Emergence of Mobile GPS Technology:-

Introduction

1. The Global Positioning System, or GPS, is a satellite-based navigation system. It was developed by the United States Department of Defense (DOD) for military and government use, but the information it provides is now available free for civilian and commercial uses worldwide. From complex military applications to handheld receivers carried by hikers, GPS offers a wide range of applications and uses. Between these two ends of the spectrum, GPS technology can provide mobile enterprises with a number of significant benefits. The first GPS satellite was launched in 1978. The full constellation of 24 satellites was in place in 1994 and the system was declared fully operational in 1995. Today, the number of satellites has been increased to 32 satellites for enhanced performance. In May 1, 2000 "Selective Availability," a means of diminishing civilian GPS accuracy was discontinued, significantly increasing the accuracy of GPS signals to what is available today.

2. In simple terms, GPS is a broad-casting system in which satellites transmit information toward Earth. GPS receivers take the transmitted information and use a form of triangulation to calculate the user's exact location. The basic premise of the technology is that the GPS receiver compares signal transmission time with the signal reception time, and then uses the time difference and the propagation speed to deduce the distance from each of the visible satellites.

User Segments (GPS Receivers) Samples

The distance calculation for each satellite creates a sphere of possible positions for the GPS receiver. The point at which the spheres representing the distances for all the GPS satellites used in the solution intersect is the user's location. The GPS receiver translates the position into latitude and longitude that can be used in software applications. Typical GPS accuracy for mobile computer-based GPS solutions is 3-5 meters. Better accuracy can be achieved though GPS correction technologies such as the Wide Area Augmentation System (WAAS), which can bring typical accuracies into the two meter range. WAAS technology is included in many GPS receivers. Today, there are two basic types of GPS in use: Autonomous, or Active, GPS ("GPS") where the GPS receiver has the ability to resolve the device's location without the need for

assistance from a wireless network; Network Assisted, or Aided GPS (aGPS) which relies on a GPS receiver associated with a Wireless Wide Area Network that is supported by network location server technology to resolve the unit's location. Another new method of assisted GPS provides performance enhancements by allowing satellite position data to flow to the GPS receiver via the internet for future use. This method of assisted GPS provides benefits such as faster times to first fix as well as the ability to get location information in places where active GPS fails, such as indoors.

GPS Receivers for Mobile Computers From "Black Boxes" to Mobile GPS

3. Some of the first commercial applications of GPS were to track long-haul trucks in real-time. These generally used single-purpose "black box" systems that were installed in vehicles to collect and transmit GPS location data for monitoring and dispatching of trucks. These systems proved their worth by increasing productivity and reducing costs, but the cost and complexity limited their use to a few limited industries. The combination of GPS receivers and mobile computers provides a powerful platform for adding location capabilities to a wide range of mobile computing applications. This technology allows traditional mobile applications to be augmented with GPS capabilities that previously were impossible for the typical mobile computer user. For example, now, a mobile computer used primarily for work order management or route accounting can also be used to provide GPS-based navigation to stops and GPS tracking for dispatch and analysis. As with the evolution of any technology there are changes constantly occurring in the GPS Field. One might ask if this is the right time to deploy a GPS solution, or would it be prudent to wait? The answer to those questions is that with the proven benefits of GPS applications and the variety of GPS hardware options there is no need to wait. You can confidently deploy a very successful GPS solution today, Mobile computer based GPS solutions also protect your overall investment in mobile computing and provide a simple upgrade path to future application and mobile computer GPS capabilities such as internal GPS.

