[Online Journal of Space Communication](https://ohioopen.library.ohio.edu/spacejournal)

Volume 5
Issue 9 *Global Navigation Satellite System (Winter 2006)*

Article 27

Space Based Real-Time Kinematic GPS for National Geodetic Survey Texas Height Modernization

S. D. Lyle

D. M. Mulcare

Follow this and additional works at: https://ohioopen.library.ohio.edu/spacejournal

Part of the Astrodynamics Commons, Navigation, Guidance, Control and Dynamics Commons, Space Vehicles Commons, Systems and Communications Commons, and the Systems Engineering and Multidisciplinary Design Optimization Commons

Recommended Citation

Lyle, S. D. and Mulcare, D. M. () "Space Based Real-Time Kinematic GPS for National Geodetic Survey Texas Height Modernization," *Online Journal of Space Communication*: Vol. 5 : Iss. 9 , Article 27.
Available at: https://ohioopen.library.ohio.edu/spacejournal/vol5/iss9/27

This Articles is brought to you for free and open access by the OHIO Open Library Journals at OHIO Open Library. It has been accepted for inclusion in Online Journal of Space Communication by an authorized editor of OHIO Open Library. For more information, please contact deborded@ohio.edu.

Space Based Real-Time Kinematic GPS for National Geodetic Survey Texas Height Modernization

S.D. Lyle, Texas A&M University- Corpus Christi;
D.M. Mulcare, NOAA, National Geodetic Survey/
Texas A&M University- Corpus Christi

BIOGRAPHY

Stacey D. Lyle, PhD., PLS is an Assistant Professor at Texas A&M University – Corpus Christi in the Computing and Mathematical Science Geographic Information Science program at the Conrad Blucher Institute for Surveying and Science.

Donald M. Mulcare, NOAA, National Geodetic Survey is Texas State Advisor and an Adjunct Professor at Texas A&M University-Corpus Christi in the Computing and Mathematical Science Geographic Information Science program at the Conrad Blucher Institute for Surveying and Science.

ABSTRACT

Height Modernization is a program in NOAA´s National Geodetic Survey (NGS) that uses the Global Positioning System (GPS) and other new technologies to increase the accuracy of elevation measurements that comprise the vertical portion of the National Spatial Reference System (NSRS). Height Modernization Program within NGS is working with states to improve the height component of their survey control networks and related products. Texas A&M University- Corpus Christi (A&M-CC) was designated as the recipient of a grant under the Program during the most recent Congressional cycle. In order to best coordinate and manage the activities funded by the grant, A&M-CC has established the Texas Spatial Reference Center (TxSRC).

TxSRC will assist state agencies, private companies, public utilities and federal agencies in their efforts to improve the statewide network of control points as well as to support their use of GPS Continuing Operating Reference Stations (CORS). TxSRC plans to support the development of a statewide system of broadcasting Networked Transport of RTCM via Internet Protocol (NTRIP) for RTK-GPS. TxSRC will research methods of using NTRIP to locate and to collect information on geodetic monuments. NTRIP use is being considered as a way to overcome the limitations of RTK. Current RTK-GPS implementations require cellular or radio modem connections as the mechanism for receiving differential corrections. This infrastructure is not available in many remote and rural areas of Texas.

It is proposed that a space-based (SB) RTK-GPS should be used to provide corrections in areas where no other corrections can be obtained without additional terrestrial infrastructure development. The proposed solution uses the Hughes Network System's Directway broadband internet satellite to send corrections to remote sites. Data would be received at the remote site and then locally broadcast to rover users. This SB-RTK-GPS will allow TxSRC to utilize the existing network of CORS sites. The CORS will be used to generate the corrections that provide NTRIP. This research will investigate the configuration concerns and other and technical aspects of this proposed methodology.

