2014

Sample Technical Description

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To: Car Rental Employees

From: Michael Stanley, Manager

Date: July 24, 2014

Subject: Technical Description of GPS

UNDERSTANDING THE GLOBAL POSITIONING SYSTEM (GPS)

Introduction

The purpose of this memo is to explain how the technology known as GPS works. Upper management requires all car rental employees to be familiar with how the Global Positioning System (GPS) operates, from inputting data into handheld GPS units, to receiving navigation steps on the unit's screen. Understanding this process will allow employees to explain the basics of GPS to car rental customers who will be using the GPS unit in the rental cars. This memo will explain how a GPS unit communicates with the network of GPS satellites orbiting the earth to target the GPS unit and the destination in order to plot a navigation course for the user.

History

During the 1970's, the United States Military used a network of satellites to develop what is now called the Global Positioning System (GPS). There are about 30 separate satellites orbiting the earth that are constantly transmitting UHF radio signals towards the earth. Beginning in the 1990's, the general public were given access to those radio signal frequencies, and with special radio wave receivers such as hand held GPS receiver units, the signals can give the receiver unit the data it needs to locate its exact position on the earth. Recent advances in technology have allowed the receiver units to use downloadable map data to plot a course from the current location to a new destination using navigation software.

The Process

Satellites Transmit Radio Signals to the Earth. Each satellite orbits the earth twice a day and the network orbits in pathways that ensures there are at least 3 satellites above the horizon anywhere on the surface of the earth at any time (See figure 1 next page). This allows GPS receivers to collect data signals that tell the unit how far away the satellites are. When the receiver unit collects distances from at least three satellites, it can calculate its exact location on the surface of the earth mathematically.

Figure 1 Network of satellites orbiting earth. **Source**: *Garmin.com* n.d. Web. 22 July 2014.

Receiver Unit Calculates Position Through Trilateration. Each satellite has a highly accurate atomic clock onboard that keeps exact time, and sends time-codes to the earth at nearly the speed of light, but there is still a fraction of a second delay before the signal reaches the surface of the earth. The GPS unit picks up the signal, and finds the distance to the satellite by subtracting the current time from the time sent from the satellite. The difference between the time code signal sent from the satellite to the current time according to the GPS receiver allows the unit to calculate distance.

Exact position is calculated by combining the distances of at least three satellite signals that are picked up simultaneously. Figure 2 shown below illustrates how trilateration is used to find exact position on a flat two-dimensional surface like a map, where the exact position can be calculated with three known distances. The distance from any single point (satellite A) creates a circle (circle A), any point on the edge of the circle is the same distance to the center. When two distances are combined, the position can be either of two points where the circles intersect (Circle A and Circle B intersections). With a third circle, the point at which all lines intersect is the exact position (red point, top of circle C). Finding a location in this way is called trilateration.

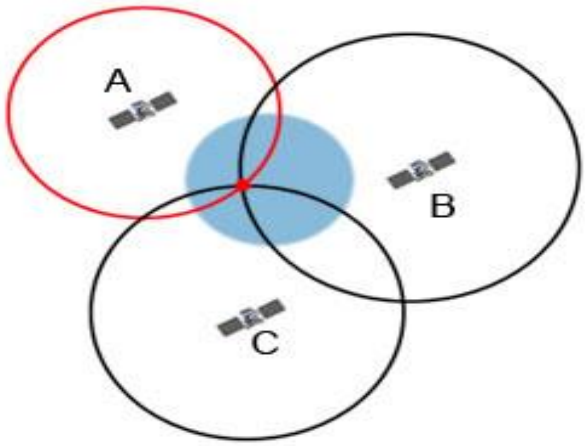

Figure 2 Calculating Position Using Trilateration**. Source:** *Physics.org* n.d. Web. 22 July 2014.

GPS operates in three dimensional space, so an extra distance is needed for the extra dimension. Instead of circles, the distances are calculated on three dimensional spheres. The first distance creates a sphere where all points on the sphere are equally far from the center. When a second sphere occupies some of the space in the first sphere, the intersection creates a circle. The third sphere creates two points of intersection on the circle, just like on the two dimensional model in figure 2, and the earth (blue sphere) eliminates one of those points because the GPS is located on the surface of the earth, and not in outer space. Using this method, only three satellites are needed, because the earth acts as the fourth distance point. Additional distance data from satellites improves the accuracy in finding current position.

The GPS Unit Plots a Navigation Course. Once the GPS unit has calculated its exact current position, it is able to use stored map data and navigation software to plot a course to a new location. The user inputs a different place they would like to travel to, the software locates the new position from an address or coordinates, and the navigation software calculates a route from the current position to the destination. Newer GPS units like Garmin and TomTom have downloadable traffic maps that allow the unit to plot courses easily using roads and highways and are not limited to plotting straight lines from point to point.

As long as the GPS unit remains turned on and is receiving distance data from at least three satellites, the unit can continuously update the current position and give turn by turn directions based on current location. Newer models are able to pick up traffic data from FM radio signals to avoid traffic jams and closed roads, and even provide estimated time of arrival.

Conclusion

A GPS unit operates by communicating with the network of satellites that orbit the earth. The satellites send information about how far away the unit is from the satellites using time codes to determine relative distance. When three or more satellites are above the horizon, the GPS is capable of using trilateration to pinpoint the exact location of the unit on the surface of the earth. The software installed in the GPS device and maps stored in the memory allow the GPS unit to plot a course of navigation from the current position to a new destination for the user.

Works Cited

Illustration. *Garmin.com.* n.d. Web. 22 July 2014. <<http://www8.garmin.com/aboutGPS/>>

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