Networked Transport of RTCM via Internet Protocol (NTRIP) – Application and Benefit in Modern Surveying Systems

Elmar LENZ, Germany

Key words: RTCM, DGPS, Correction Data, Internet, Network

SUMMARY

Real time correction services have been in use for several years and over that time have proved to be a practical solution for GPS positioning. The last year has seen a new development in the provision of real time corrections. Ntrip, or "Networked Transport of RTCM via Internet Protocol". Developed by the Federal Agency for Cartography and Geodesy of Germany Ntrip, enables the streaming of DGPS or RTK correction data via the internet using GPRS or other future technologies. This paper discusses the theoretical and technical basics of Ntrip and illustrates the practical application of the technique using a currently available product, the Survey Controller Software from Trimble Navigation Ltd.

ZUSAMMENFASSUNG

Echtzeitkorrekturdienste sind seit mehreren Jahren im Einsatz um haben sich für Anwender bereits vielfach bewährt. Im vergangenen Jahr wurde ein neues Konzept vorgestellt Korrekturdaten über das Internet anzubieten. Ntrip, dahinter verbirgt sich die Bezeichnung „Networked Transport of RTCM via Internet Protocol“. Dies ermöglicht dem Nutzer DGPS oder RTK Korrekturdaten über ein modemfähiges Mobiltelefon via GPRS oder zukünftige Technologien abzurufen und seine Messungen bez. der Genauigkeit zu verbessern. Dieser Bericht beleuchtet kurz die beim Bundesamt für Kartographie und Geodäsie entwickelten theoretischen und technischen Grundlagen dieser Möglichkeit und zeigt ebenso Anwendungsbereiche in bereits existierenden Applikationen wie der Survey Controller Software von Trimble Navigation Ltd.

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1. INTRODUCTION

The Internet and associated applications and possibilities have seen explosive growth in recent years. Techniques for the provision of multimedia content via the internet have become common place, examples being web-tv, MP-3 files, internet radio and web based telephone services. In addition to the availability of streamed content on the internet, mobile communication network providers have enabled the widespread availability of wireless internet access. Most streamed application transfer data via Internet Protocol (IP) by dividing the data into appropriately sized packages. The size of one package is limited to a maximum of 65536 bytes and every package gets its own IP address to be identified by the destination source. Compared to the data space (bandwidth) required to effectively stream a movie or music over the internet the bandwidth requirements for providing real time Differential GPS corrections (DGPS) is comparatively minute.

A new technique using the Internet for streaming and sharing Differential GPS corrections (DGPS) to allow precise positioning and navigation was announced last year under the name "Networked Transport of RTCM via Internet Protocol (NTRIP)". The development of this new technique was carried out by the Federal Agency for Cartography and Geodesy (BKG) together with partners including the University of Dortmund and Trimble Terrasat GmbH. The main intension is using the "Internet" more or less as an alternative from the current existing real-time correction services provided via radio transmission (LF, MF, HF, UHF) or mobile communication networks like GSM, GPRS, EDGE or UMTS. Ntrip is a generic, stateless protocol based on the Hypertext Transfer Protocol HTTP/1.1 and is enhanced to GNSS data streams.

There are no explicit disadvantages to using NTRIP as an alternative to the more traditionally accepted methods of obtaining real time DGPS corrections. NTRIP enables data streams from reference stations or data bases for GIS applications to be accessed by a variety of clients/users through one defined communication technique. Mobile users such as RTK or Mapping/GIS field teams, could use their hardware with a mobile GPRS phone to access the Internet in the field while at the same time stationary applications in the reference station periphery could be accessing the same data.

2. BASIC WORKING AND COMPONENTS

2.1 Basic Working

There are currently two possibilities of sending correction data. It can be handled directly from a single reference station or all observations from several reference stations used in a network can be forwarded to a central unit (server) for further processing before broadcast. In both cases NTRIP provides an ideal medium for transporting the data (see Fig. 1).

