9. Applications of GPS

9.1 Timing

In addition to longitude, latitude, and altitude, the Global Positioning System (GPS) provides a critical fourth dimension – time. Each GPS satellite contains multiple atomic clocks that contribute very precise time data to the GPS signals. GPS receivers decode these signals, effectively synchronizing each receiver to the atomic clocks. This enables users to determine the time to within 100 billionths of a second, without the cost of owning and operating atomic clocks. Precise time is crucial to a variety of economic activities around the world. Communication systems, electrical power grids, and financial networks all rely on precision timing for synchronization and operational efficiency. The free availability of GPS time has enabled cost savings for companies that depend on precise time and has led to significant advances in capability.

9.2 Roads and Highways

It is estimated that delays from congestion on highways, streets, and transit systems throughout the world result in productivity losses in the hundreds of billions of dollars annually. Other negative effects of congestion include property damage, personal injuries, increased air pollution, and inefficient fuel consumption. The availability and accuracy of the Global Positioning System (GPS) offers increased efficiencies and safety for vehicles using highways, streets, and mass transit systems. Many of the problems associated with the routing and dispatch of commercial vehicles is significantly reduced or eliminated with the help of GPS. Many nations use GPS to help survey their road and highway networks, by identifying the location of features on, near, or adjacent to the road networks. These include service stations, maintenance and emergency services and supplies, entry and exit ramps, damage to the road system, etc. The information serves as an input to the GIS data gathering process. This database of knowledge helps transportation agencies to reduce maintenance and service costs and enhances the safety of drivers using the roads.

9.3 Space

The Global Positioning System (GPS) is revolutionizing and revitalizing the way nations operate in space, from guidance systems for crewed vehicles to the management, tracking, and control of communication satellite constellations, to monitoring the Earth from space. Benefits of using GPS include:

Navigation Solutions -- providing high precision orbit determination, and minimum ground control crews, with existing space-qualified GPS units.

Attitude Solutions -- replacing high cost on-board attitude sensors with low-cost multiple GPS antennae and specialized algorithms.

Timing Solutions -- replacing expensive spacecraft atomic clocks with low-cost, precise time GPS receivers.

9.4 Aviation

Aviators throughout the world use the Global Positioning System (GPS) 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. Space-based position and navigation enables three-dimensional position determination for all phases of flight from departure, en route, and arrival, to airport surface navigation. New and more efficient air routes made possible by GPS are continuing to expand. Vast savings in time and money are being realized. In many cases, aircraft flying over data-sparse areas such as oceans have been able to safely reduce their separation between one another, allowing more aircraft to fly more favourable and efficient routes, saving time, fuel, and increasing cargo revenue.

9.5 Agriculture

The development and implementation of precision agriculture or site-specific farming has been made possible by combining the Global Positioning System (GPS) and geographic information systems (GIS). These technologies enable the coupling of real-time data collection with accurate position information, leading to the efficient manipulation and analysis of large amounts of geospatial data. GPS-based applications in precision farming are being used for farm planning, field mapping, soil sampling, tractor guidance, crop scouting, variable rate applications, and yield mapping. GPS allows farmers to work during low visibility field conditions such as rain, dust, fog, and darkness.

9.6 Surveying and Mapping

Using the near pinpoint accuracy provided by the Global Positioning System (GPS) with ground augmentations, highly accurate surveying and mapping results can be rapidly obtained, thereby significantly reducing the amount of equipment and labour hours that are normally required of other conventional surveying and mapping techniques. Today it is possible for a single surveyor to accomplish in one day what used to take weeks with an entire team. GPS is unaffected by rain, wind, or reduced sunlight, and is rapidly being adopted by professional surveyors and mapping personnel throughout the world.

9.16.4 Remote Sensing

It is also possible to integrate GPS positioning into remote-sensing methods such as photogrammetry and aerial scanning, magnetometry, and video technology. Using DGPS or kinematic techniques, depending upon the accuracy required, real time or post-processing will provide positions for the sensor which can be projected to the ground, instead of having ground control projected to an image.

9.16.5 Geographic Information System

GPS are becoming very effective tools for GIS data capture. Anyone charged with the responsibility of managing a distributed inventory, such as might be the case with the utility, municipality, or goods yard, might appreciate the ability to locate and identify this inventory quickly and accurately. This is the role played by GPS in conjunction with GIS. The initial input of data and timely updating is a huge task using conventional means of data collection. With GPS, it is possible to capture position-reinforced data in the field with a simple hand-held computer. As an example, there may be a mix of fluorescent, sodium and mercury street lights, with several varieties of each in a city. The maintenance engineer, capable of recognising the types, can use GPS-based data collector to log the location of each type of installation. This information can be loaded into a central database, so that when maintenance is necessary, the appropriate replacements can be ordered, stocked, and dispatched.

A rapidly growing and highly visible endeavour is the management of natural resources. Another field where GIS is prevalent is the environmental impact assessment studies involving the collection of large amounts of position-related data. Here, GPS can be instrumental in data collection.

Common applications of GIS where GPS can provide three-dimensional information about the features such as engineering mapping, automated photogrammetry, subdivision design (cut/fill, street layout, parcel layout), cadastral mapping, highway mapping, utility/facility mapping and management, surface-water mapping, event mapping (accident, crime, fire, facility breakage, etc.), census and related statistical mapping, watershed prioritisation, land-use planning and management, and environmental impact studies.

9.16.6 Military and Space

GPS was conceived and constructed for the use of military. The use of GPS in spacecraft has been widespread. GPS has flown on several shuttle missions, and has been useful in providing better orbital positioning in much shorter time than had been previously possible. Incorporation of GPS altitude determination in space station design is currently mandated.

9.16.7 Agriculture

GPS is opening a new era of precision farming in the advance countries. A farmer can analyse the soil condition of every region of his farm and compile a fertiliser-demand map. This map is digitised and stored in the GPS system computer. As the chemical spreader moves through his fields, its GPS-measured position is

correlated with the stored demand map to determine the exact amount of fertiliser or pesticide to be applied at every point. The farmer profits from higher yields and the environment benefits from lower chemical usage.

This same accuracy is also being applied to aerial fertiliser and pesticide delivery. With a DGPS guidance system, pilots can design exact flight paths such as a grid of application swaths and then have the system guide them precisely through it. These systems can also record the actual flight path for reporting purposes.