SATELLITE NETWORK DESIGN APPLICABLE TO ORBIT DETERMINATION FOR GNSS

DISSERTATION-II

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IN

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By

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ABSTRACT

This research work gives the suitable description of satellite orbit determination which follows emerging techniques to track the orbit of satellite. Dynamic model error and observation model error was the main factor to badly pollute the precision of orbit determination, especially in space based observation. Inter satellite distance Model is used with the consideration of orbital perturbation which calculate the initial distance between two satellite and compared with effected inter satellite distance. To predict the satellite orbit many algorithm are used with the gravitational and non-gravitational effect. The Kalman filter and extended Kalman filter are the best approaches to estimates the future position vector of the global navigation satellite. The extended Kalman filter consider the static deviation in orbit determination and the extended Kalman filter is used for dynamic also because the effect of the atmospheric forces are near to the perigee. The atmospheric forces are the main cause of the orbital perturbation which is reduce by the inter satellite distance mechanism and follow the prediction techniques to measure the satellite position vector with accurate deviation. The main effect is reflected in the orbital parameter through that i can configure that how much deviation is occurs.

LIST OF ABREVATIONS

GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GLONASS	Global Navigation Satellite System
3G	3rd Generations
UMTS	Universal Mobile Telecommunication Services
GIS	Geographic Information Systems
INS	Inertial Navigation System
DOD	Department Of Defense
SV	Space Vehicle
FBSR	Feed Back Shift Register
CIO	Conventional International Origin
ITRF	International Terrestrial Reference Frame
GTRF	Galileo Terrestrial Reference Frame
LEO	Low Earth Orbit
HEO	Highly Elliptical Orbit
GEO	Geostationary Orbit
MEO	Medium Earth Orbit
ICO	Intermediate Circular Orbit
SLR	Satellite Laser Ranging
ILRS	International Laser Ranging Service
OD	Orbit Determination
MGEX	Multi GNSS Experiment
IGS	International GNSS Service
LRA	Laser Retro-Reflector Array
OSNE	Onboard Satellite Navigation Equipment
SNS	Satellite Navigation System
AES	Artificial Earth Satellite
EOP	Earth Orientation Parameter

ECOM	Empirical Code Orbit Model
CODE	Center For Orbit Determination in Europe
ERP	Earth Rotation Parameter
SRP	Solar Radiation Pressure
PDOP	Position Dilution Of Precision
FSA	Finite State Automation
ISL	Inter Satellite Link
MATLAB	MATrix LABoratory
TTC	Telemetry Tracking Control
TEC	Total Electron Content
DCS	Differential Code Biases
BOC	Binary Offset Carrier
PLL	Phase Locked Loop
SLL	Subcarrier Locked Loop
DLL	Delay Locked Loop
FLL	Frequency Locked Loop
DE	Double Estimator
ID	Integrate and Dump
MTLL	Mean Time To Lose Lock
BJ	Bump Jump
PF	Pre Filtering
NCO	Numerically Controlled Oscillator

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CHAPTER 1

INTRODUCTION

1.1 Brief subscription of GNSS

The GNSS is a satellite system that is used to identify the geographical location of a user's receiver anywhere in the world. The Satellite route frameworks has turned out to be fundamental piece of all applications where versatility assumes an essential part. These capacities will be at the central unit of the third generation mobile communication (3G) systems, for example, the universal mobile telecommunication system. With respect to the past improvements, GPS propelled an assortment of strategies, items and, therefore, applications and administrations. The point of reference of satellite route is the constant situating and time synchronization. Therefore the execution of wide-territory expansion frameworks ought to be highlighted, in light of the fact that they permit a noteworthy change of exactness and honesty execution. GNSS advancement has an intriguing angle because of its delicate nature. Impressive occasions or advancements are constantly subject to two or three differentiators: innovative improvements and political choices.

The fundamental utilization of GNSS is centered on the capability of to decide the positioning coordinates in the Global reference framework anyplace whenever on the Globe in a basic, quick and practical way. In all fields application GNSS will assumedas a key part, the utilization transfer from the transportation area to multimodal utilize, outside and inside. The GNSS will increment fundamentally the exactness of position space. The idea from reference framework for route is fundamental since every one of the uses of GNSS are identified with the facilitate framework utilized.

With the worldwide route satellite framework (GNSS) promote improvement, running and correspondence among the satellite through between satellite connections has turned into the pattern of advancement of route framework that accomplish GNSS self-sufficient operation . The fate of GNSS system propose "entrance to a satellite, equal to get to whole group of stars idea, which accomplish the heavenly body consistent and dynamic ongoing observation, security so that guarantee route data continuous and successful. This requires build up a rapid satellite correspondence organize that in view of the ISLs innovation to meet the product refresh satellite data, guideline, between satellites extending information, space borne sensor information, satellite refresh, multi-assignment correspondence, and the client gadget refresh programming. In the meantime, to improve satellite circle assurance exactness, satellites accomplish its visual satellite extending however much as could reasonably be expected. The GPS organize receives UHF band, and the fate of the GNSS satellite system will utilize the Ka band, running must be finished in perceive ability limitations to accomplish satellite itself high exactness circle assurance without ground mediation.

1.2 GNSS Components

The GNSS contains three main sections which used for whole navigation process.
Space section, Control fragment and User portion.

1.2.1 Global Positioning System

The NAVSTAR GPS has developed by the United States Department of Defense (DOD).That is an all-climate, space segment based route framework to investigate the issues of the USA military powers and precisely decide their position, speed, and time in a typical reference framework, anyplace in space or close to the Earth consistently (Wooden, 1985).

GPS has had a significant effect on all situating, route and observing applications. It gives especially coded satellite flags whichis prepared in GPS collector, enabling the recipient to gauge position, speed and time. The four GPS satellite flags which are utilized to figure positions in different measurements and time balance in beneficiary clock. GPS includes three fundamental parts:

- Space section: The Space Section of the framework comprises of GPS satellites. The radio signs transmitted by space vehicles from space section.
- Control portion: The Control Segment comprises of an arrangement of following stations situated in the world. The Master Control office is situated at Schriever Air Force Base (previously Falcon AFB) in the State of Colorado, USA.

- User section: The GPS User Section comprises of GPS recipients and client group. GPS beneficiaries change the space vehicle (SV) signals into speed, position, and time gauges.

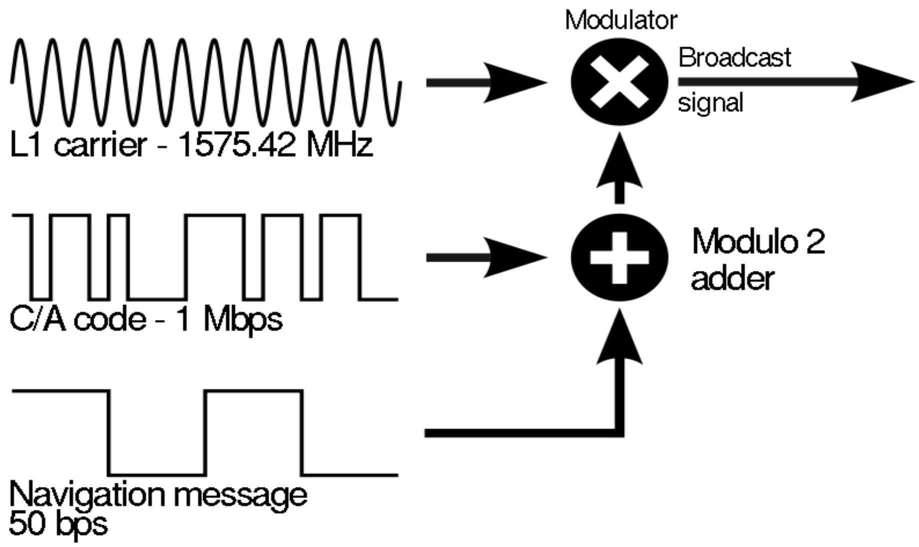

Figure 1.1 GPS Satellite Signals[28]

The satellites are scattered among six orbital planes for all the intents and purposes round orbits with a height of around 20,200 km over the surface, inclined by 55 degree concerning equator and with the orbital circumstances of about 11 hours 58 minutes. As shown in the figure 1.1 the GPS signal consider the carrier frequency, some psudorandom codes and informaion which is modulated with the carrier frequency and then transmit to the receiver.