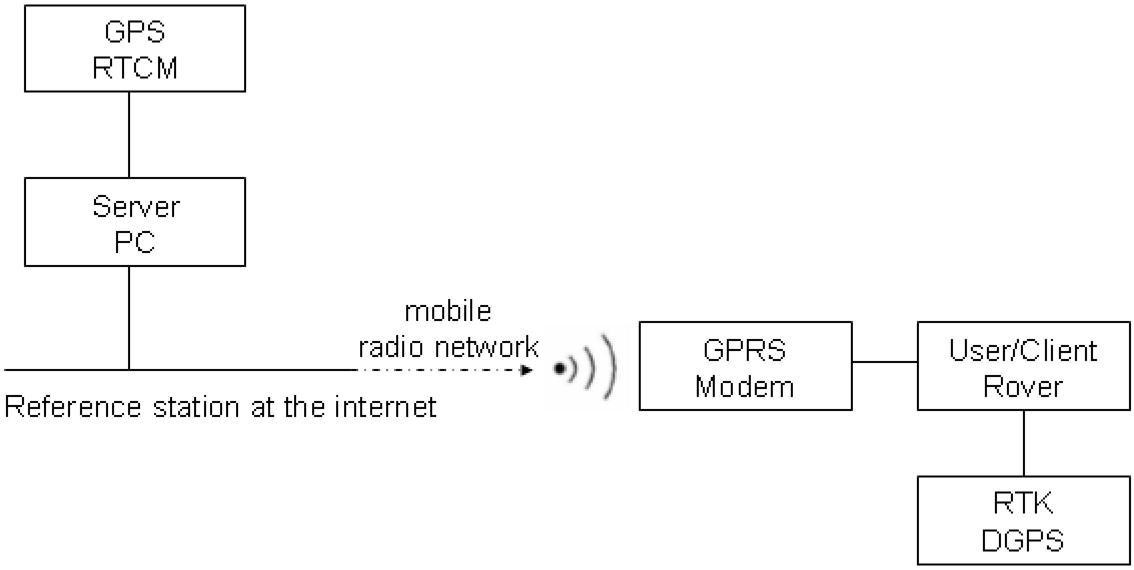

Fig.1: RTCM data stream on the internet (source BKG)

Figure 1 shows the classical case of a mobile user in the field. The user gets access to the internet using a modem (mobile phone) via a defined client software that streams DGPS correction data from a server to the mobile GPS receiver. The correction data needs to be sent from the Server / PC via a wired Internet connection and then out to the rover utilising a mobile radio network.

As already described in the introduction users in the field have the choice to decide the technique for receiving DGPS or Real Time Kinematik (RTK) through the Internet. GSM, GPRS, EDGE and in future UMTS are suitable choices. Details of the various techniques are as follows:

– GSM: is a public digital cellular network using techniques for multiplexing and using transmission band around 900 MHz. It is a worldwide standard. A GSM network can provide, besides telephony services, data communication in circuit and/or package mode. A more recent version uses an 1800 MHZ band (Europe) whereas a 1900 MHz access network is running in the United States.

– GPRS (General Packet Radio Service): is a global system for mobile communication that increases the channel speed from 9.600 to 14.400 bits per second (bps), adding data compression. With GPRS, mobile data transmissions can be as fast as 115.000 bps using the existing GSM base station infrastructure.

– EDGE (Enhanced Datarate for Global Evolution): is a new modulation scheme that is more bandwith efficient for the use in standard GSM networks. The modulation scheme is called 8PSK (8 Phase shift Keying modulation) and enables each pulse to carry 3 bits of information versus GPRS with 1 bit per pulse rate. Overall this enables EDGE to increase the data rate of existing GSM systems by a factor of three (384kbit/s).

– UMTS (Universal Mobile Telephone System): is seen as the third European generation of the mobile communication system. The spectrum for MTS lies between 1900 MHz to 2025 MHz and 2110MHz to 2200 MHz. A satellite service will also be available. UMTS offers a "multimedia" choice which means in this sense a simultaneous transfer of speech, pictures and data with a maximum data rate of 2 Mbit/s. Transmission of speech and low data rate applications will continue to be carried out by GSM.

