Artigo

GEOMETRIC QUALITY ANALYSIS OF THE GNSS NETWORK LOCATION OF UFU - SANTA MONICA CAMPUS

Lorena Araújo Silva
Maria Lígia Chuerubim
Ana Carolina Gonzaga Pires
Plínia Guedes Gomes

p. 30-47

revista

CIGA
CENTRO DE CARTOGRAFIA APLICADA E INFORMAÇÃO GEOGRÁFICA
UNIVERSIDADE DE BRASÍLIA - DEPTo. DE GEOGRAFIA

T - T - T

Eletronic Magazine:
Time - Technical - Territory,
V.4, N.1 (2012), 30:47 ISSN:
2177-4366

DOI: https://doi.org/10.26512/ciga.v4i1.16323

Como citar este artigo:
SILVA, L. A., *Ana Carolina Gonzaga Pires, Maria Lígia Chuerubim, Plínia Guedes Gomes.* GEOMETRIC QUALITY ANALYSIS OF THE GNSS NETWORK LOCATION OF UFU - SANTA MONICA CAMPUS.
Revista Eletrônica: Tempo - Técnica - Território, v.4, n.1 (2013), p. 30:47 ISSN: 2177-4366.
DOI: https://doi.org/10.26512/ciga.v4i1.16323

available in:
http://inseer.ibict.br/ciga/index.php/ciga/article/viewFile/172/131

GEOMETRIC QUALITY ANALYSIS OF THE GNSS NETWORK LOCATION OF UFU - SANTA MONICA CAMPUS

Lorena Araújo Silva[1]
Maria Lígia Chuerubim[2]
Ana Carolina Gonzaga Pires[1]
Plínia Guedes Gomes[1]

[1] Aluna de Graduação da Faculdade de Engenharia Civil da Universidade Federal de Uberlândia - UFU/FECIV
Caixa Postal 593 – 38408-100 - Uberlândia - MG, Brasil
araujolorena.s@gmail.com
anacarolina.g.p@hotmail.com
plinia_guedes@hotmail.com

[2] Professora Mestra da Faculdade de Engenharia Civil da Universidade Federal de Uberlândia - UFU/FECIV
Caixa Postal 593 – 38408-100 - Uberlândia - MG, Brasil
marialigia@feciv.ufu.br

ABSTRACT: In order to suit the development of researches, practical classes and others outreach activities, it was verified the importance of improve the quality of the network Global Navigation Satellite Systems (GNSS) location of Federal University of Uberlândia (UFU), Santa Monica campus. The GNSS network of the university is the passive network that was implanted six years ago, with approximately 19 stations. In the following years, new densification was performed by adding four stations: CIV01, CIV02, CIV03 and CIV06. However, many stations were uprooted and/or relocated because of the campus ' expansion and the servers and community's lack of information. These factors directly affect the geometric quality network, interfering in the development of topographic and/or geodesic activities. After the diagnosis of the pre-existing network, were developed strategies to verify the best locations for the deployment and materialization of the new stations. At this stage, it was considered the recommendations of the Brazilian Institute of Geography and Statistics (IBGE), and it was analyzed the master plan of the university. Fifteen new stations were materialized and integrated into the existing network. The processes of densification and integration of the local network GNSS at the university have been contributing with the activities undertaken by members of the Laboratory at the Civilian

Topographic Engineering Faculty (FECIV), which includes teaching, research and extension activities.

Key words : Geodesic Marks, GNSS Network, Geodetic Survey.

