India’s New Map Policy – Utility of Civil User

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ABSTRACT:

With the implementation of India’s new map policy user community is looking towards a transformation in the spatial database (from Everest 1830 ellipsoid, Polyconic projection system to WGS 84 ellipsoid, UTM projection system). To bring them on same platform, problem of existence of different transformation parameters has to be dealt with, since due to unavailability of such data from Survey of India. Secondly due to mismatch in the two datum error in registration of topographic database is obvious. This study aims at finding out the difference between two geodetic datum with different transformation parameters, and to determine the extent to which the existing database can be used without losing accuracy. Results show that there are some geographic locations whose topographic database can be used without the need of transformation and within the acceptable positional accuracy requirements, depending on the scale of toposheet.

1. INTRODUCTION

With the objective of unrestricted production, maintenance and dissemination of spatial data, a new map policy (NMP) has been declared by National Topographic Database of SOI. This is an outcome of the consistent demand from several quarters including GIS industry to consider Topographic Database as national asset and to make it available without much restriction. Keeping in view of national security objectives two series of maps have been proposed in the policy namely Defense Series Map (DSM)– to cater for defense and national security requirements and Open Series Map (OSM) - for common civilian use.

The OSMs will be produced in UTM projection system on WGS-1984 datum. WGS-1984 is a conventional terrestrial system (CTS) with earth centred earth fixed coordinate system (ECEF). It is a geocentric ellipsoid established by U.S. Department of defense, with its origin or geometric centre at the Earth’s centre of mass. The WGS-1984 series maps will be openly made available to civil users, in both paper and digital form.

Geodetic datum facilitates the mapping of an area by mathematical representation of complex and irregular Earth surface. Presently Survey of India topographic database is based on the Everest 1830 ellipsoid as its geodetic datum along with the polyconic projection system. For India and adjacent countries (except China) Everest-1830 ellipsoid is used as reference datum. Everest-1830 is a topocentric reference surface with its origin at Kalyanpur in M.P (Nagarajan, 2001). (Latitude 24° 07′ 11".26 and Longitude 77° 39′ 17".57).

2. PROBLEM DEFINITION

Since the new map policy proposes the conversion of reference datum and projection system of existing database with the introduction of OSM’s, the question arises on: how much difference in spatial information will the proposed changes in topographic database lead to? And since the availability of new map series will take time, can the currently available topographic database in polyconic projection and Everest datum can be used without losing accuracy and to how much extent?

It is possible to theoretically define infinite datum for a large area. But to avoid complexity and to ensure compatibility at National, regional and global level the geodetic infrastructure should be founded on uniform and single layer of well defined datum.

The difference between positions in terms of an individual local datum and positions in terms of a global datum may be of the order of several hundred meters, and may vary considerably even for a single local datum.

To use the existing maps without introducing error in spatial database is to convert the existing maps through datum transformation techniques. Different types of transformation exist like geocentric coordinate transformation, direct transformations, and geographic coordinate transformations. Different mathematical models have been developed to establish relationship between coordinates in two different datum, among which Molodensky-Badekas model and Bursa-Wolf model are most popular (Singh, 2002). These models require transformation parameters which are required to be developed from the position of known points on local geodetic networks to a uniform regional datum. Simplest transformation to implement involves applying shifts (translation) to the three geocentric coordinates, with the assumption that axes of the source and target systems are parallel to each other (Eliffe, 2002). For higher accuracies 7 parameter transformations can be applied (3 translational, 3 rotational and 1 scale factor), but it is found that consequent errors are generally less than the observational accuracy of the data.

Datum transformation parameters define functional relationship between two reference frames. From time to time it has been tried by many ways to find the transformation parameters for Indian reference datum and WGS-1984, due to restrictions put over by SOI. Now the situation is that several values of these parameters are available from different sources, which is also creating a lot of confusion in spatial user community. SOI has already completed a task of determining the transformation parameters for whole country through GPS observations (Singh,2002), but those values are not available to the user community.

Moreover, due to the availability and ease of using digital form of maps after the introduction of National Map Policy it becomes necessary to assess the effect of variations at different scale of maps. With the increasing use of spatial data in digital form, it becomes absolutely necessary to integrate all aspects of such a system in terms of datum and accuracy.

3. OBJECTIVE

The aim of this study is to find the difference in spatial coordinates of same position in two reference datum (Everest-1830 and WGS-1984) with different sets of transformation parameters (proposed by different organizations) and to estimate the extent up to which existing topographic maps can be used with OSM's.

4. METHODOLOGY

India is a country of huge dimension. It lies approximately between 68° to 98° in Longitude and 8° to 37° in Latitude. The country is divided into grid measuring 1° X 1° by SOI for the purpose of numbering topographic maps on the scale of 1:250000. Coordinates of the corners of this grid covering of the whole country have been considered for this study. Transformation is performed between geographic coordinates in Everest to WGS-1984 using transformation models : (i) GEOTRANS v2.2.6 software developed and released by NIMA (National Imagery and Mapping Agency), USA; (ii) transformation parameters based on Molodensky model; (iii) parameters published by NIMA using Molodensky model; (iv) parameter values calculated by Molodensky Inverse method from observational data. The models differ from each other in several ways including a priori conditions, the type of coordinate used and the interpretation of results.

