Near Real Time Processing of Differential GPS Observation using Internet Technology

O. A. Isioye, I. Enebeli, M.W. Shebe, and M. Mefe

Abstract—**The study is focused on transmitting GPS observed data via the internet for near real-time post-processing solution. It exploits possible and available technology in integrating the basic concept of real-time GPS survey and post-processing technique to achieve a near real-time post-processing result. This was achieved by exploring the internet as a means of communication and transmission of GPS data for a near real-time post- processing solution. The base and rover stations were equipped with wireless mobile internet modems and portable mobile computer systems to provide the internet accessibility required for online transfer of downloaded observed GPS data in near real time. The research work with a view to saving the time required for post-processing of GPS data, process the observed base and rover data as fast as possible on-site as soon as the reference station data is received. This allow for check and correction of any observed error or anomaly on site. Based on the evaluated methodology, the positions of some points were determined. An independent web interface was also designed and tested using PHP ('Hypertext Pre -Processor', a server side HTML scripting/programming language) for practical assessment and validation of the concept.**

Keywords— Near Real Time, Post Processing, Differential GPS, and Internet Technology.

I. Introduction

For many construction and surveying projects, the accuracy of GPS data can be improved by using relative GPS positioning methods, in which two or more receivers observe simultaneously. The underlying principle of relative GPS positioning, is that any two receivers that are relatively close together will experience similar atmospheric errors. Differential GPS requires that a GPS receiver be set up on a precisely known location. This GPS receiver is the base or reference station. The reference and rover receivers simultaneously collect GPS data. Thus, it is necessary to match the GPS log data from the base station to the raw GPS data collected by the rover. To do this, the log data from the reference receiver is sent to the rover almost instantaneously in real-time or downloaded for post-processing using suitable processing software. For post-processing, the observed base and rover data are transported to the office for downloading and processing to provide processed GPS results **[1 - 3]**.

The increase of available bandwidth of Internet enables data streaming applications like Internet-Radio or Internet-TV possible. Researchers are now trying to use Internet as an alternative method for transmitting GPS data for the real-time or near real-time corrections of GPS observations **[4]** and **[5]**. A new technique using the Internet for streaming and sharing Differential GPS corrections (DGPS) to allow precise positioning and navigation was announced in 2003 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 to 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 **[6]**.

Due to the unavailability of the methods like WAAS, LAAS and VRS techniques, the most common method of real-time high accuracy positioning in many countries is carrying out DGPS or RTK with Very High Frequency (VHF) radio signal transmitter. Even though, it has been observed that the radio communication technology has improved from time to time; still there are significant numbers of difficulties in using VHF signal in RTK or DGPS. For example, the difficulties of accessing VHF signal in the field without distraction and limitations of baseline distance. The development of systems

The main objective of this study is to design and test an interface for processing and transmitting acquired GPS data

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through the internet to where needed for processing, whether between the base and rover stations, or between site and the office as well as relatively process the data on site as fast as possible for the end users who may require such survey results to proceed with their work. The results of the study considers the internet as particularly well suited for transmitting data between different providers over long distances. Rather than transporting data from base stations and rover back to the office for post-processing, the fast improving internet technology can provide a seamless communication link between base and rover sites, as well as between the site and office.

The motivation for this study emanated from the fact that there is often the need for a seamless transfer of GPS survey data between sites, either as raw GPS observation files or as processed GPS data. Conventionally, for post-processing, GPS data observed in the field are transported back to survey headquarters or head office in the case of construction companies for post- processing. Most times, the sites are not situated close to such survey head offices and considerable amount of time is wasted in transporting such data back to the office for post-processing, after which the required GPS survey data or result is again transported to the site for work to continue. Also, in practice, after all necessary data have been observed following all necessary precautions, some errors and anomalies are usually detected while post-processing at the office. When such errors and anomalies are detected, the site has to be re-visited to observe another set of data for the points or stations concerned, leading to delay in the progress of the work and hence, increasing project cost and completion time as workers have to be paid for idle time while they are being delayed by the survey results required to proceed with the work and additional cost incurred for delay of rented instruments. Malfunctioning of GPS equipment is another problem encountered during relative GPS survey work. Such a problem (especially with 'low grade' GPS units without display units) can only be noticed on site if the data were to be downloaded while on site. Such problems may imply going back to the site to re-observe, resulting in unwanted extra costs and increasing completion time of the work.