RESUMO: Para o desenvolvimento adequado de pesquisas, ensino e atividades de extensão, verificou-se a necessidade de melhorar a qualidade da rede *Global Navigation Satellite System* (GNSS) local da Universidade Federal de Uberlândia (UFU), campus Santa Mônica. A rede GNSS da UFU é uma rede passiva que foi implantada há cerca de 6 anos no campus, com aproximadamente 19 estações. Nos anos seguintes, foi realizada uma nova densificação desta rede, com a adição de 4 estações: CIV01, CIV02, CIV03 e CIV06. No entanto, a expansão do campus e a falta de informação dos servidores e da comunidade em geral, fez com que muitas estações fossem removidas ou realocadas indevidamente. Estes fatores afetam diretamente a qualidade geométrica da rede, interferindo no desenvolvimento de atividades topográficas e/ou geodésicas. Após o diagnóstico da rede existente, foram elaboradas estratégias a fim de se verificar as melhores localidades para a implantação e materialização das novas estações. Nesta etapa, foram adotadas as recomendações do Instituto Brasileiro de Geografia e Estatística (IBGE), bem como a consulta do plano diretor do campus. Materializou-se 15 novas estações que, posteriormente, foram integradas a rede pré-existente. Os processos de densificação e integração da rede GNSS local da UFU vêm contribuindo com as atividades desenvolvidas pelos membros do Laboratório de Topografia da Faculdade de Engenharia Civil (FECIV), no que contempla às atividades de ensino, pesquisa e extensão.

Palavras-chave: Marcos Geodésicos, Rede GNSS, Levantamento Geodésico.

RESUMEN: Para el desarrollo adecuado de las actividades de investigación, enseñanza y extensión, hay una necesidad de mejorar la calidad del sistema de satélites de la red global de navegación (GNSS) de la Universidad Federal de Uberlândia Local (UFU), campus Santa Mónica. La red GNSS UFU es una red pasiva que se ha implementado durante unos seis años en la escuela, con aproximadamente 19 estaciones. En los años siguientes, se realizó una nueva densificación de la red, con la adición de 4 estaciones: CIV01, CIV02, CIV03 y CIV06. Sin embargo, la expansión del campus y la falta de información de los servidores y de la comunidad en general, fueron las razones para la eliminación de los puntos, así como su reubicación indebida. Estos factores afectan directamente la calidad de la red geométrica, lo que interfiere con el desarrollo de las actividades topográficas y / o geodésica. Después del diagnóstico de la red existente, las estrategias fueron desarrolladas con el fin de verificar las mejores ubicaciones para la aplicación y realización de las

nuevas estaciones. En esta etapa, hemos adoptado las recomendaciones del Instituto Brasileño de Geografía y Estadística (IBGE), así como la consulta del plan maestro del campus. Materializada 15 nuevas estaciones que posteriormente se integraron en la red existente. Los procesos de densificación y la integración de los GNSS red local UFU están contribuyendo a las actividades llevadas a cabo por miembros del Laboratorio de Topografía de la Facultad de Ingeniería Civil (FECIV), que incluye las actividades de docencia, investigación y extensión.

Palabras clave:

Introduction

According to the Brazilian Institute of Geography and Statistics (IBGE), the geodetic surveys comprise a set of activities focused on measurements and observations of physical and geometrical quantities that lead to obtaining parameters of a points system (IBGE, 1983). Thus, the elaboration of General letters, the control and the rental of engineering projects, drainage studies and gradients in areas of high topography, as well as other activities, are related to the observation and getting results from geodetic surveys (MONIC, LEICK, 2004 and 2008).

These surveys are carried out with the help of points on the Earth's surface materialized, which together form the passive or active geodetic networks. In Brazil, the IBGE data planimétricos, different offers and gravimetric stations linked to the Brazilian geodetic system, through the Brazilian network for continuous monitoring (RBMC).

For the measurement of points it must be parsed any limitations that each lifting technology offers. Although ensure good accuracy, data collection through the use of *Global Positioning System* (GPS), for example, can become infeasible in urban areas or dense vegetation cover due to the presence of physical obstructions, leading to loss of cycle and multipath (SEEBER, 2003). So, it is necessary to resort to the use of other GeoTechnologies as, for example, a total station to terrestrial angular and linear measurements. To avoid such problems, it is necessary for the establishment of a geodetic network follow the principle of network optimization (MONIC, 2008 and SEEBER, 2003).

The optimized network concept is connected to the configuration of the points and the hierarchy between the measurements. The quality of a network must be bound to accuracy and reliability that it provides (MARINI, 2002).

