Journal of Geomatics Vol 13 No. 2 Oct 2019

Surveying and mapping of Gandhinagar city using IRNSS/NAVIC system

Jayrajsinh D. Jadeja and P.R Patel
Civil Engineering Department, Institute of Technology, Nirma University,
Email: jayraj.jadeja1121@gmail.com

(Received: Jan 09, 2019; in final form: Nov 18, 2019)

Abstract: Surveying and mapping are the most essential parts of any infrastructure project. The conventional method of surveying is very cumbersome, time-consuming and costly, as it requires a huge workforce to carry out the detailed survey. Due to advancement in space technology, various Regional and Global navigation satellite systems have emerged as an important tool for survey and mapping purpose. India has recently launched its own regional navigation satellite system called Indian Regional Navigation Satellite System (IRNSS) or NAVIC (Navigation with Indian Constellation). In this paper, an initial attempt is made to carry out surveying using high-performance Global Navigation Satellite Systems (GNSS) receiver. The objective of this research is to analyse the stability of the reference station and to prepare the map of Gandhinagar with reasonable accuracy by using the positional data collected from IRNSS/NAVIC system. Two stations, reference station and a temporal station was established at Nirma University campus. The true value and the observed value were measured between both stations using NAVIC receiver. The longer average mean of reference and temporal station were also calculated. The percentage error was 3.44% where true distance was 5.40m and observed distance was 5.22m. Surveying of Gandhinagar was done by using IRNSS/NAVIC receiver and collected data were imported on GIS Platform. The IRNSS/NAVIC receiver has been used here to generate a map, thus its potentials are needed to be explored for various mapping and navigation applications.

Keywords: IRNSS, NAVIC, True value, Observed value.

1. Introduction

In today's scenario, it is necessary to develop a low-cost method, which collects data from the field quickly and is robust in preparing Maps. Traditional methods are Time consuming and costly with many Limitations. In Difficult terrains, conducting survey with surveying instruments is very tedious and sometimes it causes human casualties. Since last two-decade use of Global Navigation satellite system (GNSS) (Geodesy, 1994) like Global Positioning System (GPS) and Globalnaya Navigazionnaya Sputnikovaya Sistema (GLONASS) has increased exponentially in the field of surveying and mapping. The advantages of using GNSS satellite systems over traditional instrumental surveying systems are that the satellite navigation systems are more reliable, economical, efficient and convenient over the conventional methods of surveying. Larger areas can be surveyed with great accuracy within a short time and map of the area can be made after processing the collected data. India has recently launched the navigation satellite system called Indian Regional Navigation Satellite System (IRNSS) or NAVIC (Navigation with Indian constellation). (ISRO-IRNSS-ICD, 2017) IRNSS is an autonomous regional navigation satellite system, which provides navigation and location service to its users. It's been developed by Indian space research organisation (ISRO), for navigation and military purpose. Primary Service area covered by it is Indian regional boundaries and it extended up to 1500 km from the Indian boundaries (Ravi, 2016). IRNSS consist of total three segments Space segment, Ground segment and a User segment. Space consist of 7 satellites, 3 in geostationary orbit and 4 are in geosynchronous orbit. The Ground Segment consists of the IRNSS Ranging and Integrity Monitoring stations (IRIM) and Navigation control centre (INC). The user segment consists of IRNSS receivers operating in different modes Single Frequency mode and Dual-Frequency mode (Ganesh, 2014). The two different services mode offered to IRNSS users are Standard Positioning Service (SPS) and Restricted Service (RS). SPS mode is free of cost to the users and the signals are unencrypted, RS mode is only for few authorised users and the signals are encrypted. There is a need to explore various applications of IRNSS. In this paper, an attempt is being made to develop a low-cost method to collect terrain data and prepare map with reasonable accuracy using IRNSS/NAVIC receiver.