II. Materials And Method

A. Data and Instrumentation

To evaluate the approach of streaming GPS data via the internet, portable laptop computers with BAFO BF-810 adapters for downloading were provided at the base station as well as at the test site (16 stations) where the rover was to observe, as these are essential for performing near real-time data processing- especially in remote locations. Wireless internet modems from Visafone and Starcomms wireless networks were used to provide the required internet connectivity for the base and rover stations. Sokkia Stratus geodetic GPS receivers were used as reference and rover receivers for field observations.

B. Data Transmission and Communication Link

To access the World Wide Web (www), both computers at the reference station and site were equipped with World Wide Web programs (Internet Explorer, Mozilla Firefox, and Opera). Visafone and Starcomms wireless internet modems were used to provide the required internet service. The internet modems were connected to the computers to make them internet complaint. Independent and unique electronic addresses were created for each receiver to aid data transmission and communication. These include geomatics.base@gmail.com for the base station, geomatics.rover@gmail.com for the rover site. Downloaded base data were transferred via the internet as attachment (using the created electronic mail addresses) to the site (rover) computer for processing. The transfer was done within seconds of sending the data for processing between sites. This depended on the bandwidth (measured in number of bits per second, bps) of the network.

For purpose of this study, to enhance and evaluate the process of uploading and downloading GPS data and processed results, an independent web interface was designed using PHP (Hypertext Pre-processor), a scripting language that's usually embedded or combined with HTML and has many excellent libraries that provide fast, customized access to Database Management Systems (DBMSs). Downloaded GPS data from the rover receiver and that of the base station transmitted and downloaded via the internet were processed on site using the Spectrum Survey Version 4.00 software. Using the web-interface, reference station data can be converted into RINEX format and uploaded onto the site, allowing users with different receiver types to access and download such data for post-processing. Fig (1) shows the architecture of the system design.

GPS Data Transmission between Base and Rover Sites

- *The Internet Evaluated Concept*

With the project work focused on using Internet information technology (IT) applications to minimize time,risk of transportation and labour, providing GPS results in near real-time, the Internet methodology was used to provide Control points around the test site. Using the unique electronic address created for the base station, the base data was sent to the rover site on request (See Figures 2-4 for some screen shots of the approach). The basic requirement for post-processing DGPS data is to have both the base and rover observation data together to enable the processing software performs its processing operations. This was made feasible using the Internet technology to transfer the observed GPS data at the base to the site where the rover is situated on request. On receiving the base data, with the rover data already downloaded, post-processing was immediately carried out to provide the required DGPS results. The time from download, transferring online and processing at the rover site was well within considerable time compared to the time-consuming conventional method of office post-processing.

