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REVIEWED PAPER

GLOBAL POSITIONING SYSTEM AND ITS WIDE APPLICATIONS

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ABSTRACT

Global Positioning System (GPS) is part of satellites orbiting round the universe. It sends the details of their position in space back to earth. GPS has many applications in diverse areas. It is available to any user with a GPS receiver. It has its usefulness in military, weather conditions, vehicle location, farms, mapping and many other areas. This paper reviewed the types of GPS receivers, applications and future.

KEYWORDS: GPS, U.S. Department of Defense, Application, Military, Civilians.

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INTRODUCTION

According to TomTom (2015), The Global Positioning System (GPS) is a satellite-based radio navigation system developed and operated by the U.S. Department of Defense. The GPS satellites can be used free of charge by anyone. GPS provides accurate position, velocity, and time (PVT) information to an unlimited number of suitably equipped ground, sea, air and space users.

A GPS satellite functions by transmitting signals to equipment on the ground (Fig 1). GPS receivers passively receive satellite signals; they do not transmit. GPS receivers require an unobstructed view of the sky, so they are used only outdoors and they might perform less well within forested areas or near tall buildings (TomTom, 2015). GPS operations depend on a very accurate time reference, which is provided by atomic clocks at the U.S. Naval Observatory. Each GPS satellite has atomic clocks on board. The Global Positioning System (GPS) uses a network of satellites which let people with GPS receivers pinpoint their location anywhere in the world.

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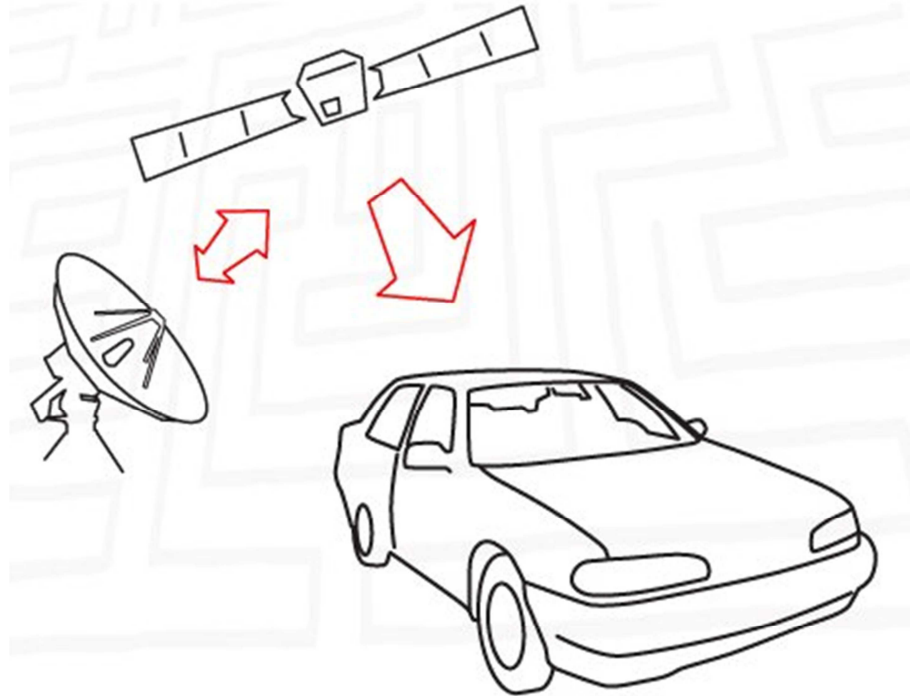


Fig 1: How a GPS functions

Satellite Selection

Navstar (1996) noted that a typical satellite tracking sequence begins with the receiver determining which satellites are visible for it to track. If the receiver can immediately determine satellite visibility, the receiver will target a satellite to track and begin the acquisition process. Satellite visibility is determined based on the GPS satellite almanac and the initial receiver estimate (or user input) of time and position.

If the receiver does not have the almanac and position information stored, the receiver enters a "search the sky" operation that systematically searches the PRN codes until lock is obtained on one of the satellites in view. Once one satellite is successfully tracked, the receiver can demodulate the navigation message data stream and acquire the current almanac as well as the health status of all the other satellites in the constellation.

Depending on its architecture, a receiver selects either a "best" subset of the visible satellites to track or uses all healthy satellites in view to determine an "all-in-view" PVT solution. The all-in-view solution is usually more accurate than a four satellite solution although it requires a1-11 more complex receiver and receiver processing. The all-in-view solution is also more robust, since the temporary loss of a satellite signal (for example due to a physical obstruction near the



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receiver) does not disrupt the flow of PVT data while the receiver attempts to reacquire the lost signal. Many receivers will track more than four satellites, but less than all-in-view, as a compromise between complexity, accuracy, and robustness. Receivers that select a "best" subset do so based on geometry, estimated accuracy, or integrity (Navstar, 1996).