2. Study area and methodology

The capital of Gujarat, Gandhinagar city have been chosen as the study area for this project. It is situated in the western region of India, 23 km north of Ahmedabad. It is also one of the planned city of India. The total area covered by Gandhinagar is 177 km^2 and it has a population of 2, 92,167 and a population density of Gandhinagar city is 1700/ km^2 as of census 2011. Figure 1 shows the coordinates describing the extent of the study area. Figure 2 shows the adopted methodology for surveying and mapping of Gandhinagar

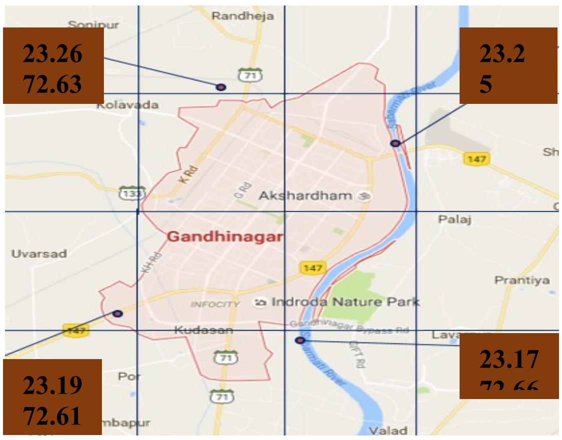

Figure 1: Study area

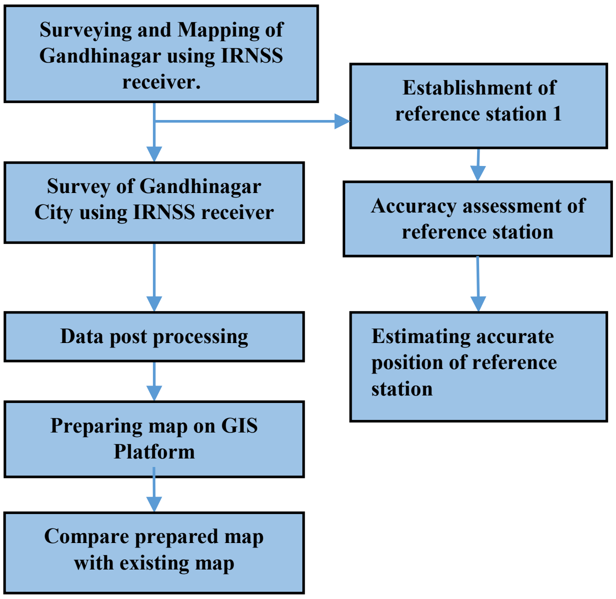

Figure 2: Methodology

3. Experimental setup

A reference station was established at Nirma university campus at B Block building, Institute of Technology. Positional data is being collected regularly for reference station from 21/07/2017. IRNSS Antenna is capable to receive signals of IRNSS L5 and S1 bands and GPS L1 band signals. It has TNC female connector, which Further takes received signals to IRNSS receiver (Figures 3 and 4).

IRNSS receiver is capable of working in three different modes IRNSS, GPS and Hybrid. LED display on receiver provides visual information. The computer system is connected with receiver Via Ethernet cable for data transfer/storage.

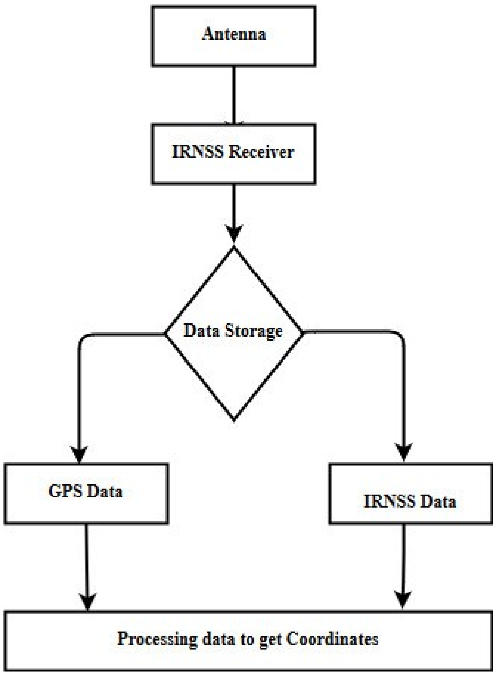

Figure 3: Flowchart for IRNSS Receiver System.