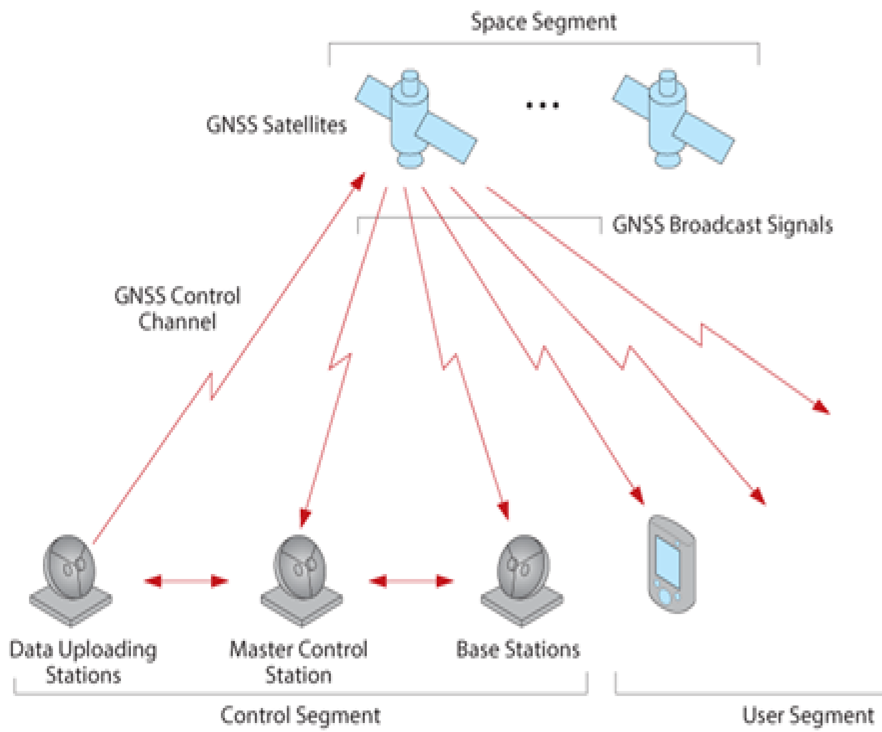

Figure 1.2 GPS Segments Aerospace Corporation, 2003[28]

1.2.2 GPS Signals

The frequency used to generate onboard signals of the satellites is f1=10.23 MHZ.The nuclear checks control the flag and havethe security in the scope of 10−13 more than a day. In L band two motions which are indicate L1 and L2 are produced by whole number duplications of the transporters these bearers are bi-stage balanced to give satellite clock readings to the collector and transmit data by codes. The codes comprise of a grouping with states +1 or - 1, comparing to the paired qualities 0 or 1. The diphase regulation is performed by 180° move in transporter stage at whatever point an adjustment in the code state happens; see Figure 1.1. The reasonable get to code and exactness code (P-code) are utilized for satellite clock perusing those are portrayed by pseudorandom commotion grouping. The route message is regulated utilizing two bearers when the chippingrateis of 50 bps.

It has data on the satellite orbit, circle annoyances, GPS time, ionosphere parameters, satellites clock and framework status messages. L1 by P code, C/A-code and route message (D)are adjustedby utilizing the quadrature stage move keying plot. On L1bearer C/A code with 90° balance by the P-code.From two bearers we get:

$$L_1(t) = a_1 P(t)\omega(t)\cos(2\pi f_1 t) + a_1 c/a(t)d(t)\sin(2\pi f_1 t)\ldots\ldots(1)$$

$$L_2(t) = a_2 P(t)\omega(t)\cos(2\pi f_2 t)\ldots\ldots(2)$$

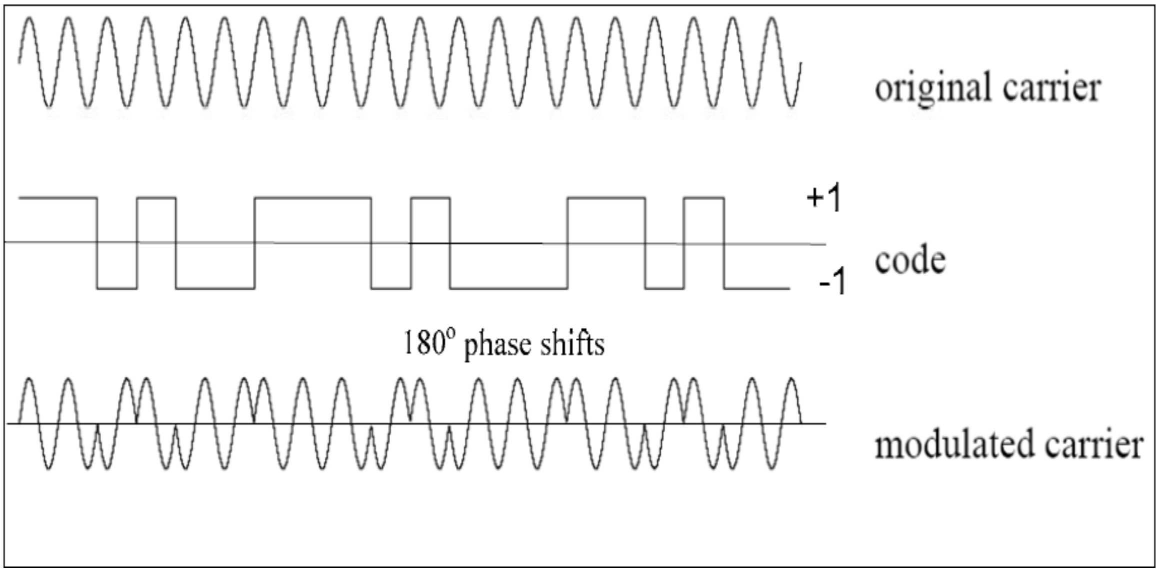

Figure 1.3 Bi-Phase Modulation of Carrier[28]

The fundamental idea of spread range procedure is that the data waveform with little transfer speed is changed over by regulating it with a huge transmission capacity waveform. The extraction of pseudo random noise (PRN) in the code depends on the utilization of a communication equipment gadget got back to tapped bolster move enlists (FBSR). This gadget can create an extensive assortment of pseudo irregular codes, yet along these lines the produced code repeats itself after some long time.

1.3 GNSS Signals

Each satellite framework has particular flag attributes, however every framework endeavors to be perfect with the others so as to keep the obstructions and constriction between the signs. Consider that the preparing of all signs ought to be performed utilizing a similar collector, in this way a mind boggling recipient configuration should be outlined and fabricated. As said over, The GNSS recurrence arranges might regard the radio-controls as they are talked about and concurred on at ITU discussions.

1.4 Reference Coordinate System

The coordinates of the authority is figured concerning the position of satellite. The range vector is considered for association among satellite and the gatherer, the organize of satellite and beneficiary should be imparted in a comparative encourage system. In satellite geodesy, the two systems in satellite geodesy are utilized and change parameters among the space settled and earth settled are outstanding and clearly used in GNSS authority and post dealing with programming to analyze the position of the beneficiaries in earth settled structure.

The depiction of position vector in geocentric Cartesian headings (X, Y, Z) has less centrality in course. In this way, the ellipsoidal depiction (longitude, degree and stature over the ellipsoid) are more for the most part use for sort out depiction.

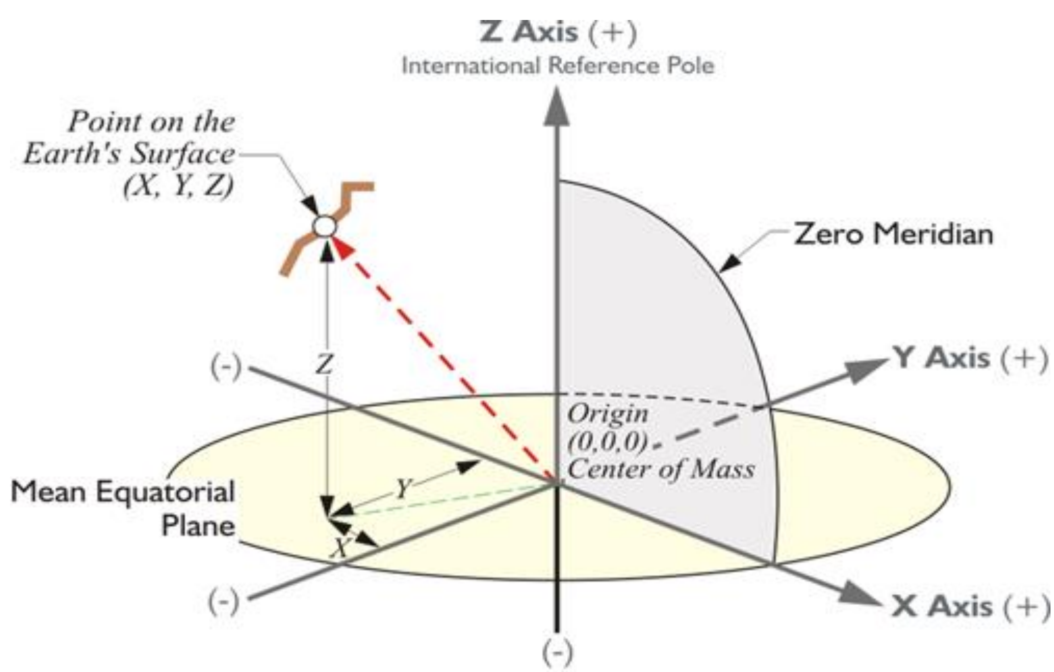

Figure1.4ECEF coordinate system and ellipsoidal coordinates[28]

1.5 Satellite Orbit

The orbit of the satellite is continuous path followed in the space. Every satellite is established in different orbit with different altitude. The different orbits are Highly Elliptical Orbit (HEO),Low Earth Orbit (LEO), Geostationary Orbit (GEO)and Medium Earth Orbit (MEO).