In order to maintain the reliability of the estimated results, the IBGE establishes specifications and standards for each type of survey (triangulation, trilateração, poligonação, tracking satellites). In this way, the necessary guidelines are established for the binding of the Brazilian geodetic system

(GBS), and these documents are obtained from the e-mail address: http://www.ibge.gov.br/home/geociencias/geodesia/default_normas.shtm (access: 03/2013).

From this point of view, this research aimed to densify, integrate and adapt the GNSS network site of the Universidade Federal de Uberlândia (UFU), Santa Monica campus, the SGB, IBGE's recommendations and clarifications provided by the placement existing GeoTechnologies as GNSS. To this end, the diagnosis of the pre-existing network and its densification process and integration to the SGB, based on the use of control stations belonging to RBMC MGUB station, located in the municipality of Uberlândia/MG and in the own campus of study. This work also contributes to the maintenance of the network and to the activities of research, teaching and extension developed by the University.

1 Geodetic Marks

In order to standardize the materialization of all seasons of altimetric, gravimetric and plan networks that are part of the SGB, the IBGE provides rules that deal with the materialization of the GEODESIC (IBGE, 2008). According to the standardization of geodetic landmarks of IBGE, the deployment of these landmarks can be performed in three ways (IBGE, 2008):

1. Spiked Plate in existing stable surface on the site;
2. Marco or concrete pillar with inlaid on the top plate;
3. Concrete Pillar with forced centering device encrusted on the top and spiked on the side plate.

The IBGE also makes recommendations as to the place of materialization of the mark, in order to avoid degradation and difficulties. Thus, the GEODESIC mark must be deployed in stable and visible locations (IBGE, 2008).

In addition, to ensure the reliability of results, must-avoid places near the microwave transmission stations, radars, radio antennas, repeaters and high-voltage transmission lines, locations near the trees and dense vegetation, as well as sites that have influence of vibrations and shock (IBGE, 2008).

Santa Mônica campus of the UFU, there is only one materialization of forced centering: the IBGE16. The other campus stations are just spiked plates on the surfaces (Figure 1) or encrusted plates on top of concrete pillars (Figure 2).

Figure 1 . Spiked plate on stable surface.

Source : Authors (2013).

Figure 2 . Inlaid plate on a concrete pillar.

Source: CHUERUBIM et. Al. (2013).

2 Methodology

Initially, assessed the quality of network local pre-existing UFU GNSS, the feasibility of use of geodetic and topographic applications.

Later, the mark selected based on your criteria of conservation and location were such by means of screening with Promark2 model GPS receivers of simple frequency of ASHTECH, in three distinct and sidereal days in different intervals of the day, with a minimum duration of 30 minutes (Figure 3).

Figure 3. GNSS network stations Tracking the UFU.

Source: Authors (2013).

At this stage, the GPS data from GNSS network site of the UFU (FECIV01, FECIV02, FECIV03, FECIV04, FECIV05, FECIV08, FECIV13, FECIV10, FECIV14, FECIV17, FECIV19, FECIV20, CIV01, CIV02, CIV03, CIV06, IBGE16), Santa Monica campus, and the reference station RINEX files MGUB, as well as the precise orbits of the *International GNSS Service* (IGS), available at http://igscb.jpl.nasa.gov/components/prods_cb.html (access: 03/2013), and the absolute calibration parameters, provided by the *National Geodetic Survey* (NGS), available at http://www.ngs.noaa.gov/ANTCAL/(access: 03/2013), were processed and set in the *software* and processing data adjustment Topcon GNSS Tools version 8.2 to obtain the coordinates of the stations and their details. The estimated coordinates were then compared with the information provided in their descriptive with the topography of FECIV lab, as a way to check the reliability of the coordinates of the stations and relocated points.

Made network analysis, strategic deployment of new geodetic marks, i.e. the density of the GNSS network site of the UFU, considering the expansion plan of Santa Monica campus. To this end, recommended materialization forms were used by the IBGE as sheet metal spiked directly on surfaces stable and concrete mark stuck in the ground (Figure 4).

