

Application Note on Network RTK for the OEMV Receivers

Introduction

This application note includes background information on Network RTK and general guidance on how to use it. The majority of the content in this paper is from a distribution report done for NovAtel Inc. titled *Network RTK Status Western Europe* by Hans-Jürgen Euler from *inPosition gmbh*.

About Network RTK ¹

Network RTK development started over ten years ago with the introduction of real-time GPS baseline solutions. Around the world, there were activities surrounding Network RTK but in Germany, the idea to install permanent base stations for high-precision RTK applications was fostered. Network RTK uses permanent base station installations, allowing kinematic GNSS users to achieve centimeter accuracies without the need for setting up a GNSS base station on a known site.

Using permanent base stations is advantageous in areas with considerable GNSS surveying activity because many users can share the infrastructure and the associated costs. Some of the installations are operated by companies that provide service to the surveying community. Installations can be a single base station, a number of single base stations, or networked base stations. A single base station within 20-30 km from the rover is typically required if a user is operating in a standard base to rover mode. Otherwise the performance, accuracy, and the reliability of user's RTK may be degraded.

For the base operator, networking reduces the number of base stations that are needed to provide a given level of accuracy to the rover so integrating several base stations into a network improves the accuracy and increases the overall user system performance. Networking also reduces the number of base stations required to cover a large area. These permanent base station networks require real-time communication to a networking computation center and real-time estimation of biases between bases.

An understanding of applied corrections or the processing procedure is also very important because the installations rely on proprietary computation algorithms and formats that could restrict the field equipment. It is in the interest of service providers to supply the service for more than a single type of RTK field equipment.

Many Network RTK methods exist, but currently, VRS (Virtual Reference Station), iMAX, FKP (Flächen Korrektur Parameter - the German phrase for spatial correction parameter) and MAC (Master-Auxiliary Concept) are the most common. See pages 2 and 3 for more information on individual methods.

The calculations required to produce the observation information follow these principal sequences for data handling:

1. Base station observation information transfer to a central location
2. Integer ambiguity resolution for observations between base stations
3. Fit model parameters to deviations
4. Determination of corrections for rover position and correction of observations
5. Calculation of the rover's position based on its observation information and network information

These principal steps are used by different Network RTK software and remote firmware. Some of these calculation steps might be combined into one step, but this does not change the overall principle. See Figure 1.

¹ Hans-Jürgen Euler (December 2005), Reference Station Network Information Distribution. International Association of Geodesy Commission 4: Positioning & Applications. Retrieved October, 2007 from, [IAG WG 4.5.1: Network RTK](#).

Independent RTCM Format

Traditionally, the communication interface between different manufacturers' GNSS equipment is the manufacturer independent RTCM format. Networking services based on either FKP or VRS approaches provide the observations via the RTCM standard, but are currently operating in a mode not defined in the standard document and/or disseminating additional information in a proprietary message. RTCM delivers a container (message type 59) for proprietary information, but the content is not specified in the standard.