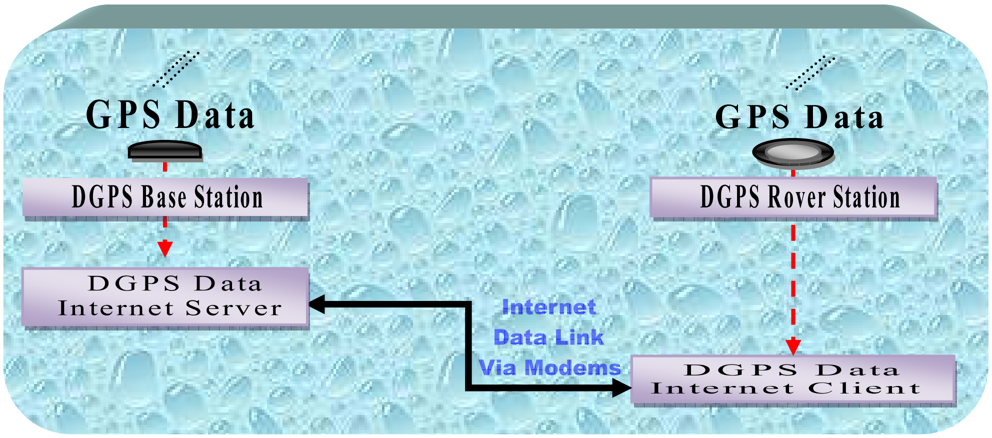

Fig. 1. Architecture of Application

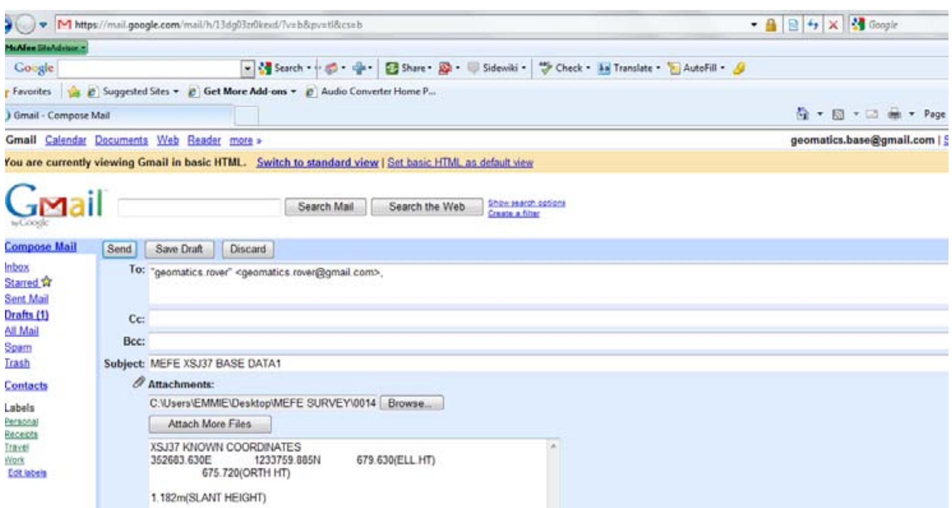

Fig. 2. Sending base data via the Internet (geomatics.base)

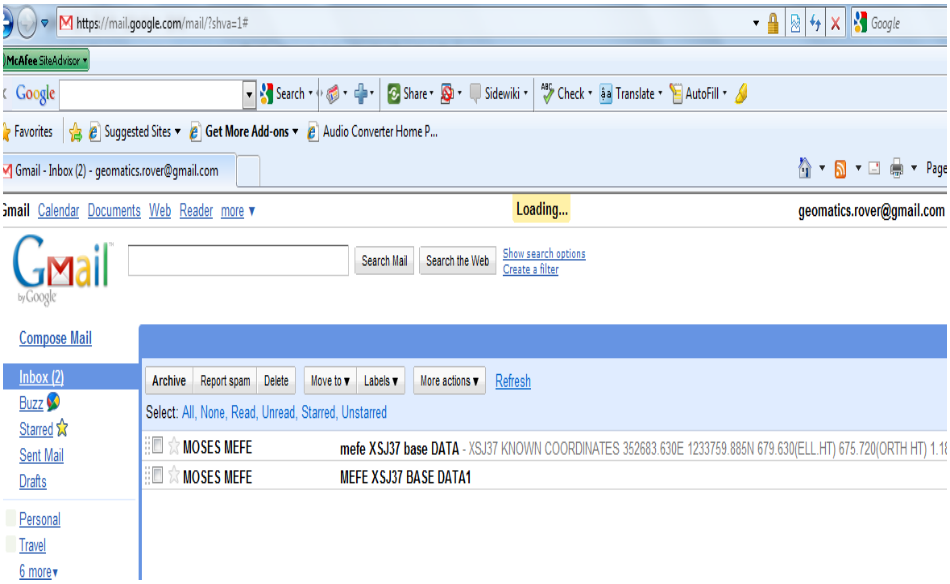

Fig. 3. Received base data (geomatics.rover)