Figure 4. Metal plate carved in concrete block.

Source: Authors (2013).

After the network densification, the screening of the new points obeying IBGE's recommendations with regard to the survey of existing landmarks. In this step, in addition to the use of the Promark2 model GPS receivers, was also used Promark100 of simple frequency receivers. The data obtained and the MGUB station RINEX files have been processed and adjusted to obtain the coordinates of the new stations.

From the results obtained joined the pre-existing network to new stations deployed through connection stations, i.e. points common to both networks, applying the Parametric Method with the addition of new equations and observations (GEMAEL, 1984). Therefore, the geodetic network of University was densified and SGB-integrated, resulting in a passive network with more than 30 points distributed throughout campus, serving in support of the work of various natures, geodetic and topographic are.

3 Pre-existing geodetic network

From the data obtained in the laboratory of topography of FECIV, it was observed that there are approximately six years, were deployed on the campus to purely passive stations 19 academics: FECIV01, FECIV02, FECIV03, FECIV04, FECIV05, FECIV07, FECIV08, FECIV13, FECIV10, FECIV11, FECIV12, FECIV14, FECIV15, FECIV16, FECIV17, FECIV18, FECIV19, FECIV20 and IBGE16. These stations have been materialized through sheet metal spiked in soil, with the exception of the vertex IBGE16, comprising a forced centering station and materialized on a concrete pillar.

Later, there was a small network densification with the deployment of four seasons: CIV01, CIV02, CIV03 and CIV06. These were also materialized with spiked metal sheets on the ground and were all located near the block 1Y of FECIV, unlike the first deployed stations that were distributed throughout the campus of the University. However, in the light of this densification have been more recent, their data were not tabulated by the laboratory of FECIV topography.

Making the diagnosis of these stations, it was found that the pre-existing network suffered changes and degradation as a function of the campus expansion plan and the lack of information from servers and other members of the community, which would follow the points deployed even with copyrighted notice present in spiked boards on the same (Figure 5).

Figure 5 . Marco GNSS network UFU site removed.

Source: CHUERUBIM et. Al. (2013).

It was found, after the Network Diagnostics, that FECIV07, FECIV11, FECIV12, FECIV15, FECIV16 and FECIV18 have not been located. Soon, the old network had a *deficit* of six stations, topographic and geodetic works limiting, as well as of other users that require spatial information.

Stations that were located in good conditions of use were occupied with Promark2 receptors in three different times and at different intervals of the day with a 30-minute screening, applying the method of relative positioning (Figure 6). It took the height of 2 meters as standard for all points, to minimize the influence of multipath.

The results obtained with the *software* Topcon Toolsin SIRGAS2000 are shown in table 1. For processing, the determinations were considered technical standard of Georeferencing of rural properties-NTGIR (INCRA, 2010), which recommends the following quality parameters: horizontal accuracy less than 0.1 metres and vertical precision less than 0.3 metres to vertices of Class C1. Also considered as the dilution of precision as a function of the geometry of the satellites during the screening of the seasons, following the recommendations of NTGIR, which recommends less than 6 PDOP relative static lifting fast.

Figure 6 . Pre-existing local GNSS network stations UFU.

Source: Google Earth (2013).

From Table 1, it is observed that the vertical precision were higher than horizontal details, except for the IBGE16, FECIV2 and FECIV17 stations. These last two seasons have kept details of 0, 002m to the three determinations of coordinates. IBGE16 station, in turn, presented details of 0.001 for the three components as well. This fact has led to results quite satisfactory for the vertical component, since according to the literature, higher precisions are expected for the determination of geometric altitude.

As the reference station (MGUB) is located within the University campus, the passive stations formed short baselines with the base. In this way, the process has led to reliable results, with details rather than specification limits imposed by the NTGIR.

Table 1 . Geodetic Coordinates network GNSS stations pre-existing local of the UFU (2000.4 SIRGAS).

