ISSN: 2278-0181
ICRTT - 2018 Conference Proceedings

Study and Analysis of Data from GPS and IRNSS

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Abstract: **There are many different satellite orbits that can be used the ones that receive the most attention are the geostationary orbit used as they are stationary about a particular point on the earth. Many communications satellites similarly use a geostationary orbit. Circular orbits are classified in a number of ways. Terms such as Low Earth orbit, geostationary orbit are the like detail distinctive elements of the orbit . The choice of the satellite orbit will depend on its applications. while geostationary orbits are popular for applications such as direct broadcasting and for communications satellites, others such as GPS and even those satellites used for mobile phones are much lower. In this paper we review the detailed comparative study on detail specific obstructions and circumstances, evaluating and analysing them comprehensively, and bringing forward a new perspective for learning and understanding between GPS and IRNSS, with a main focus was on analysing, evaluating and understanding different obstructions that affect the reception and strength of received signals through both manual and receiver.**

1. INTRODUCTION

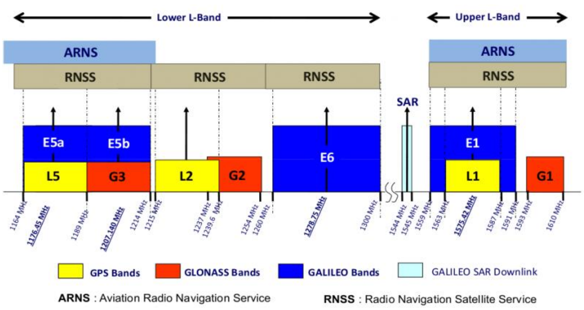
The **Global Positioning System** (**GPS**), originally **Navstar GPS**, is a space-based radio navigation system owned by the United states government and operated by the United States Air Force. It is a global navigation satellite system that provides geo location and time information to a GPS receiver anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.

GPS provides two different positioning services:

- Precise Positioning Service (PPS)
- Standard Positioning Service (SPS).

GPS Technology operates in the following frequency bands:

- GPS L1 Band: 1575.42 MHz with a bandwidth of 15.345 MHz
- GPS L2 Band: 1227.6 MHz with a bandwidth of 11 MHz



- GPS L5 Band: 1176.45 MHz with a bandwidth of 12.5 MHz

Indian Regional Navigation Satellite System (IRNSS) is an independent, indigenously developed satellite navigation system fully planned, established and controlled by the Indian Space Research Organization (ISRO).

The IRNSS architecture mainly consists of:

- Space Segment
- Ground Segment
- User Segment

The basic services offered by IRNSS

- Standard Position Services (SPS) an open service without encryption
- Restricted Service (RS), an authorized with encryption

The IRNSS SPS service is transmitted on L5 (1164.45 – 1188.45 MHz) and S (2483.5-2500 MHz) bands. The frequency in L5 band has been selected in the allocated spectrum of Radio Navigation Satellite Services as indicated in and S band

2. GAGAN

The Indian Space Research Organization (ISRO) and Airports Authority of India (AAI) have implemented the GPS Aided Geo Augmented Navigation-GAGAN project as a Satellite Based Augmentation System (SBAS) for the Indian Airspace. The objective of GAGAN to establish, deploy and certify satellite based augmentation system for safety-of-life civil aviation applications in India has been successfully completed.

Uses: GPS signals and with additional information provided about the position of the satellites, it tells you which GPS satellites are giving you a more accurate position. It corrects the errors in GPS signals with the help of 28 receiving stations spread across the country. With all the ionospheric corrections that are required for instant computation, the information is provided in GAGAN. That’s how GAGAN enables you to get better accuracy than GPS.

3. TRILATERATION

The GPS receiver gets a signal from each GPS satellite. The satellites transmit the exact time the signals are sent. By subtracting the time the signal was transmitted from the time it was received, the GPS can tell how far it is from each satellite. The GPS receiver also knows the exact position in the sky of the satellites, at the moment they sent their signals. So given the travel time of the GPS signals from three satellites and their exact position in the sky, the

GPS receiver can determine your position in three dimensions - east, north and altitude.