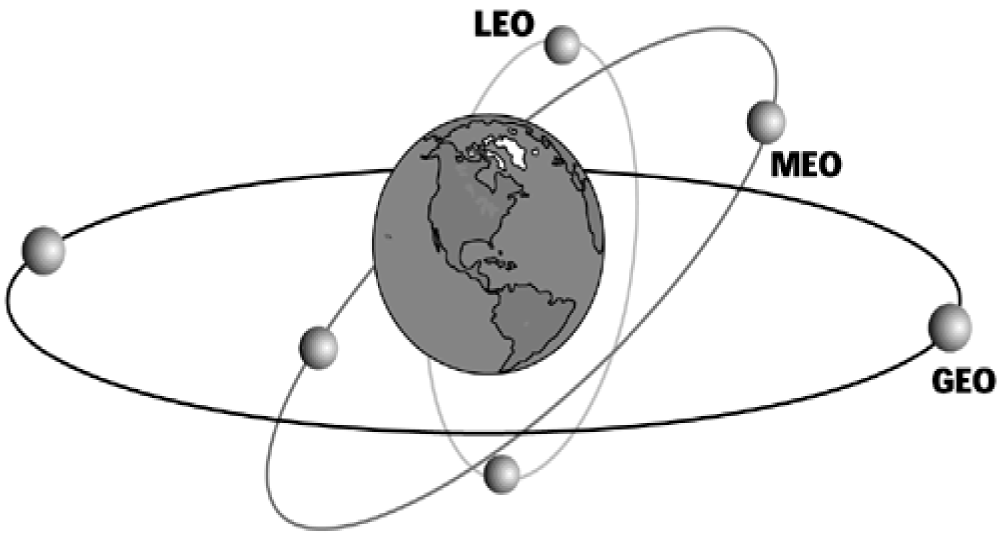

Figure 1.5Different types of orbits[28]

1.5.1 Low Earth Orbits

In Low Earth Orbit the existed satellites are Hubble Space Telescope,International Space Station and Space Shuttle. This orbit is similar to previous baseball orbiting example, but it is not much enough to miss all mountains and atmospheric drag won't affect it. It existsin the 120-150th degree of the Tropical zodiac, among 125.25 and 152.75 degree of celestial longitude.

1.5.2 Medium Earth orbit

The Medium Earth orbit are also called as intermediate circularorbit (ICO), because of the area which is around the Earth and above low Earthorbit (altitude of 2,000 kilometers) where below geostationaryorbit (altitude of 35,786 kilometers). It is not a perfect circular orbit or a perfect elliptical orbit.

1.5.3 Highly Elliptical Orbits

According to Kepler's second law: The object which is in orbit around Earth moves significantly quicker near to earth than when it is more in remote area. Perigee is nearest point and apogee is most distant. On the off chance that the orbit is extremely curved, the satellite will invest the majority of its energy close apogee and there it moves gradually. Along these lines it can be above home base more often than not, and to speed over the opposite side it takes a break after every circle. A profoundly circular circle (HEO) is an elliptical orbit with low-elevation (frequently under 1,000 kilometers) perigee and high-height (regularly more than 35,786 kilometers) apogee.

With the profoundly circular circle portrayed over, the satellite has long abide time more than one zone, yet at specific circumstances and there is no scope in the coveted territory when satellite moves fastly in orbit. To take care of this typical issue two satellites can be taken on comparative circles, yet planned to be on opposite sides of circle at any given span of time.

On the off chance that we need consistent scope on whole planet at all circumstances, for example, the Department of Defense's Global Positioning System (GPS), we should have a constellation of satellites with circles that are both distinctive in area and time.

Along these lines, a satellite which is over all aspects of the Earth for any time. On account of GPS framework, the three satellites are required to cover any area of the planet.

1.5.4 Geosynchronous Orbits

The geosynchronous orbit described for the special worldwide satellite system which used for defense. Another answer for stay time issue is achieved by continually sitting the satellite on the identical area of the planet. To implement this method there is requirement to have the orbital time of satellite precisely same with turn time of the Earth i.e. day. It is known as a geosynchronous orbit or GEO. On the off chance that you review, the space carry, so as to stay up high, must circle the planet at regular intervals.

The Kepler's third law can be used to make sense that on what distance a satellite must be to invest all of its energy more than a player in Earth. The appropriate response is that a satellite must be set around 36,000 km far from the Earth surface keeping in mind the end goal to stay in a GEO orbit. That is a great deal more distant from low Earth orbit, or a moderately close profoundly capricious GPS orbit. Be that as it May, then you just need one satellite to carry out the employment and it is at work 24 hours for every day.

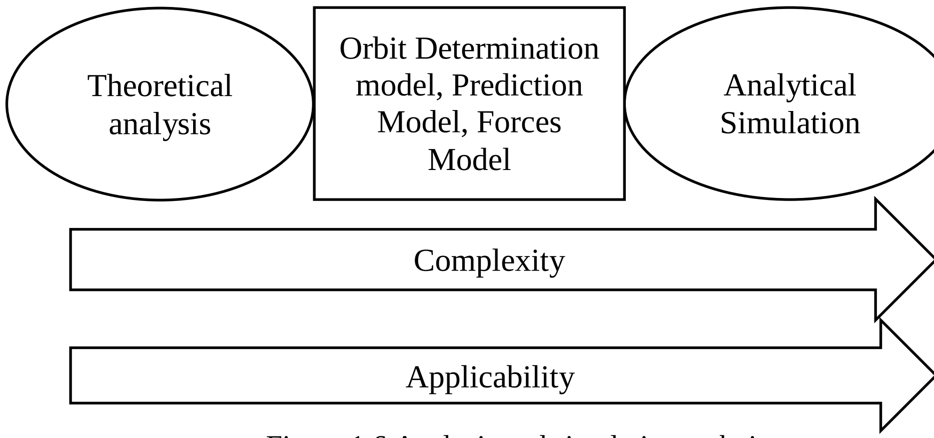

Figure 1.6 Analysis and simulation techniques

1.6 Prescribe Satellite orbit determination (OD)

Satellite orbit assurance (OD) can be portrayed as the strategy for deciding the position and speed (i.e., the state vector, state, or ephemeris) of a circling article, for example, an interplanetary rocket or an Earth-circling satellite. The OD issue is for the most part depicted by the computational procedure (for the most part settled by applying factual estimation methods) of deciding the condition of a satellite as an element of time utilizing the arrangement of estimations gathered locally available the satellite or potentially by ground-based following stations. The OD conditions are likewise profoundly nonlinear, linearization is regularly performed so that straight estimation procedures can be utilized to determine the OD issue. The state vector of a circling satellite is made out of an arrangement of position and speed parts that are typically opposed in a Cartesian reference outline, regularly referenced to the Earth's focal point of mass gravity gradiometers. The main utilizations of OD are for Earth-circling satellites. The Satellite Orbit Determination by Inter satellite ranging of sufficient Quality. Multi-GNSS Experiment (MGEX) of the International GNSS Service (IGS), a worldwide system of multi-GNSS observing stations has been built up and different examination focuses have begun to decide circles of chose GNSSs on a normal premise.

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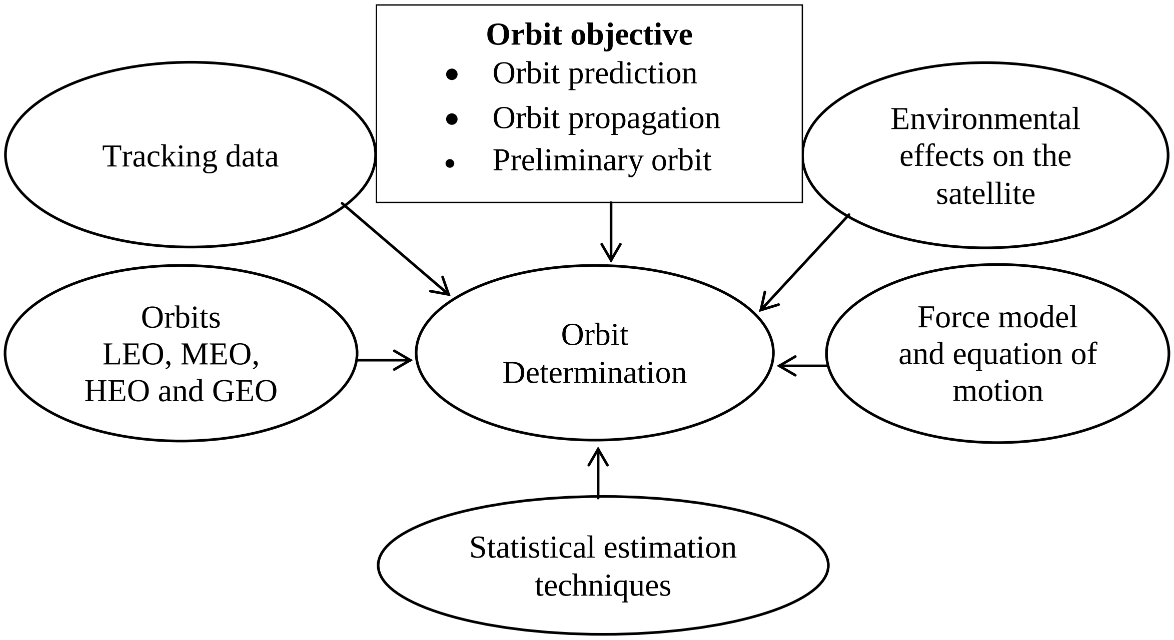

Figure 1.7 Orbital constraints

Table 1.1: Six Orbital Parameters for determination

Keplerian Parameter	Notation
a	Semi-major Axis
e	Eccentricity
i	Inclination Angle
w	Argument of Perigee
Ω	Right Ascension of Ascending Node
M	Mean Anomaly

