Communication Options for Network RTK / SAPOS® Realization[1]

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Abstract - Real-Time Kinematic (RTK) service providers compute RTK corrections based on the observations of networks of GNSS (Global Navigation Satellite Systems like GPS or GLONASS) reference stations with station distances of about 50 to 80 kilometres. This correction data enables Network RTK users to position themselves with centimetre accuracy in real-time using a single GNSS-receiver. The selection of appropriate communication channels for the distribution of Network RTK corrections is the key to a successful positioning service. The German Satellite Positioning Service SA*POS*® was one of the first RTK-services using the Network RTK approach. More than 250 reference stations are deployed nationwide. Presently, SA*POS*® Network RTK corrections are mainly received by mobile phone (GSM).

1 Network RTK

Real-Time Kinematic (RTK) positioning with centimetre accuracy requires the reception of GNSS code and carrier phase correction data. Observations or observation corrections of a single reference station are transmitted for single-base RTK. In the case of Network RTK the observations of several reference stations are usually pre-processed in a central computing facility and network corrections are then made available to the user. The crucial part of the pre-processing consists of the resolution of the carrier phase ambiguities in the network data [1].

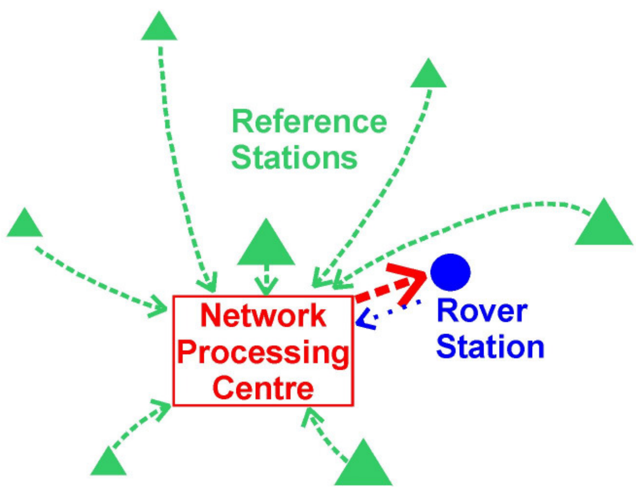

Fig. 1: Network processing centre and data flow.

2 Communication Options

The selection of one of the existing Network RTK pre-processing methods [1] affects the information content and the data format of the messages to be transmitted to the rover, and it also affects the selection of an appropriate communication channel. Only wireless communication technologies are to be

[1] Erschienen in Kyamakya, K. (Hg.) (2005): Joint 2nd Workshop on Positioning, Navigation and Communication 2005 (WPNC '05), Shaker Verlag, S. 115-118.

used for RTK applications since almost all RTK users work in mobile mode. Many more aspects need to be considered when selecting a communication technique for the transmission of RTK corrections [2].

● Technical aspects

Range and coverage, transmission bandwidth, protocol, reliability and error correction. Furthermore, the accuracy of RTK positions decrease with an increasing latency of the reference data. Centimetre accurate positioning requires data transmission latencies of one second or shorter. Another aspect concerns the size of the communication antenna/receiver which must be small enough to be integrateable into the GNSS equipment or at least small enough to be carried by the RTK user.

● Economical aspects

The communication costs often consist of the purchase price of the appropriate transmitters and receivers only. But when using a communication service, as e.g. mobile phone, additional costs, like a monthly charge plus additional charges depending on the communication time or transmitted and received data volume, must be taken into account.

● Administrative aspects

Radio frequency bands cannot be used freely since governmental restrictions in power and frequency exist in most regions of the world. In many countries parts of the UHF frequency band may be used for low power transmission which, however, limits the communication range to just a few kilometres.