Mobile GPS Applications

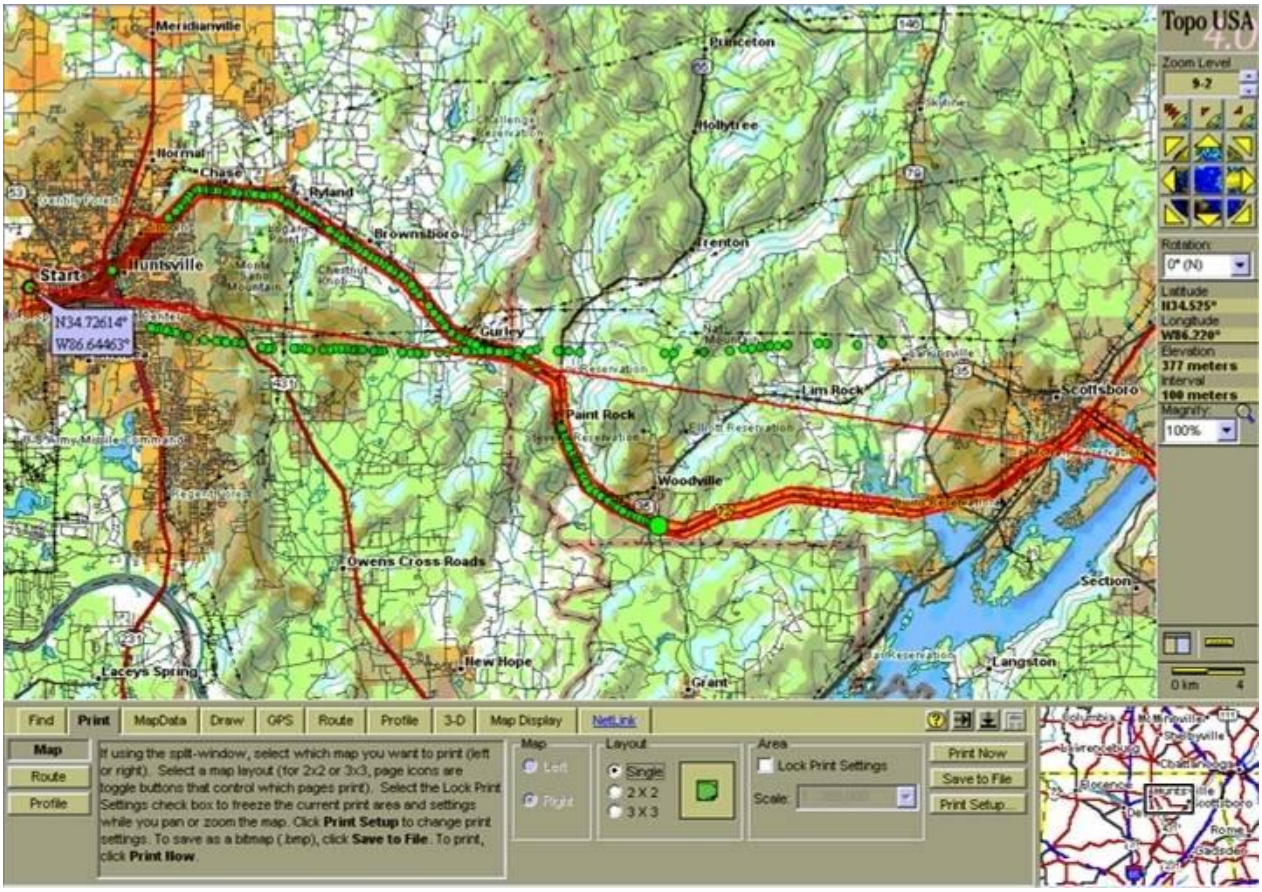
4. The value of GPS technology can be significant when it is integrated with business Processes in the field to improve efficiency and accountability. Mobile computing has made it possible to automate the management and documentation of activities in the field. GPS adds a location dimension to field 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 of GPS applications using mobile computers is that the solution can evolve over time to fit the mobile computing platform. For example, a solution designed to use a "snap-on" style GPS receiver can be easily migrated in the future to new mobile computers that feature internal GPS receivers.

How does GPS Technology Work?