1.7Non gravitational effects on orbit of satellite

The perturbations are arises in the motion of earth satellite due to the effect non-gravitational forces. There is having two categories: atmospheric drag and solar radiation pressure which is further has subcategories:

(a) Direct solar radiation pressure

(b) Re-radiation of the earth

These all forces are effect the satellite's shape and orbit so these are satellite dependent. The main equation which covers all the effects is given as:

$a_{non-gravitational} = P_{drag} + P_{solar} + P_{earth} + P_{thermal}$……………………………….(3)

Where

P_{drag} = perturbations arise from atmospheric drag

P_{solar} = perturbations arise from solar radiation pressure

P_{earth} = perturbations arise from earth radiation pressure

$P_{thermal}$ = perturbations arise due to thermal radiation

1.7.1 Atmospheric drag

An arbitrary shaped satellite near to earth moving with velocity v in an atmosphere which has atmospheric density ρ experiences the drag force[9]. The mathematical representation is given in equation 2:

$$P_{drag} = -\frac{1}{2}\frac{\rho\, C_d\, A}{m} v^2 \qquad (4)$$

Where

$\rho$is atmospheric density

$m$is mass of the satellite

A is cross sectional area

$v$is velocity of the satellite

C_d is drag coefficient

The part $\frac{C_d\, A}{m}$ of equation 2 is ballistic coefficient. There are various models used to describe the atmospheric density .The density has error percentage in the range of 10% to 200% it depends on solar activities [5].Some models to measure the density are Jacchia 71[8], Jacchia 77[9], DTM-2000[10] and the drag temperature model [8].The deviations in density from the computed values of density ρ_c is observed by modified the computed density by empirical parameters and then use it in equation of orbit solution. The density affected due to these parameters is evaluated on per revolution basis and given in equation 3:

ρ = ρ_c [1+C_1 cos (M+ω) +C_2 sin (M+ω)] ………………………………………………(5)

Where

C_1 AndC_2 are the once per revolution density coefficient

M is mean anomaly

ω is argument of perigee

1.7.2 Earth Radiation Pressure

For orbit determination only solar radiation pressure is not sufficient to taken into consideration. The radiation pressure emitted by flux of earth is also considered for near earth satellite to determine the orbit precisely. The equation 5 gives the earth radiation pressure[8]:

$P_{earth} = (1+\eta)\grave{A}\frac{A}{mc}\sum_{j=1}^{N}[(\tau a E_s \cos\theta_s + \mathrm{e}M_B)\acute{r}]_j$ ……………………………………..(7)

Where

η satellite reflectivity for earth radiation pressure

À is the attenuated area of earth

A is cross section area

m is the mass of satellite

c is speed of satellite

τ is 0 or 1(darkness or daylight)

N is total number of segment

a is albedo

$E_s$is solar momentum flux density

$M_B$is existence of earth

ŕis unit the vector from center of element j

1.7.3 Thermal Radiation

The temperature on surface of satellite is not uniform due to internal and external heat fluxes so the force is comes into existence. This effect depends on orbit properties, shape, thermal property and thermal environment of satellite [16],[17].

1.8 Gravitational effect on orbit of satellite

The gravitational forces act on the satellites which are the main factor of the satellite which balanced the motion with the fixed speed. Due to the elliptical orbit the gravitational forces is different at the different portion in orbital path, So that the consideration is dynamic orbit determination. The gravitational forces are centripetal which are act in side due to the gravitational and the centrifugal forces is act outside the orbit so that the orientation is balanced with the same speed. These are specified in the equation 1, equation 2.

$$Fcentripital = -\frac{G\,Me\,m}{r^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .(8)$$

$$Fcentrifugal = \frac{m\,v^2}{r} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots ..(9)$$

$$v = \sqrt{G\,Me/r} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots ..(10)$$

Where,

G=Gravitational Constant

Me=Mass of earth

m=Mass of Satellite

r=Altitude

V=Velocity of the satellite

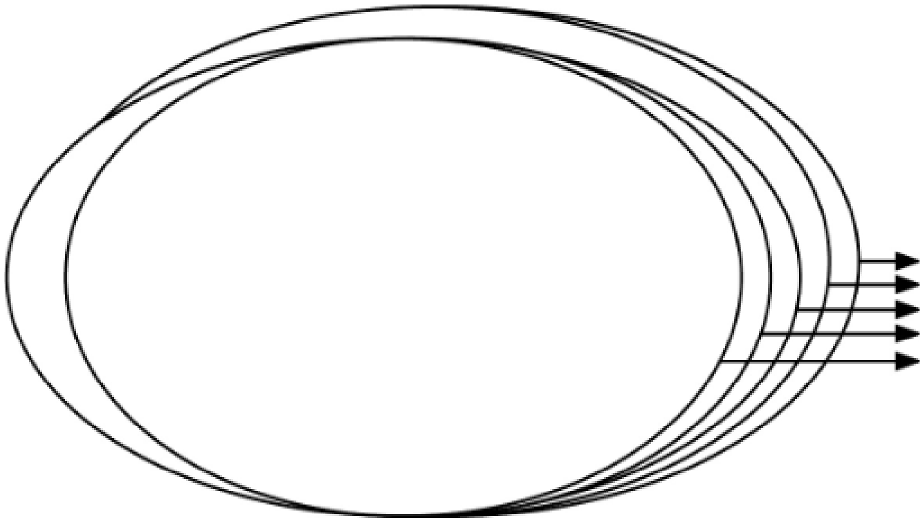

Figure 1.8.Orbit Deviation Due To Atmospheric Effect

Figure 1.8 shows that in the space the gravitational and non-gravitational forces are established which causes in the orbit deviation in term of semi-major axis and eccentricity. The semi-major axis and the eccentricity are the two factors which are mostly affected by these forces in space.

Table 1.2.Various techniques of orbit determination

Paper	**Technique used**	**Ingredients**
2014[10]	Extension of Gauss method	All perturbations are considered., Reduces the statistical errors and reproduces the better estimates.
2012[11]	Gauss method	Process faster, the number of iteration are reduced significantly, Improves the accuracy without increasing the iterations.
2014[12]	Extended Kalman filtering(EKF) and least square(LS) method	Extended Kalman filtering and least square method, EKF is faster than LS method and EKF is more accurate because of its recursive nature.
2011[13]	Sigma point Kalman filtering and extended Kalman filtering.	The sigma point Kalman filtering is more robust than extended Kalman filtering because of its faster convergence.

CHAPTER 2

SCOPE OF THE STUDY

The scope of the study is very vast in orbit determination part of the satellite communication. Every satellite earth station try to provide the exact information to the user. To provide the accurate and reliable service throughout the word every ground station need to orbit determination. We have various orbit determination algorithms i.e. Gradient method, Kalman filtering, least square method and extended Kalman filtering which estimate the velocity vector and position vector of the global navigation satellite system. Orbit determination is technique which exists in the space segment and in space segment various gravitational and non-gravitational forces are occurs on satellite. The gravitational forces are the centrifugal force and centripetal force which are established for accurate balancing of satellite in the direction of moment. The effect of the gravitational forces are decreased with the increasing the altitude. The Global navigation satellite systems are mostly established in MEO so that effect of gravitational force is less as compare to the non-gravitational forces. The non-gravitational forces are atmospheric drag, tidal effect, solar radiation pressure, solar third body. The orbital perturbation is caused by non-gravitational effect which is engaged with Keplerian element i.e. semi-major axis, mean anomaly, eccentricity, inclination angle, argument of perigee,right ascension of ascending node. The effect of atmospheric drag is more effective parameter in orbit determination and the semi-major axis and eccentricity is more deviated orbital element which is the directly engaged in the shape of the orbit. To predict the orbital position with atmospheric effect the inter satellite distance algorithm is considered. The inter satellites distance method depicted that the initial orbit position and after atmospheric effect the position of the satellite is deviated with direction.

CHAPTER 3
PROBLEM FORMULATION

In the satellite communication main task is to pinpoint the exact location of the object throughout the world. To achieve that phenomena the satellite orbit determination the appropriate techniques which also include the orbital perturbation. The gravitational and non-gravitational forces are generally involved in the orbital perturbation. The atmospheric drag and solar radiation pressure is the main effect which engaged in the orbital perturbation. There are various methods to predict the position of the satellite and orbit deviation of the satellite in space.

Problem

(a) The problem I found in the orbit determination i.e. Inter satellite distance deviation**.** The deviation is the main factor in the satellite orbit determination which introduces the forces act on the satellite in the space.

(b) The effect of the atmospheric drag is more with respect to altitude and that is directly effect on the satellite orbit shape.

(c) The semi-major axis and eccentricity is more effected orbital parameter in the medium earth orbit.

(d) To provide the more accurate and reliable position information of object throughout the word .We need to reduce the Orbit deviation and it is still the main task.

(e) The effect of the centrifugal and centripetal forces is more near to the perigee which cause of the orbit deviation.

CHAPTER 4
OBJECTIVES OF THE STUDY

In the orbit determination techniques the six orbital elements are mainly required which are depicted as shape, size, and position in the plane. In the atmosphere various forces are act on the global navigation satellite which are cause of the orbital deviation. Orbit deviation is may be due to atmospheric drag, solar radiation pressure and tidal effect.