2.2 Components

The Ntrip "network" consists of three types of applications namely NtripClient, NtripServer and NtripCaster. The NtripCaster operates as a real server or splitter (HTTP) and the programs NtripClient and NtripServer act more like clients according to the classical internet communication that is usually based on the classic server / client principle (one or more servers share resources with users within a network). The communication between NtripServer and NtripCaster as well as NtripClient and NtripCaster is fully compatible HTTP 1.1. In case of loosing the TCP (Transmission Control Protocol) connection between the described communicating system components (NtripServer-NtripCaster, NtripClient-NtripCaster) the involved TCP-sockets will recognize this and ensure a fully automated reconnection.

Ntrip "network" consits of (see Figure 1)

– NtripSources, generating DGPS and RTK datastreams at specific locations
– NtripServers, transfering data from one or multiple sources to NTRIP
– NtripCaster, major broadcaster, integrated between data sources and data receivers

NtripSource ID's are called "mount points" so a NtripClient has the choice to select a mounpoint where he thinks this fits in best. To provide the NtripClient with suitable information the NtripCaster offers a list of mount points that is called the source-list. This source-list is maintained by the NtripCaster and provides the Client with a variety of attributes such as coordinates and format identifier. When an NtripClient requests a wrong mount point and/or no mount point is available, the NtripCaster answers by uploading a new source table via HTTP. The NtripClient gets new information via this new source-list, an eventual GNSS data stream is blocked due to no availability.

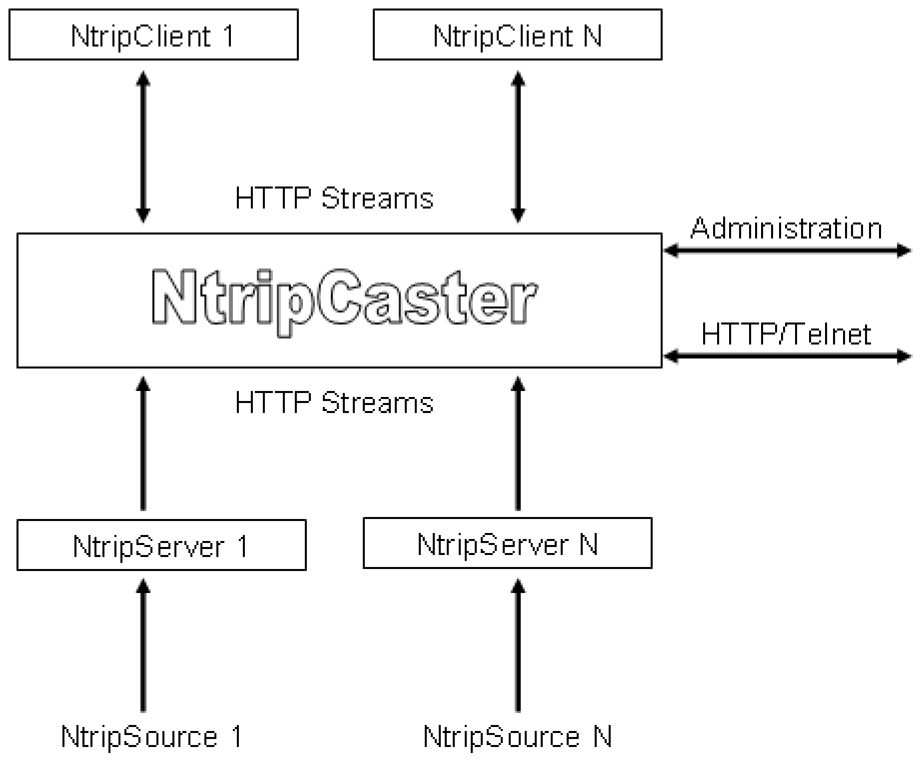

Fig. 2: Ntrip Components (source BKG)

2.2.1 <u>System Elements</u>

NtripSource:
The NtripSource is a GNSS receiver that provides continuous GNSS data such as RTCM-104 corrections that refer to a known or specific location. A US organization, the Radio Technical Commission for Maritime Services (RTCM), works within a special Committee No. 104 (SC-104) with standards for real time transfer of observations of satellite based navigation systems for differential applications. The special committee is responsible for RTCM standards for differential GNSS. The HTTP-based TCP protocol NTRIP is currently undergoing this procedure via the special committee No. 104 to become a worldwide standard.