5. GPS technology comprises of three segments namely Space segment, Control segment and User segment. Space Segment consists of at least 24 GPS satellites that orbit the earth twice a day in a specific pattern. They travel at approximately 7,000 miles

per hour about 12,000 miles above the earth's surface. These satellites are spaced so that a GPS receiver anywhere in the world can receive signals from at least four of them. Each GPS satellite constantly sends coded radio signals (known as pseudorandom code) to the earth. These GPS satellite signals contain the following information:

- The particular satellite that is sending the information
- Where that satellite should be at any given time (the precise location of the satellite is called ephemeris data)
- Whether or not the satellite is working properly
- The date and time that the satellite sent the signal



GPS Computer Screen Shot

6. The signals can pass through clouds, glass, and plastic. Most solid objects such as buildings attenuate the signals. The signals cannot pass through objects that contain a lot of metal or objects that contain water (such as underwater locations). The GPS satellites are powered by solar energy. If solar energy is unavailable, for example, when the satellite is in the earth's shadow, the satellites use backup batteries to continue running. Each GPS satellite is built to last about 10 years. The Department of Defense (USA) monitors and replaces the satellites to ensure that GPS technology continues to

run smoothly for years to come.

7. The Control Segment is responsible for constantly monitoring satellite health, signal integrity, and orbital configuration from the ground. The control segment includes Master Control Station ((MCS), Monitor Stations and Ground antennas. At least six unmanned monitor stations are located around the world. Each station constantly monitors and receives information from the GPS satellites and then sends the orbital and clock information to the master control station. The MCS is located near Colorado Springs in Colorado. The MCS constantly receives GPS satellite orbital and clock information from the monitor stations. The controllers in the MCS make precise corrections to the data as necessary, and send the information (known as ephemeris data) to the GPS satellites using the ground antennas.

8. The GPS user segment consists of your GPS receiver. Your receiver collects and processes signals from the GPS satellites that are in view and then uses that information to determine and display your location, speed, time, and so forth. Your GPS receiver does not transmit any information back to the satellites. The following points provide a summary of the technology at work:-

- The control segment constantly monitors the GPS constellation and uploads information to satellites to provide maximum user accuracy.
- GPS receiver collects information from the GPS satellites that are in view.
- GPS receiver accounts for errors.
- GPS receiver determines your current location, velocity, and time.
- GPS receiver can calculate other information, such as bearing, track, trip distance, distance to destination, sunrise and sunset time, and so forth.
- GPS receiver displays the applicable information on the screen.

Who Uses GPS?

9. GPS technology has many amazing applications on land, at sea, and in the air. How people or professions already using GPS technology are discussed below:-

(a) **Agriculture:** In precision farming, GPS technology helps monitor the application of fertilizer and pesticides. GPS technology also provides location information that helps farmers plough, harvest, map fields, and mark areas of disease or weed infestation.

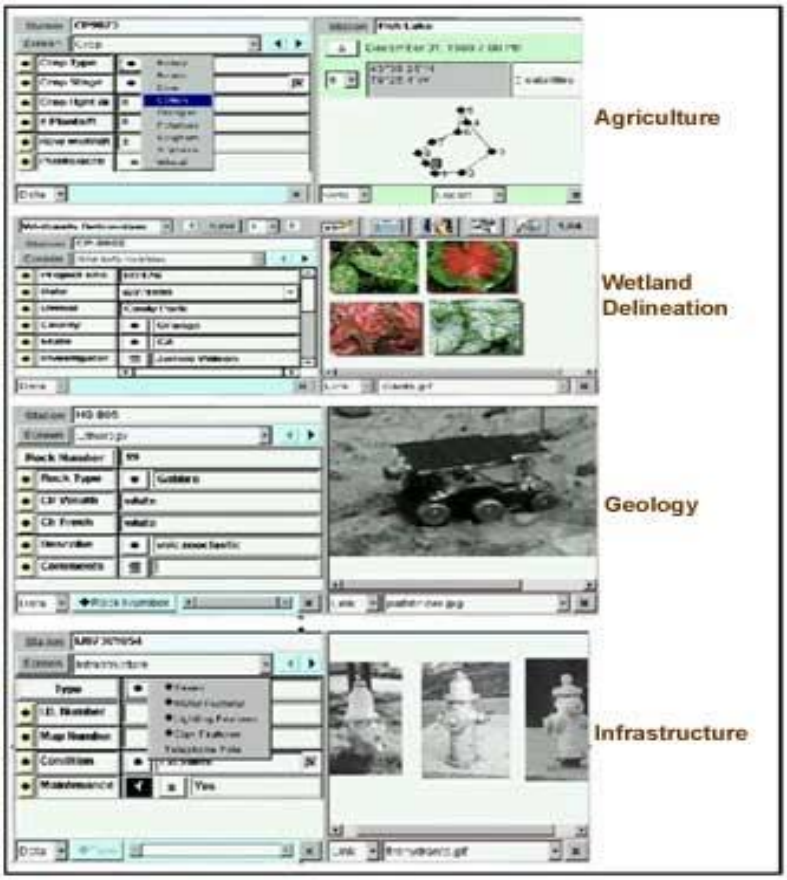
(b) **Aviation:** Aircraft pilots use GPS technology for en route navigation and airport approaches. Satellite navigation provides accurate aircraft location anywhere on or near the earth.

