recommended messages are 1004 (1003), 1006 (1005), 1008 (1007), 1012 (1011), 1019, but their availability depends on the particular software. The messages in brackets are acceptable when the software does not support the first values.

Note that clock steering is required for RTCM 3.1 raw data transmission.

Table 1: RTCM 3.1 Recommended Message Types

Message Type	Content	Data rate
1003	GPS L1/L2 pseudorange and carrier phase measurements	1 s
1004	GPS L1/L2 pseudorange and carrier phase measurements + time and CNR	1 s
1005	Antenna Reference Point coordinates	60 s
1006	Antenna Reference Point coordinates with height information	60 s
1007	Antenna Descriptor	60 s
1008	Antenna Descriptor and Serial Number	60 s
1011 (optional)	GLONASS L1/L2 pseudorange and carrier phase measurements	1 s
1012 (optional)	GLONASS L1/L2 pseudorange and carrier phase measurements + time and CNR	1 s
1019	Ephemeris	On change

RTCM 3.1 limitations:

With RTCM 3.1 it is possible to transmit data for only one signal per carrier frequency. As a result of this limitation, for receivers which provide both C/A and P-code derived pseudoranges and carrier phases for GPS L1 and both L2C and P(Y)-code derived pseudoranges and carrier phases for GPS L2, the network operators can not provide all available information to the neighbouring country. Only one code+carrier combination can be transmitted per frequency. It is recommended that in this case network operators transmit L1(C/A) and L2(P(Y)) as these signals are still state of the art and sufficient for RTK networks.

Similar limitation applies to the RTCM 3.1 transmission of modernised GLONASS signals (GLONASS-M satellites transmit a second civil signal on L2).

In general when more signals become operational it is anticipated that the RTCM standards will be upgraded to support them.

Another point related to the limited number of observables is that one have to chose whether to transmit raw pseudoranges or carrier smoothed pseudoranges (only one is possible). In data exchange between national EUPOS networks unsmoothed pseudoranges should be transmitted.

2.3 Acceptable data formats and Message Types

Temporarily, if RTCM 3.1 is not supported by the networking centres' software modules the format RTCM 3.0 and Message Types listed in Table 2 can be used for data exchange.

Recommended messages are 1004 (1003), 1006 (1005), 1008 (1007), 1012 (1011), but their availability depends on the particular software. The messages in brackets are acceptable when the software does not support the first values.

Table 2: RTCM 3.0 Recommended Message Types

Message Type	Content	Data rate
1003	GPS L1/L2 pseudorange and carrier phase measurements	1 s
1004	GPS L1/L2 pseudorange and carrier phase measurements + time and CNR	1 s
1005	Antenna Reference Point coordinates	60 s
1006	Antenna Reference Point coordinates with height information	60 s
1007	Antenna Descriptor	60 s
1008	Antenna Descriptor and Serial Number	60 s
1011 (optional)	GLONASS L1/L2 pseudorange and carrier phase measurements	1 s
1012 (optional)	GLONASS L1/L2 pseudorange and carrier phase measurements + time and CNR	1 s

RTCM 3.0 limitations:

RTCM 3.1 limitations apply also to RTCM 3.0. In addition, there is no RTCM 3.0 Message Type available for the transmission of ephemeris information. The missing information should cause no significant problems, because the ephemeris can be collected in each national network from other raw data streams.

A further RTCM 3.0 limitation is related to clock steering:

When using RTCM version 3.0 one has to assume that both GPS and GLONASS as well as the signals for different frequencies are related to individual clocks each. This causes a weakness in the modelling which will affect the performance of a network.

RTCM 2.3 format should not be used for data exchange because it does not contain the CNR values.

3. Transmission method, transport protocol

Whenever it is possible networking centre to networking centre data transmission is preferred over direct external station to networking centre communication. The configuration of external receivers is not allowed, only passive connections can be used.

For the dissemination of the real-time exchange data streams the NTRIP (Networked Transport of RTCM via Internet Protocol) transport protocol is recommended. NTRIP is supported by all available GNSS networking software applications and also free NTRIP software tools are available for download for several platforms. NTRIP v. 1.0 relies on TCP/IP (Transmission Control Protocol/Internet Protocol), which is a suitable protocol for data streaming over IP. However, it is anticipated that an upgraded version of the NTRIP protocol will also allow the use of UDP (User Datagram Protocol). UDP-based data

transmission is advantageous because it is less susceptible to network congestions compared to TCP/IP.

It is also accepted to transmit raw data streams via direct TCP/IP or UDP (if supported by the networking software) connections. It is recommended to use secure Virtual Private Network (VPN) tunnels for direct TCP/IP or UDP server-client communication.

4. Access rules and usage regulations

Raw GNSS data exchange between neighbouring EUPOS member countries must be based on bilateral agreements. These agreements should control all aspects of data transport methods, applied data formats, access rules and data usage. In all case it is the responsibility of the reference station owner country to operate and maintain the station, repair it within the shortest possible time in case of a malfunction. The reference station owner should inform the partner country about planned outages due to network or station maintenance works. It is necessary also to inform the partner country's NSC if the reference station equipment will be moved, replaced, or if the host country decides to discontinue the operation of the station.

Reference station data can only be accessed by partner country's networking station, access details (username and password) must not be provided to third parties.

Incoming raw GNSS data streams can only be used in the central networking software applications to extend the coverage areas of the EUPOS DGNSS and EUPOS Network RTK services if it is not negotiated differently in the bilateral agreement. The same is valid for RINEX files, they must not be generated from the external data streams for distribution to the public. RINEX files can however be exchanged between NSCs for the checking purposes of the quality of the provided coordinates prior to integration of an external station.

Individual antenna calibration results can be provided only according to the licence agreement with the calibration supplier.

References:

personal communication with Dr. Gerhard Wübbena, CEO of Geo++ GmbH, 2006 November