AN OVERVIEW OF GNSS APPLICATIONS

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ABSTRACT

Global Navigation Satellite System (GNSS) is basically a system of satellites providing autonomous geo spatial positioning with global coverage. There are mainly four GNSS systems currently in operation. They are the United States' Global Positioning System (GPS), Russian Federation's Global Orbiting Navigation Satellite System (GLONASS), Chinese BeiDou Navigation Satellite System (BDS) and European Galileo. The possible uses of GNSS are enormous and spanning many domains. In this paper effort has been taken to highlight some recent and practical applications of this technology, special focus on military and commercial applications in various fields.

Key Words: GNSS, GPS, GLONASS, BeiDou, Navigation.

1.0 INTRODUCTION

Navigation basically means any of several methods of determining or planning an object's position and course by geometry, astronomy, radio signals etc. This combines two concepts. The first is the determination of the position and velocity of a moving body with respect to a known reference, sometimes known as the science of navigation. The second is the planning and maintenance of a course from one location to another while avoiding obstacles and collisions. This is sometimes known as the art of navigation and may also be known in many cases as guidance, pilot age, or routing, depending on the vehicle. The very first satellite navigation system was Transit, a system deployed by the US military in the 1960s. The system then developed and became more accurate and user friendly with time. Global Navigation Satellite System (GNSS) receivers which use the GPS, GLONASS, Galileo or BeiDou system, are used in many applications. These systems are day by day becoming popular among both in civilian and military purposes without considering any borders of nations. Now, with the term GNSS, the first thing that comes to mind is the interoperability between any of this systems in order to meet the increasing demand and safety of life.

This paper basically tries to explain all the different applications of GNSS briefly. The applications are divided in two parts to explain clearly. The first section describes the military uses of GNSS. In the later section the commercial uses of GNSS are described. At the end the overview of the whole discussion and future scopes are stated in the conclusion section.

2.0 MILITARY APPLICATIONS OF GNSS

The satellite navigation system was originally developed for military uses only. Satellite navigation allows for highly accurate precision in the delivery of weapons to target, greatly increasing their lethality whilst reducing inadvertent casualties from misdirected weapons [1]. Of all GNSS, GPS has been most widely used in military applications. Essentially, GPS was developed to satisfy military requirements for a global positioning, navigation and timing service. Military application of GPS started in late 1970s when GPS was used for weapon testing in the then US Navy Submarine Launched Ballistic Program (SLBM). GPS was used to track the

Submarine Launched Ballistic Missiles from a ship as the missile travelled down the Atlantic. The GPS military equipment used for the missile testing then made use of translator. Subsequently, other weapon testing was conducted in the air and ground vehicles. Today, GPS can be deployed to variety of military applications.

2.1 Navigation

Navigation is one the most vital fields of GNSS application in military sector. For example a soldier who is operating under cover of darkness in enemy territory faces the biggest challenge due to navigation as there are unfamiliar territory and lack of easily identifiable landmarks on ground. Soldiers have been using night skies for ages to find out direction but their location on ground cannot be determined. Those age old methods are not completely reliable. There are some real life examples of using GNSS in war zones. The necessity of knowing their own position by troops during war was very clearly highlighted during the Gulf War (1990) [2] and the Kargil conflict (1999). Initially about 1000 GPS receivers were issued for use during the Gulf war but by the end nearly 9000 handheld devices were in use. Similarly, during the Kargil conflict, Indian patrols operating in rugged terrain along the line of control, initially strayed into enemy held areas with disastrous consequences but later on the availability of handheld GPS receivers proved to be invaluable to them. Special forces and crack teams can draw air and artillery fire accurately by providing the accurate positional data [3]. Further, gun positions can be occupied quickly using GPS, as in modern warfare, artillery batteries must move often to keep pace with assault troops and to avoid being hit by counter fire.

2.2 Tracking

Potential targets need to be constantly tracked before they are declared hostile and engaged by various weapon systems in military zone [4]. This tracking data is fed as input to modern weapon systems such as missiles and smart bombs etc. For an example, the US Army has developed a GPS Truth Data Acquisition, Recording and Display System (TDARDS). It is a compact, lightweight, low-cost and easily transportable or mobile GPS-based tracking system that uses up-to-date GPS data, radio data link and computer technology to provide highly accurate, real-time time-space position information (TSPI) on up to ten test objects, such as ground vehicles, aero planes, helicopters and fixed-winged aircraft.