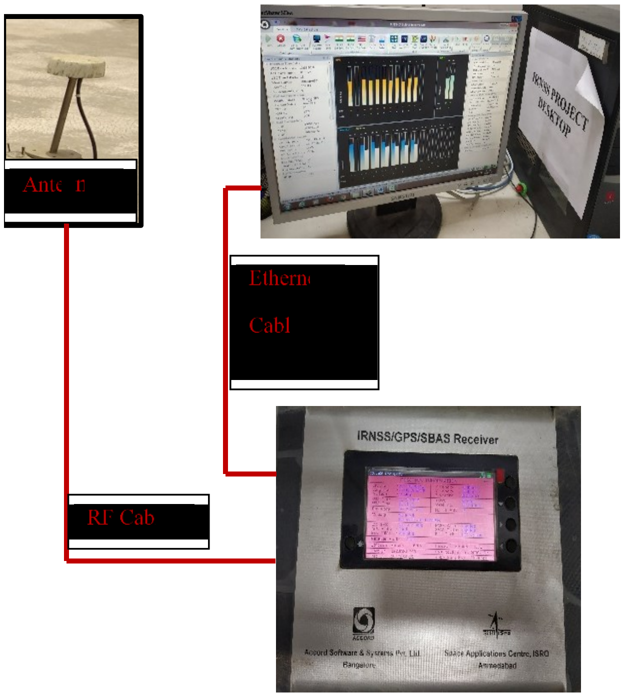

Figure 4: Experimental setup for the IRNSS receiver system

3.1 Estimating accurate position of the reference station

The reference station is continuously collecting positional data for a longer period, data were extracted using IRNSS_UR software. Data output supports two different formats .csv and.rinex. We have used .csv format to extract positional and other required information form the received data. IRNNS and GPS signals are used here to extract positional information. Radio waves get affected by the presence of electrons in the ionosphere, the total electron content (TEC) is the total number of electrons present along with a path between a radio signals transmitter and receiver. Few research studies suggest that the average standard deviations (STDs) of the satellite Differential Code Bias estimated during daytime data are higher than that with night-time data (Li et al. 2015). Therefore, we have used data collected between times 03.00 to 06.00 for better accuracy. Further positional information is extracted from POSB file, it consists of information such as TOWC (Time of week count), Week number, System Status, Block count, Mean sea level Correction and Latitude, Longitude and Altitude (X, Y, Z) of a given point. Average mean of extracted positional information is calculated for 3 hours (03.00 to 06.00) of each day. Position information is retrieved every second so for every three hours, we get 10,800 positional values for reference station. Minimum value, the maximum value and standard deviation of retrieved positional data is calculated for each day. Following are the graphs showing the Mean and standard deviation of Latitude, Longitude and altitude of reference station for the month from July to September (Figures 5-7).

