REGME-IP Real Time Project

David Cisneros[1], Mónica Zabala[2(✉)], and Alejandra Oñate[2]

[1] Instituto Geográfico Militar, Quito, Ecuador
david.cisnero@geograficomilitar.gob.ec
[2] Escuela Superior Politécnica de Chimborazo, Riobamba, Ecuador
{m_zabala,mayra.onate}@espoch.edu.ec

Abstract. The high demand for positioning-based services has generated the development of measurement correction techniques for GPS data, with Real-Time techniques presenting the best results. The architecture of a Real-Time correction system is based on the RTCM message transport protocol (NTRIP) and consists of a server called a caster that concentrates the streams of the GNSS stations and distributes them to the users through internet acting as a gateway. Currently there are international projects such as IGS-RTS or EUREF-IP and in Latin America such as SIRGAS-RT which encourages all member countries to participate in the implementation of this service in real time. Being responsible for the administration of the Continuous Monitoring Network of Ecuador, the Military Geographical Institute optimizes technological resources and implements the national caster and caster backup in collaboration with Escuela Superior Politécnica de Chimborazo to provide the correction service on time. real through the NTRIP protocol for the release of GNSS data to Ecuadorian citizens as well as including Ecuador as one of the countries that complies with the SIRGAS requirements.

Keywords: GNSS · NTRIP · Real time corrections

1 Introduction

In Ecuador, positioning activities based on Global Navigation Satellite Systems - GNSS, are developed mainly with the relative Static Differential positioning method, being mandatory the post-process with specialized software, to obtain points with coordinates linked to the geocentric framework, official reference, below an acceptable level of accuracy. Obviously, GNSS positioning technique takes time to deliver results, however, it is important for maximum accuracy work, in which it is mandatory to achieve the least possible error in terms of coordinates at the millimeter level, for example in the case of establishing high accuracy GNSS networks, national, regional, global reference frameworks, accuracy engineering, among others.

However, there are several georeferenced activities, which do not require maximum accuracy, it is enough to obtain coordinates in the sub metric and centimetric order, before which it is not mandatory to apply the method of relative positioning Static Differential Post-process, since it requires results faster and in less time, opening the possibility

M. Botto-Tobar et al. (Eds.): ICAETT 2020, AISC 1302, pp. 42–57, 2021.
https://doi.org/10.1007/978-3-030-63665-4_4

of applying relative positioning methods in Real Time. The techniques, procedures for observation and acquisition of geospatial information evolve over time, the world trend is to provide GNSS information in real time, evolving the transmission of traditional DGNSS corrections, based on radio frequency and downloading files for post-processing, to an Internet-based data transmission; this is undoubtedly solved with the use of relative GNSS positioning methods in Real Time, mainly based on the NTRIP protocol.

2 International Real Time Projects Related Work

2.1 Euref-Ip

With the increased capacity of the Internet, applications that transfer continuous data streams by IP-packages, such as Internet Radio, have become well-established services. Consequently, EUREF decided in June 2002 to set up and maintain a Real-Time GNSS infrastructure on the Internet using stations of its European GPS/GLONASS Permanent Network EPN. The goal of the pilot project is to evaluate and stimulate the use of the NTRIP technology. All data are sent to a EUREF Broadcaster from where they can be received by authorized users. EUREF-IP is a trial service. Data are available for test and evaluation purposes only [1].

2.2 IGS Real-Time Service (IGS-RTS)

IGS-RTS is an operational scientific service of the International Association of Geodesy and one of several services contributing to the Global Geodetic Observing System (GGOS) with the development of the Real-Time service using the Network Transport of RTCM by Internet Protocol (NTRIP) for internal operations and for the delivery of Real-Time products to its user community [2].

2.3 Geocentric Reference System for the Americas (SIRGAS)

SIRGAS Resolution No. 6 of May 29, 2008 on the SIRGAS Real-Time policy project resolves: Establish a pilot project called SIRGAS in Real Time (SIRGAS-RT), which will aim to investigate the fundamentals and applications associated with the distribution, in the SIRGAS regions, of observations and corrections to GNSS measurements in real time using NTRIP or any other long-range means [3]. Under this activity, a service called Experimental SIRGAS Caster has been implemented with the main purpose of publishing GNSS data in real time using NTRIP. This caster is hosted by the Laboratory of the Rosario Geodesy Satellite Group, at the National University of Rosario, Argentina [4].

