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Review on National Geodetic Control Network - Sri Lankan Datum 1999 (SLD_99)

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Abstract: Any country in the world has its own geodetic coordinate system and it is very useful in all types of surveying activities. Accuracy of the geodetic control network is very important in every aspect. In Sri Lanka (Early named as Ceylon), the systematic triangulation process began in 1857 and completed in 1885. This network was recomputed with some additional observation done in 1890 due to inconsistencies occurring mainly in the minor triangulation. But later found that, the new introduced fixing values have serious error. A new horizontal control network was established in 1999 with using Global Positioning System (GPS) and there were included thirty two (32) old network points to calculate the transformation parameters between the old local datum (Kandawala Datum) and the new horizontal network. But new system and old system gives different coordinates for same control points.

In this study, Kandawala network is compared with new SLD_99 network to find differences between these two networks. Scaled out figure of the ten secondary control points of SLD_99 were observed with GPS observations and analyzed to perform a network adjustment and for comparison.

Keywords: GPS, SLD_99, Kandawala Datum, Network Adjustment, Triangultion

Introduction

Any country the national geodetic control network is the most important part of their surveying and mapping activity. Sri Lanka (Early named as Ceylon) is an island, which is located in an Indian ocean and having a total area of 65,610 Km2. In Sri Lanka, the systematic triangulation began in 1857 with the measurement of Kandawala to Halgasthota base line and the measurements were made using 8 and 13-inch vernier theodolite. This process was completed in 1885. This network was connected with the Indian triangulation network by using narrow chain in 1887. This narrow chain was run on the Batticaloa – Trincomalie – Manner – Delft area. In 1890, this network was recomputed with some additional observations due to inconsistencies occurring mainly in the minor triangulation. The minor triangulation is the triangulation of first order point triangulation. Using results of these observations the “new fixing values” were introduced and these “new fixing values” were later found to be in serious error. Therefore, this result led to significance review of Sri Lankan geodetic triangulation network. After that the studies were carried out by the Survey Department of Ceylon after 1930 and they used new technologies to evaluate the reliability of the network that formed the Kandawala Datum and computed values were included in Jacksons report and whole process was completed in 1933 (Jackson, 1933).

After 1996, this network was surveyed by using GPS and Sri Lankan Datum 1999 (SLD_99) was defined as the new datum. This SLD_99 datum has been used since 1999 for surveying and mapping purposes in Sri Lanka and both systems (Kandawala and SLD_99) were used to the requirement and availability.

When defining the Kandawala horizontal datum, the origin was fixed at Kandawala and the orientation was fixed to Halgasthota from Kandawala. For the adjustment of the network Everest ellipsoid was used and following jackson's values for semi major (a) and semi minor (b) axis were used for adjustment (Jackson, 1933).

a = 2091 2931.80 ft (6374261.613 meter)

b = 2085 3373.58 ft (6356108.572 meter)

SLD_99 datum was introduced and released for survey and mapping purposes in 1999 and GPS monument in Institute of Surveying and Mapping Diyathalawa (ISMD) was used as the origin for GPS observations and the network was adjusted by using these observations. Thirty-two (32) old points in Kandawala network were also included for this network for determining the transformation parameters between those two networks. New network is defined with the transformation from the WGS 84 (Geodetic Survey Unit, 2000).

Abeyratne et al., 2010 pointed out that ISMD origin point, GPS surveys and network adjustments that used to form the new datum (SLD_99) are not optimal and have been questioned. They also suggested that the GPS processing and the network adjustment should be re-examined. And also when examine the residuals of the adjusted network from the "Report on Sri Lanka Datum 1999" some evidences are found to be support the above suggestions.

Peculiarities in the national geodetic datum of a country would drastically affect the surveying and mapping system activities in a country. It is necessary to identify and rectify those to upgrade the national network in par with the international acceptance.

The main objective of this research is a thorough review on established and the adjustment of the Sri Lankan national geodetic network SLD_99. And also it is suggested that to carry out an experiment to mimic the GPS observations and the network adjustment of 10 base/secondary base stations of SLD_99 by scaled down geometry of the national network along with performing a GPS network adjustment The limitations of this research are, it is difficult to carry out GPS observations at the places where suspected to be problematic in the national network and also the original GPS data (raw data) which were observed for performing national Datum SLD_99 by Geodetic Survey Unit in Survey Department of Sri Lanka is not available.

Methodology

Firstly, the Report on Sri Lanka Datum 1999 was thoroughly examined to find the accuracy requirements that used to generate the SLD99 Datum.Then using the report data, an experiment was suggested to repeat the GPS observations and perform a network adjustment of base and secondary base stations of scaled down version (1:5000) the geometry of layout of SLD_99 network (base points were set out at a place where suitable for making GPS observations).

