GPS Newsletter – General

A Newsletter On System 500 GPS, Vol 03, No. 02.

Introduction

More and more often people hear about reference station networks and the benefits they provide to surveyors in terms of increased positioning accuracy and reliability over longer distances.

This newsletter briefly summarizes the concepts of RTK networks and introduces the correction information that they can yield, in particular, the area correction parameters known as 'FKP's. With the use of these correction parameters, the performance and reliability of RTK positioning can be increased.

What are Reference Station Networks?

Typically, these are arrays of continuously operating reference station sensors connected to a central computing centre by means of fixed communication lines. The main benefits of these permanent 'active' real-time networks over conventional stand-alone reference stations are that they:

- permit the modelling of distance-dependent errors relating to satellite orbits, ionospheric and tropospheric delays;
- eliminate the need for local temporary base station installations, reducing hardware costs;
- provide corrections for all users based on a consistent datum; and
- provide measurement redundancy affording higher accuracy and higher reliability for precise real-time positioning.

If you need to refresh your memory about reference stations, check out the Leica GPS Newsletter GPS01-26 Reference Stations: http://www.leicaatl.com/support/gps/gps_faqs/PDF_Vol_01/GPS01-25%20Ref%20Stations%20Newsletter.pdf

What is / are FKP?

The German acronym FKP, first defined by Geo++®, stands for 'Flächen-Korrectur-Parameter' and translated to English means 'area correction parameter'.

That's their name but *what exactly are FKPs*? – this is a point of much discussion. FKP is not so much a positioning concept but rather the particular **representation of area correction parameters in an openly available and efficient format!**

These FKP messages contain information about the distance-dependent errors affecting the L1 and L2 GPS signals observed in the reference network area.

In fact, the use of FKPs supports more positioning concepts than most people appreciate. With the correct configuration of a reference network software, FKPs can be used in not only duplex (two-way) communications such as GSM, but also simplex (one-way) broadcast methods using, for example, VHF radio.

This flexibility to support both simplex and duplex media means using FKP messages has several advantages:

- **Simplex** media can serve an **unlimited number of users** within the area of transmission.
- **Duplex** affords **greater reliability** over longer distances.
- **Openly available format** of area correction parameter information from a reference network.

Why use FKPs?

As with all reference networks, errors affecting a network rover's measurements can be predicted or interpolated from the reference network. Unfortunately, the current generation of RTCM messages (Version 2) are not optimised to provide information to rover users about errors affecting observations. Hence the need to come up with a message format that contains this necessary information on the magnitudes of the distance-dependent errors within the reference network.

The German Association of State Surveying Departments (AdV), responsible for the operation of the SAPOS RTK reference networks in Germany, has specified that Geo++®'s FKP format be used as the standard representation of network information to any rover user operating in a SAPOS network.

Accordingly, for use within these SAPOS networks, the AdV has defined and published linear FKPs and the corresponding interpretation algorithm.

The name of this area correction message standard is RTCM Message Type 59 FKP-AdV, and as the name states, it conforms to the RTCM-SC104 Version 2 standard. The parameters in this open standard are described in this document: (http://www.geopp.de/download/geopp-rtcm-fkp59.pdf).

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How are FKPs calculated?

FKPs are typically derived from the state space vector information calculated by the GNSMART (GNSS State Monitoring and Representation Technique) software program as developed by Geo++®.

Geo++®-GNSMART is a universal software package for real-time adjustment of undifferenced GPS observations based on a rigorous multi-station solution using a Kalman filter approach.

The simultaneous adjustment and complete state space modelling of GPS observations from multiple stations within a reference network makes it possible for GNSMART to determine the dynamic GPS state vector, i.e. the size and behaviour of the satellite orbit errors, ionospheric and tropospheric delays as well as the satellite clock errors over the network area.

This more rigorous state space approach yields greater performance, in terms of measurements redundancy and resistance to biased model estimates, than other approaches using fewer stations (typically three).

The GPS state information described above then needs to be represented in some format that is easily understood by rover firmware. It is the representation of this correction information as area correction parameters, or FKPs, that we are interested in!

Considering a network's dimensions and the coverage of the distribution media, a linear FKP representation is sufficient. Each FKP set is referenced to a **real reference station** and has coefficients representing the horizontal gradients of the geometric (orbital and tropospheric) and ionospheric errors.

Check out these links http://www.leica-geosystems.com/news/2002/gnsmart.htm & http://www.geopp.com/ for further technical information on the GNSMART software.

How can I use FKP?

FKPs were originally developed for use in networks where only broadcast (one-way) communication means were available. With the recent advances in duplex communications, in particular GSM communications, duplex systems are now extremely popular and FKPs are also ideally suited for transmission over such media.

