AN OVERVIEW ON TIME SERIES OF GEODETIC AND GPS NETWORK OF NEPAL

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ABSTRACT:

This paper makes an overview of different geodetic and GPS networks of Nepal established in different time, with different accuracies and with different objective. Before 1945 the importance of surveying and its application was poorly understood in Nepal, therefore the surveys were limited to the measurement of land parcel covering a small area, considering it as a plane. After launching the land reform policy HMG/ Nepal 1963 and also because of the various development project, the importance and the requirement of establishing the geodetic control, defining the ellipsoidal shape of the earth as the reference surface is felt necessary in the country for the surveying and mapping activi ties. Interestingly various countries has been involved in establishing the high precision geodetic networks in the time series of evolution of scientific mapping in the country. Different networks being established by different institutions but very little interest had been given in integrating them. As a result problem persists in understanding and integrating spatial measurements in the geodetic field of survey department. This literature tries to identifythe existing problems in defining the relationships between the networks and demonstrates the status of existing geodetic and GPS network of Nepal.

1. INTRODUCTION:

All national and regional surveying and mapping works are based on one single framework of Geodetic control which is considered as the primary network of the country conventionally called the first order network subsequently the control points of different orders are fixed by densifying within the primary network based on their relative precesion and categorically depending on the distance between two points. The primary or the first order network is defined by means of well defined three-dimensional reference system of co-ordinates related to the earth fixed reference system. Such a reference system is defined by the dimension of the reference ellipsoid in terms of five parameters such as semi-major axis ‘a’ and flattening ‘f’ and its position represented by regional X, Y, Z or ö,ë, h system specifying the orientation with respect to the global system, hence with respect to earth or geoid.

Usually the centre of the ellipsoid does not coincide with the earth’s centre of mass but that axes are made parallel to the earth’s axis of rotation with a pre assumption that global Xg, Yg, Zg rectangular co-ordinate system, has the origin which lies on the earth’s centre of mass and a Z axis coinciding with the mean rotating axis of the earth, a X- axis passing through the mean of the Greenwich meridian. The Y- axis as defined by the plane which is perpendicular to X and Z-axis (
Torge, 1991, p138).

Determination of the parameters of such a reference datum defined by shape, size, and orientation of ellipsoid of revolution in other words the three dimensional co-ordinate system requires the high precision spatial measurements. This work requires highly trained and skilled manpower.
Survey Department of Nepal (SDN) adopted Everest Spheroid (1830) parameter as the reference datum to fulfil immediate need of controlled mapping in the country.

2. INDIAN DATUM:

The Indian datum is defined by the following parameters

Reference Spheroid : Everest (1830)
a = 20922931.80 ft
f = 1/ 300.8017
Indian datum origin : Kalianpur

Latitude (ö) = 24° 07 ' 11''.25
Longitude (ë) = 77° 39 ' 17''.57

Deflection of vertical in the
meridian (î) = - 0''.29
prime vertical (ç) = 2''.87
Geoid height (N) = 0 meters.

Survey of India (SOI) established control points in Nepal for the topographical mapping in the scale 1'' = 1mile. The co-ordinates of these control points were derived by using Everest Spheroid (1830) parameters. The coordinates of these controls were provided to Survey Department/Geodetic Survey Branch (GSB) by Survey of India.

Geodetic Survey Branch (GSB) established second, third and fourth order network of control points in the districts where cadastral survey has to be done. The computation and the adjustments was done based on co-ordinates of points made available from SOI converted into

UTM rectangular system modified for Nepal large scale mapping (Triangulation Instruction book p30). As these coordinates were not from rigorous primary geodetic network it is called the
provisional co-ordinates but as referred by late Z. M. Wiedner former director of GSB in his final report these coordinates are basically used for the cadastral purpose should be named as cadastral co-ordinates.