Coordinates of base and secondary base stations were collected from Report on Sri

Lanka Datum 1999. The ellipsoidal distances between ISMD base points to secondary base stations were converted to plane distances by using C++ program and this program was used to calculate all azimuths from ISMD base to all other secondary stations. When selecting the location for GPS observation some considerations were taken to minimize the obstacle for GPS observation and selected ground area was large enough to relocate the scaled down figure of the original network. Tree canopy and other obstacles such is high rise buildings, electrical utilities and water bodies should be less to get the maximum precision in GPS observations. Considering those facts, the playground of Saari Puthra Maha Vidyalaya – Imbulpe was selected to carry out the GPS observations. Figure 1 shows the established figure on the ground.

Seventeen (17) numbers of network GPS observation sessions were carried out in those points to cover the whole base lines same as used for obtained the SLD 99 network. Due to the time frame given thirty minutes observations was done in each station.

Observed GPS data was processed using LEICA Geo office software and processed data was used for network adjustment was written using Geolab software for adjust the GPS network. Then comparison was done between the results obtained from adjustment and available in the Report on Sri Lanka Datum 1999.

Results

Residuals of the adjustment of SLD_99 were re-plotted and analyzed. The resultant residuals for both in latitudes and longitudes were shown in figure 2.

The geodetic coordinates of GPS maker were calculated and compared. Here the Cartesian coordinates of WGS 84 coordinates were obtained from International Doris service (IDS) and comparison of the GPS marker at Survey General Office (SGO) shown in table 1.

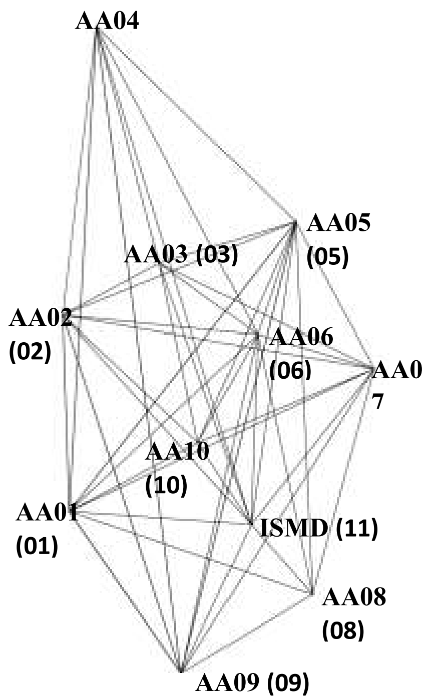

Figure 1. Scaled Down all base/ secondary GPS observation points

When the observed GPS data was processed to used network adjustment it was obtained variance factor as 37.9098 and the test was failed.

Report on Sri Lanka Datum 1999 shows, the same type of adjustment was used by Geodetic Survey Unit for Doris point at SGO and ISMD station and it was also failed with variance factor 1343.6393.

Analysis

Figure 2 shows the unpredictable trend of propagation of error throughout the network. Since there are 46 flag residuals in the Report on Sri Lanka Datum 1999 it clearly shows a possible numerical instability in the adjustment of SLD_99 datum and the situation is clearly shows in the figure 2. The international standard allows none flag residuals in a national geodetic network.

Computed coordinates of the GPS marker show in table 1, confirms and further questioned the values of WGS 84 coordinates at the ISMD. Though, it would not be affected to the local surveys, it gives difficulties when computation done with global data. For example, local GPS coordinates are different when working with the Earth geo potential models (EGMs) which are based on WGS 84.

dataset for the network adjustment and to check whether there is a relationship for the geometry and the size. When change the scale, the original shape of the network is remained due to angles are not going to be changed. However, the adjustment with adding distances was failed and further analysis of the adjustment could not be made as done by Report on Sri Lanka Datum 1999.