INTRODUCTION

The purpose of this research is to determine how to implement a Space Based RTK GPS (SB-RTK) solution. SB-RTK will allow users to communicate with CORS generating NTRIP type solutions. TxSRC investigated the most economical and ergonomic method to obtain broadband Internet connection via satellite communication. The method and equipment used to accomplish SB-RTK are discussed. SB-RTK usage by TxSRC for height determination is the driving force to this research. A description of the technology in broadband internet satellite is provided within the context of this paper as well as an evaluation of the system as it relates to use by production-type surveying GPS.

Published by OHIO Open Library,

Conclusions are drawn to outline future testing and integration into TxSRC activities.

METHODS.

The system was developed to support users with typical geodetic-quality GPS receivers capable of using RTK corrections. Figure 1.0 illustrates how the GPS base station communicates to an internet server. The base station configuration consisted of a Trimble® 5700 receiver with a Zephyr® antenna connected to a PC running Trimble GPSBASE® server software. The software is configured to produce NTRIP correction and broadcast, also known as web cast, the correction via the server's IP address. In this configuration, a local internet service provider (ISP) was tested to determine its proxy IP address within a De-Militarized Zone (DMZ) firewall. A DMZ firewall restricts outside access to only specified ports and applications. DMZ is less secure because all unassigned firewall ports are open for that computer (Gateway, 2005). The ISP issues an IP address to our server; this IP address is used by the rover GPS to obtain the correction from the web. The local DSL internet connection used offered incoming connections at 3008 kbps and outgoing connections at 512 kbps. This is more than adequate as the Compact Measurement Record (CMR+) with 7 satellites L1 and L2 produced only, on average, 0.087 kbps records.

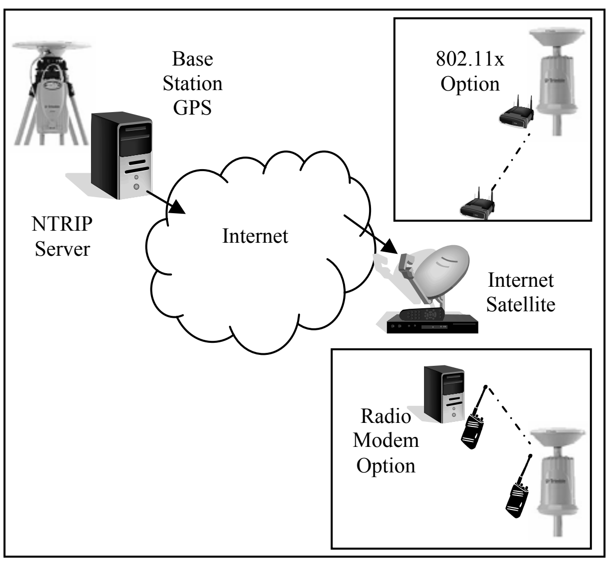

Figure 1.0 Space Based RTK configuration

GPSBase® was configured to connect to the 5700 GPS unit and generate the CMR+ that were to be webcast. User access was configured in the GPSBase® software. Individual passwords and logins were created for each user. Rovers used this information to login and obtain the GPS corrections.

For this test, the NTRIP Client, GNSS Internet Radio version 1.4.3, was used. A notebook PC was used to obtain the NTRIP broadcast via a network cable link to the broadband satellite modem. The corrections were redirected to the rover via a COM port. Figure 2.0 show GNSS Internet Radio 1.4.3 that was used to send the CMR+ to COM 1 of the PC.

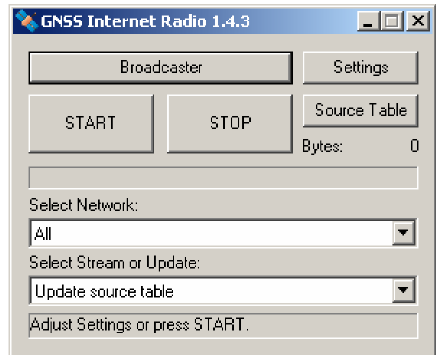

Figure 2.0 GNSS Internet Radio 1.4.3

The broadband internet satellite system used in testing was the Hughes Network Systems, LLC (HNS) DIRECWAY® service. Key hardware includes satellite dish and satellite modem. HNS provides different plans based on the required communication transmit and receive speeds. The basic plan allowing 700 kbps download and 128 kbps upload is adequate for NTRIP data.

