

# **KING FAHD UNIVERSITY OF PETROLEUM & MINERALS**

**City & Regional Planning Department**



## **Global Positioning System Applications**

(Final Term Paper Report)

**By**

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## **Abstract**

GPS is a Satellite Navigation System, an innovative breakthrough that has revolutionized travel and navigation of all kinds. New ways of using GPS capabilities in everyday life are continually being found. The combination of GPS and mobile computing offered solutions that can reach into and improve every aspect of enterprise field operations. One of the key advantages of deploying a GPS application on a mobile computer is that you are not limited to a single function. An additional benefit is that the solution can evolve over time to fit the mobile computing platform. From improving worker productivity to gaining better understanding and control of mobile activities, GPS promises to change the way enterprises manage their operations in the field.

### **Acknowledgment**

I would like to gratefully acknowledge Dr. Baqer Al-Ramadan for his efforts and support throughout the semester (081) and particularly for giving me the opportunity to conduct this report. His ability to motivate students while teaching GIS 514 course, his knowledge in the field and trust on students was clearly recognized.

## **1. Introduction**

As part of CRP 514 course requirements, each student shall conduct a term project/term report throughout the semester about any GIS application. Being not fully aware of ArcGIS software, tools, applications and data sources, the decision was made by the majority of the class to go with a term report selection. Time might be another constraint that could be affecting the decision of conducting a term project. In addition, availability of data is not an easy task.

There are a number of topics that I have been thinking about during the first couple of weeks of the current term. The final selection was to conduct a technical report about Global Positioning System (GPS) in order to get further information and knowledge about this huge field of science and engineering.

### **1.1 Objective**

The objective of this report is to carryout a comprehensive study about Global Positioning System (GPS) to further strength my knowledge in this field in addition to the GIS fundamentals taken in the CRP 514 course during this semester (081). Further system understanding will be gained through real life examples.

### **1.2 Study Methodology**

Study will be conducted by summarizing some references related to this subject that will cover the followings:

- Technical definition of GPS
- GPS Basic Concepts & Components
- GPS Types and Accuracy
- GPS Applications: Location Based Services

Literature review will be conducted to touch on previous efforts made related to GPS. A case study will be presented about GPS applications and uses that are meeting business needs and improving productivity.

### **1.3 Study Limitations**

Due to the limitations of time, resources and other constraints, study will mainly focus on the basic fundamentals of GPS, uses and the critical factors affecting its operations.

## 2. Literature Review

GPS is a Satellite Navigation System, an innovative breakthrough that has revolutionized travel and navigation of all kinds. New ways of using GPS capabilities in everyday life are continually being found. As an example, GPS has been used in aircrafts for flying, ships for sailing, and in cars for driving around countries and cities. Never the less, it has been built in



our mobile devices for personal navigation to be used while walking to get the direction for the most interesting locations and features.

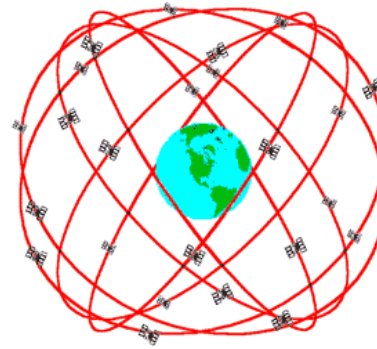
The use of GPS technology is increasing rapidly. It is bringing efficiency and cost savings to businesses, governments and individuals throughout the world. GPS can be used in agriculture & farming, auto sales & rentals, bus & taxi, camera & photography, emergency response, fishing, fleet management & tracking, law enforcement & police, recreation, science field work, kids and Pets monitoring ... etc. GPS is also used to determine your location on earth. It can help you find where you are, where others are and how to go to where you need to go. The future of GPS is unlimited as your imagination. New applications are in continues development as technology evolves. GPS satellites are like stars in the sky, they will be guiding us well throughout the 21<sup>st</sup> century.

### 2.1. What is GPS?

GPS stands for Global Positioning System. It allows users to determine their location on land sea, and on air around the Earth. It does this using satellites and receivers. There are currently 24 satellites in orbit operated by the US Department

of Defense that provide worldwide coverage 24 hours a day, 7 days a week, in all weather types (3).