NtripServer:
In practise, the NtripServer is software running on a conventional PC that sends correction data from a GNSS receiver (COM-port) to a third installation (from NtripSource to NtripCaster). As an example NTRIP could be used within a virtual reference network where the protocol is able to transport RTCM data. The RTCM corrections could be taken into consideration at the users approximate position. As an example this virtual reference station data is comparable with a NtripSource that could be transmitted by one of the Ntrip components, the NtripServer. As a summary the NtripServer transports GNSS data of an NtripSource (GNSS receiver) directly to the NtripCaster. Before doing this in the described

way the NtripServer sends a request to the mountpoint via HTTP 1.1. After the connection is established the data can be send via TCP/IP.

NtripCaster:
The NtripCaster is in general a HTTP server and acts, as already described, as a broadcaster integrated between the data sources (NtripServer) and the data receiver (the NtripClients). The NtripCaster receives data streams from NtripServers (generated by NtripSources) and manages, for example, the handling of mountpoints for NtripSources, passwords, billing, and access.

The NtripCaster is based on the GNU General Public License developed Icecast software that was originally developed to stream MP-3 data with bit rates from 32 kbit/s up to 128 kbit/s. The current NtripCaster used by the Federal Agency for Carthography and Geodesy (BKG) is a re-designed Icecast for

- DGNSS corrections (about 0.5 kbit/s per stream)
- RTK corrections (about 5 kbit/s per stream)
- Raw GNSS receiver data (about 5 kbit/s per stream).

3. APPLICATIONS AND BENEFIT

The required accuracy for land survey purposes is generally accepted to be at the centimetre level, occasionally below. Reaching this accuracy in differential mode is possible only via evaluating the carrier phase. In practise we are talking about a precise differential GNSS called PDGNSS. PDGNSS under usage of GPS is now established successfully for more than 15 years. Over Europe as a whole ministerial and private GNSS reference stations are now networked and / or will be in the near future. Countries such as Germany already operate installed reference networks like SAPOS and ASCOS, providing complete country wide availability of real time correction data from a VRS (Virtual Reference Station) network. With the necessary hardware and software available to his conventional RTK rover a user has the ability to use data sent from a VRS network and acheive the same level of accuracy with "net-RTK" in real time. In addition the VRS network provide a much higher level of data integrity than the more traditional standalone RTK base.

The effectiveness and availability of GNSS, particulary for RTK-surveys, has grown to a point of preciseness that PDGNSS can be practically used for topographic survey on a day to day basis.

Figure 3 gives an overview of the currently existing GPS receivers in Europe streaming test data through Ntrip (provision of RTK, DGPS and Raw data are differentiated). Institutions like the GREF (a continuously operated network in Germany) is monitored by the BKG in Frankfurt. Based on these networked references a new service, GREF-IP (via Internet Protocol), has been announced that provides DGPS correction data with a positional accuracy of up to 0.5 m. The average delay time is between one and two seconds.