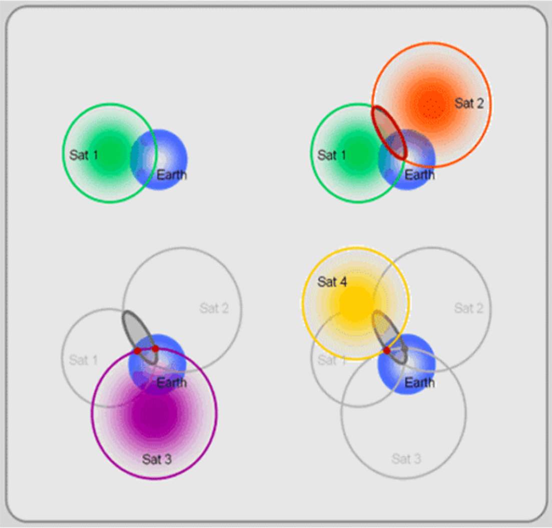
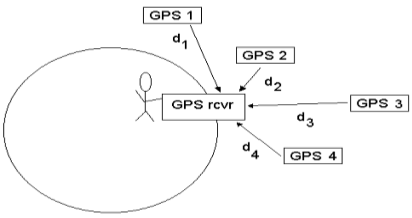


Figure: trilateration

The first satellite locates you somewhere on a sphere (top left of Figure). The second satellite narrows your location to a circle created by the intersection of the two satellite spheres (top right). The third satellite reduces the choice to two possible points (bottom left). Finally, the forth satellite helps calculate a timing and location correction and selects one of the remaining two points as your position (bottom right)

4. CALCULATING GPS POSITION



The GPS calculation in the receiver uses four equations in the four unknowns x, y, z, tc, where x, y, z are the receiver's coordinates, and tc is the time correction for the GPS receiver's clock. The four equations are:

$$d_1 = c(t_{t,1} - t_{r,1} + t_c) = \sqrt{(x_1 - x)^2 + (y_1 - y)^2 + \sqrt{(z_1 - z)^2}}$$

$$d_2 = c(t_{t,2} - t_{r,2} + t_c) = \sqrt{(x_2 - x)^2 + (y_2 - y)^2 + \sqrt{(z_2 - z)^2}}$$

$$d_3 = c(t_{t,3} - t_{r,3} + t_c) = \sqrt{(x_3 - x)^2 + (y_3 - y)^2 + \sqrt{(z_3 - z)^2}}$$

$$d_4 = c(t_{t,4} - t_{r,4} + t_c) = \sqrt{(x_4 - x)^2 + (y_4 - y)^2 + \sqrt{(z_4 - z)^2}}$$

where

- *c* = speed of light (3 ´ 10^8 *m/s*)
- $t_{t,1}$, $t_{t,2}$, $t_{t,3}$, $t_{t,4}$ = times that GPS satellites 1, 2, 3, and 4, respectively, transmitted their signals (these times are provided to the receiver as part of the information that is transmitted).
- $t_{r,1}$, $t_{r,2}$, $t_{r,3}$, $t_{r,4}$ = times that the signals from GPS satellites 1, 2, 3, and 4, respectively, are received (according to the inaccurate GPS receiver's clock)
- x_1, y_1, z_1 = coordinates of GPS satellite 1 (these coordinates are provided to the receiver as part of the information that is transmitted); similar meaning for x_2, y_2, z_2, *etc.*
  The receiver solves these equations simultaneously to determine *x*, *y*, *z*, and t_c.

5. ALMANIC AND EPHIMEREIS DATA

To determine the location of the GPS satellites two types of data are required by the GPS receiver: the almanac and the ephemeris. This data is continuously transmitted by the GPS satellites and your GPS receiver collects and stores this data.