The Global Positioning System (GPS) is a growing technology, which provides unequalled accuracy and flexibility of positioning for navigation, surveying and GIS data capture. The GPS provides continuous three-dimensional positioning 24 hours a day throughout the world. The technology seems to be beneficiary to the



GPS user community in terms of obtaining accurate data up to about 100 meters for navigation, meter-level for mapping, and down to millimeter level for geodetic positioning. The GPS NAVSTAR (Navigation Satellite Timing and Ranging Global Positioning System) is a satellite-based navigation, timing and positioning system (1).

Global Positioning System (GPS) technology is a great boon to anyone who has the need to navigate either great or small distances. This wonderful navigation technology was actually first available for government use back in the late 1970s. In the past ten or so, it has been made available to the general public in the form of handheld receivers that use this satellite technology provided by the U.S. government (2).

## 2.2. GPS Basic Concept & Components

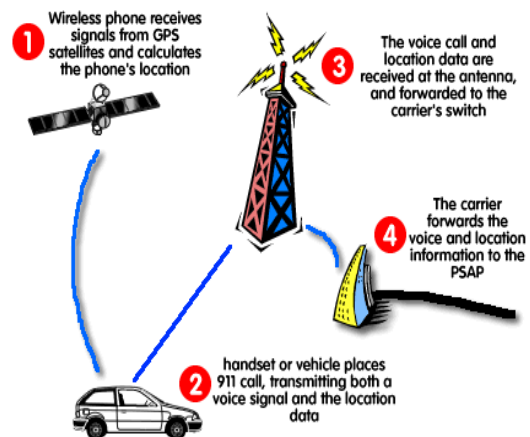
*Positioning* means the determination of stationary or moving objects. It can be possibly achieved as follows:

- In relation to a well-defined coordinate system, usually by three coordinate values
- In relation to other point, taking one point as the origin of a local coordinate system



While the first mode is known as a *point positioning*, the second mode is known as a *relative positioning*. If the object to be positioned is stationary, it is termed as static positioning. When the object is moving, it is called kinematical positioning. The static positioning is usually used in surveying and the kinematical positioning in navigation.

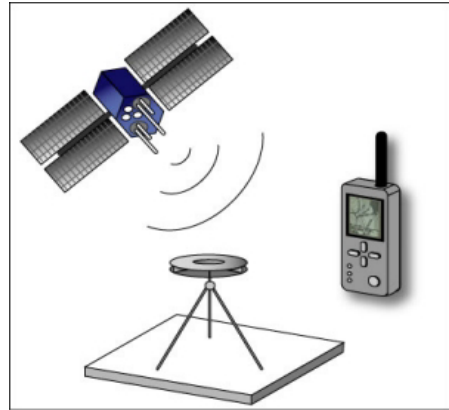
How the system works is by the satellites sending information to receivers. This information includes time, position, and satellite strength. The receivers pick up this information and use it to determine the users location. Using the signals from at least four satellites, a receiver can determine latitude, longitude, and elevation. Some receivers can then convert the latitude and longitude into other coordinate system values (3).



The basis of the GPS technology is a set of 24 satellites that are continuously orbiting the earth. These satellites are equipped with atomic clocks and send out radio signals as to the exact time and their location. The GPS receiver picks up these radio signals from the satellites and once it locks on to four or more of these satellites, it can triangulate its location from the known positions of the satellites (2).

The GPS uses satellites and computers to compute positions anywhere on earth. The GPS is based on satellite ranging. That means the position on the earth is determined by measuring the distance from a group of satellites in space. To compute a position in three dimensions, we need to have four satellite measurements. The GPS uses a trigonometric approach to calculate the positions. Satellites are so high up that their orbits are very predictable and each of the satellites is equipped with a very accurate atomic clock (1).

GPS is comprised of three segments; a space segment, a ground segment, and a user segment. The space segment is the set of satellites providing known locations for resection, the ground segment is a set of ground control stations that communicate with the satellites and determine their locations, and the user segment is the receivers and



people who use them. The segments work together; the control stations locate the satellites precisely in space, each satellite generates radio signals that allow a receiver (user) to estimate the satellite location and distance between the satellite and the receiver, and the receiver uses those measurements to calculate where on the Earth the user is located (4).

