# ENERGY SAVING TECHNIQUES FOR GPS BASED TRACKING APPLICATIONS

*Bharath Patil, Radhika Patil, Dr. Andre Pittet,*
*Center for Electronics Design and Technology (CEDT), Indian Institute of Science, Bangalore, India*

## Abstract

Several GPS based positioning and tracking applications need to be very conservative in terms of energy consumption. Some of these applications can even compromise on real time performance and accuracy to lower energy consumption. In the process of acquiring a GPS location fix, the GPS ephemeris download takes a long time, especially in poor GPS signal conditions, hence forming a significant component of the energy consumption of GPS receiver systems. This is one of the major reasons for the GPS receivers to perform poorly under thick coverage like foliage and concrete. The ephemeris acquisition problems were prominently observed during the development of a low power elephant tracking collar using GPS and GSM. Currently, assisted GPS or AGPS is used to solve this problem where GSM connectivity is available. Here, ephemeris is fed via the GSM network. But existing AGPS systems do not work in remote areas where mobile networks do not provide coverage. Other augmentation systems like Wide Area Augmentation System (WAAS) focus primarily on improving the accuracy and reliability of the GPS fix but do not help in getting a faster GPS fix. In this paper various methods to reduce the Time-To-First-Fix (TTFF) by avoiding ephemeris download are proposed, thus reducing energy consumption.

## Introduction

The main concern in most battery powered GPS based tracking applications is low power design to prolong the lifetime of the battery or to avoid frequent recharge. For example, consider the case of animal tracking. Animal tracking is done to study the seasonal migration patterns and also to avoid man-animal conflicts in cases where animals stray into human inhabitation. Such systems acquire GPS fixes at preset intervals and transmit the fixes to a base station via some means of communication. They are expected to work without the need to change batteries for years. In these applications, for most of the time, the system is in sleep mode and intermittently the system comes up to get a GPS fix. After a deep sleep, GPS receivers wake up in what is known as a ``warm start". In warm start, GPS ephemeris for each of the GPS satellites being used for obtaining a fix, needs to be downloaded. This download takes about 30 seconds during normal signal conditions owing to the low GPS data rate. If there is signal disruption during this time, the download has to be repeated causing further delays. Thus, ephemeris download consumes a lot of valuable battery life. Other cases where battery power can be a concern is during expeditions done by adventurers. They might not be able to charge GPS handhelds at all or very rarely.

This paper proposes two methods for reducing the time taken for obtaining a GPS fix to bring down the energy consumption of the tracking system. The first method bypasses the need for ephemeris download and the second method enhances the rate at which ephemeris download is achieved. Apart from niche applications such as animal tracking, commercial systems such as handheld devices and asset tracking systems can also use this infrastructure to reduce battery consumption significantly.

## Different Phases of Operation of GPS Receiver

The typical phases of GPS receiver while obtaining a location fix are acquisition, tracking, ephemeris download and computation of position. To obtain a 3D navigation solution, two essential things are:

- Distances between GPS satellites and the GPS receiver(also called as pseudoranges) for at least 4 SVs (GPS Space Vehicles) to perform trilateration.
- Ephemeris data for the SVs it will use in the navigation solution.

Once the receiver has found a SV and is able to track the signal thereafter, pseudorange and carrier phase information is available to the Position

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Determination Algorithms. Also ephemeris data for a SV can be decoded (Figure 1).

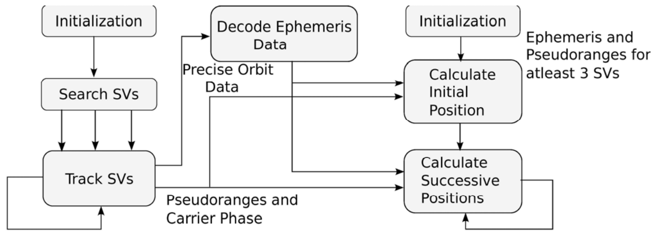


**Figure 1. GPS Receiver Basic Operation Cycle**

Ephemeris data is very precise orbital and clock correction for each SV and is necessary for precise positioning. Thus, ephemeris describes the path that the satellite is following as it orbits the earth. Each SV transmits its own ephemeris data. Ephemeris is updated by the satellite every 2 hours [1]. To accurately calculate the location, ephemeris data is only usable for a limited time (a few hours or less). Up-to-date data is needed to minimize error that results from minor variations in a satellite's orbit.