The main objective of our study is to find out the initial position vector of global navigation satellite and how the orbital elements are affected with atmospheric forces.

- To find out the orbit deviation due to the gravitational and non-gravitational forces using inter satellite distance.
- To estimate the position of the global navigation satellite considering atmospheric perturbation.
- To construct an algorithm for orbit determination using inter satellite distance mechanism.

CHAPTER 5

LITERATURE REVIEW

In this chapter the literature is presented on techniques of orbit determination and the effects which affect the satellite orbit motion. The following papers are reviewed:

Yang XiaokuiYue (2016), et al. in paper entitled **"GPS-Based Onboard Real-Time circle Determination for LEO Satellites Using Consider Kalman Filter"**depicted that the orbit assurance for those shuttle which are locked in with the GPS are obvious in the LEO orbit. To deciding the speed vector and the position vector continuously, a consider Kalman channel is utilized which depends on the diminished element circle assurance. The decreased element orbit are brought with the dynamic mistake because of sunlight based radiation weight and environmental drag bother. The consider Kalman channel with decreased element circle assurance is executed to lessen the sun based radiation weight and climatic drag. The Consider Kalman Filter-Reduced Dynamic Orbit Determination arrangements are contrasted and the Reduced Dynamic Orbit Determination arrangements and simply kinematic comes about too. it is seen that GPS circle and clock estimation with alluring precision is the key point in the continuous OD at the present stage. With the high-accuracy GPS items accessible locally available later on, the proposed CKF-RDOD approach has potential applications for ongoing Precise Orbit Determination in space missions.

Murat BAĞCI (2016),et al. in paper entitled **"Incorporated NRM/EKF for LEO Satellite GPS Based Orbit Determination"** recommended that Newton-Raphson Method (NRM)/Extended Kalman Filter for Global Positioning System based circle assurance for a Low Earth Orbit (LEO).The NRM and EKF calculations are consolidated to gauge satellite's position and speed vector parts. Beginning position values registered at NRM preprocessing step are given as estimation contribution to EKF calculation. Orbital movement of LEO satellite is demonstrated with Keplerian and Newtonian conditions thinking about the J2 bother impact brought on by Earth's oblateness. Circle proliferation models including perturbative increasing speeds, flag recurrence (single/twofold) choices and estimation systems are assuming crucial part in the circle assurance prepare. The Pseudoranging Four Points(P4P) model is utilized to decide the clock predisposition and estimation clamor and it required to four estimation from various GPS satellite at once. It required utilizing two calculations because of linearization.

Aly M. El-naggar (2012),et al. in paper entitled **"New technique for GPS circle assurance from GCPS organize with the end goal of DOP estimations"** presented that change of GPS estimation exactness. For more exact GPS estimation application weakening of accuracy ought to be anticipated for perception. The orbit assurance calculation described in the paper is actualized by utilizing a few reference stations and ascertained the circles by the new calculation; backwards GPS. Converse GPS implies that reference stations are considered as satellites and satellite as beneficiary. This new calculation used to compute the satellite orbit which is fundamentally used to ascertain the DOP. An examination is done among the evaluated PDOP by utilizing satellite directions from some new technique and from SP3 document. In this the Ground Control guides system are utilized toward decide the satellite facilitates by utilizing the distinctive organize framework. The pesudorange is need is ascertains between no less than four satellite through the proposed arrange.

Xiaoyou Yu (2013), et al. entitled that **"Satellite Network Design Method Applicable to Orbit Determination and Communication for GNSS"** entitled that the satellite system plan strategy which is presented for the circle assurance and correspondence for GNSS. It actualized the entomb satellite correspondence and extending for the exact exactness of weakening. The route group of stars is utilized which lead the 24 satellite in a for correspondence and 4 satellite control reason. This paper drew in with the forward connection assignment strategy for least mean PDOP estimation of star grouping and the littlest correspondence interface cost, satellite PDOP esteem go about as limitation condition, the start of satellite PDOP qualities is under 3 server is essential, less exorbitant correspondence connection is chosen priority to guarantee the heavenly body arrange correspondence execution.

M.H. Ashtari Larki (2012), et al. entitled that **"Satellite Orbit Determination Based on Gradient Method"** recommended that the technique for circle assurance which utilized ground track parameter rise point, azimuth edge and scope of the satellite and discover the position and speed vector in the ECI outline. In this paper an enhancement procedures is utilized with the info information that is debased by commotion. The proposed advancement systems utilized the steepest not too bad strategy that the execution of the slope technique is helpful as far as the gauge precision and meeting rate. It additionally demonstrates that the usage is utilized high commotion level information. The principle favorable circumstances of the proposed calculation demonstrate its capability to be appropriate for effective Real-Time satellite circle assurance.

Pan Yi (2016), et al. entitled that **“An Algorithm for Inter-Satellite Autonomous TimeSynchronization and Ranging in the Beidou Navigation SatelliteSystem”** presented the time synchronization in the route framework. In this paper the calculation is actualized for , the between satellite clock-balance and range with negligible blunder are gained by using the mix of clock-balance fitting polynomial and range fitting polynomial in view of the minimum square fitting of information produced from the between satellite two-way time synchronization. The bury satellite connection is utilized with the utilization of the calculation to the between satellite self-sufficient time synchronization and extending, the high-precision estimation of between satellite clock-counterbalance and pesudorange of BDS can be come to. In this the connection length model and heavenly body parameter of BDS is utilized to decide the irritation in the way of the satellite and in the middle. The impacts of satellite movement on the exactness of the entomb satellite two-way time synchronization and going calculation are investigated by reenacting the deviation law of between satellite range in various planes of the satellite group of stars.

N.V.Mikhailov (2011), et al. entitled **“Autonomous Satellite Orbit Determination Using Space-borne GNSS Receivers”**suggested that the impact of space conditions on the route, handling calculations has been examined. The fundamental issues that should be comprehended by scientists in creating techniques for computerized flag preparing in locally available satellite route gear have been portrayed. It has been recommended that the stochastic "arbitrary walk" show in light of the Kalman channel ought to be utilized for clock displaying. It has been exhibited that this model is a great deal more effective than the established polynomial model for GEO satellite route. This paper presented in two sections. The initial segment is worried with the examination of particular elements of OSNE that impact route arrangement techniques. The primary assignments to be comprehended in outlining a route arrangement in OSNE are considered. The route arrangement strategies for OSNE are integrated. They incorporate a stochastic model for a locally available clock, techniques for building up a satisfactory model of satellite movement, and a strategy for deciding Earth Orientation Parameters (EOP) on board a satellite. The usage of a stochastic clock show requires more advanced methodologies, for instance, the Kalman separating technique, rather than the standard minimum squares strategy.

D. Arnold (2015), et al.entitled **“CODE’s new solar radiation pressure model for GNSS orbitdetermination”** recommend that the Empirical CODE Orbit Model of the Center is the techniques of Orbit Determination in Europe (CODE), which has been produced in the mid-1990, is generally utilized as the measure part of the International GNSS Service (IGS) people group. We show that exclusive even-arrange brief period symphonious annoyances acting along the bearing Sun-satellite happen for GPS and GLONASS satellites, and just odd-arrange irritations acting with the heading opposite to both, the vector Sun-satellite and rocket's sunlight based board hub. In view of this knowledge we survey in the third step the execution of four competitor circle models for future ECOM. The fundamental reason for this paper is to audit the ECOM, which was effectively connected by CODE and different IGS examination focuses in the previous 20 years and to make it fit for the following 20 years. Strikingly, the ECOM issues might be generously diminished, if a specific element of the ECOM is not assessed for the GLONASS satellites. The ECOM and proposed what is called today the diminished ECOM, which just tackles for the three zero-arrange terms of the development and the principal arrange term in one of the parts. The creator demonstrated that the orbit enhanced as a result of this specific parameterization. Each satellite strategy for space geodesy needs to decide parameters of circle watched satellites when comprehending for worldwide parameters of geophysical intrigue.

Yossi Elishaa (2007), et al. entitled**“Orbit determination system for low earth orbit satellite”**investigates that to determine the Preciseframework for Low Earth Orbit satellites is displayed. The framework depends on GPS pesudorange and bearer stage estimations and actualizes the Reduced Dynamics strategy. The GPS estimations display, the dynamic model, and the minimum squares circle assurance are examined. Results are appeared for information from the CHAMP satellite and for reenacted information from the ROKAR GPS beneficiary. In both cases the one sigma 3D position and speed exactness is around 0.2 m and 0.5 mm/sec individually. Circle Determination frameworks for Low Earth Orbit satellites have been actualized in IAI/MBT. Both, on-board and ground station frameworks are utilized. The on-board framework depends on the ROKAR GPS collector. The dynamic approach is to utilize drive and satellite models with a specific end goal to register the satellite's speeding up. For the "Kinematic Orbit Determination a Kalman channel is utilized to apply geometric amendments to the dynamic direction therefore of the GPS estimations.