Two setup methods can be considered for installation. Both are made to be mobile. The first is the tripod configuration seen in Figure 3.0. This option requires manual orientation of the dish based on the given parameters to locate geosynchronous satellite.

Figure 3.0 Directway broadband internet satellite antenna on tripod configuration.

The second configuration option is permanent installation of a vehicle. This is a motorized system that can automatically lock on the satellite utilizing a controlled motor system. Figure 4.0 shows the motorized antenna configuration.

Figure 4.0 A DataStorm MotoSAT robotic antenna installations.

RESULTS

Our testing at this time was centered on configuration issues. Therefore, the base and rover were within 30 meters to facilitate configuration changes. The radio modem option shown in Figure 1.0 above was selected for the test. A standard Trimble COM cable was plugged directly into the receiver with the correction coming from the PC (See Figure 5.0). This allowed for analysis of latency and communication errors due solely to the broadband internet satellite. A baud rate of 38400 was used and configured with GNSS Internet Radio 1.4.3 and the Trimble 5700 GPS. The satellite antenna was mounted on a pole and placed near Trimble 5700 GPS as seen in Figure 6.0.

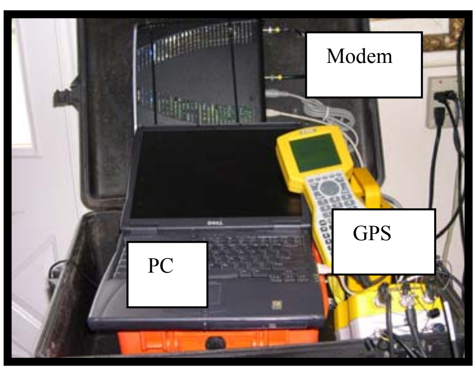

Figure 5.0 Equipment Configuration

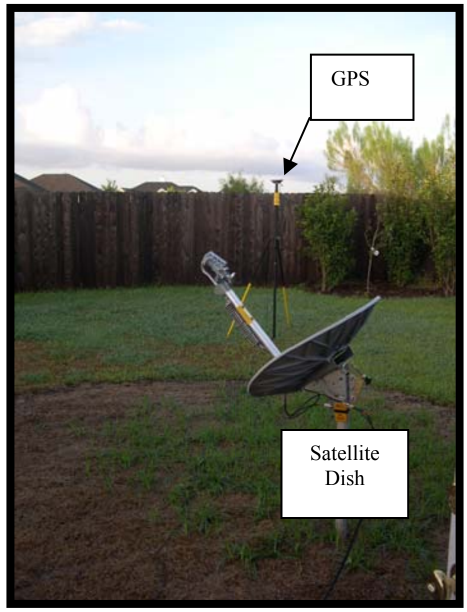

Figure 6.0 Broadband Internet Satellite Dish and GPS Antenna.

Data was collected in continuous mode with a collection interval of 1 second. Several signal drop outs were noted. They appear to be related to communication problems between the server and the broadband internet satellite. Connection to the server took approximately 20 seconds. This reflects the round-trip time of sending requests up and receiving data back down. Ping tests were run to determine the latency to the NTRIP server. As seen in Figure 7.0 the average latency was approximately 700ms. Noted major loss due to communication failures occurred six (6) times during a two (2) hour period. Times of large internet traffic could explain these losses. It is not certain if the losses are from the server ISP or the broadband internet satellite.