2.4 Experimental Caster Server ESPOCH

Initially, a pilot project is proposed in 2016, which consists of implementing the experimental caster with BKG standard version software as cooperation between the Faculty of Computer Science and Electronics and the National Electricity Company of Riobamba city only for internal use. The infrastructure consists of a single GNSS station called

EREC connected to the caster server, the main element of the project, monitored continuously during two years of operation. The integrity of the information transmitted checked using BNC software and applying the corrections in Real-Time on the Mobile Mapper 20 GPS devices, reaching a accuracy scope at the PVT solution's centimeter level [5].

3 Red de Monitoreo Continuo del Ecuador (REGME)

The GNSS Continuous Monitoring Network of Ecuador - REGME, constitutes the principal national georeferenced infrastructure, installed, and administered by the Military Geographical Institute (IGM) since 2008 [6]. It is made up of 45 CORS-type stations (See Fig. 1), distributed in all the national territory, tracking GNSS signals of all the observables given by the L-band frequencies of GPS L1/L2, GLONASS L1/L2, and the near future GALILEO E1/E5) providing the necessary information to execute correction activities through the Static Differential and Real-Time relative positioning method. REGME was designed to provide radio coverage of 100 [km] for each station. Due to the requirements and the applications from users derive from redefining the radio coverage decreasing at 50 [km] and increasing the GNSS station with their equipment, focus as a goal of 50 permanent stations.

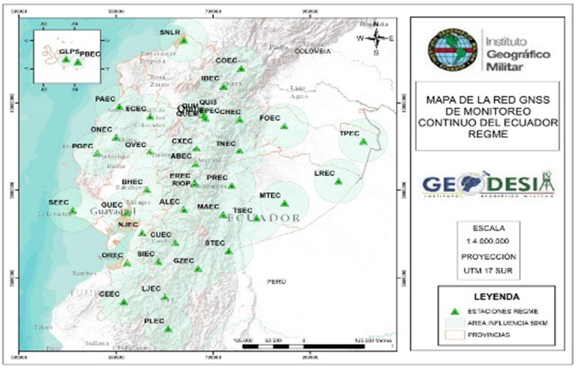

Fig. 1. REGME, Coverage radio around 50 [km] (August 2020).

4 Network Transport RTCM Internet Protocol (NTRIP)

It is an application-level protocol that supports GNSS data transmission over the Internet, based on the HTTP/1.1 hypertext transfer protocol. NTRIP develops to transmit differential correction data or other types of GNSS data transmission to stationary or mobile users over the Internet. NTRIP is an open, non-proprietary protocol. Significant characteristics of the NTRIP dissemination technique are the ability to distribute any kind of GNSS data, potential to support mass usage, disseminating hundreds of streams simultaneously for up to thousand users possible when applying modified Internet Radio broadcasting software, and enables streaming over any mobile IP network because of using TCP/IP [7]. NTRIP constitutes the transport layer, and the transmitted data is in the RTCM format, generally in versions 2.x and 3.x. The messages contain observables, type of antenna, coordinates of the reference station linked to the national official reference system, code, and phase corrections from GNSS constellations as GPS, GLONASS, and GALILEO.

The RTCM version 3.0 additionally transmits a network solution message, made up of the differential corrections of several permanent stations, which increases the consistency and quality of Real-Time positioning solutions.

4.1 Architecture

NTRIP architecture is based on the following components: NTRIPClients, NTRIPServers, and NTRIPCasters (see Fig. 2) [8].

- **NTRIPSource:** Is the GNSS reference station that generates and transmits the corrections (data streams) in the RTCM format. The version currently generated by REGME stations is 2.3 and 3.0 versions depending on the receiver datasheets.
- **NTRIPServer:** acts as an intermediary in the transmission of data between the GNSS reference station and the caster server, recommends using it only when the GNSS station don't have available setting related to NTRIP protocol.
- **NTRIPCaster:** It is the transmitting agent, its primary function is the dissemination of GNSS corrections to end-users; likewise, it is responsible for monitoring the quality and integrity of the data received, authentication to the system through user and assigned password, for this it is mandatory to have a constant and uninterrupted internet connection.
- **NTRIPClient:** Final devices or rovers which are connected to the caster. Final devices are considered PCs, tablets, GPS receivers, mobile phones, PDAs, and the software and hardware to support the NTRIP protocol [9].