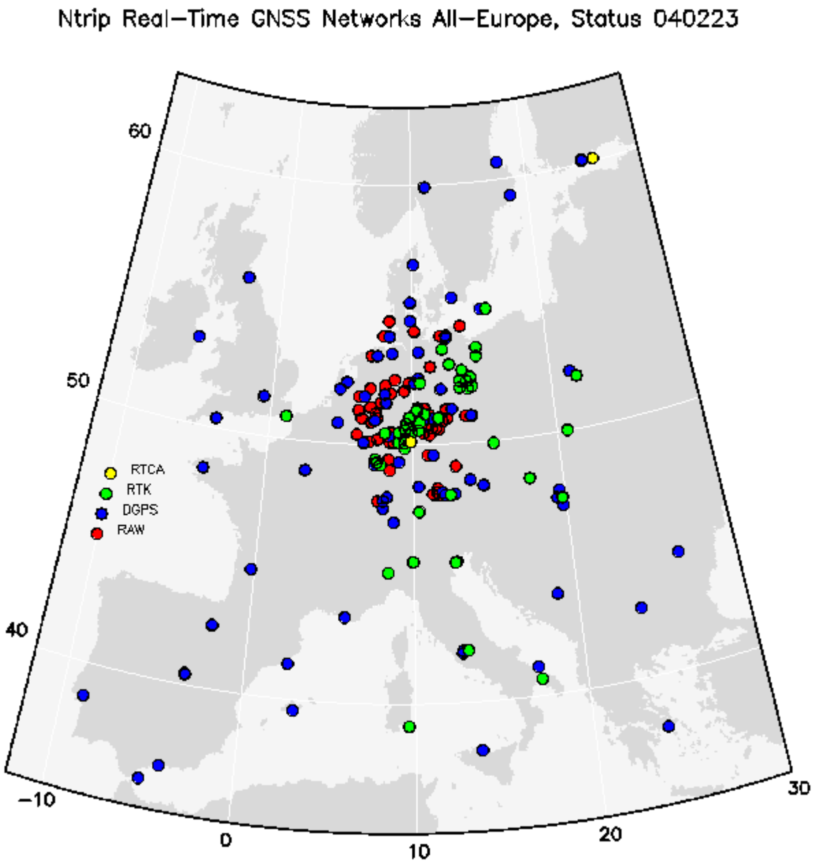

Fig. 3: available Real-time data in Europe through Ntrip, February 2004 (source BKG)

Beside the DGPS correction data state agencies, such as in the German state of Hessen, provide also test correction data for RTK applications which is shown in Figure 4. The service is currently free of charge.

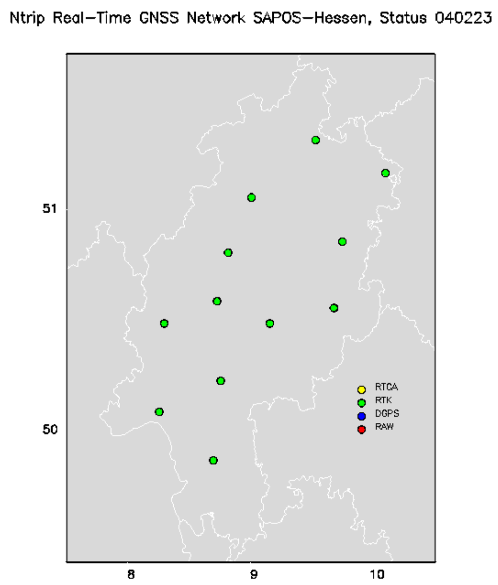

Fig. 4: available RTK correction data in Hessen, February 2004 (source BKG)

The introduction to this paper mentioned that Ntrip has been developed together with partners such as the University of Dortmund and Trimble Navigation Ltd. Trimble has developed commercially viable products to utilise the Ntrip protocol.

The primary implementation of Ntrip by Trimble is in the Survey Controller Software. Trimble Survey Controller Software is a field data collection application that can be operated on a choice of hardware devices and combines data from a range of positioning sensors including Totalstations and GPS receivers in one active database.

The addition of NTRIP capability to Survey Controller provides the user with greater flexibility in obtaining centimetre level positions. The following example shows how Survey Controller utilises Ntrip with the appropriate steps necessary to operate an RTK-GPS Rover to receive RTCM corrections via an IP adress.

At the GPS Rover it is necessary to be set the type of survey and the broadcast format. In this example the broadcast format is set to RTCM RTK to access the test correction data that is currently offered from the Hessen reference station network (single base solution). Within a suitable area (network) VRS-RTCM data could also be received. For the selected format it is necessary to select the receiving medium for the data. For Ntrip this will be done via Internet connection. It is important to set the correct IP-adress and the IP-Port (normally the standard port 80), the IP-address links to the selected Broadcaster (see Fig.5). A complete list of the current available Ntrip Broadcasters is available on the Internet (http://igs.ifag.de/root_ftp/misc/ntrip/streamlist.htme).

