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# A Survey on Global Positioning System Processing Methods

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## Abstract:-

The Global Positioning System (GPS) is the newest achievement in this search for precise positioning. Though originally intended for military use, GPS has been found useful in many civilian applications including surveying and navigation exceeding its original purpose. The receiver then calculates the distance to the satellite by measuring the difference between the time when the signal is received and the time when it was sent, and multiply by the speed of light.

To calculate its precise latitude, longitude, and altitude, the receiver measures the distance to four separate GPS satellites. Conventional methods of surveying and navigation require tedious field and astronomical observations for deriving positional and directional information. Rapid advancement in higher frequency signal transmission and precise clock signals along with advanced satellite technology have led to the development of Global Positioning System (GPS).

The outcome of a typical GPS survey includes geocentric position accurate to 10 m and relative positions between receiver locations to centimeter level or better.

**Keywords: -** Positioning System (GPS), GPS satellites, GPS receivers, GPS signal.

## 1. INTRODUCTION

Global Positioning System (GPS) is a satellite-based navigation system that has been used widely both in civilian and military for positioning, navigation, timing and other position related applications. The hardware-based GPS receivers provide the least user flexibility. Thus, it is necessary to have Software-based GPS receivers for easy and quick implementation, simulation and analysis of algorithms. Software-based GPS receiver processes the GPS signal at the radio frequency or intermediate frequency depending on the hardware configuration of the receiver. The Global Positioning System consists of 24 satellites, that circle the globe once every 12 hours, to provide worldwide position, time and velocity information. GPS makes it possible to precisely identify locations on the earth by measuring distance from the satellites. GPS allows you to record or create locations from places on the earth and help you navigate to and from those places. Originally the System was designed only for military applications and it wasn't until the 1980's that it was made available for civilian use also. The Global Positioning System (GPS) is the newest achievement in this search for precise positioning. Though originally intended for military use, GPS has been found useful in many civilian applications including surveying and navigation exceeding its original purpose.

The first GPS satellite was launched in 1978. The first ten satellites launched were developmental satellites, called Block I. From 1989 to 1997, 28 production satellites, called Block II, were launched. The last 19 satellites of this series of satellites were called Block IIA, which were the updated versions. The initial operational capability of GPS was established in December 1993. The primary system was completed with the launch of the 24th GPS satellite in 1994. In February 1994, the Federal Aviation Agency (FAA) declared GPS ready for aviation use . The third-generation satellite, Block IIR, was first launched in 1997. These satellites are being used to replace the aging satellites currently in the GPS constellation. The next generation of satellites, Block IIF, is scheduled for its first launch in late 2005. A GPS satellite provides a platform for radio transmitter, atomic clocks, computers, and various equipment used for positioning and other military projects. Each satellite broadcasts messages that allow the user to recognize the satellite and determine its position in space. The GPS system is capable of providing real-time navigation data to all users including high dynamics users such as spacecrafts. Since the system is aimed at providing global coverage including the Polar Regions, the satellites must be orbiting instead of stationary. Since originally designed for military applications, the system also has some built-in tolerance for jamming signals.

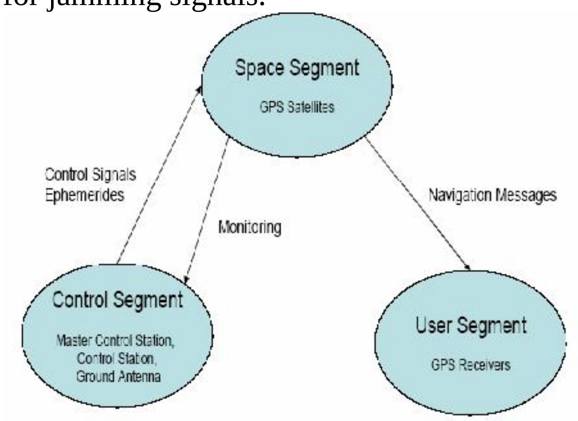



**Figure1: Space Segment**

The entire GPS system consists of three segments: the control segment, the space segment and the user segment. The control segment consists of five GPS earth stations. The master control station is located at Falcon Air Force Base in Colorado Springs, CO. The main function of the earth stations is to monitor the performance of the GPS satellites. Each monitor station has two cesium clocks as reference for the GPS system time. Each of the five earth stations makes continuous pseudo range and delta range measurements to all satellites in view every 1.5 seconds. These measurements are used to update the satellites' navigation messages. The data collected from the satellites by the earth stations is transmitted to the master control station for processing. The master control station is responsible for monitoring GPS performance, generating and uploading the navigation data to the satellites to sustain performance standards, as well as promptly detecting and responding to satellite failure to minimize the impact.

## 2. SEGMENTS OF GPS

**The Space segment:** The space segment consists of 24 satellites circling the earth at 12,000 miles in altitude. This high altitude allows the signals to cover a greaterarea. The satellites are arranged in their orbits so a GPS receiver on earth can always receive a signal from at least four satellites at any given time. Each satellite transmits low radio signals with a unique code on different frequencies, allowing the GPS receiver to identify the signals. The main purpose of these coded signals is to allow for calculating travel time from the satellite to the GPS receiver. The travel time multiplied by the speed of light equals the distance from the satellite to the GPS receiver. Since these are low power signals and won't travel through solid objects, it is important to have a clear view of the sky. **The Control segment**: The control segment tracks the satellites and then provides them with corrected orbital and time information. The control segment consists of four unmanned control stations and one master control station. The four unmanned stations receive data from the satellites and then send that information to the master control station where it is corrected and sent back to the GPS satellites.