The amount of data which has to be transmitted to the user of single-base RTK or Network RTK heavily depends on the data format used and on the number of visible satellites. The RTCM v2.3 format [3] requires about 4800 bits per second (bps) to broadcast dual-frequency code and carrier-phase observations or observation corrections of 12 satellites. The same information content is send with about 1800 bps in the newer RTCM v3.0 format [4]. Distributing Network RTK corrections in the form of Virtual Reference Station (VRS [5]) observations demand the same communication bandwidth as single-base RTK. All other Network RTK methods need between a few hundred and a few thousand additional bits per second for the transmission of network corrections

The most common communication method for single-base RTK is to utilize radio transmission in the UHF band or sometimes in the VHF band at data rates up to 9600 bps. The exact choice of frequency depends on the licensing requirements for the specific area. Mainly due to power restrictions the working range is usually limited to a few kilometres in maximum. With a more powerful amplifier the range can be extended to a few tens of kilometres in open areas.

Network RTK is usually offered as a service covering a certain region. Hence, it is convenient to utilize existing communication services, which cover the same region, for the transmission of Network RTK corrections. In recent years mobile phone networks based e.g. on the GSM standard developed to the primary means for Network RTK data transfer. Network RTK service providers usually establish "dial in" access servers providing data communication without any protocol. A further enhancement for data transfer with GSM was introduced under the acronym GPRS. Latest developments include EDGE and the third-generation mobile phone technologies CDMA2000 and UMTS. These newer techniques divide the data streams into packets and thus require a communication protocol. Examples of other modes of delivery are: FM sub-carrier broadcast using the Data Radio Channel (DARC) protocol, terrestrial television broadcasting with the data stream being modulated onto the audio sub-carrier, and terrestrial digital audio broadcasting (DAB).

An important aspect with respect to delivering Network RTK corrections is whether the communication techniques are able to operate just in simplex or in duplex mode. Mobile phone networks are examples for duplex communication techniques, sub-carrier radio or video broadcast are examples for simplex techniques. Some forms of Network RTK require duplex mode of operation since the user has to send his approximate position to the central computing facility in order to

- identify the surrounding reference stations and provide him with their observation data streams or
- identify the appropriate sub-network and provide him with network observations on a common ambiguity level or
- identify the closest reference station and provide the user with its observation data plus the coefficients of regional network correction models or
- compute Virtual Reference Station (VRS) observations to be delivered to the user.

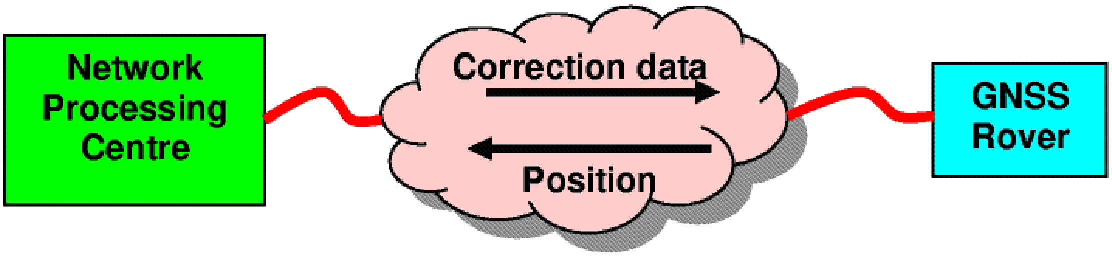

Fig. 2: Communication in duplex operating mode.

Communication channels operating in simplex (broadcast) mode are sufficient if the user

- selects the surrounding reference station himself and establishes communication links to each of these stations or
- selects the appropriate sub-network himself in order to receive network observations on a common ambiguity level or
- selects the closest reference station himself in order to receive its observation data plus the coefficients of regional network correction models or
- selects the appropriate VRS data stream out of many VRS data streams offered for a dense grid of VRS-locations.

Communication channels operating in simplex mode have the advantage that they can serve an infinite number of users. An important advantage of duplex mode operation is the ability to identify each user individually for billing purposes.

