Evolution of the Global Positioning System

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ABSTRACT

GPS stands for Global Positioning Systems. It is a technology that was devised by the United States, and is presently used globally. It uses satellites to provide location and time information about from anywhere. It consists of a receiver which communicates with four or more satellites at once and provides a message packet containing the information about the location of the subject being tracked. It provides various navigational applications, both civilian and military. Its development dates back to the 1960s and has been in constant evolution ever since. It is used in computers, cameras, mobile phones and tracking devices. This paper provides a brief review on the evolution and development of this technology.

Keywords:-
GPS; OCX; Navigation; Satellite; FCC; DoD

1. INTRODUCTION

The Global Positioning System is a technology that provides location and time information irrespective of weather conditions anywhere on or near earth, although it requires an unobstructed line of sight to multiple satellites (usually four or more). It provides many civilian and military applications all over the globe. This system was originated in the United States and can be accessed by anyone with the help of a GPS receiver. It was earlier known as NAVSTAR GPS.

GPS was originally designed by United Stated Department of Defense (DoD) in the 1973 and became fully operational in 1995. The invention of the GPS was credited to Bradford Parkinson, Roger L. Easton, and Ivan A. Getting. Today this technology is used worldwide by civilians and military people alike. It provides various applications ranging from everyday common usage to the mainstream tasks.

The Global Positioning System or GPS works with the help of satellites and a receiver. The receiver connects to four or more satellites at a time to provide real time navigation data such as, time, speed, location, bearing.

2. EARLY SYSTEMS DEVELOPMENTS

In the year 1960, the United States Air Force devised a radio-navigation system called MOSAIC, a system which was based on a system equivalent to a 3-D LORAN. Another study which went by the name of Project 57, was performedin 1963 and it was considered the main birth point of the GPS. During the same time duration, this study was used as principle research for another study named as Project 621B, which was said to incorporate the many features of the present day GPS systems and

provided a reliant architecture for the United States Military systems. At that time, Navy Transit provided the Air Force with updates for navigational purposes, but they proved to be inefficient for the Air Force. The Naval Research Laboratory continued advancements with their Timation (Time Navigation) satellites, first launched in 1967, and with the third one in 1974 carrying the first atomic clock into orbit.

Another important predecessor to GPS came from a different branch of the United States military. In 1964, the United States Army orbited its first Sequential Collation of Range (SECOR) satellite used for geodetic surveying. The SECOR system included three ground-based transmitters from known locations that would send signals to the satellite transponder in orbit. A fourth ground-based station, at an undetermined position, could then use those signals to fix its location precisely. The last SECOR satellite was launched in 1969. Decades later, during the early years of GPS, civilian surveying became one of the first fields to make use of the new technology, because surveyors could reap benefits of signals from the less-than-complete GPS constellation years before it was declared operational. GPS can be thought of as an evolution of the SECOR system where the ground-based transmitters have been migrated into orbit.

3. PARALLEL DEVELOPMENTS OF GPS SYSTEMS

With these parallel developments in the 1960s, it was realized that a superior system could be developed by synthesizing the best technologies from 621B, Transit, Timation, and SECOR in a multi-service program.

During Labor Day weekend in 1973, a meeting of about twelve military officers at the Pentagon discussed the creation of a Defense Navigation Satellite System (DNSS). It was at this meeting that "the real synthesis that became GPS was created." Later that year, the DNSS program was named Navstar, or Navigation System Using Timing and Ranging. With the individual satellites being associated with the name Navstar (as with the predecessors Transit and Timation), a more fully encompassing name was used to identify the constellation of Navstar satellites, Navstar-GPS, which was later shortened simply to GPS. Ten "Block I" prototype satellites were launched between 1978 and 1985 (with one prototype being destroyed in a launch failure).

After Korean Air Lines Flight 007, a Boeing 747 carrying 269 people, was shot down in 1983 after straying into the USSR's prohibited airspace, in the vicinity of Sakhalin and Moneron Islands, President Ronald Reagan issued a directive making GPS freely available for civilian use, once it was sufficiently developed, as a common good. The first satellite was launched in 1989, and the 24th satellite was launched in 1994. The GPS program cost at this point, not including the cost of the user equipment, but including the costs of the satellite launches, has been estimated to be about USD$5 billion (then-year dollars). Roger L. Easton is widely credited as the primary inventor of GPS.

Initially, the highest quality signal was reserved for military use, and the signal available for civilian use was intentionally degraded (Selective

Availability). This changed with President Bill Clinton ordering Selective Availability to be turned off at midnight May 1, 2000, improving the precision of civilian GPS from 100 to 20 meters (328 to 66 ft). The executive order signed in 1996 to turn off Selective Availability in 2000 was proposed by the U.S. Secretary of Defense, William Perry, because of the widespread growth of differential GPS services to improve civilian accuracy and eliminate the U.S. military advantage. Moreover, the U.S. military was actively developing technologies to deny GPS service to potential adversaries on a regional basis.

