

First Nationwide High-density GPS Geographic Expansion Possible

In October 2005 LNR Globalcom presented its nationwide GPS RTK network under the name GlobalNET 2005. This article describes the origin and history of the network, the technique used for the network calculations and the advantages for the users of the network.

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Figure 1, the GSM box.

History

Since the implementation of the Global Positioning System (GPS) in the early 1990's, land surveying with centimeter-level accuracy has been possible, using the post-processing technique. In 1998 a new technique, GPS RTK (Real Time Kinematic) became operational, making real-time centimeter accuracy at the GPS receiver in the field the new reality.

In keeping with the developments in the GPS technique, LNR Globalcom developed various software programs between the years 1994 and 1996. There is GlobalREF software to direct the reference stations, and GlobalCALL software for the automatic hourly download of the data from the reference stations. GlobalBASE is the database program in the server and the Globalcom program allows the user to download the RINEX data from the reference stations into his own office computer.

The LNR Globalcom system and the Active GPS Reference System – for research and certification purposes (AGRS) were both introduced in June 1996. As of that time the first 5 GPS reference stations in LNR Globalcom's network were operational.

GPS RTK

In 1998 a new GPS technique was introduced: Real Time Kinematic GPS (RTK). Using GPS RTK the user in the field is able to achieve centimeter accuracy. Post processing was steadily being replaced by RTK GPS. To facilitate this trend, starting in 1998, the GlobalNET reference stations began sending corrections out via radio connections, and six months later also via GSM connections. The major advantage of GSM connections over radio connections is the greater reach.

Alongside this inevitable technical development, the number of GlobalNET reference stations steadily increased. This growth was always project-related. At the start of 2005 sixteen GlobalNET reference stations existed in the western part of the Netherlands. These reference stations sent local RTK corrections via radio and GSM connections, and the RINEX data was continuously being saved. The corrections were being sent via the receiver in independent RTCM format, thus all receiver types were being supported.

GlobalGSM Program

To allow several users simultaneous access to the corrections from the same reference

station, LNR Globalcom developed a so-called GSM box, see Figure 1. The GlobalGSM program made it possible to authorize GSM (cell phone) numbers contained on the SIM cards in the modems. Since the user was able to place his own SIM card in the station, cost saving was achieved. In this manner, the user was able to call under the auspices of his company's telephone subscription and utilize the lowest available rate. Since the RTK corrections are sent directly from the receivers, an initialization time of less than 10 seconds can be guaranteed.

Additionally, a high degree of reliability is also achieved. However, this solution is only applicable for users located close to the reference station. In order to provide RTK corrections to users, located further away from the reference station, with at least this same high degree of accuracy, GlobalNET has been expanded to include 41 reference stations and uses a network solution. With the help of SpiderNET software from Leica Geosystems, all the stations are connected to one another to offer a nationwide network solution to the users.

Technique

The 41 reference stations are not more than 50 kilometers apart. The western part of Holland still contains a higher concentration of reference stations, due to the fact that the highest concentration of users is (still) within this area. In order to achieve complete coverage also along the border areas, a few reference stations from the Belgian FLEPOS network and the German SAPOS network are also incorporated within GlobalNET.

The heart of GlobalNET can be found in Rijswijk, the Netherlands, where the main servers are located. These servers are in continuous contact with the reference stations. All the raw data is available in a split second via ADSL lines. The raw observations are saved as RINEX data and are also used for sending the RTK corrections to the user in the field. Alongside corrections for RTK receivers (centimeter accuracy), dGPS corrections are also offered for users with GIS receivers (sub meter accuracy) and for shipping vessel navigation purposes.

The quality of the data from the reference stations is also being continuously monitored. In this manner, each station is being verified for the completeness of the data, the degree of

RTK Network in the Netherlands

multi-path, the signal/static ratio and the number of cycle slips. Thus, the quality of the data used can be continuously controlled.

