Chapter 7 GPS modernization

GPS modernization basically improves the old GPS by adding new signals for navigation to the satellite constellation. GPS III is a great achievement proposed in the field of modernization as it provides the correct and more accurate architecture for future correspondence. Its expectation is to achieve the goal to reduce the cost required for government ownership and to provide a sufficient flexibility and more accurate architecture by 2030. Position and timing accuracy with high integrity solution and satellites interlink capability could be achieved to meet all requirement of military.

GPS has become a critical component of today’s life because of following:-

- Global information infrastructure.
- Scalable applications enable broad capabilities
- Innovations in efficiency, safety, security, environmental & science.
- Transportation systems worldwide, providing positioning, navigation and timing for aviation, ground and maritime operations.
- With the help of GPS signals farmers, surveyors, and geologists perform their work more efficiently, safely, economically and accurately.
- Life-saving missions like emergency services and disaster relief depend upon GPS for location and timing.
- Banking, mobile phone operations are improved by the accurate timing provided by GPS.

For civilian improvement, government is processing three signals i.e. L1C, L2C & L5.

Legacy civil Signal: L1C

It will continue broadcasting to 18 to 24 satellites to create total of four GPS signals. After that it will used for multi-purpose. Majority of new signals is basically made for limited purpose. The new signals is continuously incrementing their phase as new GPS satellite launches and replacing older ones.

Second Civil Signal: L2C

L2C is basically designed to overcome all needs related to radio frequency based signals and others for civilian use. Two military signals are followed at L2 frequency. L1 C/A (Coarse/Acquisition) code in a dual frequency receiver provides aided functionality enabling L2C for ionospheric correction with great accuracy. Civilians having dual frequency receiver enables the equal accuracy as the military have. Faster signal acquisition, enhanced operating range with high reliability makes L2C more accurate. For the better receiving of signals under trees and under roof, L2C enables a very effective broadcasting with higher effective power compared to L1C C/A signals.

The estimation according to commerce department provides $5.8 billion in economical productivity by the year 2030. In 2005, first GPS IIR (M) satellite has been launched featuring L2C transmitter.
Third Civil Signal: L5

L5 is defined as a third civilian GPS signal to fulfill the requirements of transportation safety and other high quality or accuracy applications. Instead of increasing safety, it also enhance capacity and fuel efficiency in many cases i.e. airspace, roadways, waterways & highways etc. It also act as radio band based broadcast for safety services which comprises of many features of higher power, sufficient bandwidth & designs of signals. Apart from transportation, worldwide applications have been provides using these signals. L5 will provide a highly performance service even when there is a combination of L1C and L2C. For enabling sub meter accuracy & very wide range operation without any obstacles, Trilaning techniques should used.

To enhance accuracy to enable ionospheric correction and flexibility to enable signal redundancy in future, combination of L5 and L1 C/A can be used. First L5 signal on experiment basis has been broadcasted by air force in 2009 on GPS IIR-20 (M) satellite. After that in 2010, first GPS IIF satellite with high performance L5 transmitter has been launched which does not include data message.

7.1 Future developments in GPS

Semi-Codeless/Codeless Transition Plan

The need of Semi-Codeless/Codeless Transition Plan has been increasing to achieve very high accuracy after L2C and L5 working fully operational. The U.S. government encourages all users to use Semi-Codeless/Codeless GPS receivers over the enhanced civil signals with effect from 31st December, 2020. This plan depends on the exploiting characteristics of the encrypted signal of military at L2 to perform highly efficient dual frequency capability.

Ground control segment improvements

The control segment provides a capability to determine the orbital position of satellites and enables the transmission of information to satellites to stay GPS up to date and operational within needed specification. The Operation Control Segment (OCS) act as a control segment after replacing older computer to provide daily up gradation and new security features in September 2007. It supports all GPS users all over the world to keep GPS functional and fully updated.

In 2010, Government introduced more developed plans which act as a modern control segment which is an essential and critical part of GPS modernization. OCS will use for ground control system consistently whereas new system OCX (new generation operation control system) is operational and fully initiative. OCX also comprises of many features i.e. reduce cost, enhanced schedule and minimize technical risk. It is modeled for cost saving and high performance designs through more efficient softwares compared to OCS and expected to provide four times more capability. These capabilities will prove as a cornerstone for GPS revolution and enables fully operational GPS services to forces, Civilians & their partners with both national and international users.

The GPS OCX program behave as a critical part of GPS modernization and made availability of more efficient information regarding assurance improvements compared to OCS program.
OCX will provide a strong capability to control and manage old and new generation based GPS satellites that affect the full array of signals used for military.

Present and future users have possibility to access GPS data immediately and secure accurate and more reliable features for the constellation status because of new flexible architecture to easily adopt all effects.

Provide more empowerment to war fighter by getting more secure and predictive information for all situational and non-situational awareness enhancements.

M-code capability enables all new enhanced and modernized signals while earlier, it was not possible with legacy system.

Prevention and detection of cyber attacks can be done with the help of OCX program by getting all assurance and significant information.

Enables real time command and control ability to support high volume.

**Military (M-code)**

One important component of modernization or further development in GPS is M code which is used to enhance anti-jamming and easily accessibility with more security. It is defined as autonomous so that users can automatically calculate their relative position using M-code signal instead of P(Y) code. P(Y) code receivers do not receive P(Y) code signals directly. It receives signals by first locking into C/A code and then converts that lock into P(Y) code. M-code is also same in case of L1 & L2 frequencies. The new features are to shape maximum energy at the edges.

M-code signal on full earth is basically used for block IIR-M satellites. Spot beam antennas or directional antenna will not work until Block III satellites are deployed. M-code signal enables broadcasting from a high-gain directional antenna with aided functionality of wide range full earth antenna. Spot beam antenna is provided at the specific region within several hundred kilometers in diameter and strengthening the local signal by 20 db. The limitations of having two antennas are appearing two GPs satellites having same position inside that beam.

M-code characteristics are follows:-

- Two distinct signals via two antennas i.e. full or whole earth coverage having -158 dB signals and spot beam having -138 dB signals.
- Bandwidth of 24 MHz
- Packetized instead of framing facilities also termed as MNAV navigational message enabling flexible data loads.
- M- Code refers to modulation having offset carrier in binary.
- Error detection.
- Spot beam having 20 dB more signals proves more efficient compared to full or whole earth coverage beam.
- Multiple data per frequency and per antenna can be sent via four data channels.