**The User segment:** The user segment consists of the users and their GPS receivers. The number of simultaneous users is limitless.

### 2.1 APPLICATIONS OF GPS

- Providing Geodetic control.
- Survey control for Photogrammetric control surveys and mapping.
- Finding out location of offshore drilling.
- Pipeline and Power line survey.
- Navigation of civilian ships and planes.
- Crustal movement studies.
- Geophysical positioning,
- mineral exploration and mining.

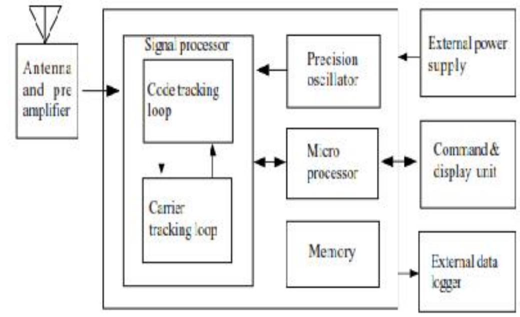
Determination of a precise geoid using GPS data.

- Estimating gravity anomalies using GPS.
- Offshore positioning: shiping, offshore platforms, fishing boats etc.

## BASIC CONCEPT OF GPS RECEIVER AND ITS COMPONENTS

The main components of a GPS receiver These are:

- Antenna with pre-amplifier
- RF section with signal identification and signal processing
- Micro-processor for receiver control, data sampling and data processing
- Precision oscillator
- Power supply
- User interface, command and display panel




Major components 0f GPS

- Memory, data storage

## 3. USER POSITION SOLUTION

Though the GPS signal travels to the ground at the speed of light, it still takes a measurable amount of time to reach the receiver. The receiver then calculates the distance to the satellite by measuring the difference between the time when the signal is received and the time when it was sent, and multiply by the speed of light. To calculate its precise latitude, longitude, and altitude, the receiver measures the distance to four separate GPS satellites.

### 3.1 Solution of User Position from Pseudorange Measurements

To determine the user position in three-dimensional space, three satellites and three ranges from different satellites to the receiver are required. The intersection of the three distances should indicate the user's position. However, a fourth satellite is necessary to calculate the unknown bias between the satellite clock and the receiver clock. The need for the fourth satellite is due to difference in the precise atomic clock that is used in the satellite and the normal clock used in the receiver.

### 3.2 GPS C/A CODE SIGNAL ACQUISITION

The GPS signal from the simulator is a combination of carrier wave, C/A code and navigation message. In order to extract the navigation data from the GPS signal, it is necessary to remove the carrier wave and the C/A code. The process of receiving GPS signals may be divided into three steps: acquisition, tracking, computing the position solution from recovered navigation data bits. Acquisition is used to detect the presence of a signal from a particular satellite and calculate the initial code offset and Doppler shifted carrier frequency. The tracking process, bit synchronization, and sub-frame synchronization are used to keep lock on the carrier and code and to obtain pseudo range, carrier phase measurements from the recovered navigation data bits. In a conventional receiver, the frontend, the acquisition and tracking processes, are implemented in hardware while the navigation solution calculations are completed in software.

### 3.3. GPS Post-Processing Methods

What has been described in previous chapters concerning data quality is what can be achieved with measurements from a single stand-alone GPS receiver. However, GPS data can be refined using post-processing methods if supplementing measurements has been done simultaneous to the original measurements. Position data quality can be improved to some degree depending on refining method and quality on additional measurements. Two different methods of position measurement refining are available at Saab for use on data from tests and verifications at EDS. The dominating method is differential GPS and that is normally used as standard during all tests. The other method is to combine GPS measurements with inertial measurements consisting of gyro- and accelerometer measurements.

### 3.4 Differential GPS

One of the most common GPS refining methods is differential GPS (DGPS). DGPS can be explained as a family name of several related procedures. Common to all DGPS procedure is that position measurements are corrected for errors introduced by for example atmospheric delays, satellite clock biases and satellite position inaccuracies. The DGPS procedures include at least two receivers to reach desired result, a rover receiver and a minimum of one reference receivers. The rover receiver is making measurements on the unknown location and the reference, or base, receivers are placed on well-known positions, preferably not too far from the rover receiver. The reference receiver is usually only one set of equipment placed on a single location. But in some installations there can be several reference receivers forming a grid with a more advanced DGPS capability. The differential correction in DGPS is generally done by using the additional simultaneous measurements from the reference receiver. These additional measurements result in a continuous error estimate covering the interval of interest that can be used for the differential correction as described in Appendix A. Standard procedure at EDS for all measurements in focus during the thesis project is post-processing of GPS data with differential methods. Compared to stand-alone GPS measurements, with a typical accuracy in position somewhere below 10 meters, the differential methods can offer position measurements of a decimeter level. As it is a well-established, precise and a rather easy-to-use method, DGPS has become the choice for positioning in many system tests at Saab. Differential processing of data is done post tests using various software solutions described below.

## CONCLUSION

Ongoing development of the software GPS receiver. Global Positioning System (GPS) is currently designed to provide navigational accuracy of ±10 m to ±15 m. However, sub meter accuracy in differential mode has been achieved and it has been proved that broad varieties of problems in geodesy and geo-dynamics can be tackled through GPS. GPS service consists of three components, viz. space, control and user.

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