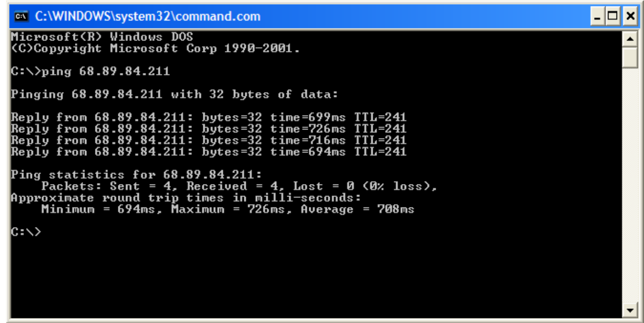

Figure 7.0 Average Ping Latency

From Figure 8.0 and 8.1 of coordinate collected using SB-RTK no significant errors were experienced.

Published by OHIO Open Library,

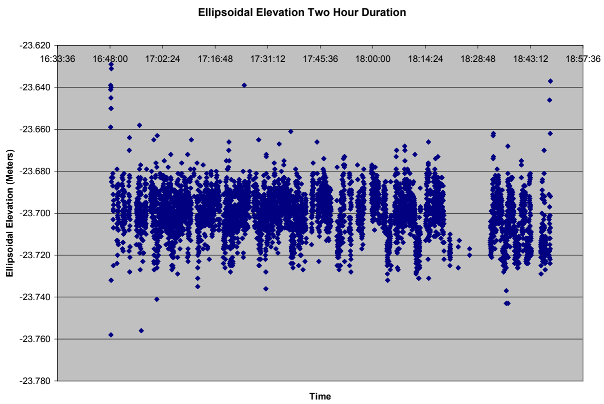

Figure 8.0 Elevation over two hours of time using SB-RTK

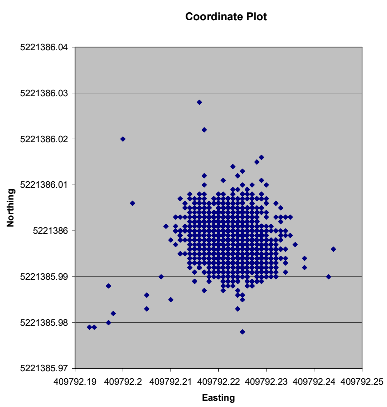

Figure 8.1 Coordinate Plot over two hours of time using SB-RTK

CONCLUSION

The range of the cost of the configuration is listed in Table 1.0.

Table 1.0 Cost of Space Based RTK

Option	Description	Cost
1	Robotic Satellite Installation	~ $5,000 - $10,000 (US)
2	Tripod Configuration	~$750 - $1,500 (US)
3	Permanent Pole Configuration	~$500- $600 (US)
Monthly Service Cost	Basic Data Rate Plan	~$60 - $100 /Mnth (US)

The most difficult aspect of the test was the time it took to orientate the broadband internet satellite antenna. This took more then 30 minutes of one individual's time. A robotic configuration could drastically improve installation time when system must be moved from point to point. The system, when connected to radio modem or wireless 802.11x, will be subject to their known range limitations, typically less then 5 miles.

The next stage of this test will be to use the SB-RTK system to determine how much gain in production we will experience in actual applications. TxSRC plans to use the system in combination with campaign-type GPS to identify problems in the Texas vertical network. This work will also allow us to assess the accuracy of the method against other techniques like Rapid Static GPS. As this work is intended to support our height modernization efforts, we are especially interested in height determinations. Our work will be based on permanent NGS CORS stations that have NTRIP capability in Texas. Texas plans to install 71 new CORS with NTRIP capability by 2006.

ACKNOWLEDGMENTS

We would like to acknowledge Mr. Carl M. Thompson, Trimble Navigation, Mr. Nathan Pugh, Trimble Navigation, Mr. Rodger Odom Global Satellite Solutions and Mr. Chad Mayfield, Mr. Richard Smith, Mr. John Adams Texas A&M University – Corpus Christi Conrad Blucher Institute.

REFERENCES

Gateway, 2005 "Editing Firewall Settings" Retrieved from http://gateway.2wire.net/security/edit_firewall_settings.html on September, 12, 2005