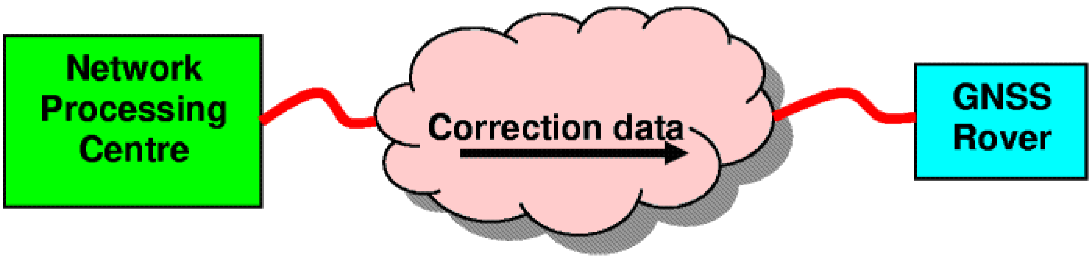

Fig. 3: Communication in simplex operating mode.

In recent years the transfer of real-time data over Internet Protocol (IP) capable communication channels gained importance. The application-level protocol NTRIP was designed to disseminate differential correction data or other kinds of GNSS streaming data to users over the Internet [6, 7]. It allows simultaneous computer or receiver connections to a broadcasting host. NTRIP supports wireless Internet access through mobile IP networks like GSM, GPRS, EDGE, or UMTS. It is part of the RTCM standard [8].

3 SA*POS*® Realization of Network RTK

3.1 SA*POS*® Data Formats

The real-time service SA*POS*® HEPS (Network RTK) uses RTCM v2.3 format definition. SA*POS*® HEPS provides different message types depending on the user's requirements [9]. All federal states agreed on a national stipulated data provision format using the RTCM v2.3 message types 20 and 21 and additional networking information in form of FKP (*Flächenkorrekturparameter*) [10]. The data must not to be encrypted or compressed. Additionally, the federal states may supply other message types which meet various customer requirements. These message types comprise of RTCM v2.3 message types 18 and 19, or the provision of VRS correction data. Furthermore, encrypted and compressed data may be provided in RTCM-AdV format [9].

3.2 SA*POS*® Communication Media

Standard broadcasting medium of SA*POS*® HEPS is GSM. This medium is used in Germany for the most positioning applications with SA*POS*® HEPS. It is available almost area-wide, cost-efficient and accepted. Additionally, in some regions HEPS data are transmitted in the VHF radio band.

Presently, broadcasting Network RTK corrections using internet protocol (IP) and NTRIP is tested. With this method SA*POS*® data can be transmitted via all IP-capable media and accessed e.g. with GPRS (General Packed Radio Service) or UMTS (Universal Mobile Telecommunications System) mobile phones.

4 References

[1] Wanninger, L. (2004): Introduction to Network RTK, http://www.network-rtk.info/intro/introduction.html.

[2] Wegener, V., Wanninger, L. (2005): Communication Options for Network RTK, http://www.network-rtk.info/wegener/communication.html.

[3] RTCM (2001): RTCM Recommended Standards for Differential GNSS (Global Navigation Satellite Systems) Service, Version 2.3, RTCM paper 136-2001/SC104-STD.

[4] RTCM (2004a): RTCM Recommended Standards for Differential GNSS (Global Navigation Satellite Systems) Service, Version 3.0, RTCM Paper 30-2004/SC104-STD.

[5] Wanninger, L. (2003): GPS on the Web: Virtual Reference Stations (VRS), GPS Solutions, 7:143-144, http://www.wasoft.de/lit/gpswebvrs.html.

[6] NTRIP (2004): Networked Transport of RTCM via Internet Protocol (NTRIP), Version 1.0, http://igs.ifag.de/pdf/NtripDocumentation.pdf.

[7] Weber, G., Dettmering, D., Gebhard, H. (2003): Networked Transport of RTCM via Internet Protocol (NTRIP), IUGG General Assembly, Sapporo.

[8] RTCM (2004b): RTCM Recommended Standards for Network Transport of RTCM via Internet Protocol (NTRIP), Version 1.0, RTCM Paper 200-2004/SC104-STD.

[9] SA*POS*®: http://www.sapos.de

[10] Wübbena, G., Bagge, A. (2002): RTCM Message Type 59-FKP for transmission of FKP, Version 1.0, Geo++ White Paper 2002.01 http://www.geopp.de/download/geopp-rtcm-fkp59.pdf.