3. PROBLEMS IDENTIFIED IN ADOPTING SOI CO-ORDINATES:

3.1 Difference in semi-major axis:

Geodetic Survey Branch (GSB) established second and lower order networks calculated in plane rectangular UTM (modified) system with the same value of the Everest Spheroid. As the Govt. of Nepal decided to adopt metric system in the country it was necessary to use the factor of conversion from foot to meter (This factor of conversion was taken from TM5 – 241 – 7, Department of Army Technical Manual: Universal Transverse Mercator Grid Table 0 – 45)

The conversion factor and the value of semi- major axis was
1 Indian foot = 0. 30479841 m
a = 6 377 276.345 m

Adopting the Everest Spheroid (1830) with the value of semi-major axis stated above using SOI controls GSB started to establish new control points. Subsequently latter it was found that the conversion factor adopted in India was

1 Indian foot = 0.3047996 m
Therefore the value of semi-major axis comes to be
a = 6 377 301. 243 m

Since these values are used in Survey of India and apply to all SOI co-ordinates made available and used in GSB, the major axis is incorrect by 24.898 m (phuyal et.al 1992). Because of the difference of the semi-major axis, there will be a different values of co-ordinates of the SOI points converted to the rectangular UTM system, also in the coordinates of the points established by GSB and the difference have to be verified.

3.2 Correction in Longitude:

The survey of India (SOI) established a series of control point in Nepal and these points are based on the India datum. The Indian datum origin is based on the astronomically determined values at Kalianpur. Because the published value of geodetic longitude (λ) on the Indian datum require a correction of –3.16 seconds of arc to agree with accepted definition of datum origin therefore the prime vertical component in [λa –(λg – 3".16)] . cosφ and similarly , the Laplace azimuth condition is Aa-Ag = [λa -3".16)] . sinφ (Report and Results of Geodetic Survey of Nepal 1981-84) or (Bomford 3rd Ed.,pp117) therefore the values of longitude of points established by SOI in Nepal and the other values derived from these values require correction of –3.16" seconds of arc.

3.3 Features of Survey of India (SOI) Triangulation Network (1946-63):

In report made available to Geodetic Survey Branch such as co-ordinates, statement of the results and triangulation chart of control points survey made during 1964-63, following features were identified. Nine different series of triangulation chains were established to make a framework of control for the topographical mapping (1" = 1 mile) of Nepal. The average and maximum triangular errors in nine different series are given below.

Table – 1(Triangular error table)

Series	Instrument used	AverageTriangular error(arc seconds)	MaximumTriangular error (arcseconds)	Closing error On Base	Remarks
A	1arc sec Theodolite	3	8	1/42000	Adjusted series
B	do	5	17	1/15000	do
C	do	4	12	1/5000	do
D	do	4	13	1/12000	do
F(main)	do	3	10	1/14000	Unadjusted (closing error not adjusted)
E(a)	do	4	10	-	do
E(b)	do	4	10	1/10000	do
E(c)	do	5	10	-	Unadjusted Series
F(sub)	do	3	16	-	do

The remaining triangulation network inside Nepal was based on stations of the above series with average triangular error 5 seconds and maximum triangular error 30 seconds. (Source: SOI Report, 27 June 1977)

The table-1 shows the triangulation series do not form a single network and are not homogeneous. The triangulation series named F (main), E (a) and E (b); the closing error in these chain were not adjusted where as E(c) and F (sub) the chains are left unadjusted. The reason behind this could be perhaps the starting and closing of the triangulation chain was not done in higher order stations or may be misclosure were exceeding this tolerance or the accuracy obtained was enough for the topographical mapping project.

4. National Geodetic Network (Nepal Datum) :

Geodetic Survey Branch (GSB) was aware of the requirement of National Geodetic datum defined by the network of points of first order controls. With the agreement between the government of Nepal and the United Kingdom's Directorate of Military Survey, Ministry of Defense (MODUK) established the first order geodetic control net consisting of 68 stations
covering the east-west extent of Nepal leaving the far north area because of the rugged and difficult terrain. The task was completed in 1986.

4.1 Datum defined :

References spheroid: Everest (1830)
a = 6 377 276.345m
f = 1/300.8017 and (e^2 = 0.00663784663)
With the Geodetic Origin Station 12/57 Nagarkot defined as
Latitude (φg) = 27° 41' 31''.04 N
Longitude (λg) = 85° 31' 20''.23 E
meridian (ξ) = -37''.03
Prime Vertical = -21''.57
and assuming the geoid height
(N) = 0 meter

The deflections quoted are derived from an astronomic position observed by Czechoslovak Geodetic Institute.