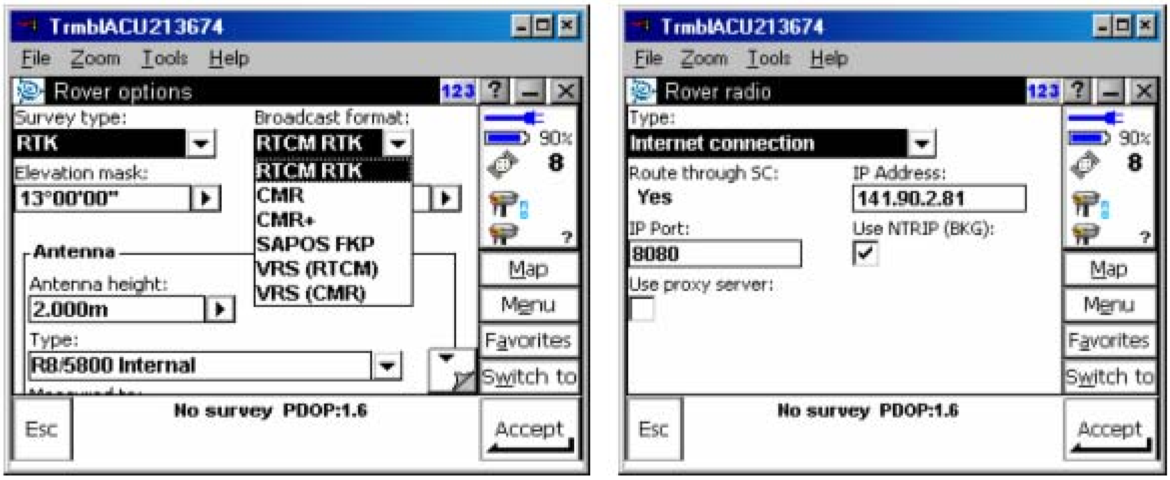

Fig. 5: settings in Trimble Survey Controller Software (Version 10.72) for using Ntrip

Trimble Survey Controller Software itself runs on the Windows CE operating system, and therefore has access to all of the communications functionality provided by Microsoft on this platform. This makes setup of a GPRS connection with a mobile phone a straightforward and intuitive process to anyone familiar with Microsoft Windows. Once the connection is established the user can start his survey by selecting his own defined Survey Style (see Fig. 6).

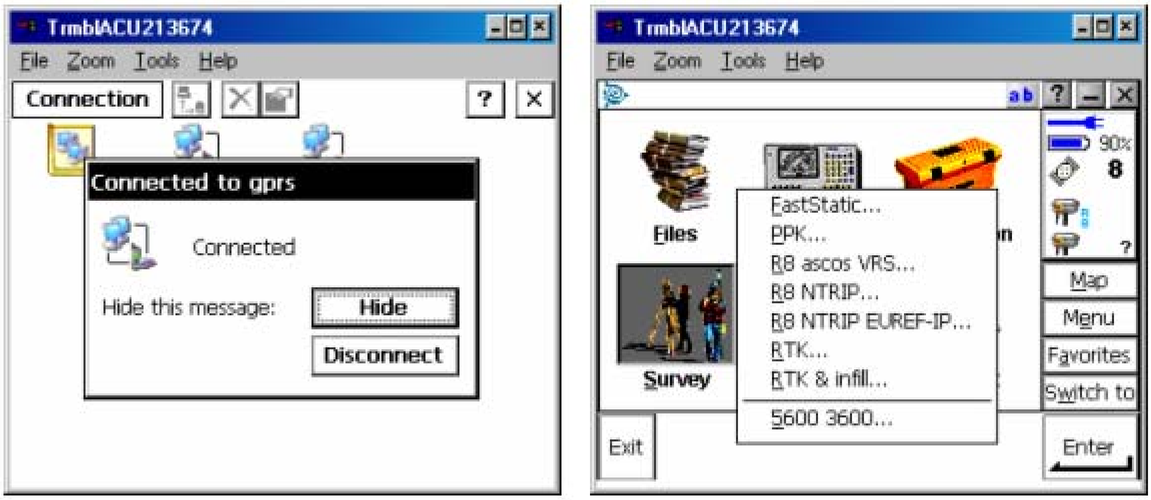

Fig.6: established GPRS connection and selection of Survey Style (e.g. R8 NTRIP)

Selecting the Survey Style (e.g. R8 NTRIP) automatically establishes the connection to the defined broadcaster. The user is presented with a full list of the available sources for receiving RTK correction data (mount points) within his project area,. The user simply selects the most appropriate mount point. In addition to the mount points the source list also provides an identifier (mostly the location of the reference station), the streamed correction data (format and format details) and the type of solution (e.g. single base). Once the mount point is selected the software sends out a command to receive correction data, a few seconds later the RTK-GPS Rover will obtain a successful initialisation and is ready to commence surveying (see Fig. 7).