Application

GPS has become a widely deployed and useful tool for commerce, scientific uses, tracking, and surveillance. It facilitates everyday activities such as banking, mobile phone operations, and even the control of power grids by allowing well synchronized hand-off switching. This technology also has its usefulness in studying the movements and feeding habits of deer, measurement in buildings, assists in settling property disputes between land owners, used by Marine archaeologists in researches and other areas of applications (GPS data revealed that Mt. Everest is getting taller)(Kaplan, 2011).

GPS has many applications for both the military and civilians. Civilians applications include (Navigation, astronomy, cartography, mapping, cellular telephony, disaster relief, radio occultation, clock synchronization, geotagging, geofencing, fleet tracking, air tracking, mining, tours, recreation, robotics, surveying, sports, tectonics, telematics and other uses), while in the military it has found its usefulness in the following areas: navigation, target tracking, missile and projectile guidance, search and rescue, reconnaissance, as nuclear detonation detectors) (US Airforce, 2013).

Agriculture

GPS equipment manufacturers have developed several tools to help farmers and agribusinesses become more productive and efficient in their precision farming activities. The various benefits are:

- Precision soil sampling, data collection, and data analysis, enable localized variation of chemical applications and planting density to suit specific areas of the field.
- Accurate field navigation minimizes redundant applications and skipped areas, and enables maximum ground coverage in the shortest possible time.
- Ability to work through low visibility field conditions such as rain, dust, fog and darkness increases productivity.
- Accurately monitored yield data enables future site-specific field preparation.
- Elimination of the need for human "flaggers" increases spray efficiency and minimizes over-spray.

Aviation

GPS is used to increase the safety and efficiency of flight. With its accurate, continuous, and global capabilities, GPS offers seamless satellite navigation services that satisfy many of the requirements for aviation users. The advantages to aviation are:



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- Continuous, reliable, and accurate positioning information for all phases of flight on a global basis, freely available to all.
- Safe, flexible, and fuel-efficient routes for airspace service providers and airspace users.
- Potential decommissioning and reduction of expensive ground based navigation facilities, systems, and services.
- Increased safety for surface movement operations made possible by situational awareness.
- Reduced aircraft delays due to increased capacity made possible through reduced separation minimums and more efficient air traffic management, particularly during inclement weather.
- Increased safety-of-life capabilities such as EGPWS.

Environment

- GPS data collection systems complemented with GIS packages provides a means for comprehensive analysis of environmental concerns.
- Environmental patterns and trends can be efficiently recognized with GPS/GIS data collection systems, and thematic maps can be easily created.
- GPS data can be quickly analyzed without the preliminary requirement for field data transcription into a digitized form.
- Accurate tracking of environmental disasters such as fires and oil spills can be conducted more efficiently.
- Precise positional data from GPS can assist scientists in crustal and seismic monitoring.
- Monitoring and preservation of endangered species can be facilitated through GPS tracking and mapping.

Marine

GPS is playing an increasingly important role in the management of maritime port facilities. GPS

- Allows access to fast and accurate position, course, and speed information, saving navigators time and fuel through more efficient traffic routing.
- Provides precise navigation information to boaters.
- Improves precision and efficiency of buoy positioning, sweeping, and dredging operations.
- Enhances efficiency and economy for container management in port facilities.
- Increases safety and security for vessels using the AIS.

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Public Safety and Disaster Relief

This is another important area where GPS is useful. It assists in:

- Delivering disaster relief to areas in a more timely and accurate manner, saving lives and restoring critical infrastructure.
- Providing position information for mapping of disaster regions where little or no mapping information is available.
- Enhancing capability for flood prediction and monitoring of seismic precursors and events.
- Providing positional information about individuals with mobile phones and in vehicles in case of emergency.

Rail

GPS improves rail safety, security, and operational effectiveness. The technology helps reduce accidents, delays, and operating costs, while increasing track capacity, customer satisfaction, and cost effectiveness. It also:

- Increased situational awareness for improved safety of trains and maintenance crews.
- Prevention of collisions, derailments, work zone incursions, and rail switch errors.
- Increased capacity and efficiency for all rail users.
- Dependable schedule and equipment location awareness.
- Automated track surveys and inspections.
- Time synchronization for communication systems.

Recreation

- Highly accurate all-weather positioning information using GPS receivers helps outdoor adventurers with safer exploration anywhere in the world.
- Ability to return to favorite fishing spots, trails, campsites or other locations with precision year after year, despite changing terrain conditions.
- New and interesting activities (based solely on the capabilities of GPS) are developed every day by outdoor enthusiasts and shared with others.
- Relatively small, portable, and affordable handsets can be used for multiple types of recreation activities.