Station	Latitude (φ)	σ_φ (m)	Longitude (λ)	σ_λ (m)	Geometric Altitude (h)	σ_h (m)
FECIV01	18° 55 ' 07.95383 "	0.003	48° 15 ' 26.11376 "	0.003	859.044	0.005
FECIV02	18° 55 ' 03.45407 "	0.002	48° 15 ' 27.01144 "	0.002	856.008	0.002
FECIV03	18° 55 ' 02.78438 "	0.004	48° 15 ' 22.73563 "	0.004	858.585	0.006
FECIV04	18° 55 ' 02.07531 "	0.006	48° 15 ' 19.56998 "	0.006	860.437	0.008
FECIV05	18° 55 ' 05.69046 "	0.002	48° 15 ' 22.30829 "	0.002	859.949	0.003
FECIV08	18° 55 ' 07.63364 "	0.003	48° 15 ' 22.23186 "	0.004	860.718	0.005
FECIV13	18° 55 ' 11.65620 "	0.006	48° 15 ' 29.86797 "	0.006	857.285	0.009
FECIV10	18° 55 ' 08.96679 "	0.003	48° 15 ' 31.27476 "	0.003	855.597	0.005
FECIV14	18° 55 ' 12.88946 "	0.005	48° 15 ' 34.50337 "	0.006	852.97	0.007
FECIV17	18° 55 ' 13.52208 "	0.002	48° 15 ' 37.41100 "	0.002	853.036	0.002
FECIV19	18° 55 ' 14.27437 "	0.007	48° 15 ' 43.28612 "	0.007	848.912	0.01
FECIV20	18° 55 ' 11.57177 "	0.004	48° 15 ' 41.61471 "	0.004	848.248	0.06
CIV01	18° 55 ' 04.82939 "	0.003	48° 15 ' 18.93879 "	0.003	862.098	0.005
CIV02	18° 55 ' 07.44485 "	0.003	48° 15 ' 18.32384 "	0.003	864.65	0.005
CIV03	18° 55 ' 07.62059 "	0.005	48° 15 ' 20.33918	0.005	861.903	0.007
CIV06	18° 55 ' 02.55437 "	0.007	48° 15 ' 22.82877 "	0.006	858.341	0.009
IBGE16	18° 55 ' 01.93676	0.001	48° 15 ' 19.47003	0.001	860.51	0.001

To verify the discrepancies between the data collected in the field and the data provided by the laboratory of FECIV topography, PROGRID tool was used, provided by IBGE at address http://downloads.ibge.gov.br/downloads_geociencias.htm (access: 03/2013), to convert geodetic coordinates in Cartesian coordinates. With this conversion, it was possible to calculate the errors in terms of three-dimensional Cartesian coordinates as follows in Table 2. However, the laboratory did not have the scheduled records of all seasons, which culminated in the need to make a sampling (increase in the number of traces, etc.) of data to check the reliability of the network.

It was observed that the stations FECIV05 and FECIV14 showed gross errors, as well as discrepancies were largest in the horizontal components, the mistakes were quite high. In an analysis in conjunction with lab technicians, there was the possibility of having been a reallocation of these milestones and their coordinates have not been amended in descriptive of the University.

The FECIV17, FECIV19 and FECIV20 stations, in turn, presented the smallest discrepancies, with errors of less than 0, 06 m. It turns out that the three stations are quite close, located on a campus that has a few physical obstructions.

Due to the large afforestation of the University, the errors present in other seasons may have been accentuated by the obstacles imposed on GPS signal reception. For example, the FECIV13 station is located under trees, which hindered the achievement of results that meet the NTGIR, requiring the occupation of the station for more than three times.

Table 2. Discrepancies between the coordinates collected in the field and the coordinates obtained in the laboratory of FECIV topography.