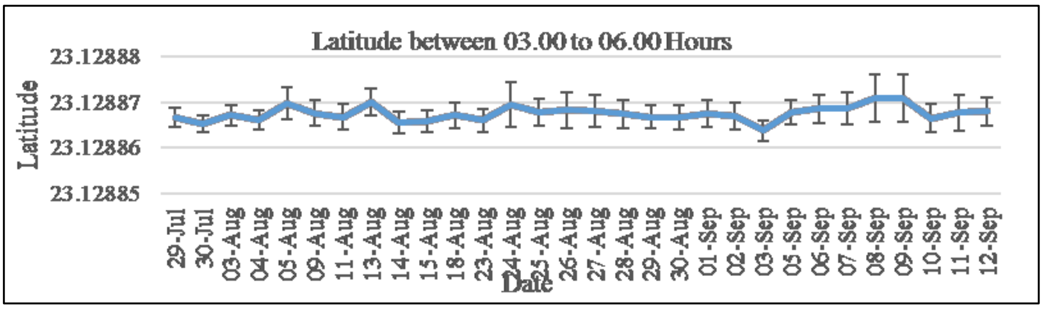

Figure 5: Latitude of the reference station from 29 July to 12 September

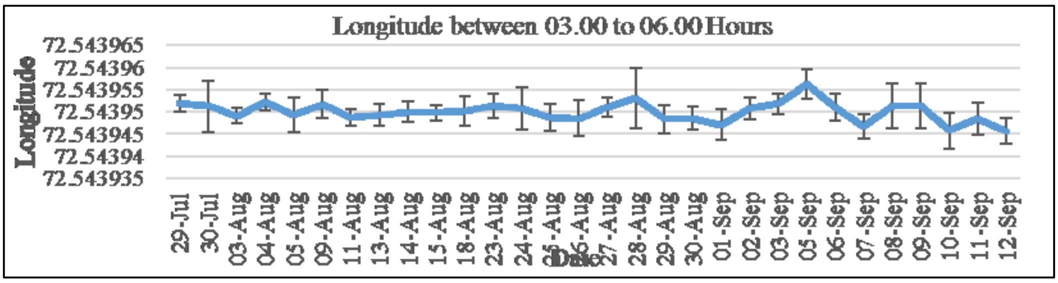

Figure 6: Longitude of the reference station from 29 July to 12 September

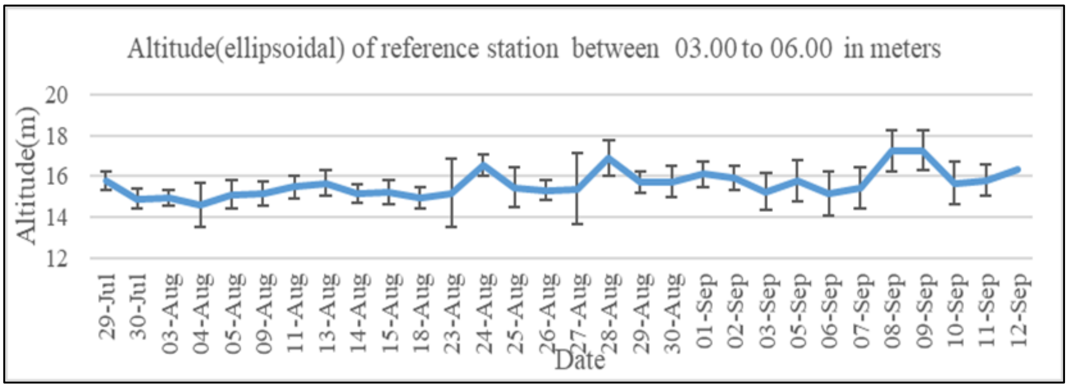

Figure 7: Altitude of the reference station from 29 July to 12 September

3.2 Accuracy assessment of reference stations

In order to check the horizontal stability of received positional data for reference station. The temporal station was established at B Block building, Nirma University campus. It was established 5.40 Meters distance from the reference station (Towards North direction from reference station) (Figure 8). Data had been collected of the temporal station for almost same time-period as of reference station. The longer average mean is calculated of received position data for both reference station and temporal station, so that single most accurate X, Y and Z position value can be estimated. The physically measured distance between temporal and reference station was 5.40 Meters which is termed as the true value and the distance Measured between both stations by calculated longer average mean was 5.22 Meters which is termed as Observed value. Absolute error in the distance was 12 Centimetre and percentage error was 3.34%.

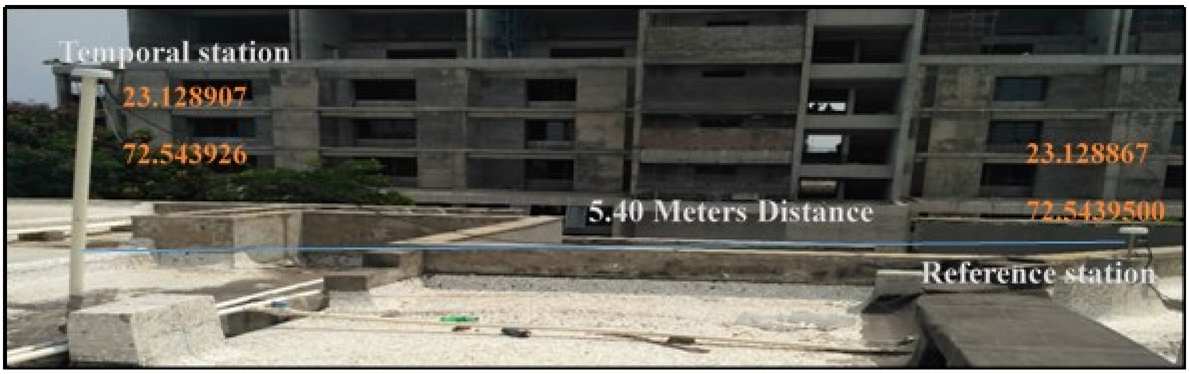

Figure 8: True value and observed value of the distance between the temporal station and reference station.