Shivam Mishra (2016), et al. entitled **“Satellite network design approach to orbit determination for GNSS”** proposed that the technique to decide the orbit and system to examined the pesudorange mistake. In This paper we have additionally examined that how we can plan a system for orbit assurance of GNSS at the ground station. The fundamental issues that should be fathomed by scientists in creating systems for advanced flag handling in locally available satellite route hardware have been depicted. In this paper talked about that how we exchange the information data through the satellite laser connection and satellite radio recurrence joins. As the foundation of IGMAS, a system of multi-GNSS observing stations has additionally been conveyed around the world. Up to this paper arranged, IGMAS following system comprises of twelve stations. In this we have additionally endorse the Inter-satellite connections for coordinated the exact extending, exact time and recurrence exchange correspondence and information exchange. The clock demonstrating is utilized to recoup the flag travel time of satellite and to synchronized transmitter and beneficiary satellite. To enhance the solidness of the clock demonstrating we have to security of the deferrals of electronic segment utilized as a part of the satellite beneficiary receiving wire. The virtual topology strategy views the LEO satellite system as limited state computerization so that the system has a settled topology in each state.

David Hobbs (2006), et al. entitled **"Precise Orbit Determination for Low Earth Orbit Satellites"** proposed that the exact orbit assurance issue is to precisely decide the position and speed vectors of a circling satellite. In this paper we survey the general substance of the circle assurance handle, with specific accentuation on Low Earth Orbit (LEO) satellites. The distinctive circle assurance approaches and the diverse compel models contained inside are quickly examined. The two fundamental estimation strategies, the bunch slightest squares approach and the Kalman channel, are audited and their relative benefits examined. Numerical outcomes are utilized to consider the effect of various displaying blunders on the last circle exactness, notwithstanding mistakes because of the way of close continuous preparing conditions. Slightest squares estimation includes finding the direction and model parameters for which the square of the contrast between demonstrated perceptions and genuine estimations, i.e. residuals, progresses toward becoming as little as could reasonably be expected. There are three primary ways to deal with this issue: the kinematic or geometric approach, the dynamical approach and the decreased element approach. There are two sorts of GPS perceptions: Pseudo reaches and bearer stages.

Daniele Borio (2011), et al. entitled **"A Semi-Analytic framework for fast GNSS tracking loop simulations"** invented the investigation of following orbits for worldwide route satellite frameworks (GNSS) beneficiaries is frequently bound to Monte Carlo schemes that can bring about much times and a predetermined number of reenactment iterations. An alternate scheme in view of Semi-Analytic standards is considered here. The code structure is gritty and two particular cases actualizing a standard PLL and a Double Estimator for unambiguous parallel balance bearer following are given. The code has been sorted out separately, and can be effortlessly altered for the recreation of various following circles. In the Semi-Analytic scheme, just non-linear pieces are completely mimicked while systematic outcomes are utilized to represent the straight parts of the framework. This guideline specifically applies to GNSS computerized following circles, in which more computationally requesting parts are incorporate and dump (I&D) squares utilized for dispreading the approaching GNSS signals.

Daniele Borio (2010), et al. entitled **"Semi Analytic Simulations: An Extension to Unambiguous BOC Tracking"** discussed the Modern navigation satellite system adjustments have required advancement of new following calculations whose investigation is frequently constrained to Monte Carlo reenactments. The multifaceted nature of such calculations can bring about long reproduction times or potentially in a set number of reenactment runs. In this paper, the issue of effectively reproducing GNSS signs and frameworks, including recently proposed adjustments and calculations, is tended to. All the more particularly, the utilization of semi-diagnostic procedures for the examination of GNSS following circles is talked about and stretched out to new BOC following calculations, for example, Bump-Jump, pre-sifting and Double Estimator. The fundamental concentration of this paper is the improvement of a general semi-expository system for the reproduction of advanced Delay Lock Loops (DLL) on account of BOC tweaked signals.

WANG Yuechen (2015), et al. entitled **"Research of signal-in-space integrity monitoring based on inter satellite link"** proposed that the bury satellite connection to enhance the Global Navigation Satellite System situating exactness and uprightness of connection. In this writing the writer depicted the steadiness of the situating in view of the ISL which is the satellite and ground observing connection. The structure of satellite and ground joint situating mode compelled by quality review star grouping which for the most part incorporates the worldwide entomb satellite connection and territorial Ground-satellite connections. The Kalman sifting is utilized to appraise the precise position of the satellite with earth focused inertial directions. The creators likewise present the flag in space uprightness which is utilized for observing the satellite starting from the earliest stage. The Beidou's blended group of stars used to acquaint with the satellite and ground joint position mode can forestall undesirable dispersion of blunders and stifle general float brought about by the relative situating through choosing suitable imperative. In addition, in light of the fact that the exact data for the most part gives from ground stations, so HLLs are reuse and has less impact on enhancing the situating comes about.

Sandip Tukaram Aghav (2014) et al. entitled **"Simplified orbit determination algorithm for low earth orbit satellite using spaceborne GPS navigation sensor"** proposed that the simplified orbit assurance calculation that can be utilized for LEO route. The different information preparing calculations, state estimation calculations and displaying strengths were examined in detail, and improved calculation is chosen to diminish equipment trouble and computational cost. This is finished by utilizing crude route arrangement gave by GPS Navigation sensor. The slightest square and Extended Kalman Filter orbit estimation calculations are produced and execution investigation of the same are contrasted. EKF calculation focalizes speedier than minimum square calculation. Basic static drive models likewise achievable to decrease the equipment load and computational cost. In this the numerical coordination technique for movement acquaints which is capable with diminish the impact of various strengths on satellite in space. after that the climatic thickness model is presented and afterward apply with the orbital component and actualize the barometrical impact on the orbital parameters.

CHAPTER 6
RESEARCH METHODOLOGY

6.1 Precise Orbit Determination

Orbit determination technique is used to find out the position and velocity vector of satellite. As increased the navigation application the navigation satellites are more concerning phenomena in the satellite communication. Various algorithms are used to estimate the position of satellite and deviation of satellite from the original path. As per literature review the global navigation satellites are established in the medium earth orbit and the effect of non-gravitational effect in medium earth orbit is more which directly engaged on shape and size of orbit.

6.2 Inter Satellite Distance Algorithm

To determine the orbital perturbation we need to find out the distance between two satellite from the initial and then apply the force model on the same parameter. To apply the inter satellite distance mechanism in orbit determination we need to find out the satellite initial coordinates. The coordinates model are includes those Keplerian element which introduce the shape and size of the orbit.

Methodology: Proposed techniques are comprises in three parts.

- Find out the initial coordinates
- Inter satellite distance algorithm
- Consider atmospheric forces for orbital perturbation
- Compare with the initial distance and find out the deviated distance

Step-1 Initial Coordinates System

The inter satellite distance mechanism is the better to find out the orbit perturbation. To get the distance between the satellites we need to first calculate the initial coordinates system of the satellite. The Keplerian elements are the main cofactor for the coordinates system. After that we apply the coordinate transformation algorithm for Cartesian to cylindrical coordinates.by using the Keplerian element semi-major axis (a), inclination angle (i), argument of perigee (ω), means anomaly (θ), eccentricity (e) and right ascension of ascending node (Ω).

$$X_{initial} = r[\cos(\omega + \theta)\cos\Omega - \cos i \sin(\omega + \theta)\sin\Omega] \quad (11)$$

$$Y_{initial} = r[\cos(\omega + \theta)\sin\Omega - \cos i \sin(\omega + \theta)\cos\Omega] \quad (12)$$

$$Z_{initial} = r[\sin(\omega + \theta)\sin i] \quad (13)$$

$$r = \frac{a(1-e^2)}{1+e\cos\theta} \quad (14)$$

In the equation the initial coordinates and magnitude of position vector is depicted.

Same coordinates mechanism is applied on the other satellite and find out the coordinates of others satellite a $X_1, \ Y_1, \ Z_1$. Then we find out the inter satellite distance with the pesudorange formula mention in the equation.

Step-2 Inter satellite distance calculation

$$D = \sqrt{(X_{initial} - X_1)^2 + (Y_{initial} - Y_1)^2 + (Z_{initial} + Z_1)^2} \quad (15)$$

Now we apply the coordinate transformation algorithm which is earth centered earth fixed in cylindrical form because in space communication mostly these coordinate system are used.

Step-3 Consider atmospheric forces on satellite

The atmospheric forces are applied on the satellite which cause to the orbital perturbation and direct effect on the satellite coordinates which is shown in the given equation (16),(17),(18). The given equation shows that the effect of atmospheric forces is negligible at the z direction because the effect of non-gravitational is zero in the direction of the earth.

$$F_r = -\frac{1}{2}\frac{C_d\ A\rho}{m}\frac{\mu}{a}e^{\alpha\ cosE}\frac{(1+e\cos E)^{1/2}}{(1-e\cos E)^{3/2}}e\sin E \ldots\ldots (16)$$

$$F_{\theta=} -\frac{1}{2}\frac{C_d\ A\rho}{m}\frac{\mu}{a}e^{\alpha\ cosE}\frac{(1+e\cos E)^{1/2}}{(1-e\cos E)^{3/2}}(1-e^2)^{1/2} \ldots\ldots (17)$$

$$F_{z=}0 \ldots\ldots (18)$$

Now these forces are cause of the orbital perturbation and which is shown below in the equation 19, 20, 21, 22, 23. These equation shows that the effect of these forces considered on the orbital parameters i.e. semi-major axis, inclination angle, eccentricity, right ascension of ascending node, argument of perigee.

