RBMC in Real Time, Via NTRIP, and its Benefits in RTK and DGPS Surveys

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1 INTRODUCTION

The Instituto Brasileiro de Geografia e Estatística - IBGE has been working in partnership with the Instituto Nacional de Colonização e Reforma Agrária - INCRA on the expansion of the permanent GNSS networks RBMC (Brazilian Network for Continuous Monitoring of GPS, managed by the IBGE) and RIBaC (Community Bases Network of INCRA, managed by the INCRA). RBMC is today the main geodetic reference structure of the country, whose information is important for the scientific community and for practical purposes, providing to the users a direct link to the Brazilian Geodetic System (SGB) and the main link with international networks, like IGS and SIRGAS-CON.

Currently, IBGE is working on providing new services together with the modernization of the RBMC, such as real-time services via Internet using NTRIP (Networked Transport of RTCM via Internet Protocol), called RBMC-IP. The NTRIP is a HTTP protocol developed with the intention to substitute radio links by wireless Internet, for example using GPRS, GSM or 3G. A NTRIP caster is in operation at IBGE and receives the streams of 26 stations established in the main cities of Brazil.

RTK (Real Time Kinematics) or DGPS (Differential GPS) are positioning techniques based on the corrections of GNSS satellites' signals that are transmitted, in real time, from the reference station to a station whose coordinates need to be determined. Normally the corrections are transmitted to the rover receivers via UHF radio, which is installed together with the GNSS receiver in a station with known coordinates.

NTRIP is implemented in three system software components (Fig. 1): NtripClients, NtripServers and NtripCasters. The NtripCaster is the actual HTTP server program whereas NtripClient and NtripServer are acting as HTTP clients.

In order to evaluate this new real-time service in terms of precision and accuracy, some tests were realized in Rio de Janeiro state using code and phase observables in static and kinematic mode. Parameters like distance to the reference stations and the reliability in urban and rural areas were considered in this evaluation.

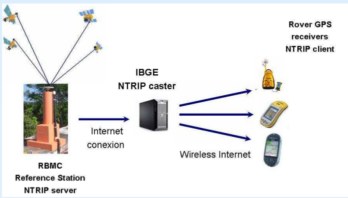


Fig. 1 – Scheme of NTRIP components.

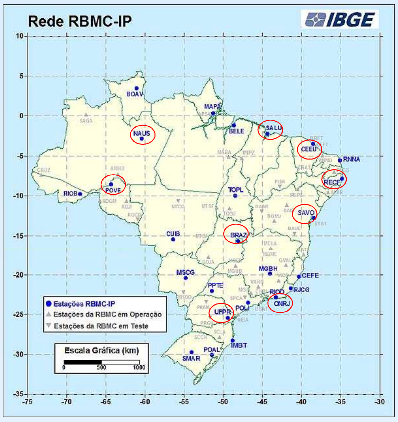


Fig. 2 – Configuration of the RBMC-IP network.

2 RBMC-IP SERVICE

It is a real-time positioning service from the RBMC, for users who make use of RTK (real time kinematics) or DGPS (differential GPS) survey techniques. The transmission of the data is carried out the following way: a GNSS receiver continuously sends RTCM messages to the IBGE server where the NTRIP caster is installed. The user, with a client application, such as GNSS Internet Radio or BNC (BKG NTRIP Client) and with wireless Internet, connects to the IBGE server and chooses the station(s) of the RBMC-IP whose corrections he desires to receive. The corrections are received by users´ (to rover) through a serial port (2101) and in such a way allows the computation of the corrected position by the rover.

Currently, IBGE caster receives data from 26 stations located in the main capitals of the Brazilian states (Fig. 2). Six of the 26 stations contribute for the global real time network, RTIGS (Real-Time International GNSS Service) and nine also contribute for the global network IGS-IP. These nine stations are marked with a red circle in Figure 2.

The access to the IBGE caster is free, however it is necessary that users fill a registration form in order to use the RBMC-IP service. Some restrictions of access are necessary in order to prevent congestion of traffic in IBGE network, they are:

1 - Users are only allowed to access three stations simultaneously.

2 - The identification and password for access will be valid for a maximum period of three months;

3 TESTS PERFORMED

The main purpose of the tests carried out was to show the confidence of NTRIP solutions in different survey modes, for example, static and kinematic.

For static mode, two tests were realized, one using different reference stations in ten different periods each. The distances from reference station vary from 12 to 669 km. The second test was realized in a local network in Rio the Janeiro state. The rover receiver occupied 11 geodetic stations with known high precision coordinates. In both cases the rover receiver was double frequency. The parameters analyzed in these two tests were: number of satellites observed, latency, precision and accuracy.

For the kinematic mode, a test was performed by the Brazilian Navy during a bathymetric survey with the purpose to update the nautical cartography in an area south of the Brazilian coast, using RTK corrections. For the validation of the NTRIP solution, and the standard RTK solutions using radio link for the transmission of corrections, the horizontal precision according to the International Hydrographic Organization (IHO) was used. A comparison between these two solutions was performed.