The Nepal datum represents a rigorous reference system. The net in properly oriented to the conventional origin (CIO) and the scale of the net is consistent with the international standards of length defined by the Doppler satellite observation.
As stated in the Report submitted by MODUK , the geographical co-ordinates of first order points are of high standard and hence fulfill the requirement of a rigorous Geodetic datum in Nepal.

5. GPS OBSERVATION IN NEPAL:

In co-operation with HMG/Nepal , University of Colorado and Massachusetts Institute of technology established the precise Global Positioning System(GPS) Geodetic network throughout the country.

The objective of establishing precise GPS geodetic network was

i) to provide a precise control gird for the geodetic survey throughout the country and
ii) to establish large scale strain grid to measure the north-south shortening, east-west extension and quantifying the uplift of the terrain across the Himalayan collision zone (Bilham & Jackson,1991)

5.1 Datum defined :

References spheroid: World Geodetic System (WGS) 84
a = 6 378 137.00m
f = 1/298.2572235
With the Geodetic Origin Nagarkot tracking station defined as
Latitude (φg) = 27° 41' 33''.778 N
Longitude (λg) = 85° 31' 16''.384E

The observation took place from March 25, 1991 and ended on April 12, 1991. The instruments used for the observation were Trimble 4000 SSI and ASTECH XII GPS receivers. Three stations were held fixed during the campaign. Nagarkot (NAGA), the central station of GPS network. Jomsom (JOMO) located in the high Himalayas of the central Nepal. Simikot (SIMI), located in the high Himalayas of Western Nepal. The station Nagarkot was fixed because this station is the
central station of Fist-order conventional national network. Each site was occupied with minimum of five days with each data measurement session exceeding 8 hours per day.
The best co-ordinate values in WGS 84 reference system for station related to Nagarkot were determined from a network solution of all stations. The network consist of 28 precise GPS controls.

6. ENTMP AND WNTMP GPS OBSERVATION:

The Eastern Nepal Topographical Mapping Project ENTMP & Western Nepal Topographic Mapping Project WNTMP was launched in order to produce new topographical map series of the country.

Geodetic controls over the project area was established by using the static relative GPS survey. In ENTMP a total of 101 stations were established and observed, the network consisting of 29 primary stations and 72 Secondary stations. Instruments used for this field survey were Astech LD-XII GPS receivers. These instruments are 12 channel and dual frequency receivers.

6.1 Observations:

One session per day was observed using four to eight GPS satellites. The length of the observation session was 180 minutes in the primary network. Carrier phase observation of GPS satellites were processed using L2 corrected L1 phase measurements and double differences phase observations. Astech Inc's Geodetic post-processing software (GPPS), version 4.4.01 was used for the data processing. The adjustment of the network was done by using in FLLNET (version 3.0.00.) adjustment program. One sigma accuracy of the baselines in the Network are all better than 1-5 ppm .

6.2 Datum defied:

The datum is defined by the following parameters.

Reference Spheroid: Everest (1830)
a = 6 377 276.345
1/f = 300.8017

Initial Station Nagarkot :
Latitude (φg) = 27° 41' 32''.956 N
Longitude (λg) = 85° 31' 24''.991 E

Defection of vertical in the
meridian (ξ) = -37''.03
Prime Vertical (η)= -21''.57

(See Yrjola and Jarvina 1993)

As compared the parameters of Nepal datum in section 4 it showed the difference in geodetic latitude and longitude. The observed difference is

φE - φN = 1''.916
λE - λN = 4''.311

The elevation difference between IMSL height and ellipsoidal height from GPS in found as 13.531 meters.

The apparent differences observed is because the initial station Nagarkot is close to the fundamental station 12/157 Nagarkot but not to it.