Name of the	Δ X (m)	ΔY (m)	ΔZ (m)
FECIV01	0.570	0.332	0.372
FECIV02	0.189	1.453	4.241
FECIV03	0.553	0.345	0.362
FECIV04	0.570	0.371	0.377
FECIV05	74.350	79.089	35.400
FECIV08	0.538	0.367	0.362
FECIV13	0.655	2.465	4.559
FECIV10	4.761	0.304	6.49
FECIV14	457.756	266.28	259.708
FECIV17	0.045	0.049	0.024
FECIV19	0.050	0.056	0.014
FECIV20	0.047	0.051	0.018
IBGE16	0.681	0.723	0.309

4 Establishment of new geodetic network

After the diagnosis of the pre-existing network and the need for deployment of new landmarks on campus, he has been trying to investigate situations that could interfere with the quality of the network in the near future, such as expansion work at the University.

So was obtained at the Faculty of architecture and Urbanism and Design (Which) of the UFU, lease campus map (Figure 7). From the sketch, it was possible to check areas that would be occupied by new buildings or areas with approved projects to be built (these areas are represented by the color blue on the map).

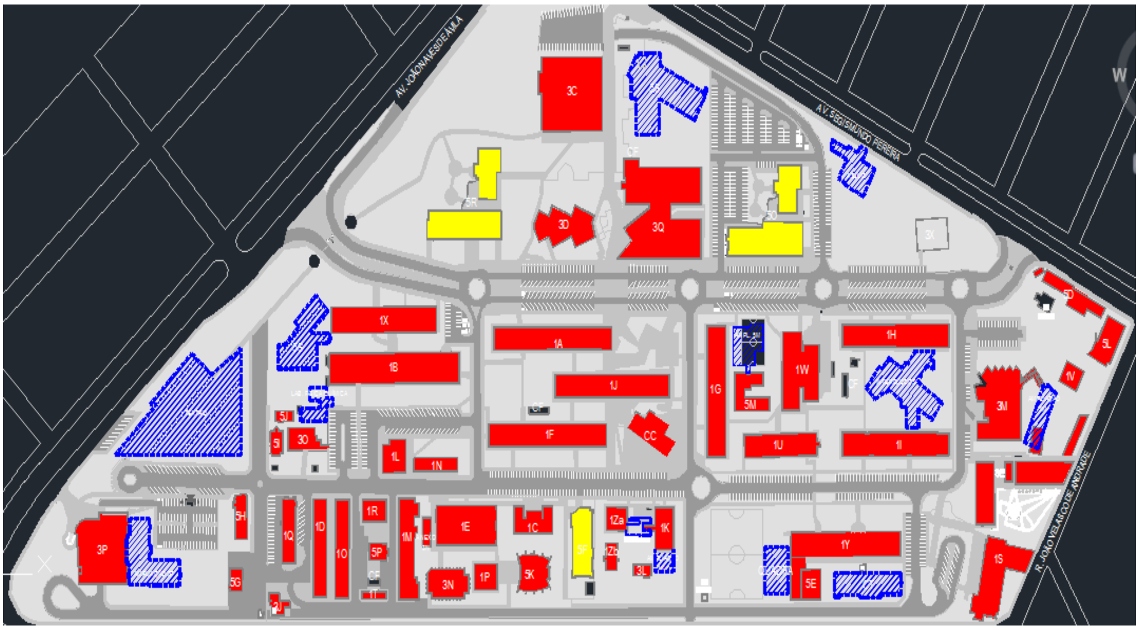

Figure 7. Map of location of the Federal University of Uberlândia.

Source: UFU/DIROB (2009a).

Through this feature, it was possible to carry out a plan to ensure a homogeneous and optimized distribution of marcos. In this way, following the criteria established stations materialization by IBGE, sought to avoid places near the trees and artificial structures, giving priority to stable areas (IBGE, 2008).

For additional information about the vegetation obstructions, we used the environmental map of the campus, also provided by Which (Figure 8).

However, despite favouring the recommendations of the Office, it was also necessary to consider the necessity of intervisibility of the seasons, to make it possible to carry out topographical surveys. Thus, the formation of polygonal campus was a substantial factor for the formation of the new network.

Figure 8 . Environmental map of the Federal University of Uberlândia.

Source: UFU/DIROB (2009b).