4. MODERN DEVELOPMENTS

Over the last decade, the U.S. has implemented several improvements to the GPS service, including new signals for civil use and increased accuracy and integrity for all users, all while maintaining compatibility with existing GPS equipment.

GPS modernization has now become an ongoing initiative to upgrade the Global Positioning System with new capabilities to meet growing military, civil, and commercial needs. The program is being implemented through a series of satellite acquisitions, including GPS Block III and the Next Generation Operational Control System (OCX). The U.S. Government continues to improve the GPS space and ground segments to increase performance and accuracy.

GPS is owned and operated by the United States Government as a national resource. Department of Defense (DoD) is the steward of GPS. Interagency GPS Executive Board (IGEB) oversaw GPS policy matters from 1996 to 2004. After that the National Space-Based Positioning, Navigation and Timing Executive Committee was established by presidential directive in 2004 to advise and coordinate federal departments and agencies on matters concerning the GPS and related systems. The executive committee is chaired jointly by the deputy secretaries of defense and transportation. Its membership includes equivalent-level officials from the departments of state, commerce, and homeland security, the joint chiefs of staff, and NASA. Components of the executive office of the president participate as observers to the executive committee, and the FCC chairman participates as a liaison.The DoD is required by law to "maintain a Standard Positioning Service (as defined in the federal radio navigation plan and the standard positioning service signal specification) that will be available on a continuous, worldwide basis," and "develop measures to prevent hostile use of GPS and its augmentations without unduly disrupting or degrading civilian uses."

5. TIMELINE

1972 The USAF Central Inertial Guidance Test Facility (Holloman AFB), conducted developmental flight tests of two prototype GPS receivers over White Sands Missile Range, using ground-based pseudo-satellites.

1978 The first experimental Block-I GPS satellite was launched.

1983 After Soviet interceptor aircraft shot down the civilian airliner KAL 007 that strayed into prohibited airspace because of navigational errors, killing all 269 people on board, U.S. President Ronald Reagan announced that GPS would be made available for civilian uses once it was completed, although it had been previously

published [in Navigation magazine] that the CA code (Coarse Acquisition code) would be available to civilian users.

1985 Ten more experimental Block-I satellites are launched to validate the concept.

1988 Command & Control of the new GPS satellites was transitioned from Onizuka AFS, California to the 2nd Satellite Control Squadron (2SCS) located at Falcon Air Force Station in Colorado Springs, Colorado.

1989 The first modern Block-II satellite was launched.

1990 The Gulf War was the first conflict in which GPS was widely used.

1991 A project to create a miniature GPS receiver successfully ended, replacing the previous 50 pound military receivers with a 2.75 pound handheld receiver.

1992 The 2nd Space Wing, which originally managed the system, was inactivated and replaced by the 50th Space Wing.

1993 GPS achieved initial operational capability (IOC), indicating a full constellation (24 satellites) was available and providing the Standard Positioning Service (SPS).

1995 Full Operational Capability (FOC) was declared by Air Force Space Command (AFSPC), signifying full availability of the military's secure Precise Positioning Service (PPS).

1996 Recognizing the importance of GPS to civilian users as well as military users, U.S. President Bill Clinton issued a policy directive declaring GPS to be a dual-use system and establishing an Interagency GPS Executive Board to manage it as a national asset.

1998 United States Vice President Al Gore announced plans to upgrade GPS with two new civilian signals for enhanced user accuracy and reliability, particularly with respect to aviation safety and in 2000 the United States Congress authorized the effort, referring to it as GPS III.

2000 "Selective Availability" was discontinued as a result of the 1996 executive order, allowing users to receive a non-degraded signal globally.

2004 The United States Government signed an agreement with the European Community establishing cooperation related to GPS and Europe's planned Galileo system. United States President George W. Bush updated the national policy and replaced the executive board with the National Executive Committee for Space-Based Positioning, Navigation, and Timing. Qualcomm announced successful tests of assisted GPS for mobile phones.

2005 The first modernized GPS satellite was launched and began transmitting a second civilian signal (L2C) for enhanced user performance.

2007 The aging mainframe-based Ground Segment Control System was transferred to the new Architecture Evolution Plan.

2009 The United States Government Accountability Office issued a report warning that some GPS satellites could fail as soon as 2010. The Air Force Space Command allayed fears of GPS failure saying "There's only a small risk we will not continue to exceed our performance standard."

2010 An update of the ground control systems caused a software incompatibility with 8000 to 10000 military receivers manufactured by a division of Trimble Navigation Limited of Sunnyvale, California. The U.S. Air Force awarded the contract to develop the GPS Next

Generation Operation Control System (OCX) to improve the accuracy and availability of GPS navigation signals, and serve as a critical part of GPS modernization.

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