2.3 Bomb and Missile Guidance

Modern day weapon systems are designed to use GPS data as input for targeting and guidance. Cruise missiles commonly used by US to accurately hit targets from large standoff distances use multichannel GPS receivers to accurately determine their location constantly while in flight [4]. The Multiple Launched Rocket System (MLRS) vehicle uses GPS based inertial guidance to position itself and aim the launch box at the target in a very short time. This reduces the chances of detection and counter bombardment. The Exploitation of DGPS for Guidance Enhancement (EDGE) program of the US army has developed a 2000 lb glide bomb, which uses a GPS seeker rather than a Laser for guidance. This bomb could accurately hit its target 11 miles from its drop point guided by four DGPS base stations about 1000 nautical miles away .

2.4 Rescue

Rescue and emergency response is another area where GPS can prove invaluable to the military. Determining the location of a casualty during operations, emergency response teams can use the GPS to reduce response time. For example, the US Air Force is already taking advantage of GPS based technology and is developing a Combat Survivor Evader Locator (CSEL) system. The new system integrates the GPS receiver with a communications radio so that search and rescue teams can locate downed aircrew members faster and more accurately than before.

2.5 Map Updation

The defense forces need accurate and

updated maps at various scales for various military headquarter levels [4]. The availability of GPS shall augment the collection of precise data necessary for quick and accurate map updating. The GPS can also be used effectively for the establishment of grid control locations for the placement of various weapons and other assets, location of targets etc. For example, the modern mapping techniques such as remote sensing and Geographic Information System (GIS) will now constantly use the DGPS technology to register the images into absolute geo-coordinates. This would enable the military personnel to utilize modern map products to accurately determine the locations of target points for use by the new generation of weapons.

Fig. 1: Image showing US soldiers using GPS receivers during GULF war

2.6 Facility Management

In almost all countries of the world, the military manages and operates large bases which cover extensive areas. To manage these facilities effectively, it is essential to prepare an accurate base map. Here GPS/DGPS can be of immense help, as existing maps are not updated regularly. GPS co-opted with GIS can effectively tackle this task. For example, at Yokosuka US Naval Base in Japan, Arc View GIS software was used to evaluate three different components for the GPS implementation. First, for modeling the optimum location for a GPS base station, secondly for selecting benchmark locations to fix the base station location and thirdly evaluating accuracy of survey by GPS.

2.7 Target Acquisition Systems

The Surveillance Target Acquisition systems are military applications aimed to encompass tracking, reconnaissance and map creation systems, in order to help the missile and bomb guidance mechanisms and battlefield management systems. The tracking mechanisms are performed by military weapons to detect potential hostile targets both in the air and on the ground, using satellite navigation information to accurately detect the target's coordinate's position. The GNSS position data is then fed into weapon systems, such as smart bombs or missiles.

3.0 CIVILIAN OR COMMERCIAL APPLICATION OF GNSS

Global navigation satellite system stands for the determination of positions with respect to the global coverage by transmitting signals. Calculating the precise time of the signal and highly accurate clocks it can provide three services -position, navigation and timing which is collectively known as PNT. GPS is the fully operable navigation system that provides variety of techniques, products and services but with the increasing demands of accuracy and commercial location based services GLONASS of Russia, Galileo of Europe and BeiDou of china are also simultaneously developed. At first navigation is only used for military purposes but now a days it is used by civilian users without considering the nationalities of each system for safety promises [5]. Though primarily its application is for outdoor activities with clear sky view but its current expansion in new environments result in numerous applications in civilian sides. The universal availability, low cost and increasing accuracy made the navigation system choice for many users. Now GNSS is means the interoperability and availability of various satellite navigation systems.

3.1 Mobile Mapping

Internet or wireless communication network makes transfer and processing of data more efficient and flawless. The advanced picture

capturing techniques, GNSS and Inertial Navigation System (INS) gives the mapping technology a new era. By using geo-spatial data this mapping is now can be used in moving vehicles such in cars, airplanes or in ships. Accurate locations of road or highways can easily be obtained by road mapping using small handheld mobile. Many internet mapping, online mapping, direction of streets are available by aerial photographs or satellite images.

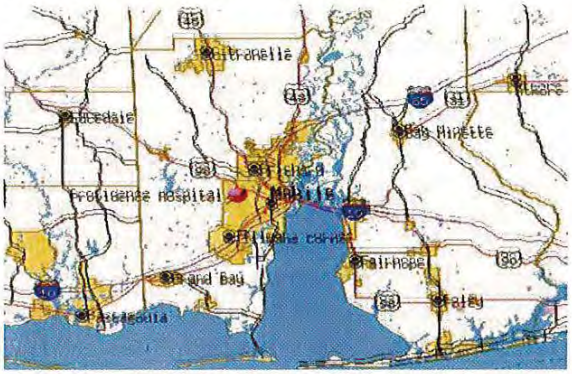

Fig. 2: Image showing GNSS Mapping of a particular locality

3.2 Surveying and GIS

In this sector the uses of GNSS is the realization of surveys and production of maps. It provides purely a surveying tool in which data turned into maps, plans and models. This cannot be done only by a small GNSS receiver but using duel frequency multi constellation system done by GNSS augmentation system. Land surveying can be done in any weather and at any time of the day where surveys are made in relation to a reference points. Equipments such as transits, tape, theodolites and GNSS receiver is used. Survey systems are mainly separated into static survey, dynamic survey and real –time dynamic survey. Mapping or GIS is another gift of GNSS- Google earth, Google map are results of it. This includes capturing and storing of all geographical data. Even archaeologists also use it for creating three dimensional map. GNSS provides low cost acquisition of data that makes GIS more suitable for general use.