In order to study the effect of variation of latitude and longitude on the difference between the two systems, one of the parameters is kept constant and the other get varied and vice versa. Also, the differences in heights in two different ellipsoids have also been studied.

5. RESULTS

It is found that if longitude is kept constant and latitude varied (i.e., in N-S region) difference between two datum varies from 2.4" (74.2 m) (at latitude 36.0° and longitude 77.0°) to -6.1" (-188.624 m) (at latitude 8.0° and longitude 77.0°), 0" somewhere between latitude 30.0° and 29°. The value of coordinate in Everest datum is higher than WGS 84 in north and lower in south. Magnitude of difference obtained is as follows-

1) Difference along the meridian (keeping longitude constant) varies from 2.4" (74.2 m) (at latitude 36.0°N and longitude 77.0°E) to -6.1" (-188.624 m) (at latitude 8.0°N and longitude 77.0°E) .
2) At latitude near 28°N the difference in coordinates change the sign which shows that in north region Everest 1830 datum has higher coordinate values and in south region it becomes negative.
3) Difference along parallel (latitude 27°00'00"N) varies from 0.6" (18.553 m) (longitude 70.0°E) to 12.9"(398.89 m) (longitude 96.0°E).
4) Maximum difference is found to be 12.9" (398.89 m) in north-east region.
5) In the case of difference in ellipsoidal heights between two datum the variation is found to be 24m to 55m along the meridian (at longitude 77.0°E).
6) The same has been found to be varying from 14m to 96m along the parallel (at latitude 27°00'00"N).

6. DISCUSSION

The effect these variations in the accuracy in spatial databases will depend on the scale of maps and the purpose.

Results obtained can be discussed from different aspects. As a user, the prime requirement will be accuracy of spatial database. It may be noted that results of transformation with different parameters are differing with each other. These issues are discussed here:

6.1 Positional accuracy at different scales

Change in scale of map leads to changing positional accuracy requirements. Survey of India provides topographical maps at following scale-

1:1000000 , 1:2,50000 , 1:50,000 , 1:25,000 , 1:10,000

Positional accuracy describes the accuracy in the position of features (ISO Standard 15046-13). It relates to the coordinate values for the geographic objects and depending on the absolute and relative positions, termed as absolute accuracy and relative accuracy respectively.

Considering that majority of error starts accumulating from plotting process, following accuracy limits can be defined:

1. Plotting accuracy = 0.25 mm
2. Accuracy while georeferencing the data= 0.2 mm
3. Digitizing accuracy= 0.3 mm

RMS value of positional accuracy resulting can be calculated as $[(0.25)^2 +(0.2)^2 + (0.3)^2]^{½} = 0.438$ mm

Hence the accuracy limits of different scale maps with this value are-

Table 1: Positional Accuracy at different scales

Map Scale	Positional Accuracy
1:1000000	438 m
1:2,50000	109.5 m
1:50,000	21.9 m
1:25,000	10.95 m
1:10,000	4.38 m

Thus, on a scale of 1:2,50000 the maximum difference (maximum being 6.1" approximates to 185m) appears as 0.8 mm on map, which can be tolerated in GIS and Remote Sensing works, and the OSM's can be used without loss of accuracy.
Difference between the datum from longitude 70º 00' 00" to 76º 00' 00" (at 27 º latitude) varies from 0.6 arcseconds to 3.6 arcseconds. At the scale of 1:2,50000 maximum difference between the datum lies well below positional accuracy obtainable from toposheets which shows that topographic maps of this area can be used in existing datum (Everest 1830) without transforming it to other geodetic datum(WGS 84).
Similarly at scale 1:50000 area varying from 70º 00' 00" to 71º 00' 00" at 27 º latitude is lying below the accuracy limits.

6.2 Different transformation parameters

Results show that, the difference among different methods (transformation parameters) used is found to be maximum 0.6" which is well within the tolerance limit of 1:50,000 map. (from the positional accuracy requirements Table1).

7. CONCLUSION

Depending on the scale and purpose of work, the unnecessary steps of transformation from one datum to another can be avoided without losing the objective of maintaining accuracy in the database. The geographical locations where use of both geodetic datum is possible without losing the positional accuracy requirements can be identified making the work of user simpler. The existing maps for North-East region are required to be transformed before using the as a source for any spatial database in WGS-1984 datum since maximum variation is found to be 12.9" in this region. This shows the requirement for establishing well defined transformation parameters and estimation of coordinates in both datum by observation method. Difference in ellipsoidal height at same latitudes and longitudes is varying from 24m to 55m which is a significant amount and need further consideration. Present study is performed on the grid size of 1ºX1º and using finer grid can refine the results.
The results obtained are calculated for whole country considering uniform transformation parameters, results may vary pertaining to the non-uniformity in geography of the country as a whole, if zone-wise transformation parameters are calculated.

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