A driving test was realized on the main road that links Rio de Janeiro to São Paulo. The distance from the reference station reached was approximately 50 km. In this test three types of receivers were used: a navigator, single frequency and double frequency. The wireless communication link used in all cases was wide band 3G. The driving speed reached up to 80 kilometers per hour. The driving route passes through forests and mountains with many curves. The main objective of the driving test was to check the system performance under the following aspects:

• Behavior of the wireless communication link while the rover receiver moves at a speed of up to 80 kilometers per hour,

•Compare real-time results with post-mission, like PPP.

4 RESULTS

STATIC

Mean values after 10 observations using the same Ref. station.

Ref. Station	Dist. from rover(Km)	σ lat (±m)	σ lon (±m)	σ vert. (±m)	Type of sol.	n° of sat. used	Horiz. Acc. Dif.(m)	Vert. Acc. Dif.(m)
ONRJ	12	0,011	0,012	0,019	integer	10	0,008	-0,206
RJCG	235	0,204	0,220	0,458	float	9	0,110	-0,110
MGBH	325	0,239	0,198	0,477	float	9	0,397	0,143
UFPR	669	0,357	0,459	0,874	float	8	0,279	0,163

After 10 sessions on each Ref. Station (or mountpoints), the convergence of solutions were achieved between 10 to 12 minutes. The horizontal components have centimeter accuracy and precision for short distances from Ref. Stations. For distances longer than 200 km a sub-meter solution accuracy and precision is achieved.

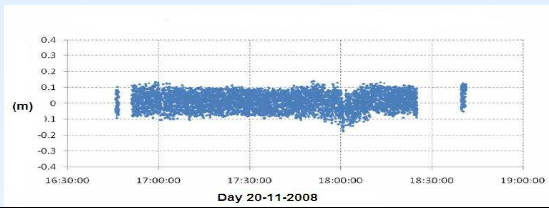
Regional Network

RBMC Station	Rover	Dist. *Rover*-RBMC (km)	σ Horizontal (±m)	σ Vertical (±m)	n° of sat. used	Horiz. Acc. Dif.(m)	Vert. Acc. Dif.(m)	Type of sol.	Latency (seg.)
RIOD	91893	91,9	0,26	0,29	11	0,04	0,82	Float	2
POLI	93937	208,7	0,25	0,32	9	0,21	0,40	Integer	3
RIOD	93640	39,3	0,03	0,03	9	0,01	0,14	Integer	3
RIOD	91964	132,7	0,26	0,33	9	0,05	0,16	Float	3
RIOD	91966	79,2	0,03	0,04	9	0,01	0,03	Integer	2
RIOD	93955	30,8	0,02	0,03	9	0,06	0,06	Integer	2
RIOD	91866	68,8	0,23	0,32	8	0,04	0,37	Float	2
RIOD	91870	47,9	0,04	0,03	10	0,02	0,02	Integer	2
RIOD	91867	77,1	0,21	0,38	9	0,34	0,17	Float	2
ONRJ	91956	205,7	0,31	0,61	7	0,06	0,30	Float	2
RIOD	91956	206,6	0,33	0,58	7	0,03	0,21	Float	2
RJCG	91956	44,6	0,03	0,05	13	0,01	0,17	Integer	2

Results are similar to the first case, but tests were realized using shorter distances. The tests showed that integer solutions are achieved until 80 km (from Reference station), and centimeter accuracy for horizontal and vertical components in most of cases.

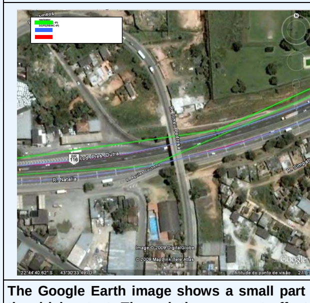
KINEMATIC

A bathymetric survey was realized along the Brazilian coast from IMBT (reference station) to Laguna (rover). The rover receiver was located 32 km from the NTRIP reference station and 4 km from the radio reference station.



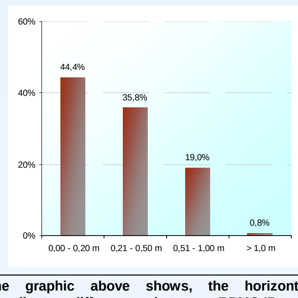
The differences between horizontal coordinates obtained from radio and NTRIP didn´t exceed 10 cm, during all period of survey. These results confirm the similar quality of RBMC-IP service when compared with radio.

Driving test



The Google Earth image shows a small part of the driving test. The solution was not affected with the presence of a bridge and the good agreement between DGPS and RTK solutions (in blue and red) is evident.

Driving test: RBMC-IP x PPP



The graphic above shows, the horizontal coordinates differences between RBMC-IP and PPP. The differences didn´t exceed 20 centimeter in 44% of observations and only 0,8% exceed 1,0 meter.

5 FINAL REMARKS

In places where the reception of mobile communications is available NTRIP is a powerful tool for a diversity of surveys, for example, cadastre, mapping, GIS, etc.

With the expansion of the RBMC and communication services of GSM, GPRS and 3G in the Brazilian cities, the NTRIP will be more present in the new culture of "real time". The NTRIP is based on the concept of diffusion of open GNSS data from different sources through long distances.

The tests carried out revealed that few centimeters of accuracy can be reached for distances up to 80 km from the reference station and a sub-meter accuracy is obtained for distances between 80 to 500 Km from the reference station.

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