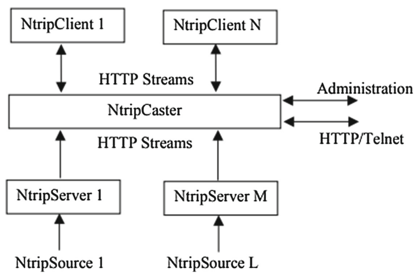

Fig. 2. NTRIP Architecture

5 RTCM Standard

The Radio Technical Commission for Maritime Services (RTCM) establish in 1947 as an advisory committee to the US Department of State. Currently, it is an independent organization made up of government agencies, manufacturers, and service providers. The high demand in using DGPS applications in Real-Time led to the establishment of the RTCM Special Committee 104, to normalize an industry-standard format for correction messages [10]. The RTCM format has developed new versions that improve data delivery and protect the integrity of these.

5.1 Rtcm 2.X

The RTCM version 2 format design was made based on the structure of the GPS Navigation Message, since word sizes, parity algorithms, and format are identical. The GPS Navigation Message transmit at a 50 Hz, and a word has 30 bits. A data link carries information from a reference station to a rover or remote receiver. The reference receiver produces GNSS data and converts it into a suitable format for transmitting and modulating the data on a carrier that it transfers to a mobile user [11].

5.2 Rtcm 3.X

RTCM SC-104 introduced a new standard known as RTCM SC104 version 3.0 to overcome disadvantages and improve RTK operations. Its renovated structure benefits RTK operations and supports RTK networks due to the efficient bandwidth used during the broadcast. The RTCM Type 1003 message is a GPS RTK dual-frequency message based on raw pseudo-range and phase carrier measurements. RTCM version 3.0 divides L1 and L2 correction into dispersive and non-dispersive components: Ionospheric Carrier Phase Correction Difference (ICPCD) and Geometric Carrier Phase Correction Difference (GCPCD) [12].

6 REGME -IP Project

Implementing a precise Real-Time positioning service requires a physical and technical infrastructure equipped mainly with geodetic equipment such as GNSS antennas and receivers, wireless communication technologies, security policies, and integrity of the information transmitted on communications protocols distributing DGNSS streams corrections in RTCM format on the Internet. REGME-IP Real-Time project represents an integrated system that includes all those elements to improve the accuracy of the final Position, Velocity, and Time (PVT) solution. The permanent GNSS stations, from REGME, are compatible with the Real-Time positioning technique and generate streams of differential corrections in RTCM format to distribute them applying the NTRIP protocol changing the traditional technique of DGPS where the correction information is transmitted through radio frequency into packed switching communication based on TCP/IP. The denomination of the term REGME-IP represents the actual and functional

REGME plus the transmission of the GNSS station information over Internet Protocol (IP) following the international recommendation of related works.

The GNSS station's streams allow correcting common errors that the GNSS signal suffers, during its travel from satellites positioned in MEO orbit, during its arrival until the earth, problems like satellite geometry, effects on the propagation channel as ionosphere and troposphere producing inaccuracy on final position solution. The correction is generated based on the coordinate of each of the permanent stations. The REGME-IP service will expect to reduce operating costs done in outdoor activities, improving the survey process because it does not require post-processing activities that produce delays for delivering results. The service's availability allows increasing the level of citizen satisfaction in obtaining products and services related to the generation of geoinformation, dissemination of geospatial sciences, and other specialized services.

6.1 Principal Caster Server

The Real-Time positioning system's architecture has a fundamental element denominated Caster server acts as a gateway between the GNSS station and the end-users. The caster's primary function is to authenticate users and transmit the stations' streams in RTCM format to the rovers.

Since 2018, the Military Geographical Institute (IGM) and Escuela Superior Politécnica de Chimborazo (ESPOCH), start the project to implement the Principal Experimental Caster Server to distribute the stream of differential GNSS corrections in Real-Time, through the NTRIP protocol using REGME stations.

The international projects in Real-Time recommend using BKG NTRIP Caster software; it allows the dissemination of GNSS data streams in RTCM format 2.x and 3.x version based in NTRIP protocol. The BKG NTRIP Caster software is developed within the framework of the EUREF-IP project. It is based on the ICECAST Internet Radio software written in the C programming language under the GNU General Public License (GPL). REGME-IP has redundancy to guarantee the national service; the Principal Caster Server is installed in IGM – Quito, Ecuador; in cases of physical or operative troubles, the caster server backup will be available being a mirror of the principal server and will assume the request connections from registers users. The Caster Server backup is in the Faculty of Computer Science and Electronics of ESPOCH – Riobamba, Ecuador.