(c) **Environment:** GPS technology helps survey disaster areas and maps the movement of environmental phenomena (such as forest fires, oil spills, or hurricanes). It is even possible to find locations that have been submerged or altered by natural disasters.

(d) **Ground Transportation:** GPS technology helps with automatic vehicle location and in-vehicle navigation systems. Many navigation systems

show the vehicle's location on an electronic street map, allowing drivers to keep track of where they are and to look up other destinations. Some systems automatically create a route and give turn-by-turn directions. GPS technology also helps monitor and plan routes for delivery vans and emergency vehicles.

(e) **Marine:** GPS technology helps with marine navigation, traffic routing, underwater surveying, navigational hazard location, and mapping. Commercial fishing fleets use it to navigate to optimum fishing locations and to track fish migrations.



Various application of GPS technology and Uses

(f) **Military:** Military aircraft, ships, submarines, tanks, jeeps, and equipment use GPS technology for many purposes including basic navigation, target designation, close air support, weapon technology, and rendezvous.

(g) **Public Safety:** Emergency and other specialty fleets use satellite navigation for location and status information.

(h) **Rail:** Precise knowledge of train location is essential to prevent collisions, maintain smooth traffic flow, and minimize costly delays. Digital maps and onboard inertial units allow fully-automated train control.

(j) **Recreation:** Outdoor and exercise enthusiasts use GPS technology to stay apprised of location, heading, bearing, speed, distance, and time. In addition, they can accurately mark and record any location and return to that precise spot.

(k) **Space:** GPS technology helps track and control satellites in orbit. Future booster rockets and reusable launch vehicles will launch, orbit the earth, return, and land, all under automatic control. Space shuttles also use GPS navigation.

(l) **Surveying:** Surveyors use GPS technology for simple tasks (such as defining property lines) or for complex tasks (such as building infrastructures in urban centers). Locating a precise point of reference used to be very time consuming. With GPS technology, two people can survey dozens of control points in an hour. Surveying and mapping roads and rail systems can also be accomplished from mobile platforms to save time and money.

(m) **Timing:** Delivering precise time to any user is one of the most important functions of GPS technology. This technology helps synchronize clocks and events around the world. Pager companies depend on GPS satellites to synchronize the transmission of information throughout their systems. Investment banking firms rely on this service every day to record international transactions simultaneously.

How Accurate is GPS?

10. GPS technology depends on the accuracy of signals that travel from GPS satellites to a GPS receiver. You can increase accuracy by ensuring that when you use your GPS receiver, you are in an area with few or no obstacles between you and the wide open sky. When you first turn on your GPS receiver, stand in an open area for a few moments. It to allow the unit to get a good fix on the satellites (especially if you are heading into an obstructed area). This gives you better accuracy for a longer period of time (about 4-6 hours). It takes between 65 and 85 milliseconds for a signal to travel from a GPS satellite to a GPS receiver on the surface of the earth. The signals are so accurate that time can be figured to much less than a millionth of a second, velocity can be figured to within a fraction of a mile per hour, and location can be figured to within a few meters.