### 2.2.1. Space Segment

The space segment of the GPS system consists of a constellation of satellites in earth orbit, with at least four visible anywhere in the world at any time. While only twenty-four satellites are needed to meet this requirement (four satellites in each of six orbital planes), several more are generally in service to provide backup. The satellites primarily consist of antennas, a transmitter, and atomic clocks. The transmitter sends a signal containing position information, a time stamp (from the atomic clock) and the pseudo-random code needed for distance determination

### 2.2.2. Ground Segment

The ground segment consists of a global network of monitoring stations and a master control station (MCS). Coordinates of the ground stations are all precisely determined. The monitoring stations communicate with the satellite constellation, collecting location information about the satellites

and sending it to the MCS. The MCS processes the information, modeling the location of the satellites as a function of time and then sending the information out for uplink to the satellites. Orbital information, atmospheric data, and other parameters are also monitored and maintained by the MCS.

### **2.2.3. User Segment**

The user segment consists of the person or system (car, airplane, ship, etc) using a receiver to determine the position of an unknown location. Receivers contain an antenna that captures signals from visible satellites, a clock to internally generate signals to synchronize with the incoming satellite signal, and a hardware and software system to process signals and calculate position.

## **2.3. GPS Accuracy**

Positional accuracy is of fundamental concern to many people using GPS. Accuracy is based on the sophistication of the technology a receiver uses to determine location. Interacting with this technology (algorithms and hardware/software) are errors. Errors may arise from atmospheric conditions, placement of satellites relative to each other, orbital errors, signal multipath (signals bouncing off of objects), and other considerations (4).

The accuracy of the receivers is dependent on the number and quality of the signals it is getting from the satellites, surroundings and from a factor called Selected Availability. Selected Availability is an intentional error that is introduced into the signals coming from the Satellites that create readings that can be off as much as 300 feet. Even so, the accuracy levels with Selected Availability turned on, is usually within 100ft. or better (3).

## 2.4. GPS Applications: Location Based Services

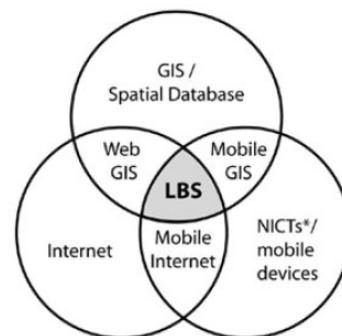
Many applications use the satellite navigation system GPS to determine the current location. GPS receivers are inexpensive and the corresponding location output is accurate, thus GPS is widely accepted. GPS however only works outdoors since the receiver must have a direct "view" to at least four GPS satellites.

The value of GPS technology can be significant when it is integrated with business processes in the field to improve efficiency and accountability. Mobile computing has made it possible to automate the management and documentation of activities in the field. GPS adds a location dimension to field activities and transactions that can translate to greater control, higher productivity and lower costs. One of the key advantages of deploying a GPS application on a mobile computer is that you are not limited to a single function. An additional benefit is that the solution can evolve over time to fit the mobile computing platform. GPS applications for mobile computing fall into a few broad categories (6):

- Vehicle History Tracking
- Real Time Tracking
- Turn-by-Turn Navigation
- Location verification for assets and transactions
- Automatic Vehicle Location

### 2.4.1. Definitions

The above categories fall under Location Based Services concept. LBS in short as a concept and a technology, have emerged from the intersection of information and telecommunication technology, and geospatial technology. LBS is a service or application that extends spatial information,



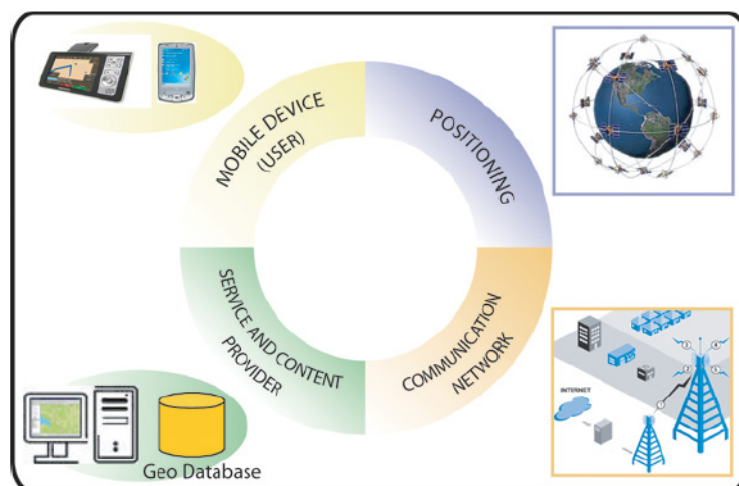
or Geographic Information System capabilities to users by cellular radio, internet or wireless network. This describes LBS as an intersection of three technologies. It is created from New Information and Communication Technologies (NICTS) such as the mobile telecommunication system and hand held devices, from Internet and from Geographic Information Systems (GIS) with spatial databases.