The temporal station was established for temporary time period i.e. July-2017 to September-2017 and reference station is still in use and data is been collected on regular basis. Following are the graphs showing Month Wise Longer average mean of positional data collected of reference station (Figures 9-11).

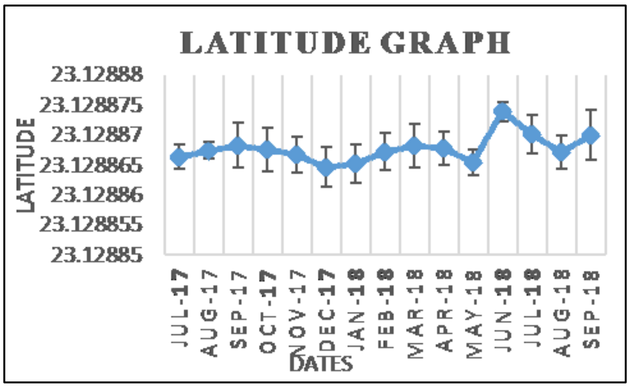

Figure 9: Month-wise graph of Longitude for reference station9

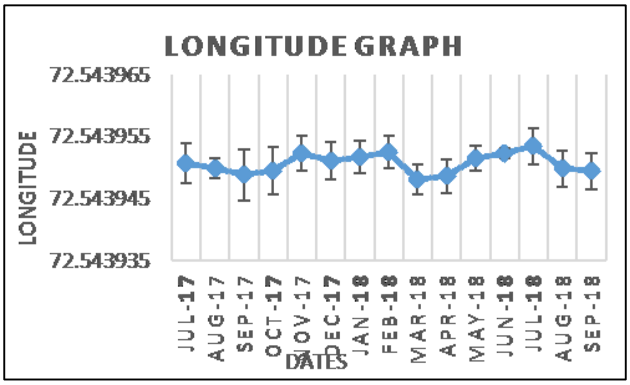

Figure 10: Month-wise graph of latitude for reference station

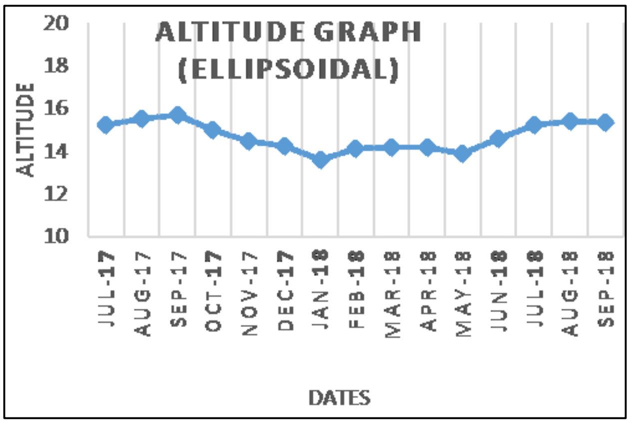

Figure 11: Altitude graph in ellipsoidal for reference station

Table 1 shows the positional data of the reference station and temporal station. Minimum, maximum, mean, standard deviation and RMSE error are been calculated for reference station and temporal station by using positional data collected by NAVIC/IRNSS receiver. It is being observed that IRNSS/NAVIC receiver provides higher horizontal accuracy compared to vertical accuracy. A value in decimal degrees to 5 decimal places is precise to 1.02 meters at the 23ºN/S from Equator. Reference station and temporal station are compared; temporal station was having high RMSE Error than Reference station. The reason for less RMSE error in reference station is due to high amount of availability of positional data. Minimum, maximum, mean, standard deviation and RMSE of reference station are been calculated by using 15-month data (July-2017 to September 2018). It is observed that RMSE error was least, which makes reference station point more accurate.