The address domain of each caster server is written below:

- **Principal Caster Server:** regme-ip.igm.gob.ec:2101
- **Backup Caster Server:** regme-ip.espoch.edu.ec:2101

6.2 Operating Considerations and Recommendations

The Real-Time correction technique takes the principle and basis of the GPS/GNSS differential technique [13]. Once finished the test period executed in outdoor environment, some recommendations can consider it.

DGPS

- The maximum/optimal operating distance between the Source NTRIP (REGME station) and the NTRIP Client (Rover), dual-frequency L1/L2, is 50 [km], for a fixed solution.
- The maximum/optimal operating distance between the Source NTRIP (REGME station) and the NTRIP Client (Rover), an L1 frequency, is 20 [km], for a fixed solution.
- The Real-Time positioning time is defined by the NTRIP Client, e.g. 15", 30", 60" s.
- GNSS corrections are transmitted in RTCM 2.3 and 3.0 format, which involves pseudo-range and frequency correction and estimates centimeter horizontal and vertical accuracy, depending on survey conditions.

The Real-Time technique represents to change the communication channel, from radiofrequency in VHF/UHF bands to transmission based on Internet Protocol. The rover device must support an internet connection with any available technology as WIFI, hotspot, and Service Mobile Advanced (AMS). In outdoor conditions, the mobile cellular network becomes the primary connectivity option.

Advanced Mobile Service (AMS)

The mobile operators in Ecuador are Conecel S.A (Claro), Otecel (Movistar), and CNT. The new technologies and demands of low latency in digital services demands to update towards new technologies that integrate an evolution in devices, antennas, operation frequency bands, and services. Every step and evolution is identified by a generation of mobile networks (2G, 3G, 3G + , 4G) corresponds to new technology (GSM, GPRS, Edge, UMTS), increasing the performance of the mobile cellular network providing quality in the service (See Fig. 3).

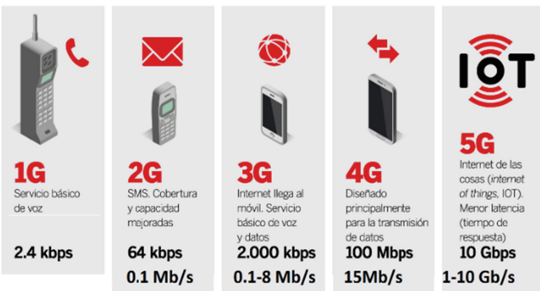

Fig. 3. AMS Generation

Coverage AMS

Figure 4 shows the evolution of radio bases installed in the national territory for the period 2008-2020. Presenting that as of March 2020 there are 18,857 radio bases with an increase of 10.48% compared to March 2019, when there were 17,069 radio bases [14].

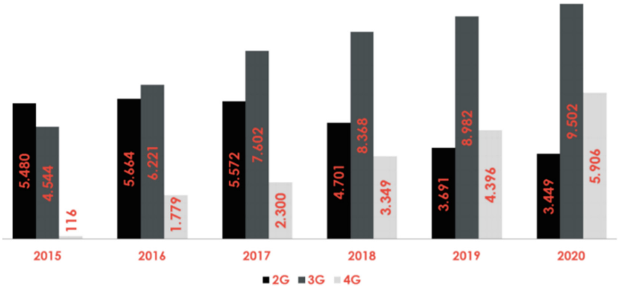

Fig. 4. Radio bases installed in 2G, 3G, 4G technologies, nationally, 2015–2020

Size of Generated Data

The RTCM format, according to the number of satellites that the rover tracking will generate the size of the packet it transmits [15].

Table 1. Data transfer in RTCM format (bits/sec)

	6 Satellites	9 Satellites	12 Satellites
RTCM 2.3	3.900	5.400	7.000
RTCM 3.0	2.500	3.000	3.550
RTCM 3.0	2.000	2.400	2.800
[CM]R1	1.400	1.800	2.100
[CM]R	900	1.300	1.600

IGM technical staff record a daily working day of 8 h of data collections from 08:00 to 16:00, considering 12 satellites as the maximum possible number of satellites (See Table 1) available for the RTCM 2.3 format above the rover bytes generated for 8 h days are calculated in (1).