Three Clusters

The total of the 41 reference stations will hereafter be referred to as the network. The network is divided into three clusters, a cluster being a sub-network within the full network of reference stations. Generally speaking, GlobalNET is divided into one cluster for the northern part of the country and one cluster for the southern part of the country. For the most part, these two clusters overlap one another. As a back-up for these two clusters, a nationwide cluster has been established containing a selection of the reference stations approximately seventy kilometers apart. The ambiguities to the available satellites are determined within each cluster by the Spider software, using the LAMBDA method which was originally developed by the Technical University of Delft. This method is used for accurate positioning, calculating the total amount of wave lengths between the GPS receiver and the satellite. The total number of wave lengths is determined by means of a 'smallest quadrants' estimation. This method appears to be quite accurate since additional mistakes are minimized.

Consequently, a collective ambiguity level for a particular cluster can be calculated. Each cluster can be subsequently divided into an unlimited number of cells. The RTK corrections are sent via these cells to the user in the field. A

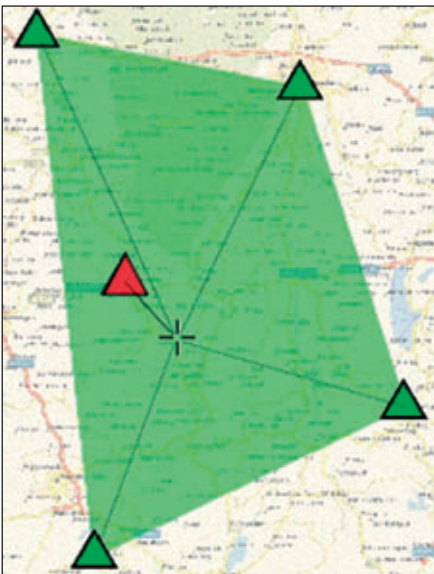


Figure 2, fixed cell.

cell can have a permanent shape or can be automatically determined by the network.

Six Variations

The available RTK corrections are available as six variations:

- Fixed reference station;
- Closest reference station;
- Fixed cell (using I-Max);
- Fixed cell (using Max);
- Automatic cell (using I-Max);
- Automatic cell (using Max).

Fixed reference station

This solution can be more or less compared to one's own reference station. This solution is appropriate for a client wanting to continuously use the same reference station.

Closest reference station

With this variation the user does not need to select the reference station from which to receive the corrections. As soon as the user in the field logs on into the GlobalNET server, the closest reference station, (based on the user's position) will automatically be determined. The corrections from this closest reference station will be sent to the user.

Fixed cell

Together with the user, a specific cell of reference stations is predetermined. When logging in the user can select either the I-Max solution or the Max solution. Within the cell, see Figure 2, one of the reference stations is designated as the 'master'; normally this is the most centrally located station. For rovers, which are not yet equipped for the Max solution, the I-Max solution has been developed. In addition, the data can later be related back to the reference stations; thus, an extra quality check based on the raw data is always possible.

This product is most appropriate for users with a permanently-defined work area.

Automatic cell

In terms of technique and network calculations, this variation, see Figure 3, is comparable to the fixed cell. The major difference is that the cell is not pre-determined. This variation is recommended for users whose work area frequently changes.



Figure 3, automatic cell.

Standard

In order to receive all the data every second, a new data format has been developed: RTCM version 3. RTCM is an internationally accepted standard for the exchange of GPS data, which is supported by all GPS receiver brands. This new RTCM v3 data format has been specially designed for the transmission of corrections from multiple reference stations.

To allow as many users as possible access to the network at the lowest cost, the various corrections are sent over the Internet via Networked Transport of RTCM via Internet Protocol (NTRIP). This can be compared to Internet radio. The Internet connection to the user in the field is achieved via a GSM (cell) phone with a SIM card supplemented with a GPRS subscription. This technique ensures the mobile connection to the Internet, as long as the mobile (cell) telephone network is available in the area.

Future

In the future the network will continually be updated to accommodate the latest available technologies, such as the implementation of extra satellite signals; for example L2C, L5 and the European system Galileo. The network can also be expanded geographically, to provide service to international customers as well.

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