To make use of these FKP-AdV parameters, then you must have some means of reading, understanding and applying them. This can be done by one of several ways:

- Algorithms capable of reading the FKP-AdV correction message are said to be capable of computing, at the rover, the rover's 'individualized' corrections. These algorithms are capable of interpreting FKP-AdV messages from simplex and / or duplex media, and can either be integrated within the rover firmware or an external hardware device.

- If duplex communications are available, then the 'individualized corrections' for the rover can be computed at the computation centre (i.e. by the GNSMART network software). The rover sends its navigated (NMEA) position to the computing centre and then receives corrections individualized for this NMEA position – essentially these are RTCM 20&21 messages containing the appropriately interpolated area correction parameter values.

This latter method of 'individualized corrections' is akin to a 'virtual reference station' solution because all relevant information is included in the data stream individualizing the corrections for a given position.

However the FKP have been derived from a more rigorous simultaneous multi-station adjustment and not just based on error predictions for a triangle of stations around the rover.

RTK Network Dataflow

The FKPs are typically generated every 10 seconds by the network software - the correction parameters they represent have lower temporal dynamics meaning that they can be updated at a lower rate. A roving user would receive the conventional RTK correction information (RTCM 20 & 21 messages) from their nearest reference station at a normal rate (1-2 seconds) as well as the FKP message for that reference station every 10 seconds.

The rover will then interpolate from the FKP messages the relevant area correction parameter values that should be applied to the rover's navigated position. With the correct application of these FKPs, the rover will then have a position free of systematic distance-dependent errors as seen through increased position accuracy and reliability.

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So to summarize, with capable communication links, FKPs can be:

- broadcast via simplex (e.g. radio) to an unlimited number of users with RTCM 20&21 messages;
- passed via duplex (e.g. GSM) to the user with RTCM 20&21 messages;
- applied on the corrections at the computing centre to provide '**individualized RTCM 20&21 corrections**' for the rover (via GSM).

Leica System 500 and FKP

Leica now offers the FKP-AdV option (Article No. 732880) as an add-on for Firmware V4.01. A security code is then provided which is entered into System 500 rovers (UTILITIES\Enter Security Code) enabling them to operate with FKP-AdV messages as transmitted by many RTK reference networks operating Geo++®-GNSMART.

After activating this FKP-AdV option, System 500 rovers are then able to interpret and apply the area correction parameters contained within the FKP-AdV message (as transmitted over both simplex and duplex comms).

How do I use FKP with System 500?

With System 500, you would configure your sensor using your normal rover configuration. When in the **CONFIGURE\Real-Time** screen as shown below, press **F6 REF** to access the Reference Service screen.

Then next on the **CONFIGURE \ Ref Service** screen, you should select **FKP** as the Ref Service.

This will configure the rover firmware to operate in an FKP network, and expect to receive FKP-AdV messages as well as the relevant RTCM Type 20&21 messages through the datalink.

If you have a GSM module attached, it will also configure the automatic output of the rover's position in NMEA format, allowing the network software to identify the nearest reference station. Simplex users would typically receive the corrections and FKP-AdV from the strongest transmitting station.

Your rover will then interpolate the relevant area corrections from the FKP-AdV message and apply them to the received RTK messages. Now you can expect to have high accuracy and reliability positions corrected for distance-dependent errors!

Remember…

- **Real-time Reference Station Networks** can provide **higher accuracy and reliability RTK positioning** than conventional single-reference station RTK methods.
- The **FKP-AdV message contains corrections** for the **distance-dependent errors on the L1 and L2 GPS signals**.

With the use of **FKP (area correction parameters)**, the distance-dependent errors can be predicted for the rover's approximate position leading to **increased RTK positioning performance** in accuracy and reliability.

- The **German AdV** organization with Geo++®, has published an open format for transmission of FKP network information. This RTCM Message **Type 50-FKP format** is used as the **standard data format** for RTK rovers in the German SAPOS networks.

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- Leica Geosystems has an **agreement** with Geo++® for the **worldwide distribution** of the GNSMART software.
- Geo++®-**GNSMART** is the only system which can correctly **calculate the correct parameters for FKP** messages from a **rigorous and reliable dynamic state space approach**.
- System 500 is capable of **receiving FKP-AdV messages over both simplex and duplex** communications media.
- System 500 is **capable of interpreting and applying** the correction information in **FKP-AdV** messages to yield increased RTK rover performance.
- Leica is **actively participating** in the RTCM discussions regarding the definition of **standardized correction messages** for the optimum transmission of reference network information to roving users.
- System 500 is the **most flexible GPS surveying equipment** in the market.
- You can always check out **previous Leica GPS System 500 newsletters** at: http://www.leicaatl.com/support/gps/GPS_All_Newsletters.htm!

Ideas for Future Newsletters…

If you have any ideas or wishes for topics that you would like to be discussed in a future newsletter, please contact your local selling unit or representative. These ideas can then be passed to Heerbrugg. Thank you.

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