# Realization of Geocentric Datum for Nepal: Ingredients, Recipe and the Cooking

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## Abstract

*The existing classical geodetic datum of Nepal called as Nepal Datum was developed and realized almost 40 years ago through the concerted surveying involving astronomic measurements by* Czechoslovakian team along with Doppler observations and Trigonometric Surveying by British team*. Since the realization of this geodetic datum by establishment of First Order Control Network at 68 locations, secular and co-seismic crustal movements has potentially disturbed the integrity of the network. Any survey activities based on use of existing datum without proper understanding and discretion can potentially compromise the outputs of surveying. On another hand, the classical datum is not directly compatible with the current surveying trends based on GNSS technologies. In order to ensure access to precise and GNSS compatible datum, there is an urgent need to develop geocentric datum. . In this article, we examine and recommend ways to realize geocentric datum by maximal utilization of already existent and necessary components for a functional geocentric datum. This paper is divided into three sections: Ingredients, Recipe and the Cooking. The ingredients section discusses the infrastructure for geocentric datum, the recipe section discusses the procedures to defining geocentric datum and the Cooking section discusses on the part of capacity development.*

**Keywords**: Geocentric Datum, CORS



## Introduction

With the advent of Global Navigation Satellite System (GNSS), nations have transitioned from classical datum to geocentric datum based on International Terrestrial Reference System (ITRS) and its realization International Terrestrial Reference Framework (ITRF). A geocentric datum is defined with its center as the mass center of the Earth. While there are several advantages of transitioning to a geocentric datum, the most pronounced is easier access to a precise datum which is directly compatible to GNSS technologies. GNSS technologies have been the choice of surveyors for surveying specially for establishing control points, thanks to rapidly dwindling price of such instruments. However, for Nepal, the larger advantage is to replace the existing datum that was established as early as 1980's. The location of Nepal between two converging tectonic plates causes considerable plates motion. Study by (Avouac, Jouanne, Flouzat, & Bollinger, 2006) showed stations at Simara, Daman, and Nagarkot with velocities in North component of 32.7 mm, 31.9 mm and 30.1mm per year respectively and the same in East component was 37.9 mm, 37.1 mm and 30.1 mm in between 1990 and 2004. This indicates there is significant change in position of the control points in absolute terms. The difference in velocities between the stations is indication that the internal consistency of the stations is disturbed. The role of national mapping agency is to define a geodetic datum which is precise, accessible and compatible to existing technologies. In this context, we present ways to define and

develop realization of geocentric datum by maximal utilization of existing facilities.

## Nepal Datum

The existing official datum of Nepal is a classical datum referred as Nepal datum with its origin at Nagarkot. There is some confusion among user community regarding whether the datum is based on Everest 1830 ellipsoid or Everest 1937 Adjustment ellipsoid. Although, conceptually these are similar, there are differences. Originally, the Everest 1830 ellipsoid was defined in terms of foot. In order to adopt it to metric system, a conversion factor of 0.30479841 for foot to meter was adopted in 1937 for readjustment of Indian triangulation network (Georepository, 2020), hence the name Everest 1937 Adjustment. This foot to meter conversion factor meant the semi-major axis of this ellipsoid is 6377276.345 meters and semi-minor axis is 6356075.413 meters. This is the ellipsoid used in definition of Nepal datum (Triangulation Instruction Book, 1976). The realization of Nepal datum was accomplished by establishment of First Order Triangulation Network as a combined effort of Astronomic observations during 1976/77 by Czechoslovakian team, Doppler observations during 1981 by 512 Specialist Team Royal Engineers, UK and trigonometric surveys by 19 Topographic Squadron Royal Engineers UK. In order to avoid confusion, it is recommended that this datum be Nepal1981 datum. This is justified since the realization of the Nepal datum started with Doppler observations in 1981 on First Order Stations.

## Ingredients for Geocentric Datum

In this section, the major components necessary for a functional geocentric datum are introduced. In succeeding sections, the existing status of each of these components are examined with discussion of prospective future developments.