The almanac contains information about the status of the satellites and approximate orbital information. The GPS receiver uses the almanac to calculate which satellites are currently visible. The almanac is not accurate enough to let the GPS receiver get a fix. If the GPS receiver is new, or has not been used for some time, it may need 15 minutes or so to receive a current almanac. In older GPS receivers, an almanac is required to acquire the satellites, but many newer models are able to acquire the satellites without waiting for the almanac.

To get a fix, your GPS receiver requires additional data for each satellite, called the ephemeris. This data gives very precise information about the orbit of each satellite. Your GPS receiver can use the ephemeris data to calculate the location of a satellite to with a metre or two. The ephemeris is updated every 2 hours and is usually valid for 4 hours. If your GPS receiver has been off for a while, it may take up to several minutes to receive the ephemeris data from each satellite, before it can get a fix.

6. CLOCKS USED BY GPS

GPS satellites use atomic clocks: a precision clock that depends for its operation on an electrical oscillator regulated by the natural vibration frequencies of an atomic system (as a beam of cesium atoms)

Types of atomic clocks

- Cesium atomic clocks employ a beam of cesium atoms. The clock separates cesium atoms of different energy levels by magnetic field.
- Hydrogen atomic clocks maintain hydrogen atoms at the required energy level in a container with walls of a special material so that the atoms don't lose their higher energy state too quickly.
- Rubidium atomic clocks, the simplest and most compact of all, use a glass cell of rubidium gas that changes its absorption of light at the optical rubidium frequency when the surrounding microwave frequency is just right.

7.DILUTION OF PRECESION(DOP)

The concept of dilution of precision (DOP) originated with users of the Loran-C navigation system. The idea of Geometric DOP is to state how errors in the measurement will affect the final state estimation. This can be defined as

$$GDOP = \frac{\Delta(\text{Output Location})}{\Delta(\text{Measured Data})}$$

DOP can be expressed as a number of separate measurements:

- HDOP – horizontal dilution of precision
- VDOP – vertical dilution of precision
- PDOP – position (3D) dilution of precision
- TDOP – time dilution of precision

These values follow mathematically from the positions of the usable satellites. Signal receivers allow the display of these positions (skyplot) as well as the DOP values.

8. LINE OF SIGHT

Line-of-sight propagation is a characteristic of electromagnetic radiation or acoustic wave propagation which means waves which travel in a direct path from the source to the receiver. Electromagnetic transmission includes light emissions travelling in a straight line. The rays or waves may be diffracted, refracted, reflected, or absorbed by the atmosphere and obstructions with material and generally cannot travel over the horizon or behind obstacles.

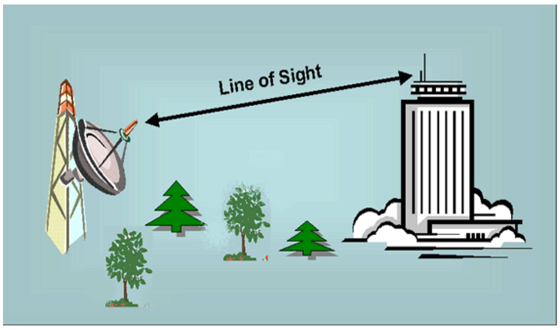


Figure:Line of sight

9. NON LINE OF SIGHT

Non-line-of-sight (NLOS) and near-line-of-sight are radio transmissions across a path that is partially obstructed, usually by a physical object in the innermost Fresnel zone. Many types of radio transmissions depend, to varying degrees, on line of sight (LOS) between the transmitter and receiver. Obstacles that commonly cause NLOS conditions include buildings, trees, hills, mountains, and, in some cases, high voltage electric power lines. Some of these obstructions reflect certain radio frequencies, while some simply absorb or garble the signals; but, in either case, they limit the use of many types of radio transmissions, especially when low on power budget. NLOS lowers the effective received power. Near Line Of Sight can usually be dealt with using better antennas, but Non Line Of Sight is usually requires alternative paths or multipath propagation methods.