Table 1: Positional data of reference station and temporal station with the minimum, maximum and mean values with standard deviation and RMSE error

	Minimum	Maximum	Mean	Standard deviation	RMSE
Reference Station	July 2017 to August 2017				
Latitude	23.128853	23.128889	23.128867	9.42753E-07	5.93E-13
Longitude	72.543936	72.543974	72.543950	9.63944E-07	6.19E-13
Altitude	12.427117	25.061950	15.472907	0.252438998	0.063725448
Temporal station	July 2017 to August 2017				
Latitude	23.128155	23.128867	23.128630	0.000411053	1.12643E-07
Longitude	72.541713	72.543951	72.543204	0.001292	1.11E-06
Altitude	15.206269	15.504228	15.351452	0.149124	0.014825
Reference Station	July 2017 to September 2018				
Latitude	23.12885273	23.12888946	23.1288677	2.30006E-06	4.93757E-12
Longitude	72.54394	72.54398	72.54395	1.62E-06	2.45E-12
Altitude	14.71194	11.13281	31.4992	0.66312	0.410413

4. Surveying and Mapping with IRNSS receiver

IRNSS dual-frequency receiver was Carried infield along with the different instruments and laptop for data surveying Purpose. The first experimental field trial was conducted at S.P Ring Road, Ahmedabad. Road network was surveyed from Vaishno Devi circle to Slilaj Circle, Ahmedabad. Positional data collected was plotted on Google earth Platform. Collected data was reasonably accurate and shows good results. Data collected has the least amount of Errors as there were no obstacles in a received signal. So we now wanted to conduct a survey at Moderate/High dense Environment. So the survey was initiated at Nirma University campus, where trees are planted along the road of both sides and there are buildings nearby each other. The results of the survey at ring road and Nirma Campus indicated that Signals are healthy and providing good results at places where there was less/no obstacle and at moderate dense/high dense areas, where signals were poor has a high amount of position error. Heavy dense part of the campus cannot be mapped due to receiver's signals were not able to penetrate at few places with dense vegetation. From this field trials, we have studied the behaviour of IRNSS receivers Signals and based on it we have initiated survey of our study area (Figures 12 and 13).

Figure 12: Road Survey for S.P Ring road.

Figure 13: Survey of Nirma University

4.1 Surveying and mapping of Gandhinagar

Surveying work of Gandhinagar city was initiated from sector-4, East of KH Road. Field data has been collected for a total of six sectors (vertically from sector 4 to sector 27). The whole survey was carried on a motorbike or by walking. IRNSS receiver, antenna and laptop were carried together for field data collection. The battery was also used in order to provide power supply to the receiver. IRNSS_UR software has been used for data extraction and storage. Extracted data consist of many different files having various information. Required positional information from the surveyed data was extracted to a new file. ArcGIS platform has been further used to import surveyed positional data. Now the data can be overlapped on Google Base map or other Geo-Reference Layers/maps. Path or shapes of points can be interpreted easily and Map can be prepared from these superimposed points, multi-point features. Figure 14 shows the field surveyed point data, overlapped on Google Maps platform. WGS 194 projection was assigned to Surveyed data so that data layer at ArcMap and imported point data both have the same projection

Figure 14: Surveyed data Superimposed on Google Maps

4.2 Digitization, classification and comparison on ArcMap Platform

Field data which were collected using IRNSS/NavIC receiver can now be digitized on ArcMap platform. Land Use map has been generated by digitizing different features. In attribution table, each feature has been had been assigned unique ID number (OBJECTID) and name. Figure 15 shows digitized of field data. On ArcMap platform, digitized data can further be classified. Using Symbology tool, different features have been classified based on its type. Here roads are classified as Highway, Primary roads, Secondary road, tertiary road and internal roads. Different colour coding has been assigned in order to identify each feature uniquely. Administrative boundaries of Sectors and sub-sectors have also been digitized. Attribute table has also been generated, which can be further be used as a database. The prepared map on

ArcMap platform for sector 4 was compared with Freely available open streets maps (Figures 15-18).

Figure 15: Digitization of Surveyed data.