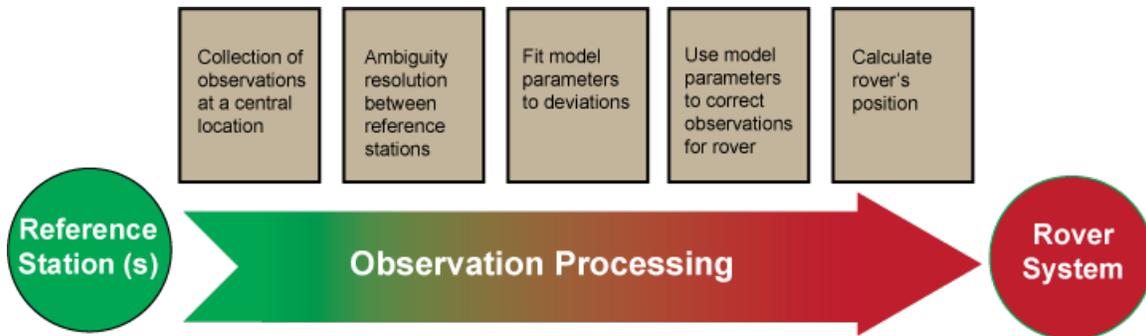


Figure 1: Data flow between reference stations and rover system

The figure above shows sequence of operations and calculations required until a rover's position is calculated. Current network approaches are to distribute the principle calculations between the software of the network and the rover. As long as calculation steps are performed within the same software, these steps can be combined into one step. For more information on these steps, refer to [Reference Station Network Information Distribution](#) by Hans-Jürgen Euler.

Network RTK Methods Supported by OEMV Receivers

VRS

The virtual reference station (VRS), or virtual base station (VBS), method, introduced by Trimble, calculates a set of corrections from a virtual base station in the vicinity of a rover receiver. All baseline-length-dependent errors, such as abnormal troposphere variation, ionospheric disturbances and orbital errors are removed from the VRS because the virtual base is so close to the rover. The rover sends the position to the network in a standard NMEA (National Marine Electronics Association) GGA message and the network software calculates the position of the VRS. The VRS corrections are sent back to the rover and the rover calculates its position. Most rovers receive VRS data for a calculated base station that is only a few meters away.

VRS data is supplied as RTCM messages RTCM1819 or RT2021 and RTCM V3 messages RTCM1003 and RTCM1004².

The VRS approach requires bi-directional communication for supplying the rover's position to the networking software.

² Refer to the *OEMV Family Firmware Reference Manual* for details on these RTCM and RTCM V3 messages.

iMAX

The iMAX method, introduced by Leica Geosystems, calculates a set of corrections based on the rover position, similar to VRS. However, instead of calculating the base station observations for a location close to the provided rover position, original observation information is corrected at the base station position and sent to the rover in a compact form. In VRS, use of a virtual base station, close to the rover, may disguise the residual ionospheric errors in the base observations. However, iMAX provides actual base station position information therefore, the real distance to the base can be computed from the base station coordinates, and the rover may be able to open its settings to estimate the remaining residual ionospheric delay. The iMAX method may trigger the rover to open its settings further than required since the networking software removes at least part of the ionospheric disturbances. However, compared to VRS above, this approach is safer since it notifies the rover when there might be baseline-length-dependent errors in the observation information.

iMAX uses RTCM 3.0 Network RTK messages and requires bi-directional communication to the networking software for supplying the base station observation information.

FKP Reference Station Information

The FKP method is another approach that delivers the information from a base station network to the rover. No precise knowledge of the rover's position is required for providing the correct information. The corrections are deployed as gradients to be used for interpolating to the rover's actual position.

FKP is the preferred method of Geo++ for disseminating network RTK information. In principle, any format capable of transporting base station raw observations can be used together with a message to transport the FKP coefficients. Geo++ combines the FKP information with RTCM version 2.3, RTCM2021 messages which has been adopted as the standard for SAPOS. For the FKP information, no standard has been adopted yet but some users and providers argue that there is a standard because the information is being transmitted in an RTCM59 message. The layout of the message is described in *RTCM Message Type 59-FKP for transmission of FKP* document from the Geo++ webpage found at <http://www.geopp.de/download/geopp-rtcm-fkp59-1.1.pdf> . This document describes the layout and the interpretation of the bit stream.

In contrast to VRS, FKP can be used for broadcast installations. Bi-directional communication between the rover and the network is not mandatory, but for large networks different access numbers or points are required. When bi-directional communication is available, FKP installations require NMEA coordinates. These positions are used to determine the most suitable base station FKP constellation for the user. The advantage of this is that only one access point is required to cover the whole network. This is important for users covering large regions with different base stations close to the working area.