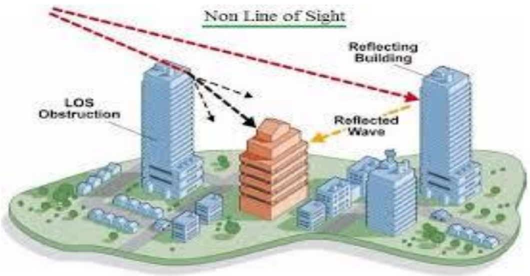


Figure:Non Line Of Sight

10.USED EQUIPMENT AND SOFTWARE

- Fixed IRNSS-GPS SBAS receiver:

Attached to a fixed computer system,the IRNSS-GPS SBAS receiver is a multi-frequency signal interpreter ,capable of receiving signals of L-1,L-5,and S bandwidths.receiving signals from both GPS and the IRNSS systems,it uses a specialized user interface to then provide visual and statistical user interface to then provide visual and statistical data.

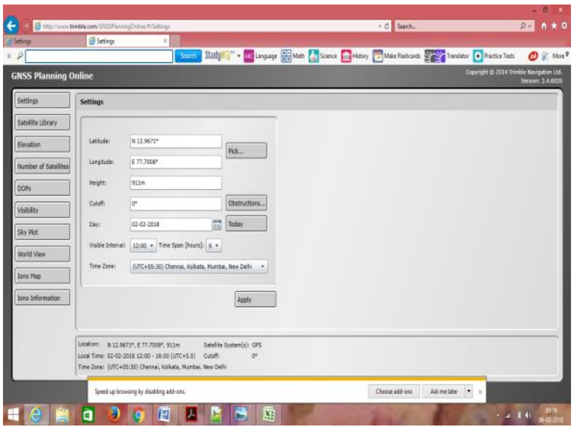
- RHCP ANTENNA

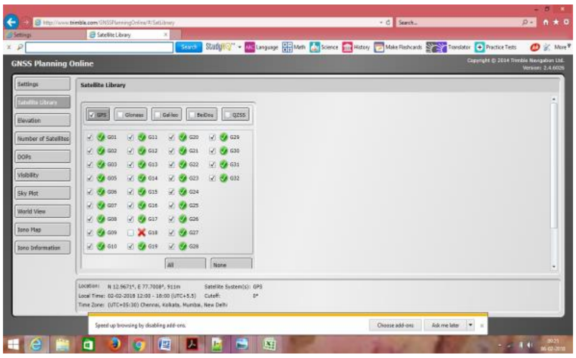
A right hand circular polarized antenna,which is hence capable and used for interpreting L-1,L-5 and even L-2 bandwidths of signals.This is subsequently used to interpret multiple levels of GPS and IRNSS satellite data simultaneously.

- GPS Reciever-Trimble Juno SC Series:

The Juno SC handheld is a durable,lieghtweight handeheld that integrates an array of powerful features.provoiding integrated cellular data and voice call capability,photo capture,and high yield GPS positioning,the Juno SD handeled will empower and increase the efficiency of your entire mobile workforce. It provides NMEA data ,skyplots,as well as satellite information on the verticals of SNR,PRN,and azimuth and elevation angles,all of the gps satellite system.

- Trimble online planning software

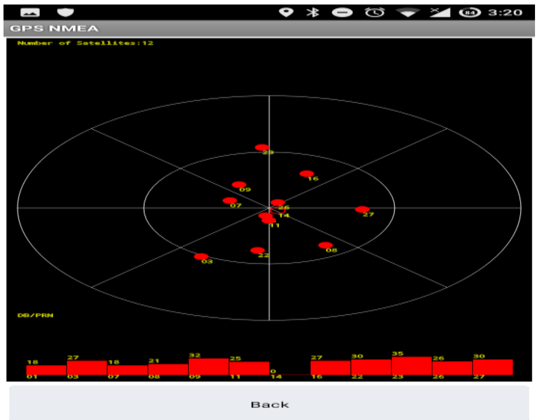




Online platform designed by trimble, the GNSS system uses real-time as well as Almanic and Ephimeres data to record and predicts satellite availability, positioning and signal information accurately to an extent.