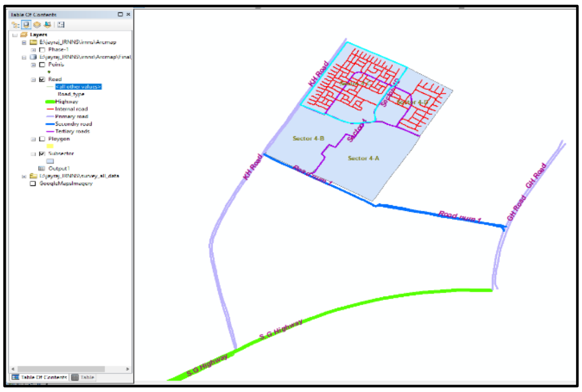

Figure 16: Sector 4 Map of Gandhinagar.

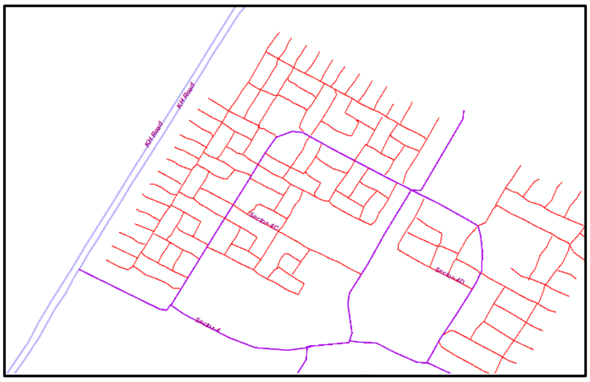

Figure 17: Sector 4 map on openstreetmaps

Figure 18: Prepared map for Sector 4 using IRNSS.

5. Conclusion

Firstly, the reference station was established at the terrace of B Block building, Nirma University and its position data were retrieved regularly. An analysis was carried out for received Positional data. The resulted accuracy provided by IRNSS/NavIC receiver was quite reasonable. So with confidence, we had initiated field trial, which was SP Ring Road. The survey was carried on a motorbike, during survey receiver and other instruments were carried in a bag. The result of the field trial was superimposed on Google earth and results were quite impressive, when it was superimposed and compared with google earth, it was providing good accuracy for collected position data. There was less/no obstruction for received signals during a survey at S.P ring road and due to that, there were less Positional errors. Survey at Nirma University Campus was conducted to check positional errors in the Moderate dense environment. There were positional errors at few places due to an obstacle in IRNSS received signals. For Phase 1 we started a survey of Gandhinagar city for a total of 6 sectors 4,5,13,15, 24 and 26 was surveyed. Land use Featured surveyed was road network and administrative boundaries. Data collected was post-processed. ArcMap platform was used to digitize the different features, further different Tools of ArcMap platform have been used for attribution and classification of digitized data. The accuracy of surveyed data was estimated by superimposing it on google map imaginary. Using the IRNSS system map generated by Sector 4, Gandhinagar was compared with OpenStreetMap. The results show that there were not many errors when it has been compared with Google Maps Imaginary and OpenStreetMap. From the results, we conclude that the data collected from the IRNSS/NavIC receiver has reasonable accuracy and can be used for various applications.

References

Ganesh, L.G.S. (2014). Performance evaluation of standard positioning service GPS receiver with LS and LQ estimators over the southern region of the Indian subcontinent. ICSEMR-2014.

ISRO-IRNSS-ICD. (2017). Indian Regional Navigation Satellite System Signal In Space ICD for Standard Positioning Service. Version 1.1, ISRO-IRNSS-ICD-SPS-1.1.

Li, L. X., D.H. Zhang, S.R. Zhang, A.J. Coster, Y.Q. Hao and Z. Xiao. (2015). Influences of the day-night differences of ionospheric variability on the estimation of GPS differential code bias. Radio Science an AGU Journal, 50(4), 339-353.

Ravi, S S. (2016). Indian Regional Navigation Satellite System. International Journal Of Research In Science & Engineering, 690-698.

Satellite Geodesy. (1994). In G. Seeber, Satellite Geodesy. Artech House Publishers, New York (USA).