### *Start Up of GPS Receiver*

When a GPS receiver wakes up, the state of the receiver is dependent on the information available. The information consists of receiver's last position, precise current time and ephemeris data. The possible starting states (see Figure 2) of a GPS receiver are:

- **Coldstart**: In coldstart, the receiver has no location or time information. This is the case when a GPS receiver has previously not been switched on at all or when it loses the backup power to it's RTC and volatile memory containing the last position fix. Since the almanac of the GPS satellites is also unknown, the receiver will have to search for any of the 32 GPS satellite signals or download the almanac first.
- **Warmstart**: In warmstart, receiver has valid almanac data or has enough correlators to directly search for all GPS satellites simultaneously. The receiver also assumes that it has not moved significantly since the last fix. This scenario can happen when the receiver has been in sleep state for a few hours but has had it's RTC running and the last position fix preserved. This allows it to predict the current visible SVs. However, since ephemeris data is not available or outdated, the receiver needs to download the ephemeris data to complete a GPS fix.
- **Hotstart** : In hotstart, the receiver still has valid ephemeris data and precise time. This is typically the case if the receiver has been shut off for less than 2 hours and the RTC has been running during that time without much drift. Since ephemeris is already known, the receiver has to only wait for the first pseudorange acquisition to complete a GPS fix.

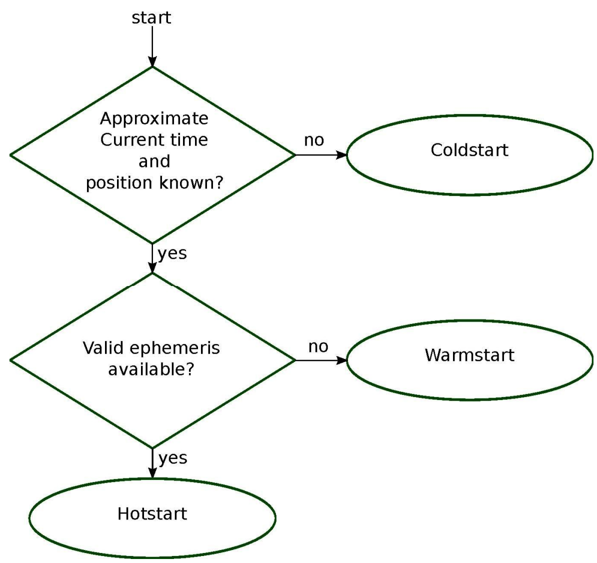


**Figure 2. Decision Tree on Startup Mode**

## Time Required to Download Pseudoranges and Ephemeris

This section explains the time required to download ephemeris data. The GPS message is a continuous stream of data transmitted at 50 bits per second. The navigation message is needed to calculate the current position of the satellites and to determine signal travel times. Data is transmitted in logically grouped units known as frames or pages (Figure 3). Each frame is 1500 bits long and takes 30 seconds to transmit [5]. The frames are divided into 5 subframes. Each subframe is 300 bits long and takes 6 seconds to transmit.

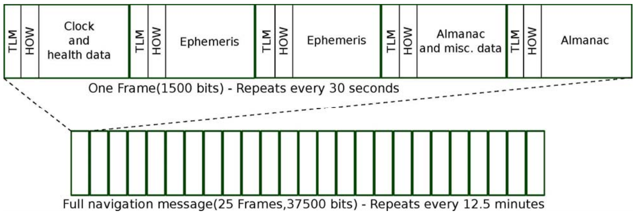


**Figure 3. GPS Navigation Message Format**

Every subframe contains the time values of the transmitting satellite. With the reception of one subframe pseudorange estimate is obtained. This takes about 6 seconds.

Subframes 2 and 3 contain the ephemeris data of the transmitting satellite. This data provides extremely accurate information on the orbit of the satellite. In the case of subframes 1 to 3, the information content is the same for all 25 pages. This means that a receiver has the complete clock values and ephemeris data from the transmitting satellite every 30 seconds. To get a 3D solution it needs ephemeris from 4 satellites. This is done in parallel using multiple correlators. During this time if the signal of any of the satellites is lost, it has to reacquire the ephemeris for that satellite. This will take additional 30 seconds. This is significant issue for animal tracking under heavy canopy cover. Practical experiments have shown that, in some cases, the systems tried unsuccessfully to download ephemeris for the predetermined limit of 5 minutes and finally shut down unsuccessfully, without having obtained a fix.

Clearly, the 30 seconds time taken to download the ephemeris forms a significant portion of the time taken to get a complete fix. Hence by reducing the time to download ephemeris or by avoiding the download alltogether, significant time and energy savings can be achieved.

### *Practical Measurements*

Practical measurements performed on U-Blox LEA-4T GPS modules for obtaining pseudoranges and Time-To-First-Fix(TTFF) (see Table1). These experiments were done under medium dense vegetation.