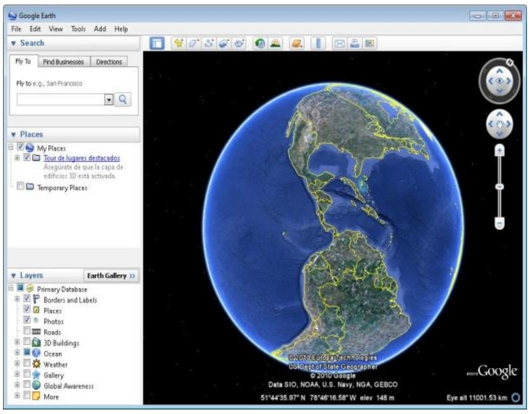
- Measurer Application:
A freely available mobile application which allows you to measure the distances between two or more points using GPS.

- GPS NMEA Applications



It is a freely available mobile application the app provide the information about available satellites their positions,and NMEA raw data

- Google Earth



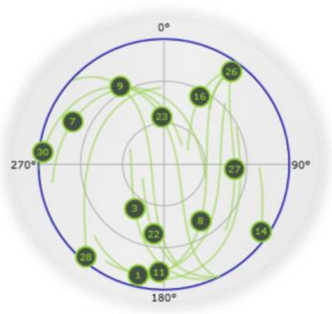
Google Earth is a computer program that renders a 3D representation of Earth based on satellite imagery.

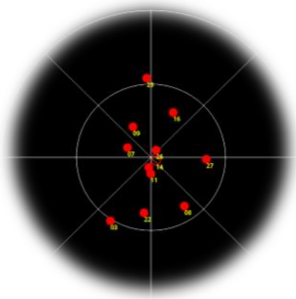
TASK 1

NMEA parameters	Trimble Planning Data	GPS Mobile Receiver Data	GPS Trimble Receiver Data
Timestamp	15:20	15:20	15:20
Latitude	N 12.9671	N 12.9671	N 12.9671
Longitude	E 77.7007	E 77.7007	E 77.7007
Altitude	896.00M	896.00M	896.00M
No. of satellites Available	14	12	8
PRN of Masked satellite		14,1	13,14,30,27,28
Signal strength of Masked satellite(db)		0,18	

The program maps the Earth by superimposing satellite images, aerial photography, and GIS data onto a 3D globe, allowing users to see cities and landscapes from various angles. Users can explore the globe by entering addresses and coordinates, or by using a keyboard or mouse.

Figure: Sky plot In Trimble planning **Figure: Sky plot and Signal strength in GPS** **Figure: Sky plot in GPS**
mobile





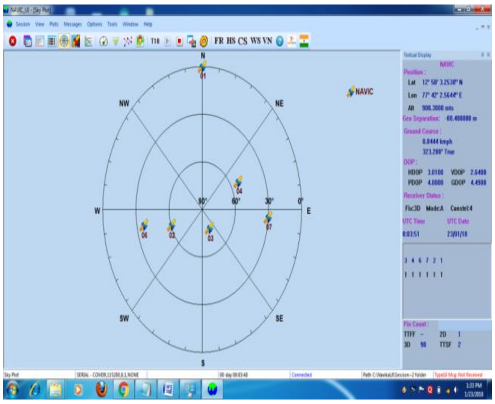
PRN Value	01	03	07	08	09	11	14	16	22	23	26	27
Signal Strength	18	27	18	21	32	25	0	27	30	35	26	30

Table :Signal Strength in Mobile Receiver

TASK 2

IRNSS

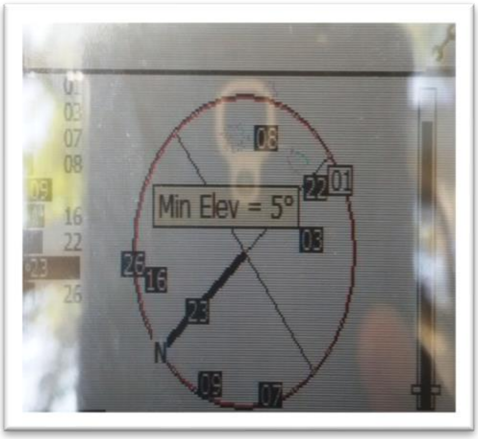
Receiving frequency
L5- 1176.45 MHz
S1- 2492.028 MHz