$$\text{Total} = \text{Number of bits generated per second} * 3600\,[\text{sec}] * 8[\text{hours}] \tag{1}$$

$$\text{Total} = 7000\,[\text{bits/sec}] * 3600\,[\text{sec}] * 8[\text{hours}]$$

$$\textbf{Total} = \textbf{25.2 Mbytes}$$

In the case of using the RTCM 3.0 correction format, with maximum satellite availability, the total bytes generated is (2):

$$\text{Total} = \text{Number of bits generated per second} * 3600\,[\text{sec}] * 8[\text{hours}] \tag{2}$$

$$\text{Total} = 3550\,[\text{bits/s}] * 3600\,[\text{sec}] * 8[\text{hours}]$$

$$\textbf{Total} = \textbf{12.78 Mbytes}$$

Latency Based AMS Generation

Depending on the AMS availability service, the rover's latency will vary. Consider the RTCM 2.3 format with full satellite line of sight (See Table 1), generates 7000 bits/sec, the time response using 2G considering on average the theoretical rate of 0.1 [Mbytes/s] (See Fig. 3), the latency estimated is 1.09 [msec]. To RTCM 3.0 format with a full satellite above the rover, generates 3550 bits/sec, the latency estimate with 2G is 0.55 [msec]. The BNC software is developed by BKG, which emulates an NTRIP client on the computer [16]; the tool allows us to measure the latency and throughput of connection to the caster server, the average latency is 0.9 [sec].

7 Methodology

7.1 Static Differential Post-process vs Real Time NTRIP Positioning Test Using REGME-IP Service

To analyze and quantify the accuracy reached in meters, evaluate a sample points tests taken by both methods. The Sucre Canton, Bahía de Caráquez city, Manabí Province, is chosen to apply the tests. The data collected correspond to 150 points located in different sites around. The REGME stations used as a reference to apply static method differential post-process and Real-Time NTRIP are located in Portoviejo and Chone city; the stream's identifier is POEC and ONEC, respectively. (See Fig. 5)

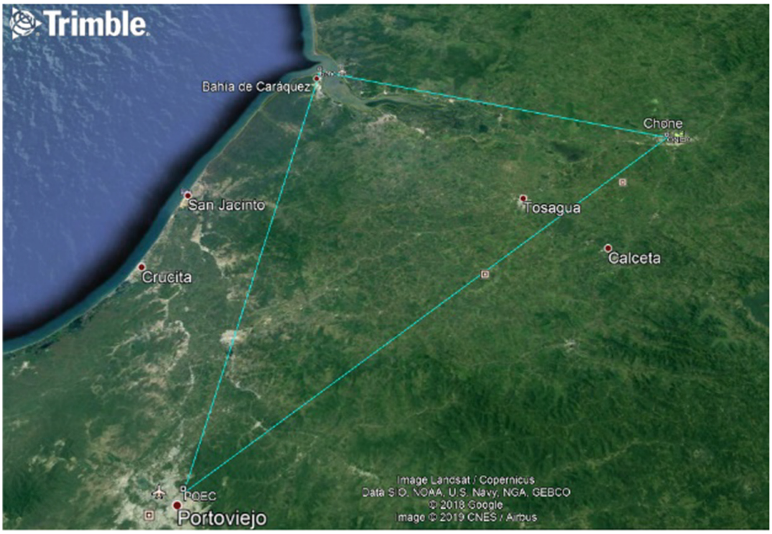

Fig. 5. Geographic location of the area used for field testing

Differential Static Positioning, Post-Process

For static positioning:

- Two Trimble R8 GNSS L1/L2 (GPS + GLONASS) rover equipment.
- Time survey duration by point: 30 min.
- Complete the survey of 150 planned points.
- Download files from the GNSS reference station using Trimble TBC software to execute post-processing.
- The final coordinate, REGME stations located in Portoviejo – POEC and Chone – ONEC are the GNSS reference stations to adjustment.

Real Time Positioning NTRIP, REGME-IP service

Real-Time positioning technique demands the rover's internet service to connect to Principal Caster Server. Huawei P8 cell phone device as a hotspot to provide connectivity to the rover. The test is considered the RTCM 3.0 message. (See Fig. 6)

Fig. 6. Trimble R8 GNSS L1/L2 rover equipment (GPS + GLONASS) configured to connect to the Principal Caster using a cell phone as hotspot

The maximum distance from the working area located in the Sucre Canton to the GNSS station is 58 [km], and the minimum distance is 25 [km]. Each point is measured (survey) for 60 s, obtaining FIXED solutions.

The NTRIP technique is affected by latency due to the distance between the Principal Caster Server and the worksite; it depends on the time that delays switching the packets to transmit the information at a specific rate and the technology of the mobile network and coverage offered by the user-selected mobile operator. It is essential to consider these observations; for this example, the distance between the Principal Caster Server to the site in the Sucre Canton is approximately 230 [km] (See Fig. 7).