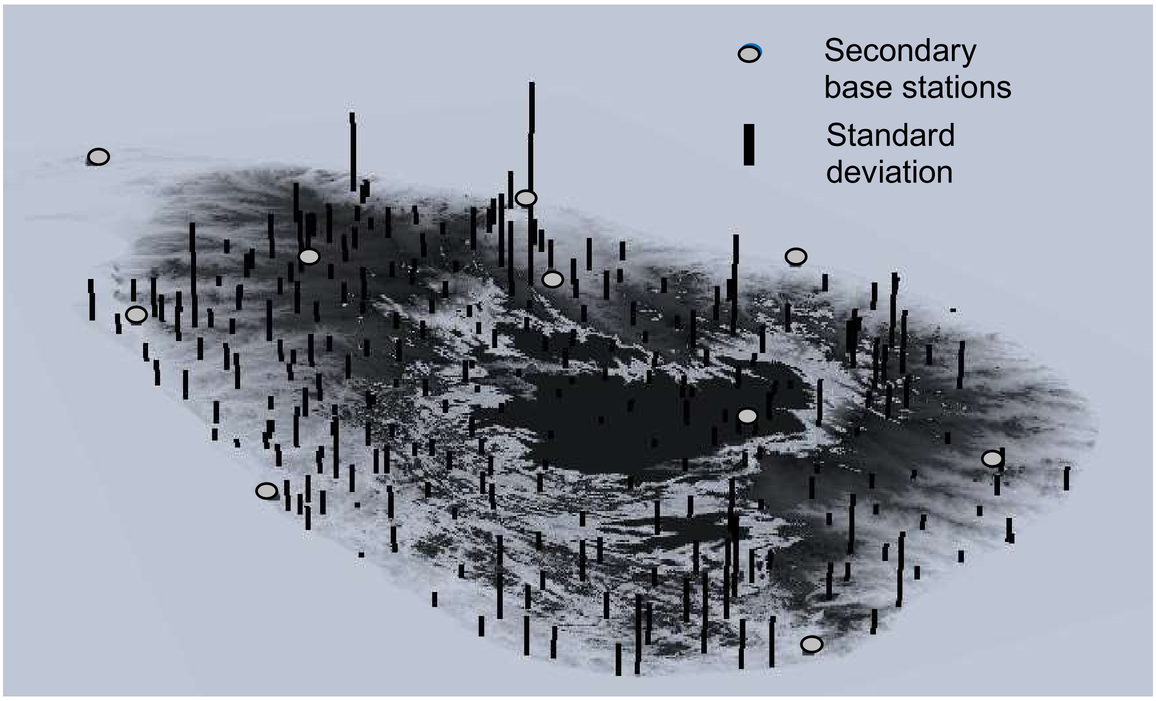

Figure 2: Total resultant residuals – both in latitudes and longitudes

Table 1. Comparison of GPS marker coordinates

Coordinate	IDS values	SGO values	Difference
Longitude	79° 52' 26.314640" E	79° 52' 26.3102" E	0.004440" (0.137 m)
Latitude	06° 53' 30.861133" N	06° 53' 30.8699" N	0.008767" (0.270 m)
Ellip. Height	-75.692 m	-76.238 m	0.454 m

Base and secondary base station network was scaled down to get a similar type of GPS suggesting that the input variances should be tightened. However, as this adjustment is used for comparison purposes, this result was accepted. One residual was flagged.

Variance factor obtained is 37.9098, but this value should be close to 1.0, when corrected or removed any measurements containing any mistakes or large systematic errors. In contrast to that the same type of adjustment was carried out by Geodetic Survey Unit, Sri Lanka (GSU) for DORIS and ISMD stations and it was also failed with variance factor of 1343.6393.

Conclusion

As a first problem with the realization of SLD_99, COLA has since been identified as one of 17 stations with poor antenna stability and was not recommended for the DORIS core network. As such, the base-station coordinates for the differential GPS baseline to ISMD may not be as precise as they might be.

The original adjustment in SLD_99 was not successful only with GPS data and found to be acceptable when equations added for distances to the adjustment model. This is fundamentally incorrect with Least Squares principle. This situation was not tested during the study due to some practical inconveniences.

The northern part of the network was not densified due to the situation existed during the concerned period. Therefore, four secondary base stations (Jaffna, Puttalam, Anuradhapura, and Trincomalee) were established in order to facilitate densification without compromising accuracy. The final accuracy of the network may adversely be affected due to this situation. Since the sub-bases have been highly constrained during the adjustment geometrically weaker areas may be having significant residuals as we can see in the figure 2.

The effect of heights has not been studied during the experiment and observed the behavior of the residuals of the horizontal coordinates only. This experiment was done due to unavailability of the original GPS data belonged to SLD_99.

Concerning all the observations made, it is questionable the accuracy mentioned in the Report on Sri Lanka Datum 1999 with all the peculiarities noted during the study.

Following recommendations can be drawn. It is suggested to re-adjust the SLD_99 network using the original raw data under minimal constraints. This allows the network to be adjusted freely. However, the effect of adjustment with stages which performed by SLD_99 should thoroughly be studied before the implementation. The data used for the field experiment in this study can be used to test the effect on the adjustment with adding equations for distances and also be compared the reliability with the adjustment under minimal constraints.

A fresh GPS survey should be carried out in the areas where showing high residuals by using different bases and the result should be compared with the SLD_99.

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Author Biography

I am Manuranga KP, Have obtained B.Sc in Surveying Sciences (Specialized in Surveying & Geodesy). I would like to do my further research regarding in geodesy, GNNS and LIDAR. My research interests are all related to surveying and geodesy and I like to find out solutions for the problems in those fields.