Roads and Highways

- Higher levels of safety and mobility for all surface transportation system users.
- More accurate position determination to provide greater passenger information
- More effective monitoring to ensure schedule adherence, creating a transit system more responsive to transportation users' needs.

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- Better location information with electronic maps to provide in-vehicle navigation systems for both commercial and private users.
- Increased efficiencies and reduced costs in surveying roads.

Space

- Providing high precision positioning with minimum ground control.
- Replacing high cost, and high mass, on-board sensors.

Surveying and Mapping (Fig 1)

- Significant productivity gains in terms of time, equipment, and labor required
- Fewer operational limitations compared to conventional techniques.
- Accurate positioning of physical features that can be used in maps and models.
- Faster delivery of geographic information needed by decision makers.
- Centimeter-level surveying results in real-time.

Development

GPS was designed by the U. S. military. The development started in the 1960s and the first satellite was launched in February 1978. The first hand-held GPS receiver was introduced in 1989 by the Magellan Corp. In 1996, President Ronald Reagan allowed the free use of GPS by civilian users (America.gov, 2006). The US Federal Government is committed to providing GPS technology for peaceful uses on a worldwide basis, free of charge.

Since its deployment, 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 the while maintaining compatibility with existing GPS equipment.

Modernization of the satellite system has been an ongoing initiative by the U.S. Department of Defense through a series of satellite acquisitions to meet the growing needs of the military, civilians, and the commercial market.

As of early 2015, high-quality, FAA grade, Standard Positioning Service (SPS) GPS receivers provide horizontal accuracy of better than 3.5 meters (GPS Accuracy, 2015), although many factors such as receiver quality and atmospheric issues can affect this accuracy.

GPS is owned and operated by the United States Government as a national resource.

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Fig 1: Maps Produced from a GPS receiver

System Description

According to Hoffman-Wellenhof, Lichtenegger and Collins (2001). GPS has three 'segments':

1. The space segment now consists of 28 satellites, each in its own orbit about 11,000 nautical miles above the Earth.
2. The user segment consists of receivers, which you can hold in your hand or mount in your car.
3. The control segment consists of ground stations (five of them, located around the world) that make sure the satellites are working properly.

Types of GPS Receivers

There lots of receivers manufactured by different companies. They perform different functions depending on the software available for them. Suitable software can be downloaded on the internet or purchased. An example of a receiver, when applying the right software can scan maps (Fig 2) if GPS is connected, it can draw trails directly on the map which is sent to the GPS.



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Fig 2: Types of GPS receivers

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Photos look exactly where they are taken. In another typical example, a receiver can combine CAD, GIS and GPS data over a map. Distance, area, location can be measured and calculated.

Accuracy

From the information provided by GPS.Gov (2015), the accuracy of the GPS signal in space is actually the same for both the civilian GPS service (SPS) and the military GPS service (PPS). However, SPS broadcasts on one frequency, while PPS uses two. This means military users can perform *ionospheric correction*, a technique that reduces radio degradation caused by the Earth's atmosphere. With less degradation, PPS provides better accuracy than the basic SPS.

Future of GPS

The future of GPS is bright, in the US modernization program is an ongoing, lots of effort are being put in place to upgrade the GPS space and control segments with new features to improve its performance (Fig 3).



Fig 3: GPS Future in the US

The modernization is introducing modern technologies throughout the space and control segments that will enhance overall performance. Legacy computers and communications systems are being replaced with a network-centric architecture to allow more frequent and precise satellite commands that will improve accuracy for everyone.

The GPS modernization program involves a series of consecutive satellite acquisitions, including GPS IIR(M), GPS IIF, and GPS III. It also involves improvements to the GPS control segment, including the Architecture Evolution Plan (AEP) and the Next Generation Operational Control System (OCX). The schedule for the parallel space and control segment upgrades is shown below.

There are a couple of things that will emerge over the next couple of years. All mobile devices will be able to integrate GPS very cost-efficiently. Cell phones will be the most important driver



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of GPS adoption over the next couple of years. As the carriers roll out services and provide information based on location there will be a major new segment that is opening up (Rojas, 2015).

A GPS device will be used to track lost ones. In tax related issues, GPS devices will be used on every car and figure how many miles one traveled and when one get gas they can tax that person by miles driven.

In a report by Fiedler (2015), the AllSport GPS route and mapping program allows you to track and map your bike rides, runs and other outdoor activities, including distance travelled, average speed, calories burned, etc. When an additional subscription application is used for cellphone, route can be automatically mapped via GPS and uploaded to one the computer. Routes once covered or by other person can also be downloaded on the phone. This can be effectively used in determining the days' run or ride.

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