Another distance that you must be considered is the one with the GNNS reference station, it is recommended to use the nearest one based on the DGPS technique (See Sect. 6.2). For the case of Sucre Canton, to the nearest and available GNSS station are described in Table 2; consider the operative condition of the station before your selection; it recommendable to check the status online on the official site web [17]. Depending on the location of the sample areas of the points, the distances are as follows (Table 2):

Table 2. Distance between the nearest GNSS Reference Station to Sucre Canton

PARROQUIA	REGME reference station with NTRIP service	Distance [km]
CHARAPOTO	PORTOVIEJO - POEC	26
SAN ISIDRO	PORTOVIEJO - POEC	68
BAHIA	CHONE - ONEC	38
LEONIDAS PLAZA	PORTOVIEJO - POEC	47
SAN AGUSTIN	PORTOVIEJO - POEC	51

Fig. 7. Distance between Principal Caster Server and Sucre Canton

8 Results

The DGPS technique consists of eliminating common errors existing between a GNSS reference station and the rover; this technique is conditioned by the distance, the epoch, and the satellites in view between them.

The first scenario (See Table 3) in the analysis is the 150-point sample survey in Sucre Canton (Bahía de Caráquez); the results show an acceptable level of accuracy between the Static Post-Process Differential and Real-Time NTRIP method. In some cases, the horizontal component's difference reaches to millimeters order considering that the Differential Static Positioning had a positioning duration of 30 min, instead of with Real-Time technique using NTRIP, the positioning has the only duration of 60 s.

Both methods show a similar accuracy level. The horizontal component (N, E) has less error than the vertical component (ellipsoidal height h). Table 4 show some results obtained by comparing the two static Post-Process Differential vs Real-Time NTRIP methods taken in Bahia de Caráquez city (Fig. 8).

The second scenario is proposed in the country's principal zone, specifically Ambato, Riobamba, and Latacunga cities, to evaluate the precision achieved using the Real-Time

Table 3. Scenario characteristics in Bahía de Caráquez

EQUIPOS MÓVILES UTILIZADOS:	TRIMBLE R8 GNSS L1/L2 GPS + GLONASS
COORDENADAS UTM 17 SUR	
ITRF 08, ÉPOCA DE REFERENCIA 2016.4	
SERVIDOR NTRIP CASTER:	REGME_NTRIP
MOUNT POINT REGME USADO COMO BASE STREAM:	CHONE - ONEC
DISTANCIA DE LA BASE AL ÁREA DE ESTUDIO:	38 [KM]
MENSAJE DE CORRECCIÓN STREAM/VERSIÓN:	RTCM 3.0
TIEMPO DE REGISTRO DE DATOS POR PUNTO:	60 SEGUNDOS

Fig. 8. Distance between ONEC reference station and Bahía de Caráquez city

correction technique using the RTCM 2.3 and RTCM 3.0 format. For demonstrative purpose, only analyze the case to the correction between Ambato and Riobamba cities. To check the complete reference maps and the results review [18]. The Fig. 9 show GNSS reference station denominated EREC located in Riobamba's city to the furthest observation point in Ambato's city, with 49.5 [km] of distance.

It is observed (see Table 5) that the Real-Time correction at the measurement point in the city of Ambato with respect to the EREC station achieves with the RTCM 2.3

Table 4. Difference between Post-Process vs Real Time to Bahía de Caráquez City

	ΔN	ΔE	Δh
MED	0.011	0.011	0.029
MAX	0.036	0.033	0.055
MIN	0.001	0.000	0.001
DESV	0.010	0.009	0.016

Fig. 9. Distance between EREC GNSS base station in Riobamba and Ambato cities

Table 5. Observed correction in Ambato respect EREC GNSS base station with RTCM 2.3 and RTCM 3.0

Format	E [m]	N[m]	Elevation [m]	HRMS [m]	VRMS [m]
RTCM 2.3	765163,028	9864514,592	2595,585	0,014	0,026
RTCM 3.0	765163,017	9864514,592	2595,593	0,011	0,018

format a HRMS (Horizontal Error) of 1.4 [cm] and VRMS (vertical error) of 2.6 [cm], while with the RTCM 3.0 format, HRMS 1.1 [cm] and VRMS 1.8 [cm] are displayed [18].

