Latest Enhancements in the Brazilian Active Control Network

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Abstract. The Brazilian Network for Continuous Monitoring of GPS – RBMC, since its foundation in December of 1996, has been playing an essential role for the maintenance and user access of the fundamental geodetic frame in the country. It provides to users a direct link to the Brazilian Geodetic System. Its role has become more relevant with the increasing use of space navigation technology in the country. Recently, Brazil adopted a new geodetic frame, SIRGAS2000, in February 2005, fully compatible with GNSS technology. The paper provides an overview of the recent modernization phases the RBMC network has undergone highlighting its future steps. From its current post-mission mode, the RBMC will evolve into a real-time network, providing real-time data and real-time correction to users. The network enhanced with modern GPS receivers and the addition of atomic clocks will be used to compute WADGPS-type corrections to be transmitted, in real time, to users in Brazil and surrounding areas. It is estimated that users will be able to achieve a horizontal accuracy around 0.5 m (1σ) in static and kinematic positioning and better for dual frequency users. The availability of the WADGPS service will allow users to tie to the new SIRGAS2000 frame in a more rapid and transparent way for positioning and navigation applications. It should be emphasized that support to post-mission static positioning, will continue to be provided to users interested in higher accuracy levels. In addition to this, a post-mission Precise Point Positioning (PPP) service will be provided based on the one currently provided by the Geodetic Survey Division of NRCan (CSRS-PPP). The modernization of the RBMC is under development based on a cooperation signed at the end of 2004 with the University of New Brunswick, supported by the Canadian International Development Agency and the Brazilian Cooperation Agency. The Geodetic Survey Division of NRCan is also participating in this modernization effort under the same project.

Keywords. GNSS, Active Control Network, Wide-Area DGPS

1 Introduction

The Brazilian Network for Continuous Monitoring of GPS (RBMC) (Fortes et al., 1998; IBGE, 2007a), since its foundation in December of 1996, has been playing an essential role in the maintenance and user access of the fundamental geodetic frame in the country. It provides users with a direct link to the Brazilian Geodetic System. Its role has become more relevant with the increasing use of space navigation technology in the country. Recently, Brazil adopted a new geodetic frame, SIRGAS2000, in February 2005, fully compatible with GNSS technology.

Observations are collected by a network of 38 stations. These observations are daily files that are made available to users, via IBGE's web site, within one day, and after their quality has been tested. This availability depends on the type of

connection between the stations and the central storage facility, located in Rio. Most stations communicate with the central facility via the internet or by phone, allowing automatic data transfer. One station communicates via e-mail, a manual, sub-optimal scheme. The stations that composed today's RBMC have been implemented in a stepwise manner since December of 1996. Several institutions and organizations have been collaborating with IBGE either providing the location to have the equipment installed or by providing both receiver and installation. For that reason, not all stations are occupied by the same type of receiver. Figure 1 (shown at the end of the paper to be better visualized) shows the spatial distribution of RBMC stations around the country. All stations use dual-frequency receivers and choke-ring antennas.

Two RBMC stations, the ones in Brasilia and Fortaleza, are part of the International GNSS Service - IGS global network (IGS, 2007a). The remaining ones compose the IGS densification network in South America. These data are processed on a weekly basis by the IGS Regional Network Associate Analysis Center for the continent – IGS RNAAC SIR (Seemueller and Drewes, 2004). A few geodetic organizations in South America, among them IBGE, will take over the responsibility of being a regional analysis centre. This fact ascertains the Brazilian geodetic reference framework to be part of the global frame in a consistent and permanent way, allowing its continuous monitoring and update.

RBMC observations are made available to both national and international communities via IBGE's web site. In February 2005 Brazil adopted a new geodetic geocentric reference frame, SIRGAS2000 (IBGE, 2007b). SIRGAS2000 is a densification of the ITRF2000, realized by means of a two-week long GPS campaign covering the whole of the Americas. SIRGAS2000 is realized in Brazil by most of the current RBMC stations.