Timestamp-15:20
Latitude-N 12.9671
Longitude-E 77.7007
Altitude-896.00M

GPS

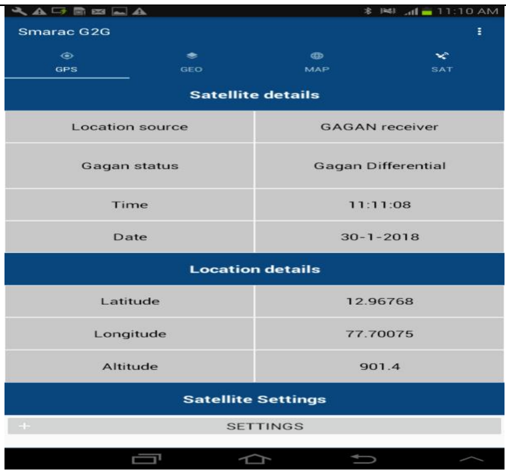
Receiving frequency
L1-1575.42Mhz



Timestamp-15:20
Latitude-N 12.9674
Longitude-E 77.7007
Altitude-896.06M

TASK 3

GAGAN DIFFERENTIAL GPS RECIEVER



Time: 11:11:08
Latitude:12.96768
Longitude:77.70075
Altitude:901.4

GPS ENABLED RECIEVER

Time:11:08:22
Latitude:12.96767
Longitude:77.70075
Altitude:902.3

ISSN: 2278-0181
ICRTT - 2018 Conference Proceedings

TASK 4

Time: 13:51:22(IST)
Longitude of Use: 77.701013 E
Latitude of User: 12.967363 N
Altitude: 886.00m
Distance of user from reference point X(m): 10
Distance of building from reference point Z(m):0

Height of Building Y(m):15
Azimuth angle: 0
Elevation angle: 56°
No. of satellites masked by Building: 1

PRN of satellites available from(TPS)	PRN of satellites Visible from(GPS)	SNR of the visible satellite	Azimuth angle	Elevation angle	PRN of satellites for calculation in GPS receiver	PRN of satellites masked by Building	View
01	01	44	223	18	01		LOS
03	03	46	293	63	03		LOS
07	07	19	259	8			LOS
08	08	23	173	15			LOS
11	11	30	209	8	11		LOS
14	14	29	91	21			LOS
16	16	40	59	69	16		LOS
22	22	43	235	71	22		LOS
23	23	44	331	27	23		LOS
26						26	
27	27	33	136	24	27		LOS
31	31	20	44	26			NLOS
32							

TIME UTC-4:00:51 ,TIME-9:30

TASK 5

No.of satellites (tms)	No.of satellites (gps)	SRN	Azimuth angle	Masked satellites	Type	No.of satellites with obstruction(tms)
8	-	0	278 deg	masked		8
14	14	40DB	316 deg		LOS	14
32	32	30DB	351 deg		LOS	32
10	10	39DB	35 deg		LOS	10
27	27	30DB	242 deg		NLOS	27
31	31	32DB	190 deg		LOS	31
21	21	31DB	154 deg		NLOS	21
26	-	0	186 deg	masked		26

CONCLUSION:

Through the course of study , this investigation’s main focus was on analyzing, evaluating and understanding different obstructions that affect the reception and strength of received signals. Through both manual and receiver based collection of data ,from multiple environments and circumstances, this investigation has been approached in the right manner, comparing and contrasting these different obstructions and systems .

In conclusion, this investigation has certainly explained and studied in detail specific obstructions and circumstances, evaluating and analyzing them comprehensively, and bringing forward a new perspective for learning and understanding.

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