(A) Semi-major Axis: It is half of the length of elliptical orbit of satellite. Atmospheric drag forces are more near to the perigee which is directly engaged in the semi-major axis. The atmospheric drag forces act on semi-major axis shown in the equation 13.

$$a = -\frac{C_d\ Aa\rho}{m}ne^{\alpha\ cosE}\frac{(1+e\cos E)^{1/2}}{(1-e\cos E)^{3/2}} \ldots\ldots (19)$$

(B) Eccentricity: It is the orbital element which involves the shape of the satellite orbit. It value is basically lies in between one and zero. The effect of the atmospheric drag is more on eccentricity so that the orientation of orbit is different with respect to the time, which is shown in the equation 14.

$$e = -\frac{C_d\ Aa\rho}{m}n(1-e^2)e^{\alpha\ cosE}\frac{(1+e\cos E)^{1/2}}{(1-e\cos E)^{3/2}}\cos\ E \ldots\ldots (20)$$

(C) Mean Anomaly: It is the term of orbit determination which is calculated to find out the angle among satellite orbital plane and the center of earth. The mean anomaly specify the angular distance of satellite in the elliptical orbit which is calculated by the eccentricity and the eccentric anomaly.

$$M = \frac{C_d\ Aa\rho}{m}ne^{-1}e^{\alpha\ cosE}\frac{(1+e\cos E)^{1/2}}{(1-e\cos E)^{3/2}}(1-e^3\cos E)\sin E \ldots\ldots (21)$$

(D) Argument of Perigee: Atmospheric drag is effect the satellite orbital parameter argument of perigee which is the angle between Ascending node and Perigee. The effect of that is shown in the below equation 16.

$$\varpi = -\frac{C_d\ A\alpha\rho}{m} n \frac{(1-e^2)^{1/2}}{e} e^{\alpha\ cosE} \frac{(1+e\cos E)^{1/2}}{(1-e\cos E)^{3/2}} \sin E \quad (22)$$

(E) Inclination angle: The effect of the atmospheric drag force is negligible on the inclination angle. It is the angle between the orbital place and earth equatorial plane which does not contribute in the orbital perturbation because it specified in the z plane and shown in the equation 17.

$$I = \frac{\cos(\omega+\theta) r F_z}{h} \quad (23)$$

After analyzing the effect of atmospheric drag forces we will consider again the same parameter which is affected and calculate the coordinates of the satellite and then again find out the pesudorange or inter satellite distance from the equation 15. Which shows that the orbit deviation in which direction either up or down,back or ahead.These are three step which are the main concerning in my proposed techniques.

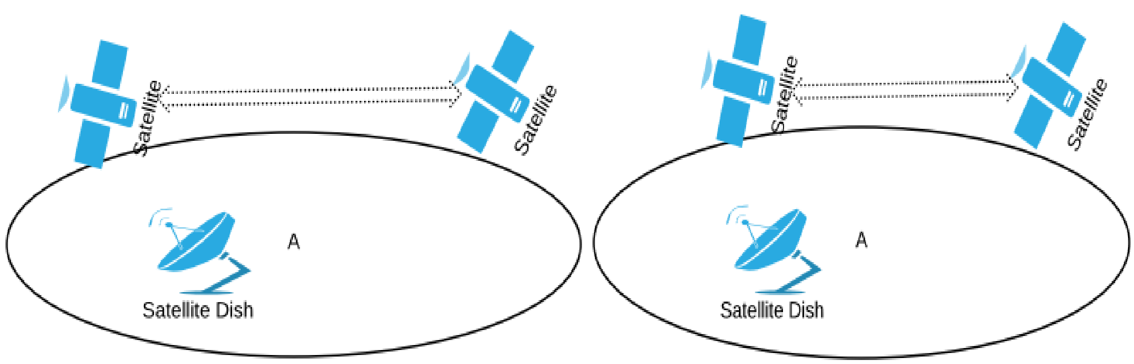

Figure 6.1. Initial Inter Satellite Distance and shrink perturbation

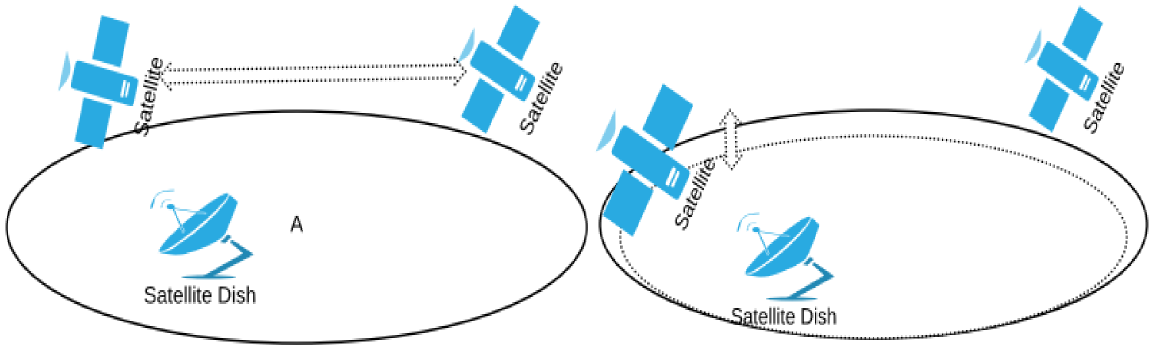

Figure 6.2.Initial and Downword perturbation of Inter Satellite Distance

The figure 6.1 and figure 6.2shows that the orbital perturbation due to the atmospheric forces. As shown in these figure we can easily configure that satellite is deviated from initial position in the back direction and other is shown as down deviation.

CHAPTER 7

RESULT AND DISCUSSION

In this chapter the results are depicted which are analyzed as the effect of atmospheric drag on orbit of satellite. The results for five orbital parameters which are used to describe the orbit of satellite are presented here which includes the semi-major axis, right ascension of ascending node, inclination angle, eccentricity, argument of perigee. The orbital parameter is also evaluated for idle case and with atmospheric effect.

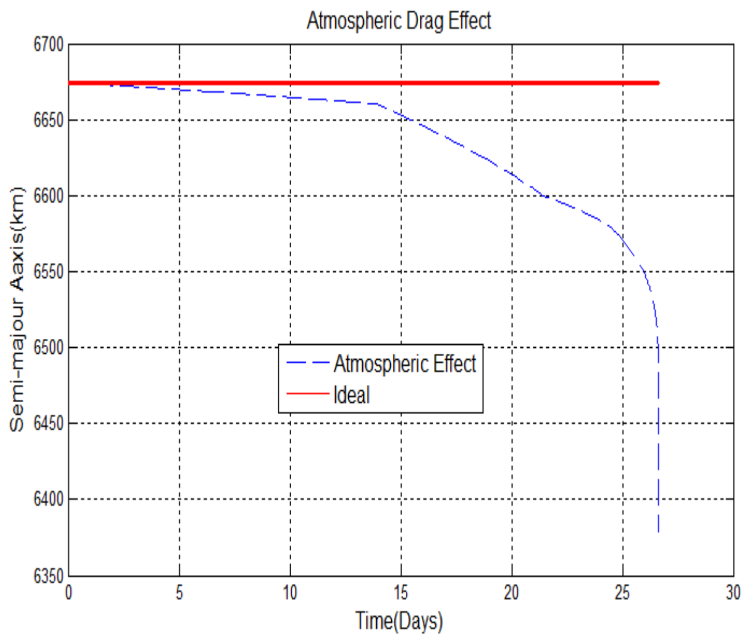

Figure 7.1. Effect of atmospheric drag on semi-major axis

The influence of atmospheric drag on semi-major axis is analyzed in figure 6.1.It has been shown that in ideal condition(with no drag) the value of semi-major axis remains constant with respect to number of days but due to drag the value of semi-major axis reduces as number of days increases. At 20th day the value of semi-major axis is 6614.7 but in ideal condition it is 6674.34 so it is observed that it drag effect reduces the orbit of satellite.

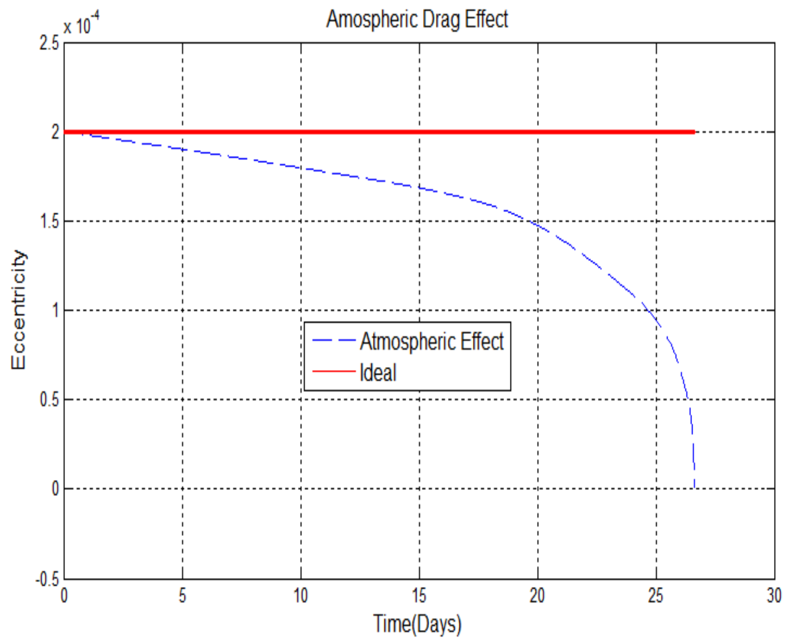

Figure 7.2. Effect of atmospheric drag on eccentricity

Figure 6.2 gives the results of eccentricity due to atmospheric drag and in ideal condition. As from figure it is analyzed that at 20th day the value eccentricity is 0.00014 but when ideal condition is assumed its value is 0.00020 which shows that this effect also degrades the eccentricity.