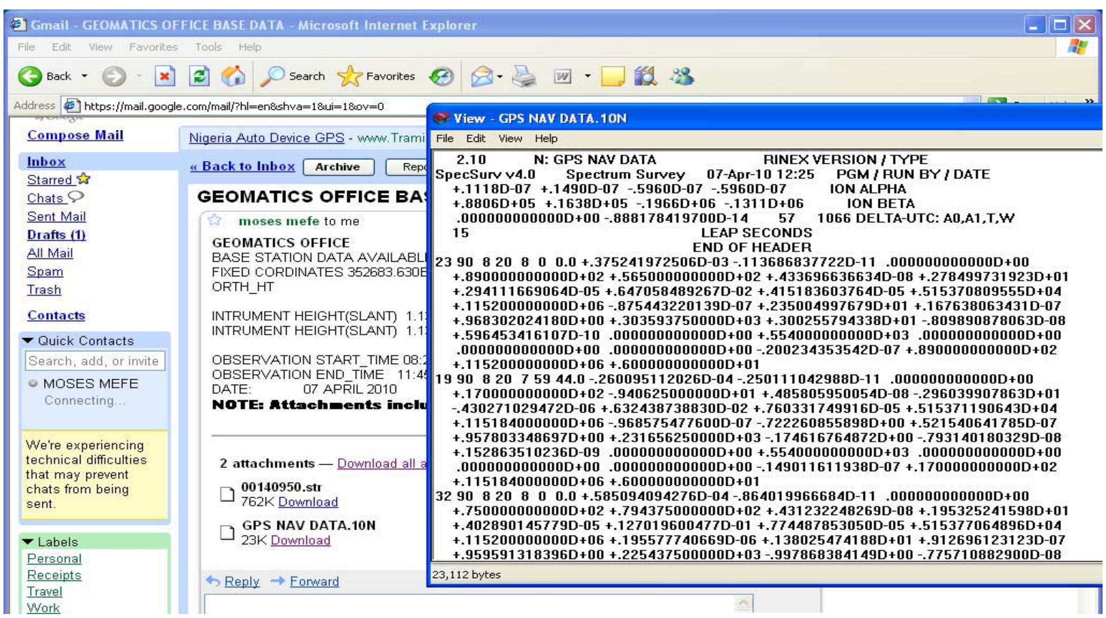

Fig. 4. Sent and received base data and rinex file

III. Result And Discussion

A. Result

Based on the evaluated Internet methodology, the reference station observed data was sent to the rover site for on-site processing of the observed rover data. Table 1 shows the results obtained on differentially post-processing the base and rover data of some observed points on receiving the reference station data.

Web Interface for ABU GEO GPS

PHP stands for 'Hypertext Pre–Processor' and is a server side HTML scripting/programming language. PHP is a tool that lets you create dynamic web pages. PHP–enabled web pages are treated just like regular HTML pages and you can create and edit them the same way you normally create regular

TABLE 1. COORDINATES OF DIFFERENT POINTS OBSERVED AND PROCESSED ON RECEIVING THE BASE STATION DATA VIA THE INTERNET ON SITE

Point ID	Easting (m)	Northing (m)	Height (m)
BB0	354277.030	1235352.267	661.864
BB1	354293.111	1235051.546	665.524
BB2	354472.370	1235289.494	664.541
BB3	354310.334	1235565.599	667.938
BB4	354021.328	1235522.630	665.685
FL1	354183.970	1235302.347	664.923
FL2	354273.868	1235156.780	666.424
FL3	354408.874	1235256.584	664.588
FL4	354352.281	1235358.162	663.724
BP1000	351927.729	1233925.806	668.904
BP1001	351968.558	1233819.193	668.571
BP1002	351890.055	1233738.871	671.162
BP1003	351759.540	1233819.820	674.764
RCP001	352156.383	1233082.715	661.826
RCP002	352144.817	1233038.852	661.951
RCP003	352188.548	1233023.458	660.810