**Table 1. Energy Measurements for GPS**

| Type | Min Time (s) | Avg. Time (s) | Max Time (s) |
|---|---|---|---|
| Pseudo- range | 2.4 | 5.6 | 10 |
| Entire fix | 18.5 | 38.9 | 56 |

Thus, it is evident that ephemeris download takes a significant portion of the time taken to obtain a fix.

## Currently Available Schemes to Aid GPS

### *Assisted GPS*

"Assisted GPS" (AGPS) describes a system that uses a terrestrial RF network to improve the performance of Global Positioning System (GPS) receivers by providing information about the satellite constellation directly to the GPS receiver. AGPS tries to aid the GPS receiver in poor signal conditions like in a city where there are multipath propagations due to buildings and in RF shadowed environment. Due to weak signal the GPS receiver will not be able to completely get the ephemeris to calculate its position. The assistance can be provided over the GSM/GPRS/CDMA/UMTS network in case of GPS enabled mobile devices or any other wireless infrastructure network (Figure 4). The aiding data includes information such as:

- Satellite Constellation (Almanac)
- Precise Orbital Data (Ephemeris, Orbits)
- Time Information
- Doppler Frequency and Frequency-Offset (Error) of the GPS Receiver

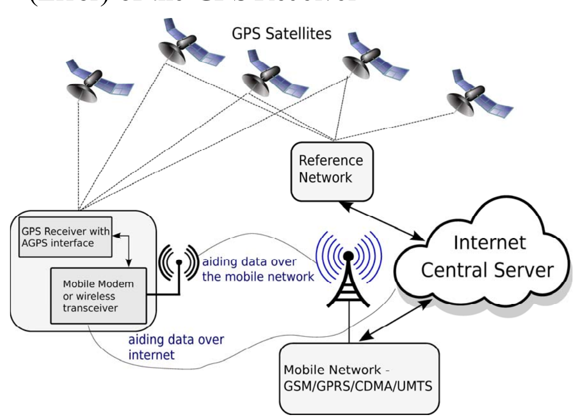


**Figure 4. Assisted GPS System**

Since the AGPS information includes identification of the visible satellites, the receiver is now searching only for specific signals, thus reducing time-to-first-fix (TTFF). Also the ephemeris data is made available to GPS receiver through AGPS so that this data does not have to be decoded from the GPS signals. The receiver must still obtain signals from at least four satellites to determine the time it took each signal to arrive at the receiver; however, it does not have to decode the entire signal. Assisted GPS effectively increases the sensitivity of the receiver so that it is able to obtain and demodulate the satellite signals in areas where unassisted GPS could not. Further, since the ephemeris data is already provided to the receiver, it can determine position more quickly than if unassisted, even in clear view of the sky. But AGPS can work only for cases where GSM mobile network is accessible or if the receiver is in the coverage area of the wireless assistance network deployed specially for AGPS. This is possible in cities but not in inaccessible mountain terrains, forests or the vast oceans.

### *Wide Area Augmentation System (WAAS) or Satellite Based Augmentation System (SBAS)*

WAAS is an augmentation to the GPS to improve the accuracy of location measurements. The central idea to WAAS is the concept of "Differential GPS"[1].

#### DGPS Classification According to the Broadcast Range

The various DGPS services available are categorized according to the broadcast range of the correction signals:

- Ground Based Augmentation Systems (GBAS): Broadcast corrections via the VHF band.
- Regional DGPS
- Wide Area Augmentation System(WAAS) or Satellite Based Augmentation Systems(SBAS): Employ satellites to transmit DGPS correction data. In these cases not just single reference stations, but whole networks of reference stations are used (Figure 5).

Therefore, although a lot has been done for increased accuracy, not much seems to have been done for reducing the TTFF.

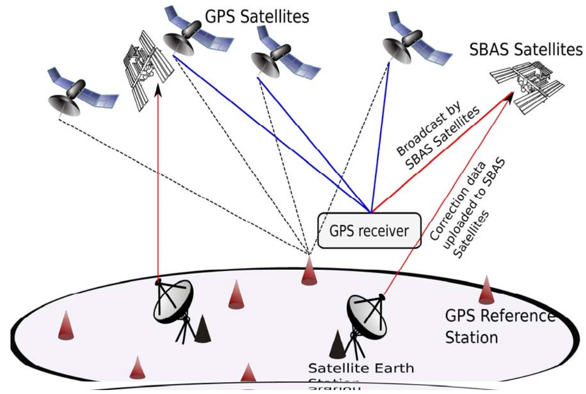


**Figure 5. Satellite Based Augmentation System**

## Proposed Solutions

As discussed earlier, in warmstart scenarios, GPS receivers consume significant energy to download ephemeris. In this paper, two solutions are proposed to alleviate this problem.