In September 2004, an international collaboration was established with the University of New Brunswick under the National Geospatial Framework Project (PIGN), a technology transfer project sponsored by the Canadian International Development Agency (CIDA) with the support of the Brazilian Cooperation Agency (ABC). PIGN (PIGN, 2007) project activities include technical issues, study on the impacts resulting from the adoption of the new geodetic reference frame and communication with user community. The modernization of the RBMC corresponds to PIGN Demonstration Project #7. This Demo Project aims at providing the background for the implementation of a modern reference structure that facilitates the connection to the Brazilian Geodetic System by users. Specifically Demonstration Project 7 will initiate the implementation of real-time and post-mission correction services in Brazil. Both services will provide corrections to facilitate user connection to SIRGAS 2000 for positioning and navigation applications. Since the corrections will be implicitly attached to SIRGAS2000, their application by the users will result in SIRGAS2000 coordinates. Users will then be directly attached to SIRGAS2000 in their positioning and navigation applications. The Geodetic Survey Division of Natural Resources Canada will contribute expertise in the development and operation of a Wide DGPS Service (CDGPS, 2007a).

2 Expansion Plan

The IBGE, in partnership with the INCRA, has been working in the expansion plan of the GPS networks: RBMC and RIBaC - Community Bases Network of INCRA, managed by the INCRA (INCRA, 2007), which will provide a larger national coverage and new characteristics of operation.

That plan is going to endow RBMC/RIBaC with an adequate infrastructure for collecting data from GPS and GLONASS, foreseeing the possibility of collecting GALILEO data in the future.

This plan was put in practice in the year of 2006, with the signature of an agreement between IBGE and INCRA. After that, in the same year, 83 last generation receivers were purchased, followed by the exchange of receiver/antenna in the existing stations, and of the localities where new stations will be installed.

In 2007, it was initiated the exchange of the old receivers/antenna in the existing RBMC stations by the new receivers/antennas acquired in 2006, besides the establishment of new stations.

At the moment, after the first step in the expansion plan (March to May of 2007), RBMC counts with 27 stations in operation, with data available daily in the Internet, and other 11 installed. Figure 1 shows the distribution of the station's network. An example of the new antenna can be seen in the Figure 2.

The data of the stations, after passing for a period of tests and evaluation of its operation, can be obtained freely by the users on the IBGE website, in the RBMC area.

The second phase, programmed for the year 2007, targets the installation of 25 new receivers, extending the present network from 38 to 63 stations.

Fig. 1 First step of the expansion of the RBMC.

Fig. 2 New antenna of the NAUS station.

The main characteristics of these new receivers are:

- Network card integrated into the receiver;
- Online configuration via web browser;
- Data download by FTP (File Transfer Protocol);
- Memory to store up to 15 days of data at 1 Hz.

Table 1 shows the current (July 2007) receivers being used.

Table 1. Type and number of receivers being used.

	Number of receivers	
Receiver Type	**Mar/07**	**Jul/07**
NetRS	2	12
NetR5	0	15
Trimble 4000ssi	17	4
Leica GSX1200	1	2
Ashtech ZFX	4	4
Ashtech UZ-12	0	1
Number of Receivers	24	38

3 Modernization Plan

The modernization of the RBMC is under development based on a cooperation agreement signed at the end of 2004 with the University of New Brunswick, supported by the CIDA and the ABC (Fortes et al., 2006a and Fortes et al., 2006b). The Geodetic Survey Division of NRCan is also participating in this modernization effort under the same project. From its current post-mission mode, the RBMC will evolve into a real-time network, providing real-time data and real-time correction to users.

The enhanced network, with modern GPS receivers and the addition of atomic clocks (Figure 3), will be used to compute WADGPS-type corrections to be transmitted, in real time, to users in and surrounding areas. It is estimated that users will be able to achieve a horizontal accuracy around 0.5 m (1-sigma) in static and kinematic positioning and better for dual frequency users.

Fig. 3 New receiver of the ONRJ station with atomic clock.

The availability of the WADGPS service will allowusers to tie to the new SIRGAS2000 frame in a more rapid and transparent way for positioning and navigation applications. It should be emphasized that support to post-mission static positioning will continue to be provided to users interested in higher accuracy levels.