Realization of geocentric datum requires at least three major components a) CORS stations b) Data and Monitoring Center c) Networking. Each of these are briefly described here.

a. CORS (Continuously Operating Reference Stations)
   In principle, CORS stations are very similar to GNSS/GPS instrument that capture signals from GNSS satellites. However, in practice, these are designed in a much rugged manner to be able to operate continuously considering factors such as security, power supply, storage, weather, etc. More importantly, communication facilities is installed for data transfer as well as monitoring of the stations. Figure 1 shows a typical CORS station. This station is established within the premises of Survey Department, Nepal.

*Figure 1: CORS Station at Survey Department, Nepal*

Establishment of CORS stations is the most challenging as well as time consuming process for development of a functional geocentric datum. In terms of the total budget, the maximum proportion of budget has to be allocated for establishment of these stations. However, this can be avoided to large proportion. Thanks to the interest shown by international scientific communities towards study of secular and coseismic crustal movement of highly dynamic and converging tectonic plates of Nepal, there are already considerable number of CORS stations. While an exact figure is not available, it was estimated that there were already more than 50 stations in 2015 (LS, 2015). There has been further increase in this number. Most of these stations are established with collaboration between international scientific communities and Department of Mines and Geology, Nepal. Survey Department operates three stations, two at Nagarkot and one within the premises of department at Kathmandu. The distribution of the CORS station is shown in Figure 1. This is in not an exclusive list.

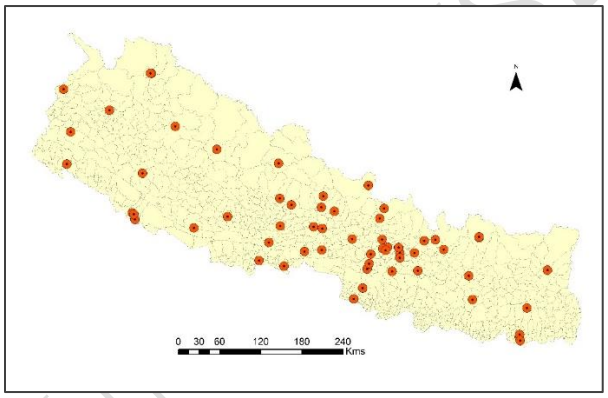


*Figure 2: Distribution of CORS stations of Nepal*

Considering there are several other stations missing in Figure 1, there already exists a good distribution of CORS stations good enough for development of a Fiducial Network. However, not every station can be part of this Fiducial network and a careful selection has to be made. This is discussed in the succeeding section.

b. Data and Monitoring Center
   The data and monitoring center performs the following functions:

- Collection, Storage and Processing of GNSS observations obtained from individual CORS stations
- Monitor the health of CORS stations
- Provide access to GNSS raw observations and/or post processing facilities
- Generates and stream corrections for RTK surveying generally in form of NTRIP

While there is no dedicated data and monitoring center at present, the government to a large extent already has facilities to establish it within a short time period. This is discussed in the following section.

c. Networking
   A secured networking is essential to transfer data and corrections between CORS stations, Data and Monitoring Center and the user community. The ways to develop this is discussed in the following section.

**Recipe for Geocentric Datum**

As discussed in preceding section, a functional geocentric datum requires CORS stations, Data and monitoring center and CORS Network. In this section, we discuss the recipe to bring these together.

a. Forming a Fiducial Network of CORS Stations

As discussed in the ingredients section, there already exists considerable number of CORS stations in Nepal. However, many of these

stations are retired and some of these are established over roofs which is not the best condition for a station to be part of the Fiducial Network. Only stations that are in operational condition and established with highly stable monument type can be part of the Fiducial network. CORS stations having either shallow-drilled braced monument or deep driven rod braced are the most stable monuments. Our examination of existing stations shows that there is a well-distributed stations with stable monument types. Figure 3 shows the stations which are active and have highly stable monument types. These stations are feasible to be part of fiducial network for realization of geocentric datum. There are at least 27 such stations. The station code and location of these stations are : BMCL:Bhimchula; BRN2:Biratnagar; CHLM:Chilime; CHWN: Chitwan; DLPA:Dolpa; DNGD:Dhangadh;, DRCL:Darchula; GNTW: Ghanteshwor; GRHI:Ghorah; HETA:Hetauda; JMLA: Jumla; JMSM: Jomsom; KKN4: Kakani; KLDN:Koldana; KUGE:Kavrepalanchok; LMJG: Lamjung; NAST:Kathmandu, NPGJ:Nepalganj; ODRE: Odare; PYUT:Pyuthan; RMJT:Rumjatar; RMTE:Ramite; SIM4:Simara4; SMKT:Simikot; SNDL:Sindhuli; SYBC:Syangboche, TPLJ:Taplejung.