Other Proprietary Network RTK methods

Mac (Master-Auxiliary Concept)

The basic principle of the master-auxiliary concept is to provide, in compact form, as much of the information from the network and the errors it is observing to the rover as possible. With more information on the state and distribution of the dispersive and non-dispersive errors across the network, the rover is able to use more intelligent algorithms in the determination of its position solution. Each supplier of reference station software will have their own proprietary algorithms for modeling or estimating these error sources. The rover system can decide to use or to neglect the network RTK information depending on its own firmware algorithm performance.

MAC uses defined RTCM messages so, in theory, each installation should be identical and have no proprietary messages. The formats of these messages are still under discussion by the RTCM standards committee but once they are defined and the initial algorithm implementation is complete, it will be easier for manufacturers of rover equipment to support MAC.

Commands

RTKNETWORK

This command sets the RTK network mode for a specific network.

Abbreviated ASCII Syntax: Message ID: 951

RTKNETWORK mode [network#]

Factory Default:

rtknetwork auto

Input Example:

rtknetwork imax

Field	Field Type	ASCII Value	Binary Value	Description	Binary Format	Binary Bytes	Binary Offset
1	RTKNETWORK header	-	-	This field contains the command name or the message header depending on whether the command is abbreviated ASCII, ASCII or binary, respectively.	-	H	0
2	mode			RTK network mode see Table 1: Network RTK Mode . The factory default is auto where the receiver switches to the first available network RTK source.	Enum	4	H
3	network#			Specify a number for the network default = 0	Ulong	4	H+4

Table 1: Network RTK Mode

Binary	ASCII	Description
0	Disable	Single reference station RTK mode. All received network RTK corrections are ignored.
1-4	Reserved	
5	VRS	The virtual reference station (VRS), or virtual base station (VBS), idea, introduced by Trimble, is that a base station is artificially created in the vicinity of a rover receiver. All baseline-length-dependent errors, such as abnormal troposphere variation, ionospheric disturbances and orbital errors, are reduced for this VRS. The rover receiving VRS information has a lower level of these errors than a distant base station. The VRS is calculated for a position, supplied by the rover during communication start-up, with networking software. The VRS position can change if the rover is far away from the initial point. The format for sending the rover's position is standard NMEA format. Most rovers receive VRS data for a calculated base station that is within a couple of metres away. The VRS approach requires bi-directional communication for supplying the rover's position to the networking software.
6	iMAX	The iMAX idea, introduced by Leica Geosystems, is that networking software corrections, based on the rover's position, are calculated as with VRS. However, instead of calculating the base station observations for the provided position, or another position closer to the base station, original observation information is corrected with the calculated corrections and broadcast. VRS works so that although the rover is unaware of errors the VRS is taking care of, there still might be ionospheric remains in the base station observations. iMAX provides actual base station position information. The rover may assume the base station is at a distance and open its settings for estimation of the remaining ionospheric residuals. The iMAX method may trigger the rover to open its settings further than required since the networking software removes at least part of the ionospheric disturbances. However, compared to VRS above, this approach is safer since it notifies the rover when there might be baseline-length-dependent errors in the observation information. iMAX requires bi-directional communication to the networking software for supplying the base station observation information.
7	FKP	The FKP method delivers the information from a base station network to the rover. No precise knowledge of the rover's position is required for providing the correct information. The corrections are deployed as gradients to be used for interpolating to the rover's actual position.
8	MAX	The basic principle of the master-auxiliary concept is to provide, in compact form, as much of the information from the network and the errors it is observing to the rover as possible. With more information on the state and distribution of the dispersive and non-dispersive errors across the network, the rover is able to use more intelligent algorithms in the determination of its position solution. Each supplier of reference station software will have their own proprietary algorithms for modeling or estimating these error sources. The rover system can decide to use or to neglect the network RTK information depending on its own firmware algorithm performance.
9	Reserved	
10	AUTO	Default value, assume single base. If network RTK corrections are detected then the receiver will switch to the appropriate mode. iMAX and VRS can only be detected using RTCMV3 however it is not possible to distinguish between iMAX or VRS. If iMAX or VRS is detected then iMAX will be assumed.

Final Points

If you require further information, regarding the topics covered by this document, please contact:

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