The survey is repeated around the Ambato city at some points, increasing the radius by 1 [km], taking as pivot a the GNSS reference station. The accuracy reached in the corrections of each point respect to both references GNSS stations EREC and CXEC cities next to Ambato is acceptable, the results support the fact to create a reference accuracy map for the Central andean zone (See Fig. 10) applying Real-Time correction technique for each RTCM format.

The Principal Caster located in IGM is the server that provides access to the correction in Real-Time. After some tests in the outdoor environment, the experiences, and

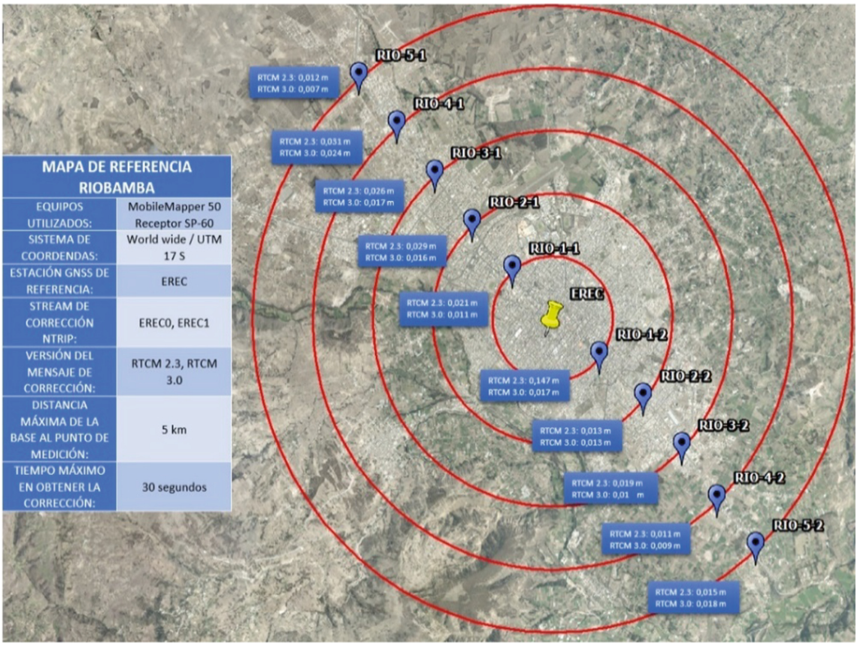

Fig. 10. Riobamba's Accuracy reference map with EREC GNSS reference station

results, there are some feedback, conclusions, and recommendations regarding the use of REGME-IP.

The Real-Time correction technique is a service based on correction data that is transmitted over the internet protocol. The rover device must maintain a constant and stable connection to an Internet Service Provider (ISP) of your preference.

The Real-Time positioning method using the NTRIP protocol does not replace the differential static positioning method, only is a different technique that gives greater productivity in the outdoor survey environment.

The static post-process differential method provides greater accuracy than the NTRIP Real-Time method but requires more processing time to deliver the results.

The advantage of the Real-Time technique is that you can achieve high accuracy with a shorter GNSS positioning time. The results of the horizontal and vertical components are obtained immediately without using post-process correction.

The Static Differential method for each point has 30 min of positioning in the outdoor environment, while the Real-Time based in the NTRIP method for each point is only 60 s.

The horizontal component (N, E) has less error than the vertical component (ellipsoidal height h). For the vertical component, a double or triple horizontal component error is expected.

Statistical results from the 150-point sample indicate an acceptable level of accuracy between the Static Post-Process Differential and Real-Time NTRIP method. In some cases, the difference in the horizontal component reaches the order of the millimeters taking into account that the Differential Static Positioning had a positioning duration of 30 min, compared to the positioning of 60 s with the technique in Real-Time – NTRIP; and at different distances from the REGME station used as Mount Point, from which RTCM 3.0 differential correction messages are generated.

The REGME-IP service, a Real-Time project, is available to users at the national level, under their responsibility with operational equipment and access to the Internet by on ISP.

The Principal and Backup caster are operatives since January 2019, initially worked with BKG NtripCaster Software version Standard; the project was planned in installation, test, fix bugs stages, the constant monitoring avoided damage on server and rovers compromising the service's quality and continuity. In 2020, the IGM plans to provide Real-Time as national service to benefit Ecuadorian citizens; it demands updating to BKG NtripCaster Software version Professional to support all the requirements technical and give quality service that include increase users and station connections simultaneous, network management, security and quality policies. Some tools are creates to facilitate the use of the service, the web site http://www.geoportaligm.gob.ec/ is available with information to register, access to Real-Time service and official documentation generated by the entity responsible. The collaboration between Public Entities and universities represents the effort, support, and teamwork to reach the biggest objectives through the knowledge transfer from their researchers to the benefit of Ecuadorian society.