The first method takes advantage of the fact that, in some of the tracking systems, the position of the object being tracked need not be known to the object itself. In this method, raw pseudoranges obtained from the GPS satellites on the tracking device can be transmitted to a base station using mobile or satellite networks and the GPS fix can be then calculated at the base station using ephemeris obtained through other means.

The second method proposes a new system of Low Earth Orbit(LEO) satellites to relay the GPS ephemeris data at high data rates. A constellation of LEO satellites can collect the ephemeris data from the GPS satellites or the ground stations and broadcast it to the GPS receivers on the earth. The paper also explores the possibility of accommodating this system of reception with minimal modifications to the existing GPS receivers.

### *Post Processing Pseudoranges to Obtain a Fix*

To avoid the download of ephemeris data by GPS receiver, pseudoranges can be directly transmitted to a remote base station where it can be augmented with ephemeris to calculate the accurate position. This transmission can be either real time or can be done later in cases where real time performance is not a concern. Pseudoranges can be obtained within 6 seconds and keeping the GPS receiver on for 30 seconds to get the ephemeris can be avoided. Hence position can be later calculated offline with help of pseudoranges obtained from the GPS receiver. This is specially useful when the GPS signals are weak. In weak GPS signal scenario if signal is lost while downloading ephemeris, then the process starts all over again. Thus, the central idea is to offload the work of GPS receiver to a remote base station which is not power constrained and has a good view of the sky.

**Obtaining Processed Pseudoranges**

Every subframe in navigation message contains a Handover Word(HOW) (Figure 3). HOW contains 17 bits of the Time of Week(TOW) information[5]. TOW information is used for calculating pseudorange. The TOW counter wraps every week. The TOW received from the subframes can be obtained only at the resolution of 6 seconds.

The TOW messages of satellites and the time difference between their arrivals forms the pseudoranges. The accuracy of the time difference of arrivals will determine the accuracy of the fix calculated at the base station. Assuming an accuracy requirement of 1m, the number of bits can be calculated as follows:

| | | |
|---|---|---|
| $c$ | = | Speed of light ($3 \times 10^8$ m/s) |
| $h$ | = | Altitude GPS satellites from earth (20,180km) |
| $R_e$ | = | Radius of Earth (6400km) |
| $D_{max}$ | = | Maximum distance of satellite (Figure 6) |
| $D_{min}$ | = | Minimum distance of satellite (20,180 km) |
| $T_{max}$ | = | Maximum time difference of arrival of signals |
| $T_{res}$ | = | Time resolution to attain accuracy of 1m |
| $N$ | = | Bits required to represent time difference of arrival |

$$T_{res} = \frac{1\text{m}}{3 \times 10^8\,\text{m/s}} = 3.33\text{ns}$$

$$D_{max} = ?\,(\ \ +\ \ )\ -\ (\ \ )$$

$$\sim 25708\text{km}$$

$$T_{max} = \frac{D_{max} - D_{min}}{c} \approx 19\text{m}$$

$$N = \log_2\left(\frac{T_{max}}{T_{res}}\right) \sim 23\text{bits} \qquad (1)$$

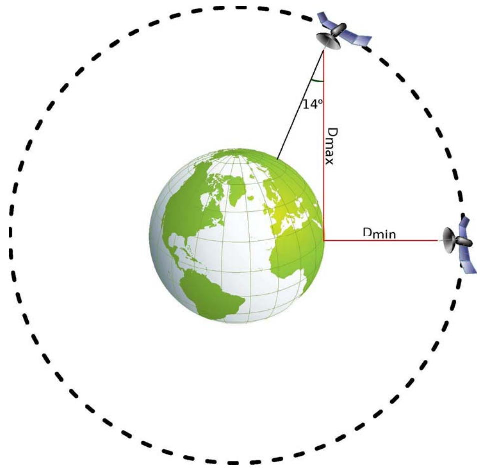


**Figure 6. Maximum Distance of GPS Satellites**

To obtain 3D navigation solution, pseudoranges from minimum of 4 satellites need to be transmitted to the base station. This information consists of Time of Week(TOW) from one satellite and time difference of arrival of signals from the other three satellites. TOW information consists of 17 bits and from result (1), the time difference of arrival requires 23 bits. Hence number bits for transmitting pseudorange information to get a position accuracy of 1m is 86 bits with 4 satellites in view. At any given point the maximum number of GPS satellites visible are 12 [5]. Hence maximum number of bits for improved accuracy, that need to be transmitted are 17?TOW? + 23(TimeDifferenceofArrival) × 12 = 293bits. Hence depending on number of satellites visible, 11 to 37 bytes need to be transmitted as pseudoranges to the base station for it to calculate the 3D fix to an accuracy of 1m. The calculation of number of bytes required for representing a full 3D fix along with time information for an accuracy of 1m is as follows:

Circumference of earth at the equator = 40075km

Number of bits required = $log_2(40075 \times 10^3)$

to represent longitude to the accuracy of 1m

Hence, number of bits required to represent entire fix data:

| | | |
|---|---|---|
| Longitude | = | 26 bits |
| Latitude | = | 25 bits |
| Altitude upto 9km | = | 14 bits |
| Time (TOW) | = | 17 bits |
| Total no. of bytes required | = | 82 bits |
| | ˜ | 11bytes |

Hence in the method of transmitting pseudoranges, almost one to three times the data compared to normal mode needs to be transmitted. Thus, while the energy required for acquiring ephemeris is saved, more energy is spent in transmitting pseudorange data than normal 3D fix data.The energy cost per bit of transmission should be taken into account for deciding on the mode of operation. In most cases, using pseudoranges turns out to be more economical. For example, consider the case of transmitting data over SMS and GPRS in a GSM network. Experiments were conducted to measure energy costs for acquisition and transmission. For GPS signal acquisition measurements, U-blox LEA-4T module was used and for GSM transmission measurements, Siemens TC-65 module was used.

| | |
|---|---|
| Cost of transmitting 1 byte over SMS | = 0.01 mAh |
| Cost of transmitting 1 byte over GPRS | = 0.129$\mu$Ah |
| Cost of acquiring GPS fix | = 0.593 mAh |
| GPS fix size | = 11 bytes |
| Cost of acquiring GPS pseudoranges | = 0.067 mAh |
| Pseudorange size (12 satellites) | = 37 bytes |

Energy cost in each case can be calculated as the sum of acquisition cost and transmission cost. The transmission cost can be calculated as cost per byte multiplied by total number of bytes being transmitted. The energy calculations for four combinations are presented in table (see Table 2).

**Table 2. Energy Measurements for GPS**

| Mode | SMS transmission | GPRS transmission |
|---|---|---|
| Pseudorange acquisition | 0.437mAh | 0.0717mAh |
| Entire Fix acquisition | 0.703mAh | 0.594mAh |
| Savings | 38% | 88% |

Clearly, measurements (see Table 2) and calculations show that, pseudorange method is economical in terms of energy. Also, the advantages will become more prominent when the time required to acquire GPS fix in weak signal environment will increase from seconds to minutes and energy required for transmitting the raw data is less.

## *Ephemeris Assist Using a LEO Satellite Constellation*

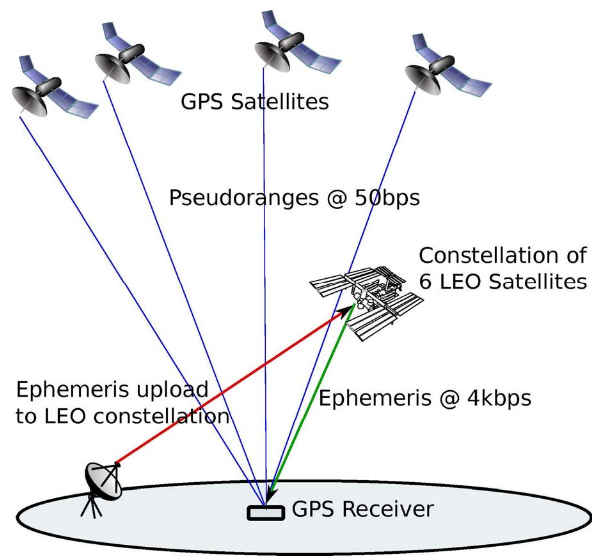


**Figure 7. Ephemeris Assist Concept**

As discussed earlier, ephemeris download at a bitrate of 50 bits/sec is the main reason for prolonged time to attain fix in weak signal environment. Hence, by increasing the bitrate of the ephemeris broadcast, we can alleviate this problem. This solution proposes the use of Low Earth Orbit(LEO) satellites for relaying data at a higher bitrate. The LEO satellites can acquire GPS ephemeris from either ground stations or directly from the GPS satellites. The acquired ephemeris can be then broadcast so that GPS receivers on the earth can download the ephemeris

(Figure 7). LEO satellites can afford to broadcast at higher rates owing to lesser transmission distances without a significant increase in the transmission power.

**Requirements of the Augmentation System**

GPS satellites update their ephemeris every 2 hours. Therefore, for best results, every point on the earth should receive the ephemeris broadcast atleast every 2 hours. Also, for significant reduction of time to first fix, the receivers should be able to download the ephemeris for all the satellites within the time taken to obtain the pseudoranges, which is about 6 seconds.