LBS are generally information services accessible through mobile phones, PDAs or other mobile devices. LBS include emergency services, car and personal navigation, point-of-interest search, track and trace, and many others. Positioning is one of the most important components of any LBS. Therefore information about features around the user can be given and changed as a function of user location (5).

#### 2.4.2. LBS Components

LBS system consist of five main components (5):

1. **Mobile Devices:** A tool for the user to request the needed information. The results can be given by speech, using pictures, text and so on.



- 2. Communication Network:** Transfers the user data and service request from the mobile terminal to the service provider and then the requested information back to the user.
- 3. Positioning Component:** The user position can be obtained either by using the mobile communication network or by using the Global Positioning System (GPS).
- 4. Service and Application Provider:** Offers a number of different services to the user and is responsible for the service request processing. Such services offer the calculation of the position, finding a route, searching yellow pages with respect to position or searching specific information on objects of user interest.
- 5. Data and Content Provider:** Geographic base data and location information data will be usually requested from the maintaining authority or business and industry partners.

### 3. Case Study

#### 3.1. School Buses Tracked by GPS Capabilities and a Smart Phone

**Company:** Paulding County School District. Includes 28 schools and more than 20,000 students.

**Industry:** Education/Transportation

**Region:** Americas

**Company Size:** Large Enterprise - 370 employees

**Challenge:** A busy transportation manager wanted a mobile device that would relay GPS information on the movement of county school buses while he was away from his desktop computer.

**Solution:** The School district now uses Comet Tracker, a wireless GPS application from Act Soft Inc. With the Comet Tracker application installed on a smart phone, they now have a solution to look up and pinpoint every GPS-tracked bus in the school district.

**Partner Solution:** Comet Tracker™ from Actsoft Inc.™

- Leading developer of mobile management and GPS location tracking software
- Offers solutions with built-in GPS services on wireless devices such as Comet Tracker, Comet Tracker Lite, Comet Transportation, Cyber Tracker Powered by Comet Tracker and Oreis Mobile by Comet Tracker

**Results:**

- Improved operations management
- Accurate decision making
- Faster responses
- More Free Time



### 3.2. Solution for Trucking Company Revolutionizes Dispatching Process

**Company:** Team Transport provides intermodal transportation services between terminals in Houston and San Antonio and customer locations.

**Industry:** Transportation

**Region:** Americas

**Company Size:** Large Enterprise

**Challenge:** Relieve the load on busy dispatchers and simplify how truck drivers receive information on their daily customer pick ups and deliveries.

**Solution:** Team Transport was able to streamline the dispatching process by giving drivers smart phones equipped with Comet Tracker, a wireless, GPS application from Actsoft Inc.

**Partner Solution:** Comet Tracker™ from Actsoft Inc.™

- Leading developer of mobile management and GPS location tracking software
- Offers solutions with built-in GPS services on wireless devices such as Comet Tracker, Comet Tracker Lite, Comet Transportation, Cyber Tracker Powered by Comet Tracker and Oreis Mobile by Comet Tracker

**Results:**

- Cuts down on calls
- Reduces errors
- Makes dispatching more efficient
- Offers accuracy for customers
- Expected to improve driver efficiency





## **4. Analysis & Discussion**

### **4.1. Accurate Information from the Road**

Using GPS application on smart phones, we can pinpoint where school buses are at all times. That's important when a school principal wants to know how far away a bus is from a location. When this involves an after-school game or field trip, where parents are waiting, the calls come more frequently.

Before, radio was used by the supervisor to communicate with the dispatcher who would radio the driver and then report back to supervisor so he could call back to the principal. Now, by just looking up the bus number on the GPS map on a smart phone, supervisor can estimate the time of arrival based on established routes. It makes operations easier to manage, but it also give parents and schools principles peace of mind.

Accurate information is also important when the supervisor is contacted by the Superintendent for his school district. When he's called during off hours and asked how many buses are still on the road, he can answer with complete certainty using his smart phone and GPS application.