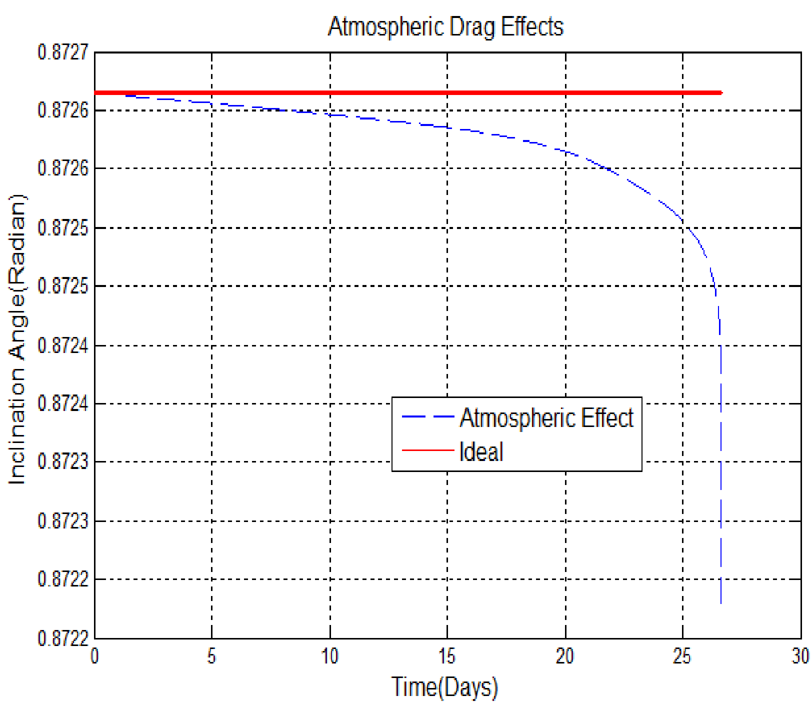

Figure 7.3 Effect of atmospheric drag on inclination angle

The effect of drag on inclination angle and on right ascension node are presented in figure 6.3 and 6.4 respectively, the value of inclination angle decreases with drag effect. At 20th day the value of inclination angle is 49.990 and 49.999 due to atmospheric drag effect and ideal condition respectively. In figure 4 the value of right ascension node increases with atmospheric effect because with ideal condition it is 20 and with effects of drag it increases to 297.47 is analyzed.

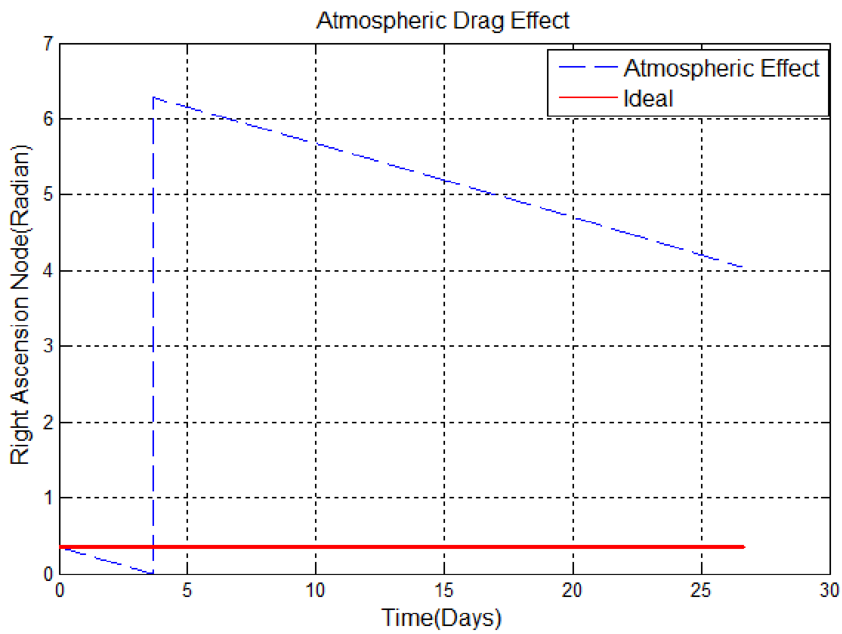

Figure 7.4 Effect of atmospheric drag on Right Ascension node

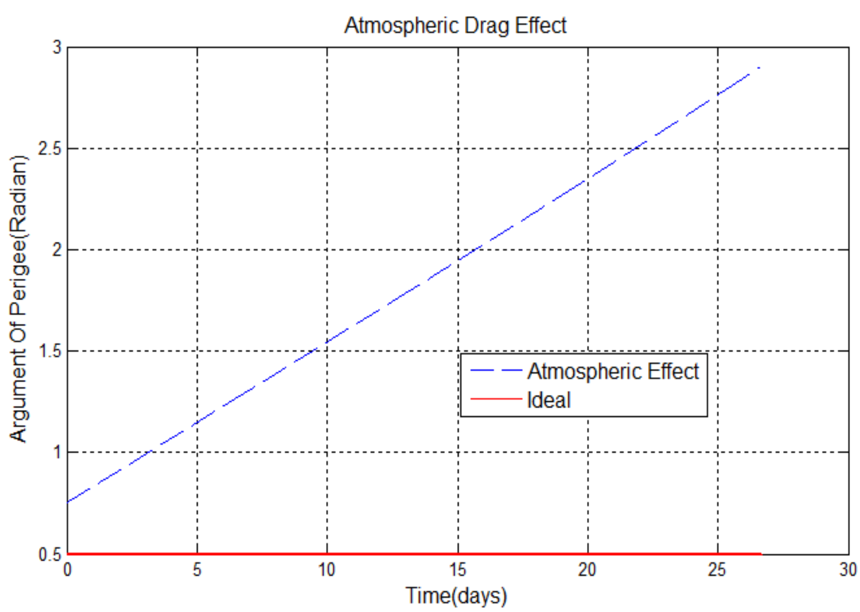

Figure7.5 Effect of atmospheric drag on Argument of perigee

The effect on argument of perigee is given in Figure 7.5 and it is observed that it increases linearly as the numbers of days are increases. With assumption of ideal conditions the value of argument of perigee is 28.647 but due to drag effect its value is 120.378 as observed on 20th day.

Table 7.1. Orbital Parameter changes due to Atmospheric Effect

Days	**Semi-major axis(a)km**	**Eccentricity(e)**	**Inclination Angle(i)**	**Right Ascension of Ascending Node(Ω)**	**Argument of Perigee(w)**	**Latitude, Longitude**
Initial	6674.34	0.00020	49.996	20.053	28.647	44.8549,-157.5967
5	6670.73	0.00190	50.0020	0.3036	51.428	48.3106,-144.2983
10	6665.2	0.00179	50.0020	352.99	74.255	49.9182,-129.5558
15	6654.4	0.00168	50.0020	325.99	96.944	49.3820,-114.3120
20	6614.7	0.00014	49.9905	297.47	120.378	46.7929,-100.0968
25	6572.1	0.00009	49.5705	269.63	143.869	-30.9152,85.9666

All the numerical values for these above mentioned parameters are given in table 2.in this table we give the values of different parameters due to atmospheric drag affect and with ideal conditions also. The influence of drag effect also analyzed for different days

SUMMARY AND CONCLUSION

The satellite orbit determination is the quite complex phenomena for the ground station but to achieve the real information with time it is necessary. In space segment the many factors are established which the cause of orbit deviation. So the gravitational and non-gravitational forces are two main forces which deviate the orbit in the shape and size. To analyze those forces I have tested all the orbital parameter with time in days. The orbital perturbation shows as in the numerical values table as well as in the output results. To predict the orbital position vector with orbital perturbation Kalman filter and extended Kalman filter is applied which show the average orbital deviation and approximated position. The inter satellite mechanism is used to determine the distance between the satellite.

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APPENDIX

PROPOSED WORK PLAN WITH TIME LINE

Timeline is defines in week-wise manner means that in which week what type of work is completed. Following timeline is followed as:

Week ▶ Month ▼	Week 1	Week 2	Week 3	Week 4
January	Understanding the concept of Satellite orbit determination.	Analysis of different research papers	Analysis of different research papers	Analysis of different research papers
February	Literature review	Literature review	Literature review + writing a paper on satellite network design	Literature review + base paper selection
March	Selection of particular Tracking algorithm.	Literature review + base paper implementation	Base paper implementation	Review paper writing
April	Work on inter satellite distance	Result formation	Report writing	Report writing
May	Report writing	Report Writing	-----	----

Author Biographies

Shivam Mishra is currently pursuing M.Tech in Electronics and Communication Engineering from Lovely Professional University, Phagwara with Wireless Communication as specialization. Area of interest in Satellite Communication. He is pursuing thesis on Satellite Orbit Determination with inter satellite distance algorithms. He has following publications related to orbit determination.

1-Paper Published

He has presented the Review Paper in the "**International Conference on Intelligent Circuits and Systems (ICICS-2016)"** which is held on 18 nov 2016.