HTML pages. At the most basic level, PHP can do anything any other CGI program can do, such as collect form data, generate dynamic page content, or send and receive cookies. Perhaps the strongest and most significant feature in PHP is its support for a wide range of databases. The web interface was designed using the PHP language due to its flexibility and capacity to support dynamic *web pages and its support for a wide range of databases.*

B. Discussion

Fig (5) , shows the home page with a welcome note introducing a user to the site and a flash movie displaying overview of ABU and some GPS/GNSS equipment. Fig (6), is the upload page which acts as a two-way medium for the user and the host. The user could either upload his observed field data which can then be downloaded using the download page (Fig 7) and processed by the host. The processed result can then be uploaded onto the site for the end user to download the processed result. Alternatively, the reference station data from a GPS/GNSS receiver can be uploaded as raw observation data or in RINEX format, such that different users could download such data to process their rover data. The web interface also has the potential capability of coordinate transformation, although limited to two-dimensional transformations due to the absent of an indigenous geoidal model.

Fig. 5. Web Interface home page

Fig. 6. Web Interface upload page

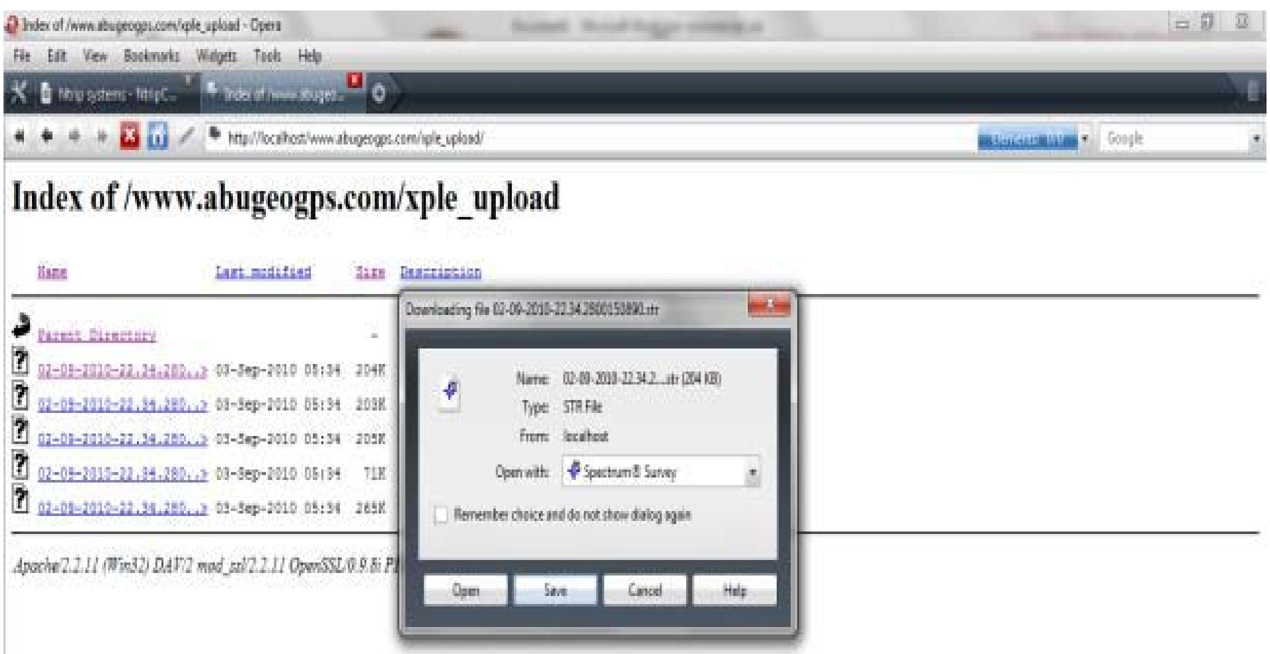

Fig. 7. Web Interface Download Page

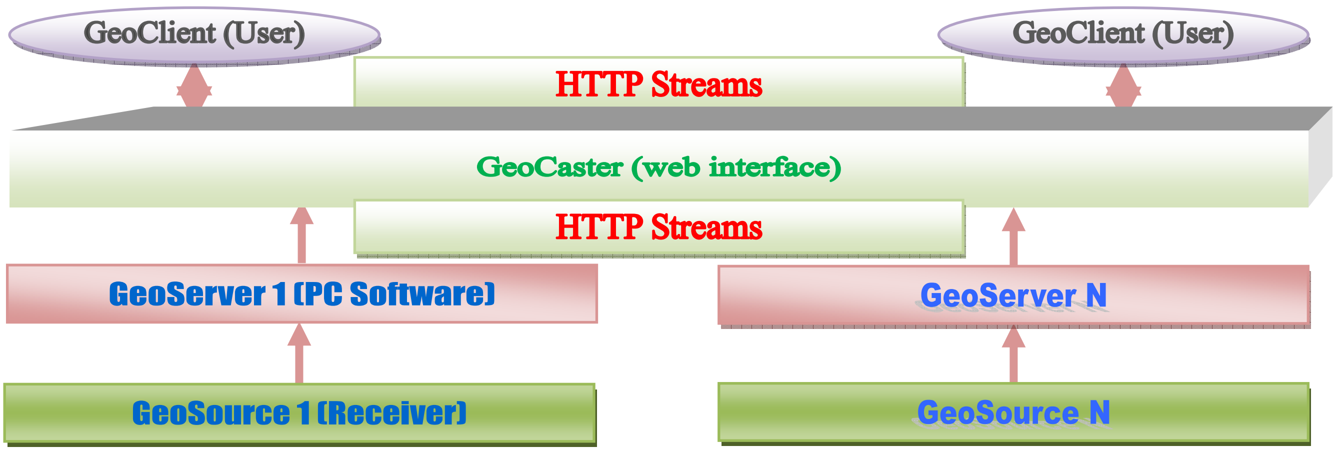

Fig. 8. System components of the designed web interface (ABU GEO)

The present IGS CORS station in ABU can be incorporated into the designed web interface to aid management and transmission of data to users on request.