The table below shows the different datums.
Table –2 Comparison of datums of Nepal

Datum	India	MODUK	ENTMP	WGS84
Source	Sources of India	MODUK	ENTMP project report	SDN & University of Colorado
Ref. Spheroid	Everest 1830	Everest 1830	Everest 1830	WGS84
a(semi-major axis)	20922931.80ft	6 377 276.345m	6 377 276.345m	6 378 137.00m
1/f (flattening)	300.8017	300.8017	300.8017	298.2572235
origin Latitude (θ)	24° 07' 11''.26 N	24° 41' 31''.04 N	24° 41' 32''.956 N	27° 41' 33''.778 N
Origin Longitude (λ)	77° 39' 17''.576 E	85° 31' 20''.23E	85°31' 24''.941 E	85° 31' 16''.384 E
Defection of (ξ) in meridian	-0''.29	-37''.03	-37''.03	-
Defection in P.vertical	2''.28	-21''.57	-21''.57	
Separation (N)	0	0	0	

From the Table-2-1 it is obvious that there exists four different sets of co-ordinates on four different datum. The transformation between these 4 datum has to be established.

7. Discussion in rebuilding of co-ordinates in National Geodetic System:

It has been felt essential that in the integration of the positions of GSB established second and lower order triangulation control points and GPS control points in National Geodetic datum to setup the homogeneity in co-ordinate system.

7.1 As the reduction of the observation and computation of GSB established points has been done on Everest Spheroid using the parameter given in section 2 with the a value of semi-major axis 'a' = 6 377 276.345m using SOI control point of the uncorrelated SOI triangulation series the second and lower order networks of Geodetic Survey Branch will have large discrepancies; more than the tolerance therefore it will be difficult to tie them into one single system. In that case the
second and lower order network is required to be recomputed using the first order controls established by MODUK. Once this is done we can abolish the coordinates based on Indian datum. Then the new set of co-ordinates can be considered as national coordinates.

7.2 The relationship between Nepal datum and GPS co-ordinates based on WGS84 reference datum is of immense need in GSB at present. Without the use of co-ordinates derived from rigorously adjusted first order controls GPS measurement cannot be introduced properly. In order to bring the uniformity and consistency it is very important to determine reliable transformation parameters. It can be determined only by making GPS observation in all first order points based on Nepal Datum.
7.3 It has been found less attention has been given by the Institution involved with SDN/GSB in integrating the conventional system with WGS84 reference datum.

7.4 Support of International organization is required to accomplish the above task..

7.5 The ENTMP GPS network is integrated with the national co-ordinates based on Nepal datum. In order to determine the relationship between the WGS84 and Nepal datum co-ordinates total of 11 primary GPS network station which are common to stations of primary geodetic network of Nepal was considered. Three Transformation parameters (ie block Shift) were determined using latitude and longitude of primary geodetic network of Nepal and WGS84 co-ordinates of the same stations considering the ellipsoidal height of

Nagarkot as fixed however block shifts determined is not a reliable transformation parameter of geodetic standard. Therefore 7-parameter transformation has to be computed to define the orientation of two reference systems.

7.6 The GPS controls established in collaboration with University of Colorado and Massachusetts Institute of technology being the high precision co-ordinate value in WGS84 reference system; it is very important to integrate the conventional first order network of Nepal with this GPS network. This can be accomplished by conducting GPS observation considering the control points of two different networks in common in the observation session.

8. References

Acharya P., Adiga G., Phuyal B.P (1992) Geodetic Datum of Nepal, Nepal Surveyors Society Journal.

Bomford, G. (1977), Geodesy, 3rd ed., Oxford University Press.

Billham R. and Jackson, M 1992, Nepal 1991 GPS Measurements, Progress Report to HMG/Nepal

Manandhar N. (1997), Geoid Studies for Nepal, M.sc Thesis, University of New South Wales, Sydney, Australia.

Reports and Results of a Geodetic Survey of Nepal, 1981-84, Technical Report, submitted to Nepal Survey Department.

The Defence Mapping Agency (1987), DMA Technical Report (Supplement to Department of Defense World Geodetic System 1984 Technical Report) Part1: Methods, Techniques, and data used in WGS84 Development. DMA TR 8350.2 2-A Washington D.C.1 December 1987. Torge, W. (1991). Geodesy. 2nd Edition. Walter de Gruyter: Berlin, 1991

Triangulation Instruction Book, Geodetic Survey Branch.

Yrijola, J and Jarvine, T. 1993, Reports on GPS Survey of Nepal, Technical Report, Nepal Survey Department.

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