9 Future Work

The DGPS technique consists of the elimination of common errors produced by the ionosphere and troposphere; the correction can reach to eliminate the error to increase the accuracy in the final solution at the centimeter level; however, the correction of the orbital errors is not considered. The future work includes improving the service of REGME-IP, increasing the Precise Point Positioning service (PPP), and interconnecting between casters servers from international projects. The full operation of the new GNSS constellation demands Real-Time technique analysis to upgrade the service to multi constellations.

References

1. EUREF Permanent GNSS Network. http://www.epncb.oma.be/_organisation/WG/previous/euref_IP/index.php. Accessed 26 Jul 2020
2. BKG GNSS data center. https://kb.igs.org/hc/en-us/articles/115002196848-Real-Time-Service-Fact-Sheet-2014. Accessed 26 Jul 2020
3. Sistema de Referencia Geocéntrico de las Américas. http://www.sirgas.org/fileadmin/docs/Boletines/Bol15/18_Hoyer_et_al_Reporte_SIRGAS_RT.pdf. Accessed 26 Jul 2020
4. Proyecto SIRGAS Tiempo Real. www.fceia.unr.edu.ar/gps/caster. Accessed 28 Jul 2020
5. Zabala, M.: Implementación del caster experimental para la distribución de medidas de GPS en tiempo real a través de NTRIP. In: Conference 2018, Vol. 13, pp. 117–120. Congreso de Ciencia y Tecnología ESPE (2018)
6. Geoportal REGME. http://www.geoportaligm.gob.ec/wordpress/. Accessed 28 Jul 2020

7. Federal agency of cartography and geodesy. https://igs.bkg.bund.de/NTRIP/about. Accessed 28 Jul 2020
8. Zabala, M.: Implementación del caster experimental para la distribución de medidas de GPS en tiempo real a través de NTRIP. In: Conference 2018, Vol. 13, pp. 117–120, Congreso de Ciencia y Tecnología ESPE (2018)
9. Hoyer, M.: Conceptos Básicos del Posicionamiento GNSS en Tiempo Real. In: SIRGAS-RT, Conference (2002)
10. Bonilla, L., Damián, C.: Diseño de un mapa de referencia de corrección en observaciones GPS considerando las restricciones de rango y mensajes de RTCM de DGPS del caster experimental medido en la zona centro del país, Tesis, 35–36, Escuela Superior Politécnica de Chimborazo (2020)
11. RTCM: Recommended standard for differential GNSS (Global Navigation Reference System) Service Version 2.3 (2001)
12. RTCM: Recommended Standard for Differential GNSS (Global Navigation Reference System) Service Version 3.0 (2016)
13. Franklin, L., Ortega, A., Zabala, M.: Análisis e implementación de diferencial GPS en configuración simple y doble. Vol. 7, N° 1, pp. 46–53, Noviembre 2017. https://doi.org/10.24133/maskay.v7i1.343
14. Infraestructura y Cobertura, Boletín N° 2020–02, Agencia de Regulación y Control de las Telecomunicaciones (ARCOTEL). https://www.arcotel.gob.ec/wp-content/uploads/2015/01/BoletinEstadistico-May2020-AMS-CoberturaInfraestructura.pdf. Accessed 15 Sept 2020
15. EUSKADI, Conexión a la red GNSS a través de Internet (2012) Last Access. http://www.gps2.euskadi.net/internet.php
16. Carranza, A., Reyes, J., Zabala, M.: Análisis e implementación de diferencial de GPS en tiempo real a través de la tecnología NTRIP para la EERSA", Tesis, Escuela de Ingeniería en Telecomunicaciones y Redes, ESPOCH, Riobamba, Ecuador (2017)
17. Geoportal. http://www.geoportaligm.gob.ec/geodesia/index.php/informacion-servicios-ntrip/. Accessed 19 Sept 2020
18. Bonilla, L., Damiá,n C.: Diseño de un mapa de referencia de corrección en observaciones GPS considerando las restricciones de rango y mensajes de RTCM de DGPS del caster experimental medido en la zona centro del país, Tesis, 46–47, Escuela Superior Politécnica de Chimborazo (2020)