Also, in establishment where observed field data must be submitted to the office for processing and analysis, as being done in most construction company, the Internet evaluated concept can be employed in transmitting observed field data to the office for processing, after which the processed results is transmitted back to the site in need of such data via the Internet. This will be useful where the company's head office is outside the state where the work is carried. Thus, the Internet will provide a reliable means of communication and transmission of survey data and deliverables.

System Elements of the Web Interface Concept

The designed web interface is an integration of various components required for proper functioning of the system. The web interface by means of the various system elements provides a link between the basic GPS/GNSS receiver at the base or remote station and the end user. The system element are illustrated in Fig(8). The different element are described as follows:

- **GeoSource:** The GeoSource is a GPS/GNSS receiver that provides continuous GNSS observation data that refer to a known or specific location.
- **GeoServer:** In practice, the GeoServer can be software running on a conventional PC that is capable of downloading observed GPS data from the receiver into the PC (from GeoSource to GeoCaster). As a summary the GeoServer transports GNSS data of the GeoSource (GNSS receiver) directly to the GeoCaster.
- **GeoCaster:** The GeoCaster is in general a HTTP server and acts as a broadcaster integrated between the data sources (GeoServer) and the data receiver (the GeoClients).
- **GeoClient:** This is a user who downloads the transmitted GPS data from the GeoCaster via the Internet. With a single reference station (GeoSource), different users can access and download the GPS observed data from the reference station via the Internet.