Soon, in order to meet criteria and/or topographical, geodetic materialized 15 new stations: CIV31, CIV36, CIV34, CIV25, CIV26, CIV30, CIV21, CIV27, CIV32, CIV33, CIV24, CIV35, CIV20, CIV28 and CIV23. The distribution of points can be seen in Figure 9.

Figure 9 . Material on campus stations.

Source: Google Earth (2013).

These stations were occupied and tracked with GPS receivers Promark2 and Promark100 models. For processing and adjustment of GPS data using the Topcon tools program, version 8.2, adopting for the estimation of coordinates and accuracies of the seasons, the same strategies used in the diagnosis of the pre-existing local area network. The results obtained are shown in table 3.

As predicted in the literature, the worst points were observed for the components vertical networks of stations, reaching magnitudes of 0.002 to 0.011, while for the plan the component values were around 0.002 to 0.008. However, both clarifications were in the order shall, with the exception of the results obtained for the FECIV21 station, which means that the reliability of coordinates obtained is satisfactory.

Table 3 .Geodetic Coordinates of the stations of new GNSS Network site of the UFU (2000.4 SIRGAS).

Station	Latitude (φ)	σ_φ (m)	Longitude (λ)	σ_λ (m)	Geometric Altitude (h)	σ_h (m)
CIV31	18° 55 ' 10.39076 ' S	0.006	48° 15 ' 35.11770 "W	0.005	852.666	0.007
CIV36	18° 55 ' 10.40468 ' S	0.005	48° 15 ' 35.09544 "W	0.005	852.665	0.007
CIV34	18° 55 ' 08.51984 ' S	0.004	48° 15 ' 35.41950 "W	0.005	852.649	0.006
CIV25	18° 55 ' 05.38394 ' S	0.003	48° 15 ' 35.13880 "W	0.003	847.633	0.004
CIV26	18° 55 ' 04.26325 ' S	0.002	48° 15 ' 36.36419 "W	0.002	848.243	0.002
CIV30	18° 55 ' 08.50085 ' S	0.004	48° 15 ' 25.86916 "W	0.004	859.342	0.006
CIV21	18° 55 ' 07.08753 ' S	0.008	48° 15 ' 32.53479 "W	0.008	851.333	0.011
CIV27	18° 55 ' 04.82509 ' S	0.004	48° 15 ' 31.62150 "W	0.004	852.125	0.005
CIV32	18° 55 ' 03.67376 ' S	0.003	48° 15 ' 34.75339 "W	0.003	846.276	0.005
CIV33	18° 55 ' 02.64201 ' S	0.002	48° 15 ' 33.81141 "W	0.002	847.013	0.002
CIV24	18° 55 ' 04.81968 ' S	0.005	48° 15 ' 34.07545 "W	0.004	849.156	0.006
CIV35	18° 55 ' 09.89404 ' S	0.002	48° 15 ' 19.66761 "W	0.002	863.326	0.002
CIV20	18° 55 ' 02.03563 ' S	0.002	48° 15 ' 32.28608 "W	0.002	849.209	0.002
CIV28	18° 55 ' 03.87220 ' S	0.006	48° 15 ' 29.18390 "W	0.005	854.547	0.008
CIV23	18° 54 ' 58.79625 ' S	0.002	48° 15 ' 30.10484 "W	0.002	848.232	0.002

5 Results

After the screening of the pre-existing network stations and the process of materialization and densification of the GNSS network site of the UFU with the new stations, it was possible to carry out the integration process of networks through connection stations (stations and control station –

MGUB). As a result, the Santa Monica campus of the UFU has currently a passive GNSS network composed of 32 stations distributed throughout the area of the University.

The final outcome of the project can be viewed in Figure 10.

Figure 10. UFU site GNSS Network.

Source: Google Earth (2013).

As stated earlier, there was the need for deployment of stations in regions with dense vegetation to the intervisibility of the stations was possible, that is, so that they could be used in topographic work.