**LEO Satellite Constellation Design**

Using a simulation software built in-house, various configurations for getting 100% coverage were tried. A minimum of 6 satellites at 881km altitude are required for 100% coverage of earth so that every point on the earth is visited by a satellite atleast once in 2 hours. Two such configurations are:

- Configuration 1: (Figure 8)
  - Circular polar orbit
  - 881km altitude
  - Orbit period = 6154.57 seconds or about 1 hour 43 minutes.
  - Number of orbits in a sidereal day = 14
  - Longitudes of ascending nodes - 0° to 160° in steps of 32°
  - Minimum coverage time is 492 seconds out of 6051 seconds
- Configuration 2: (Figure 9)
  - Circular sun-synchronous orbits
  - 881km altitude
  - Orbit period = 6154.57 seconds or 1 hour 43 minutes.
  - Number of orbits in a sidereal day = 14
  - Longitudes of ascending nodes - 0° to 160° in steps of 32°
  - Inclination ˜ 98°
  - Minimum coverage time is 553 seconds out of 6154.57 seconds
  - Sun-synchronous orbits additionally have the advantage of easily predictable coverage times throughout the year.

Figures 8 and 9 represent the simulated coverage map of the satellites. Red colour indicates highest coverage time and dark blue indicates the least.

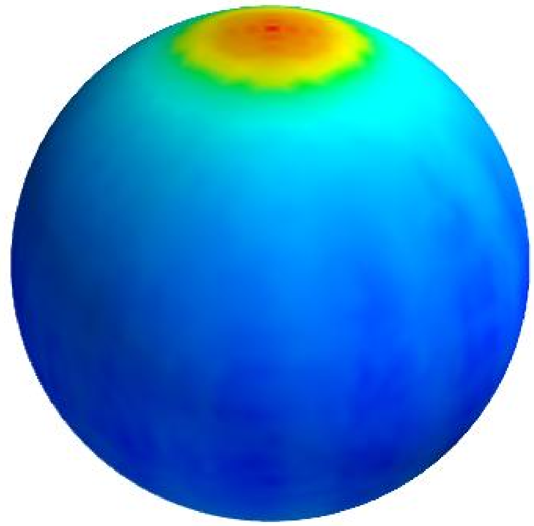

**Figure 8. Polar Satellite Coverage**

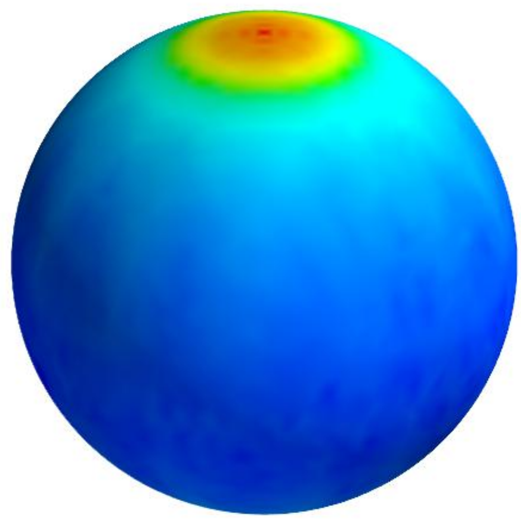

**Figure 9. Sun Synchronous Satellite Coverage**

**Maximum Distance of LEO Satellite**

Maximum operating elevation of 10 is chosen so that attenuation due to atmosphere can be neglected. Hence, the half power beam width required is calculated to be 60 (half-angle). Also, the maximum distance of the LEO satellite from the GPS receiver is calculated to be 2533 km (Figure 10).

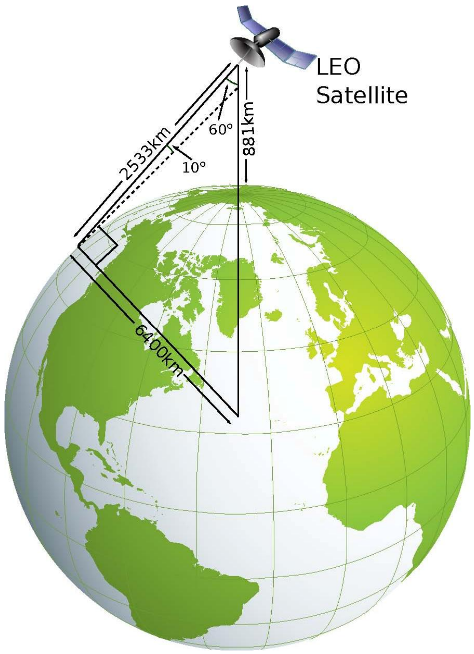


**Figure 10. Maximum Distance of LEO Satellite**

**Bitrate Required**

As discussed earlier, the bitrate should be such that entire ephemeris download of all the satellites should be possible within 6 seconds.