TABLE 2. ESTIMATED DATA TRANSFER AND PROCESSING TIME FOR THE CONVENTIONAL METHOD AND THE INTERNET

Method	**Conventional method**	**Internet evaluated method**
Mode of data transfer	Transport data to office and re-transport result back to the site.	Transmit data via the Internet.
Data transfer time	1 hour or more depending on base-rover distance and location of processing office.	10 minutes or less (seconds) depending on the bandwidth of the network.
Place of processing	Office	On site
Availability of processed data to end user	Very slow (Time-consuming).	Fast (Timesaving)
Cost implication	May be expensive and time consuming.	Relatively cheap and fast

Comparison of the Conventional and Internet Evaluated Methods of DGPS Surveys

The conventional method of carrying out DGPS surveys by post-processing at the office, though commonly employed**,** has numerous limitations as shown in Table 2. The transportation of observed DGPS data to the office and re-transporting the processed result back to the site for use is time consuming, especially when the office is located far away from the site which is the situation in most cases. The survey completion time and cost is increased when errors or anomaly are detected while processing at the office and there is need to re-visit the already surveyed site for another set of observations to correct the detected anomaly. Using the conventional method of office post-processing, processed results are delayed are rarely made available on time to the end user who requires such results to proceed with other phase of the project. Although the conventional method requires just the basic GPS receivers on site, computer system will still be required at the office to carry out the required processing. Hence, this method is not reliable if time, cost and convenience are priority.

TABLE 3. DIFFERENCE IN COORDINATE VALUE

Point ID	Differences in Coordinate Estimate		
	Easting (m)	Northing (m)	Height (m)
BB0	0.023	0.022	0.345
BB1	0.045	0.043	0.213
BB2	0.467	0.023	0.234
BB3	0.456	0.093	0.123
BB4	0.775	0.053	0.666
FL1	0.654	0.048	0.583
FL2	0.212	0.022	0.214
FL3	0.666	0.134	0.083
FL4	0.439	0.256	0.111
BP1000	0.326	0.543	0.698
BP1001	0.430	0.972	0.291
BP1002	0.009	0.863	0.583
BP1003	0.121	0.912	0.119
RCP001	0.058	0.197	0.134
RCP002	0.034	0.067	0.754
RCP003	0.074	0.823	0.234
Mean Difference	**0.299**	**0.317**	**0.337**

It could be observed that the Internet evaluated near real-time methodology has the following advantage over the conventional method of differential GPS survey.

- Results are available in the field, so checks can be verified immediately
- Staking out is now possible
- One base receiver supports multiple rovers (unlimited)
- No post-processing time required in office
- Raw observed GPS data, RINEX format; e.t.c. can all be transmitted and received over the Internet.
- Multiple users can access the same reference station data via the Internet.

The concept is simple and can easily be executed by small firms and individuals.

The result of the coordinates of test stations obtained from the internet near real time processing solution were compared with their known values and it was evident that not only did the approach offer the advantages enumerated in Table 2 but also provide accurate coordinates estimates. Table 3 shows the differences in coordinate value. It was observed the mean difference in all the three coordinate components are approximately about 30cm, which are good estimates for general engineering and surveying applications. The accuracy of the coordinate estimated can be improved by increasing observation time on field and by considering other options of processing software which are more robust in nature i.e., Bernesse and GAMIT software.

IV. CONCLUSION

The project has been able to ascertain and evaluate the possibility of using the Internet technology as a medium for the transmission of observed DGPS data or results between. base and rover stations or sites as well as the office (as situation demands) for post-processing The project work justifies the use of the Internet as a feasible solution to obtaining near real-time results of DGPS survey, using available technology at the reach of an individual. The limitations of the conventional method have been efficiently evaluated; the Internet evaluated system being comparatively cheaper and affordable as well as being easily implemented. Based on the evaluated method, the positions of some points were determined and an independent web interface designed for practical assessment and validation of the concept. In summary, the future is talking Internet GPS. It is of great belief that transmission of GPS data via Internet Protocol will become the standard for future solutions in providing correction data for DGPS near/real-time applications. With the current wide spread of mobile networks all over the country and the efforts being made to increase wider coverage and service strength, as well as the improvements in Internet technology, the Internet will be the future of DGPS applications. It will provide the most cost effective, secure and fastest means of obtaining higher accuracy level of observations.

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