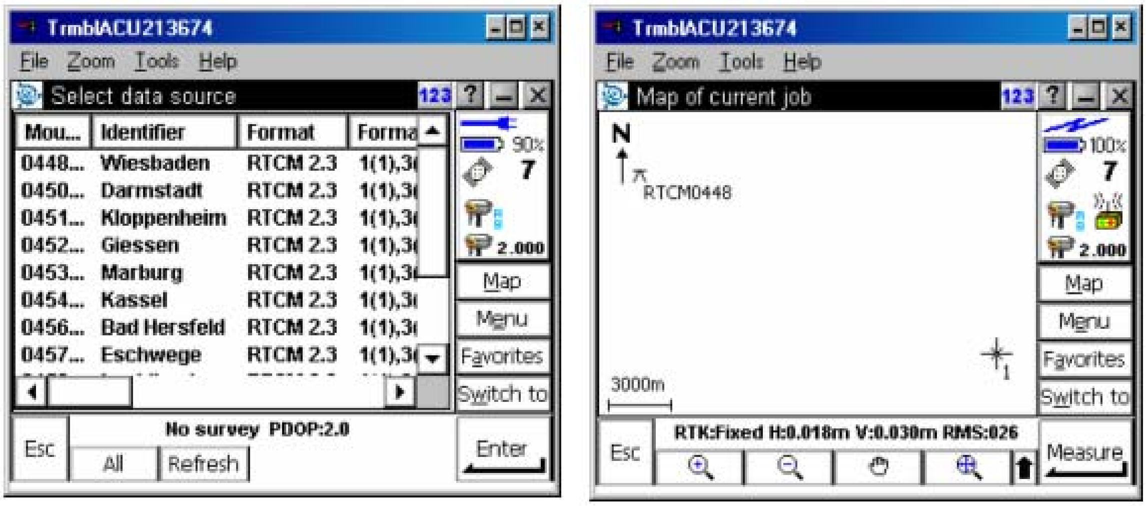

Fig. 7: available source data and fixed solution in Trimble Survey Controller (Version 10.72)

Using NTRIP with an appropriate software, such as Trimble Survey Controller brings significant benefits for the user. One of the most positive aspects is the cost factor for clients receiving correction data for DGPS applications where the accuracy lies within 0,5m. Because of the IP packing method utilised compared to GSM GPRS offers an improved speed of data transfer of up to 115.000 bps and the huge advantage that only the transmission of data will be charged to the user. The total cost saving in utilising GPRS over GSM is in the vicinity of 90%. In the case of RTK applications the use of GPRS represents only a small cost saving due to the need of a higher data rate (5kbit per stream) for its continuous performance. However this is the situation with mobile network providers and their current contracts. With the demand from the wider community for streamed data content to their mobile phones and the implementation of new more economical techniques such as EDGE and UMTS there will surely be downward movement of costs.

A further benefit of utilising NTRIP comes from the time required to send a correction data packet from the broadcaster to the client. The latency period has been rigorously tested by the BKG with the RTCM 2.0 and RTCM 2.1 formats for DGPS and RTK correction data. These investigations showed that GPRS is almost twice the speed of GSM in delivering real time RTK correction data with a latency of just 1.99 seconds.

In summary the future is talking Ntrip. It is the authors belief that Networked Transport of RTCM via Internet Protocol will become the standard for future solutions in providing correction data for DGPS and RTK applications. It will provide the most cost effective, secure and fastest means of obtaining centimetre level GPS positions.

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GSM, GPRS, EDGE and UMTS descriptions, http://umtslink.at

CONTACTS

Elmar Lenz, Dipl. Ing. (FH)
Applications Engineer Europe
Trimble GmbH
Am Prime Parc 11
65479 Raunheim
GERMANY
Tel. +49 6142 2100 0
Fax + 49 6142 2100 140
Email: elmar_lenz@trimble.com
Web site: www.trimble.com