Supervisor finds that he has improved his own ability to balance work time with free time. Before, he would have to be ready for phone calls until the last school bus finished its run. Now he can refer to the GPS application with Comet Tracker map on his smart phone, and get a sense of when he can shut off from his workday.

### **4.2. Responsiveness When It's Needed**

Faster incident response is something that can be gained with GPS applications on a smart phone. If there's a disciplinary incident on a bus, or an accident, the needs to get to the location quickly is very critical. In the event of an accident, supervisor feels that he will now save valuable travel time to the location. He will no longer have to contact a driver in a time of crisis to get detailed directions because he can look up the bus's location himself on his

smart phone.

Dispatchers will also be freed up from giving status reports to focus on helping onsite personnel. The dispatchers can look after helping the driver and organizing any medical response or law enforcement services, rather than needing to relay information to people.

#### **4.3. GPS Tracking Helps Customers, Dispatchers and Drivers**

With a GPS application installed on each driver's smart phone, Team Transport gained a quick, accurate way of getting GPS information from the road into an easy to monitor central map. When a driver updates his status in route using his smart phone, the information goes into the Comet Tracker database. Data is automatically refreshed at a rate determined by the customer and, at the same time, updated on Compcare.

All the radio calls, follow ups and misinformation soon disappeared. Drivers no longer had to call when they're leaving the customer because they're being tracked by GPS. Finance discipline has estimated that they have cut follow up calls in half since deploying the GPS tracking on a smart phone.

Because Team Transport knows where their drivers are at all times, it made it easier to dispatch drivers to the next location. When Comet Tracker indicates that a driver is five minutes away from the first drop off, Compcare automatically triggers the next dispatch.

Customers are experiencing the benefits, too. When a customer wanted to know an estimated time of arrival on their shipment in the past, they had to wait on hold while dispatchers radioed out to drivers. Now they can see on the map exactly how far a driver is from the customer and convey the news on-the-spot.

#### 4.4. Results

- **Helps with Operations management:** Looking up exact locations of school buses, accurate reporting for their arrival times to school authorities and parents can be achieved.
- **Accurate Decision-making:** Supervisor can easily and accurately assess bus traffic for the Superintendent of his School Board, he supports the ability to make better management decisions.
- **Faster Responses:** In an accident or disciplinary incident involving a bus, supervisor no longer has to rely on dispatchers or drivers to relay the location – which helps arriving to site faster and reduces the load on the dispatcher.
- **More Free Time:** Supervisor doesn't have to stay on call as much waiting for the phone to ring because he can easily check the status of all buses at any time.
- **Cuts Down on Calls:** Because drivers have everything they need on their smart phone and dispatchers can monitor their status using GPS, follow up radio calls have been cut in half.
- **Reduces Errors:** No longer relying on verbal communication, all pertinent details are input into the GPS application on the smart phone, ensuring information is more accurate.
- **Makes Dispatching More Efficient:** Team Transport sends out dispatches faster because Compcare, tied into Comet Tracker, monitors when a driver is five minutes away from a drop off and automatically sends the next dispatch.
- **Offers Accuracy for Customers:** Customers are given exact delivery times for their goods by either dispatchers looking up a driver's location or by a web site they can login to themselves; customer calls are expected to decrease.

## 5. Conclusions

This report has explained the basic concept of Global Positioning System (GPS). It has also touched some of the GPS applications. Location Based Services (LBS) was briefly introduced. Cases of studies have been discussed about firms that have utilized GPS/LBS technologies. The combination of GPS and mobile computing offered solutions that can reach into and improve every aspect of enterprise field operations. From improving worker productivity to gaining better understanding and control of mobile activities, GPS promises to change the way enterprises manage their operations in the field.

Major benefits of real time tracking includes:

- Improved management of dispatch and fleet activities
- Increased daily efficiency, productivity and accountability
- Added security for vehicles
- Can replace traditional solutions with lower cost and complexity

Major benefits of location verification for assets and transactions includes:

- Effectively track assets and infrastructure in the field
- Record locations for specific activities (pick ups, deliveries, service calls)
- Validate locations for inspections

In this report, I have reviewed the applications available from tracking to navigation and validation, and how GPS can provide numerous benefits to mobile enterprises.

In conclusion, I hope I have provided some insights and tools for venture users to begin planning a successful GPS solution. GPS technology offers powerful benefits and costs savings to enterprises that can be achieved right away, and I hope that this report with the cases of studies presented have demonstrated these solutions.

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