$n_{eph}$ = Size of ephemeris and related information of a gps satellite

= 240 x 3

= 720 bits

$n_{sat}$ = Total number of GPS satellites

= 32

$t_{tx}$ = Time required to broadcast ephemeris of all satellites

= 6 seconds

$b_r$ = Bit rate required

$$= \frac{n_{eph} X\, n_{sat}}{t_{tx}}$$

= 3840 bps

˜ 4kbps (assuming minor protocol overheads)

One way to achieve the bitrate required is to use a separate carrier. But a separate carrier will add to the complexity of GPS receivers. In this paper, an attempt is made to keep the signals as compatible as possible with the current GPS signals.

**Current Modulation Scheme at the GPS Satellites**

In order for all satellites to transmit on the same frequency, the GPS signals are spread out(modulated) with a special code. This code consists of a Pseudo Random Noise Code (PRN) of 1023 zeroes or ones and is known as the C/A-Code or Coarse/Acquisition code. The code, with a period of 1 millisecond, has a chiprate of 1.023Mbit/s. It is continuously repeated and due to its unique structure enables the receiver to identify from which satellite the signal originates. The spreading (or modulation) of the data signal is achieved with an exclusive-or(EXOR) operation (Figures 11 and 12). The result is referred to as Binary Phase Shift Keying.

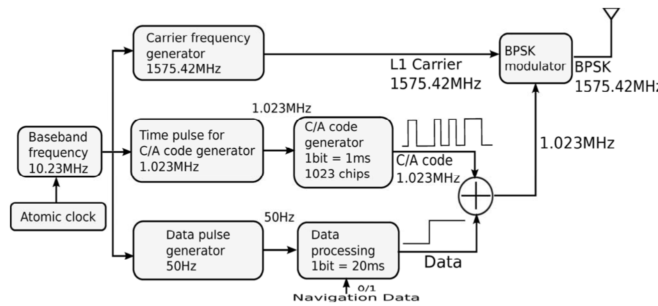


**Figure 11. Block Diagram of GPS Transmitter**

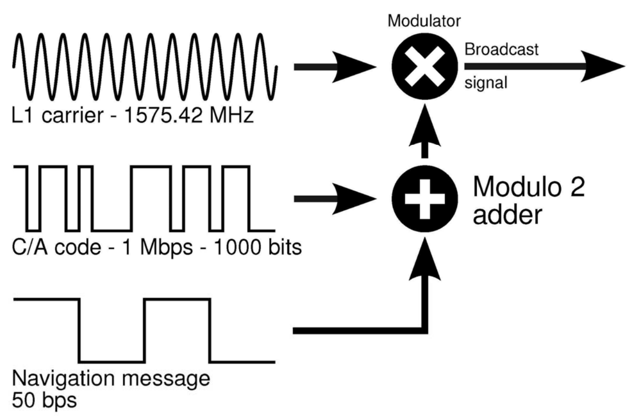


**Figure 12. Current GPS Modulation Scheme**

Since all the GPS satellites transmit on 1575.42 MHz, CDMA (Code Division Multiple Access) is used to multiplex on the channel. The nominal or baseband frequency signal is generated by one of the atomic clocks and all satellite signals, the carrier frequency, data pulse frequency and C/A are all derived from this frequency.

**Link Design**

Since the GPS satellites are at an altitude of 20,180km , Signal-to-Noise ratio(SNR) at the receiver is quiet low. To attain higher SNR, the transmit signal power at GPS satellites will have to be increased to impractical levels. According to Shannon's theorem, for a given bandwidth if the SNR decreases, the channel capacity also decreases. Therefore, GPS satellites use a low bitrate of only 50bps and trade data rate for low signal power. The maximum of the spectral power density of the received signal is about -190 dBm/Hz[1]. Spectral power density of the thermal background noise is about â€“174 dBm/Hz (at a temperature of 290 K)[1]. Thus the maximum received GPS signal power is approximately 16 dB below the power spectral density of thermal or background noise level. Averaging is employed at the receiver to improve the signal to noise ratio. But with LEO satellites, significant SNR can be achieved without averaging, owing to the less altitude of LEO satellites. As described in previous section, the current GPS signals use chip codes of length 1023 transmitted at a rate of 1.023MHz. Therefore, the maximum data rate achievable using one chip is equal to 1kbps. For increasing the data rate on each chip to 1kpbs, the signal strength required can be calculated as follows:

$SNR_{gps}$ = Current SNR of the GPS signals

$b_{gps}$ = Current bitrate/chip of GPS signals

$SNR_{leo}$ = Required SNR of the LEO satellite signals

$b_{leo}$ = Required bitrate/chip of LEO satellite signals

$$SNR_{leo} = \frac{SNR_{gps} \, X \, b_{leo}}{b_{gps}}$$

$$= \frac{SNR_{gps} \, X \, 100}{50} \qquad 0$$

~ 13dB higher

It should be noted that increasing the SNR further may cause a problem, as the GPS receivers' Low noise amplifiers(LNAs) may get saturated if the received signals far exceed the noise floor. Since, even with signal strength increase of 13dB, the signal is still below the noise floor by 3dB, receiver saturation will not be a problem in this solution. The power required on the LEO satellites can be calculated as follows:

$HPB_{gps}W$ = Beam angle of GPS satellites

~ 14 (Figure 6)

$G_{gps}$ = Antenna gain of GPS satellites

~ 13.4 dB[1]

$D_{gps}$ = Maximum distance of GPS satellites

= 25798 km (Figure 6)

$P_{gps}$ = Input power to GPS satellites' antennae

~ 21.9W[1]

$HPB_{leo}W$ = Beam angle of LEO satellites

~ 60° (Figure 10)

$G_{leo}$ = Antenna gain of LEO satellites

~ 5 dB (From simulations)

$D_{leo}$ = Maximum distance of LEO satellites

= 2533km (Figure 10)

$Ga_{leo}$ = Additional gain required

= 13dB

$P_{leo}$ = Input power to LEO satellites' antennae

$$= \frac{P_{gps} \, X \, G_{gps} \, X \, D_{leo}^2 \, X \, Ga_{leo}}{G_{leo} \, X \, D_{gps}^2}$$

~ 29.14 W

Thus, keeping the same signal structure, about 29.14W of transmission power is required at the LEO satellite transmitter to transmit at data rate of 1kbps. To achieve ephemeris download in 6 seconds, the data rate desired is 4kbps. Figure 13 explains how the data rate of 4kbps is achieved. Four carriers, each modulated separately with a chip code are added together to get the broadcast signal. Thus the signal power required at the LEO satellite is $29.14W \times 4 = 116.5W$.

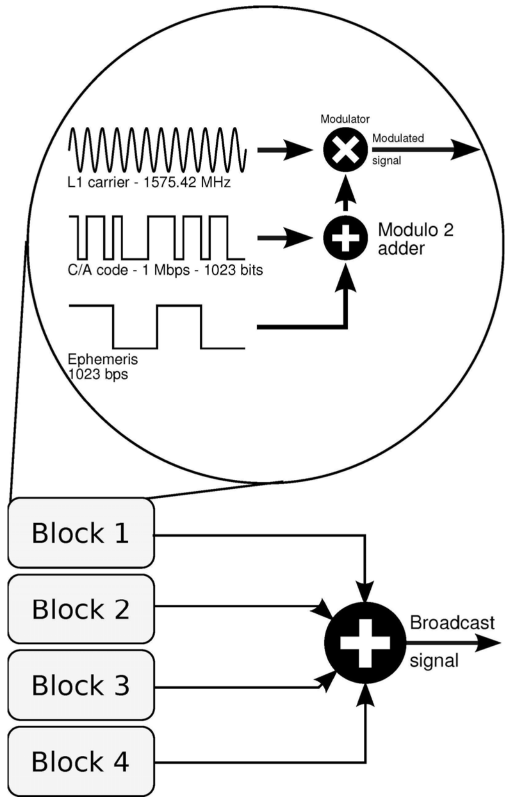


**Figure 13. 4kbps Data Rate at LEO Satellites**

## Conclusion

The work presented in this paper aims at reducing the energy costs of GPS fix acquisition in cases where real time behavior and accuracy can be compromised. In warmstart scenarios, transmitting raw pseudoranges for tracking can save more than 80% of the current energy consumption. But this means that the GPS receiver itself will not be aware of it's position in real time. This is acceptable in many cases like asset tracking or animal tracking where the animal or the asset need not know it's own position. In the alternative solution, a LEO constellation for ephemeris assist is proposed. Since, LEO satellites are low cost in comparison to the satellites in higher orbits and only 6 such satellites are necessary for acceptable performance, this solution provides an affordable strategy to assist receivers in obtaining GPS ephemeris at a faster rate than the current GPS signal rates. Since acquiring ephemeris forms a major component in the energy budget of many GPS based systems, significant energy savings can be achieved. These energy savings will help reduce the size of many battery based tracking applications.

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