This new structure, after entirely implanted, will have as main characteristics:

– Make use of remote and automatic Active Control Points (ACP);
– Transfer 1-Hz real time data from ACPs to the Network Control Center, located in Rio de Janeiro;
– Generate real-time WADGPS corrections (orbit, clocks and ionospheric);
– Make corrections available to users in Brazil (and surrounding areas) through Internet;
– Offer a Precise Point Positioning (PPP) service to users (Tétreault et al., 2005);
– Offer a horizontal accuracy around 0.5 m (1-sigma) in static and kinematic positioning and better for dual frequency users;
– Collaborate with international organizations such as the IGS-IP network .

At present, the station National Observatory – ONRJ (Figure 3), located in the Rio de Janeiro, is contributing to the IGS-IP network, has its data in real time in the following address: <http://www.igs-ip.net>.

A requirement to be satisfied is to have a subset of receivers connected to an atomic clock. At least 2 receivers can satisfy this requirement. One, which is located in Fortaleza, will be connected to a Hydrogen Maser. The other is located in Rio de Janeiro and will be collocated to the Brazilian Time Service at the National Observatory. The clocks will be used to help the WADGPS-type correction computations, which will be transmitted in real-time, to users in Brazil and surrounding areas.

To offer these services, new equipment has been procured, such as 2 high-performance workstations to handle the computations, as well as 5 servers for the storage of data, up to 1.4 TB each.

The software NTRIP - *Networked Transport of RTCM via Internet Protocol* in *stream*, has been tested to be used for the transmission of data and corrections.

A pilot project formed by a sub-network of 6 stations (as shown in Figure 4) will be used to test the real-time capabilities of the network

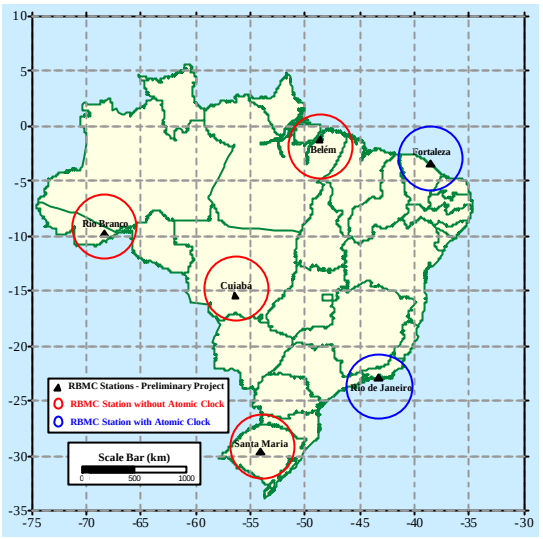

Fig. 4 RBMC stations involved in the real-time data transmission test.

4 Conclusions

The growing use of space technology in Brazil has led to the enhancement plans for the current geodetic infra-structure of the country. These plans include a modern active network delivering not only data files for post-mission positioning but also WADGPS-type corrections to be made available to users all around the country. The RBMC network has been the fundamental geodetic infrastructure in Brazil since its inception in 1996, providing accurate connection to the Brazilian Geodetic System, in post-processing mode. Modernizations steps include new receivers; adding value with the land reform network RIBaC to use some of their stations as part of the fundamental active network; fully automatic ACPs, being some of them collocated with atomic frequency standards; the generation of correction at the Master Active Control Station - MACS; transmission of corrections through various media to users. These developments are taking place under a collaborative effort with the University of New Brunswick and with the Geodetic Survey Division of Natural Resources Canada under the National Geospatial Framework Project, supported by CIDA. The Land Reform institute (INCRA) will contribute a total of 65 new geodetic receivers.

The application of WADGPS corrections will allow users to be attached to SIRGAS2000 in a direct and clear way in positioning and navigation applications. It is believed that users will be capable of real-time static and kinematic positioning with a 2D accuracy of 0.5 m (DRMS) or better, depending on the type of receiver used. For higher post-processed accuracies, a new post-mission PPP service, in addition to the current ACP data files, will also be available.

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