WAAS/EGNOS

11. The Wide Area Augmentation System (WAAS) is a system of satellites and ground stations that provides even better position accuracy than the already highly accurate GPS. Europe's version of this system is the European Geostationary Navigation Overlay Service (EGNOS). The Federal Aviation Administration (FAA) developed the WAAS program. It makes more airspace usable to pilots, provides more direct en route paths, and provides new precision approach services to runways, resulting in safety and capacity improvements in all weather conditions at all locations throughout the U.S. National Airspace System (NAS). Although it was designed for aviation users, WAAS supports a wide variety of other uses, for example, more precise

marine navigation. To take advantage of WAAS technology, you must have a WAAS-capable GPS receiver in an area where WAAS satellite coverage is available such as North America.

Sources of Errors

12. Errors can affect the accuracy of the GPS signal. Take your GPS receiver to an area with a wide and unobstructed view of the sky to reduce the possibility and impact of some errors. Here are some of the most common GPS errors:-

- **Ionosphere and Troposphere Delays:** The satellite signal slows down as it passes through the atmosphere. The system uses a built-in model that calculates an average delay to partially correct this type of error.
- **Orbital Errors:** This terminology refers to inaccuracies of the satellite's reported location.
- **Receiver Clock Errors:** The GPS receiver has a built-in clock that can have small timing errors.
- **Number of Satellites Visible:** Obstructions can block signal reception, causing position errors or no position reading. The more satellites that your GPS receiver can view; the better the fix is.
- **Satellite Geometry/Shading:** Refers to the relative position of the satellites at any given time. Ideal satellite geometry exists when the satellites are located at wide angles relative to each other. Poor geometry results when the satellites are located in a line or in a tight grouping.
- **Signal Multipath:** The GPS signal bounces off of objects, such as tall buildings or large rock surfaces, before it reaches the GPS receiver. This increases the travel time of the signal and, therefore, causes errors.

Remember, a GPS receiver is a complement to navigation and should not be the only navigational tool that you use. Using a paper map, a simple compass, and having knowledge of manual navigation is a good, safe practice.

Buying a GPS Receiver

13. Deciding which GPS receiver to buy can be overwhelming. How you want to use the unit should be the deciding factor. The following factors are worth considering:-

- **Product Level:** Do you want the basics, or do you want all of the bells and whistles? You can find a unit that fits your needs and budget.
- **Power Source:** Will you be using the unit away from an auxiliary power source? You might need to carry extra batteries. With some units, you can use a vehicle adapter or AC power source.

Mobile GPS tracking System using STRATO

- **Portability:** Do you have a preference between a portable and a built-in unit? Some units mount directly in the dashboard of your boat, car, or aircraft.
- **Mapping Capability:** Do you want to know the general direction or street-level details of your chosen path? Map data can include streets, restaurants, tourist attractions, marine data, topography, and so forth.
- **Mounts:** A mount for your GPS can be useful to keep your hands free while navigating your bike, boat, car, or airplane. Many units come with a mount, and several additional mounts are available.
- **Ease of Use:** Some receivers provide a tutorial or an easy-to-use touch screen interface. Some even have turn-by-turn voice instructions as you are navigating your route.
- **Antenna Configuration:** Where are you going to use the unit? With some units, you use only the built-in antenna. With other units, you can attach an external antenna to give you better reception.
- **Price:** Which units fit your price range? An inexpensive entry-level unit can be a great way to enter the GPS world.
- **Software:** Whether you want to save your favorite locations or plan a trip, map software can help. You can use your PC or go directly to your GPS receiver. Your preference for map detail and your specific activities determine which software is right for you.

Advancements in Technology

14. GPS Receivers: With the elimination of Selective Availability (SA), autonomous accuracy is much better. Today, a single stand alone receiver can provide an accuracy of between 10-15 meters. It is also now possible with the use of DGPS (Differential GPS) service to obtain sub meter accuracy in real time. This eliminates the need for post processing. This DGPS service is available through the use of coast guard beacon receivers and satellite based DGPS service. The coast guard service is limited to the coastal areas of the country or around 50-200 miles radius of the station itself. For areas where the coast guard beacon service is not available, real time satellite based DGPS service is available almost throughout the world at reasonable cost.