6 Conclusion and closing remarks

From the realization of this project, it was noted the deficiency of GNSS network site of the UFU, Santa Monica campus. The expansion of the campus and the degradation of some stations (normal wear and tear, vandalism, etc.), culminated in the need of a diagnosis of the situation of this place in GNSS network University, since these are substantial landmarks for the development of practical lessons of several courses, as well as to numerous research and extension activities.

On the basis of studies and experiments, it was found that 17 of the pre-existing network stations were in good condition and could be used in the process of integration of the new network. From this point of view, were deployed over 15 stations that were integrated with the old network through the reoccupation of these and related to SGB with the use of MGUB station owned by RBMC. In this step, looked for possible facts that could interfere with the quality of the same, as works and afforestation of the campus and any changes to the campus master plan.

To ensure the reliability of the results, recommended criteria were used by the NTGIR and by IBGE. Soon, the GNSS network site of the UFU meets the requirements of the rules and laws and is linked to the SGB, and may serve to support research, teaching and outreach activities, as well as to all users that need reliable spatial information.

Thanks

Special thanks to Faculty of Civil Engineering (FECIV) of the Federal University of Uberlândia, Santa Monica campus, for having provided the necessary equipment to carry out this work, the Dean of research and graduate studies (PROPP) of the UFU by approval of the research project with the public notice N° 004/2012 and by financial resources for the development of this research by the Edict, N° 004/2012.

References

AUTHORS. **Images of the GNSS network local screening of the Federal University of Uberlândia (UFU), Santa Monica campus**. Uberlândia: UFU/FECIV, 2013.

CHUERUBIM, M. L.; GARCIA, P.; PATIL, A.; SILVA, L. A.; MATOS, s. c. primary Diagnosis of GNSS Network site of the Universidade Federal de Uberlândia (UFU), Santa Monica campus: current reality and future prospects in the context of Geodetic Sciences. In: **XVI SBSR-Brazilian Symposium on Remote Sensing**. the 13 April 18, 2013. Foz do Iguaçu-PR.

Committee on the use of the physical space of the Universidade Federal de Uberlândia (UFU), Santa Monica campus-2009 Management. Diagnostic **use of the physical space of the UFU: Map. Coord. Elaine Sami-DIROB**. Collaboration: Pliny and Lucianne. Uberlândia: UFU/DIROB (2009a).

Committee on the use of the physical space of the Universidade Federal de Uberlândia (UFU), Santa Monica campus-2009 Management. Diagnostic **use of the physical space of the UFU: Map. Coord. Elaine Sami-DIROB: Environmental**Map. Collaboration: Pliny and Lucianne. Uberlândia: UFU/DIROB (2009b).

GEMAEL, c. **Introduction to the Adjustment of observations: Geodetic Applications**. Curitiba: ed. UFPR, 1984. 319p.

Google Earth . 2012. GNSS network GEOEYE Images site of the UFU, Santa Monica campus, located in the city of Uberlândia-MG for the year 2011.

The Brazilian Institute of geography and statistics (IBGE). **Resolution-PR n° 22, 7/21/83**. Rio de Janeiro: IBGE, 1983.

The Brazilian Institute of geography and statistics (IBGE). **Standardization of geodetic marks**. Directorate of Geosciences (DGC) and coordination of Geodesy (CGED). Rio de Janeiro: IBGE, 2008.

National Institute of colonization and agrarian reform (INCRA). **Technical standard for georeferencing of rural real estate.**2nd Edition. February, 2010.

LEICK, a. **GPS satellite surveying**. 3. ed. United States: John Wiley, 2004. 435p.

Marini, m. c. 2002. Integration of GPS network ITESP to Brazilian Geodetic System. Master thesis in Cartographic Sciences, 146p. Faculty of science and technology, UNESP, Presidente Prudente, São Paulo.

MONIC, j. f. g. **Positioning by GNSS: description, fundamentals and applications**. 2. ed. São Paulo: UNESP, 2008. 476p.

SEEBER, g. **Satellite Geodesy**: foundations, methods, and applications. Berlin; New York: de Gruyter, 2003. 589p.