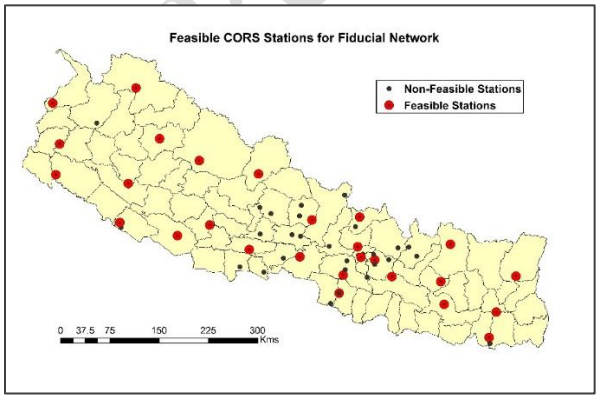


*Figure 3: Stations with highly stable monuments that could form part of Fiducial CORS Network*

There are some areas which lack sufficient CORS stations. Further investigation has to be done to assure if indeed there are no stations. In case, there are no stations, Survey Department can take initiatives to establish new CORS stations in those areas.

It is to be noted that we have only considered Fiducial stations that are necessary to realize geocentric datum. For providing Network RTK solution, a much denser network of CORS is necessary. Existing stations that are not considered as Fiducial CORS stations can also be utilized for this purpose along with establishment of newer CORS stations. However, this is not within the scope of this paper.

**Mechanism for operation and maintenance of CORS stations**

The existing CORS stations are owned by several different agencies of Nepal and majority of these stations are established in partnership with international agencies. In order to ensure smooth operation and maintenance of these stations, a mechanism has to be established which involves all the agencies. The roles of each agencies can be redefined in agreement with these agencies including modality of data distribution.

b. Data and Monitoring Center

While there is no dedicated Data and Monitoring center, Government Integrated Data Center (GIDC) could be used as data center. For monitoring of the CORS stations, a facility can be developed at Nagarkot Observatory and Survey Museum (NOSM) which is a part of Geodetic Survey Division, Survey Department. In addition to being a monitoring center, NOSM can be further

developed as a center of excellence for geodetic research.

## Cooking

All the best ingredients and the best recipes in the world do not turn to a dish unless prepared by a professionals. In order to ensure a functional geocentric datum is realized, the following issues must be addressed:

- Capacity Development

It is quite laudable that Survey Department has invested in capacity development in geodesy specifically by funding employees to receive higher education in geodesy. The fruit of this sowing is just bearing its fruit. As part of second phase, the department must prioritize its missions and accordingly conduct technical workshops and training programs, possibly welcoming professionals from abroad to collaboratively work with professionals at the department.

- Retaining Human Resources and Preserving Institution Memory

Development of geodesy within bureaucracy is challenging. Professionals spend years, if not decades to gain expertise in one of the domains of geodesy. The existing bureaucratic system does not recognize this. The department should bring about changes to encourage professional who have acquired expertise in the field to continue doing so. In addition, concrete efforts to preserve institutional memory has to be initiated.

- Partnerships

Review of the history of geodetic development in Nepal, except for handful of achievements, all of these have been realized through partnerships with international agencies. As a matter of fact, geodetic developments involve participation of all nations working collaboratively. This is quite conspicuous from the fact that ITRF stations which is necessary for defining geocentric datum is established and maintained through partnerships among several nations. Rejecting partnerships is avoiding development of geodesy.

## Conclusion

A house without a strong foundation is a disaster waiting to happen. It is the same for all surveying and mapping activities. The priority sector of national mapping agency should be development of geodetic datum. In this article, we have discussed how this can be realized by maximizing utilization of already existent facilities particularly the CORS stations. The national mapping agency should take leadership on forming a mechanism for operating CORS within Nepal in order to define and develop realization of geocentric datum. It also should realize the existing that geodesy is a pure science but currently established within a bureaucratic framework. In order to develop it, there is no other ways than focus on capacity development, encourage collaboration and partnerships and bring about policy reforms to retain human resources.

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