15. Traditional Units for data collection: The traditional units for GPS data collection use either an onboard storage memory or an external data logger. In most cases, the software on these units is extremely complicated and difficult to learn. The data collectors are vendor specific to GPS engines only and cannot be used for any other applications. The units come with a proprietary operating system which makes modifications or difficult to incorporate. These units have slower processors thus making the manipulation and processing of data and maps impossible or very slow. Also, the small screen size limits the display of data without scrolling down or panning often. The units have very low battery life and are expensive to replace. New Generation Data Collectors with the introduction of Palm Pilots followed by Microsoft's launch of a pocket PC operating system, a new generation of handheld Personal Digital Assistants (PDA's) have flooded the market. It is now possible to use these lightweight handheld PDA's, with GPS/GIS data collection software, for field applications. In addition, regular windows based laptop PC's are now available in ruggedized waterproof versions. One can use these PC's for mapping applications in tough outdoor environments. The traditional Data Collection software is difficult to learn and is vendor specific to their GPS engine only. Also the software available operates only on a Windows operating system and is expensive. Advantages of New Generation Software: Today, the new generation of software offers the user various options that can be used for his or her applications. Most of the new generation software allows the user flexibility to use any type of GPS engine beginning from a low priced recreational type unit to a high accuracy survey grade unit. The software has the capability of reading from 2 serial ports allowing the user to use a GPS receiver as well as an additional sensor, such as a laser range finder. The software can also accept digital camera input allowing the user to capture not only the location data but also the actual picture of the feature. Once the location, features and attribute data have been collected, all of the data can be exported in different GIS formats, such as ArcView shape files. Most of the new generation of software has a version available for Windows as well as a Pocket PC operating system. This results in a much shorter learning curve.

Requirement of Laser Range Finders

16. While GPS technology has made rapid advances, there are still inherent problems with data collection when utilizing GPS. First, there is the need for occupation of the point where GPS readings are required and sometimes it's just not possible to reach the point of interest. Second, the point may be reachable, however, due to other

factors, such as disturbance of wild life, areas of high traffic volume, or even evidence in crime mapping, you may not want to get there. Third, in some areas, GPS receivers cannot receive the signals, such as, in heavy tree canopy areas and near high rise buildings. Fourth, GPS mapping is slow if you have to map several features such as trees in a forest or electric poles on a road because you have to occupy each individual feature. To overcome some of the limitations of the GPS technology, laser range finders have now become available at a reasonable price and performance. These units can be used with or without GPS. The key to laser mapping is: you do not have to get there from here and occupy the feature! Instead, just shoot it with the laser. The eye-safe diode pulse laser measures distance without reflectors and has a tilt sensor built in to provide vertical angles. In addition, it has an option for a digital flux gate compass or angle encoder (not affected by magnetic fields) to provide an azimuth reading. The mapping grade range finders provide an accuracy of about 5 cm to 1.5 meters. Maximum range varies from about 500 ft to 2000 ft. The Laser Range Finder can be used in different ways depending on the application, for example, direct GPS integration, indirect GPS integration, or Independent Laser Mapping.

17. In cases where you have a clear view of the sky and are getting GPS signals, you can place the laser range finder at the same spot where the GPS antenna is placed in fact on the same range pole if possible. This is known as direct GPS integration. The laser unit sends the distance and azimuth readings to the GPS data collector and the software converts the laser readings to LAT/LONG based on the GPS antenna position as the reference. In cases where GPS signals are not being received, the GPS antenna is placed in a clear area where signals are available and the Laser is placed in any suitable area where maximum number of features is visible. This is called indirect GPS integration. The laser sends the distance and azimuth readings to the data collector and the software calculates the LAT/LONG of the features based on the antenna position.

Conclusion

18. The Global Positioning System (GPS) is a revolutionary technology that is changing the way businesses operate in the field. From its origin as a military navigation technology to its use for “black box” tracking of trucks on the road, GPS technology has proven its worth to enterprises worldwide. The combination of GPS and mobile computing offers 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. GPS location data is now accessible by users in the field and supervisors in the back office, providing greater visibility to operations and giving managers better control over operations in ways that have previously been impossible. What this means for mobile enterprises is that, for the first time, GPS can be tightly integrated into current business applications that utilize mobile computers. The result allows for increasing productivity, lower operational costs and improved safety with all these benefits leveraging the enterprises’’ investment in mobile computers.