Fig. 3: Surveying

3.3 Precision Agriculture and Fishing

In agriculture field the proper rate of seeds and chemical process is a very important issue. Using GNSS this accurate rate of seeds and chemical can be done by soil sampling. In fact a map showing the field, [6] its each corner, row and columns, spacing can be done by aerial imagery or satellite imagery loaded into GIS system. Topographic mapping, minimum water logging, centre pivot irrigation, alignment control all can be done easily with the help of GNSS systems. Now a days tractor, steer and animals locations in the field can be controlled by GNSS connecting this with the transmitter. So, the whole yield can be taken in ones control by monitoring mass flow sensor, grain moisture sensor, mapping programs and display, receiver with its antenna. Again electrodes creates current on the river and fishes are floated where they are netted. Invasive fishes are taken out of the river. The point where large numbers of native fishes are found is determined and marked by GPS and the information about the fishes are taken for further use.

Fig. 4: GNSS use in agriculture

3.4 Tree Plantation-using Fumigant Applications

Sometimes it is seen that many new trees are killed or get stunted for some soil borne diseases usually known as re-plant disease. Most of the time the real reason is not well understood, in such cases fumigant over 2 ~ 4 m wide with continuous strips centered has to apply. Manual tree planting-site-specific fumigant application is very time consuming and also labor intensive. With the help of high performance GPS computer technology the right amount of fumigant at the right location with right amount can be ensured. This reduces the probability of re-plantation and increased the accuracy of about 20 m.

3.5 Aid of Visually Impaired People

Technology is not only for enjoyment but also to make life easy for those who are unable. In this field GNSS has done an excellent job of offering blind peoples the color of life. The aid of satellites gives vision by which they can virtually see light, color, money and much more. Depending on GPS or mapping system Mobile Geo is used on the windows mobiles, pocket PC's which is the first aid system provided by GPS for visually impaired people. Blind square software is GPS software that used crowded sound data in iPad or iPhone. Ariadne GPS provides talking maps that introduce the world to the blind my moving hands on the map, helping to crossing streets by giving vibrations, announcing for bus and train stop. It works anywhere Google maps are available. In fact trekker, kapsys kapten, trinetra, MoBIC, Drishti, Noppa, navig all is different projects for blind peoples depending on the GPS system.

3.6 Remote Sensing of Water Vapour

Warming or cooling of planet is always matter of concerned to the scientists. Among all the elements of climate, water vapor is one kind of greenhouse gas responsible for global warming [7]. It continually cycles through evaporation, condensation and transporting heat energy between surface and atmosphere. It taps long wavelength radiation emitted by the earth surface and there by causing increase in temperature. Though weather forecasting is done by other techniques but GPS provides better result with additional atmospheric data for vertical resolution in the case of space based GPS receiver and horizontal resolution in the case of ground based GPS receiver, controlling propagation delay, reducing ionospheric effects using duel frequency signal.

3.7 Port Automation

Port automation or IT sectors can use the GNSS technology in their sectors. They can synchronize the loading and unloading activities with their prediction and thereby reducing traffic and double handling. Most of the modern tracking system is based on the GPS system for more accuracy in locating objects. Also for communication cellular or transmitter is used to discuss the location of vehicle with the remote user. This communication reduces the delays as well as increases the production because of accurate location, planning and handling.

3.8 Aerial Photogrammetry

Once the picture of many places of ground were taken by using aircraft. But now with the advance technology of GNSS this pictures are captured using satellites but adjusting the height and camera with the GNSS and INS. It is now possible to give the clear image of any aircraft captured by satellite.

3.9 Earthquake-geologists View

Movements always need to be detected in pinpoints. Since GPS can measured with pin point accuracy in fact in millimeter range geologists are now depending on GPS for measuring the strength of quake. GPS receiver is used to receive the satellite signals during earthquake. The movement of the earth and its direction is measured. The receiver not only measures the code and the vertical displacement, it mainly measures the carrier wave which is used with the code. The accuracy of this measurement depends on the carrier frequency. If its frequency is much higher then it will give more precise information.

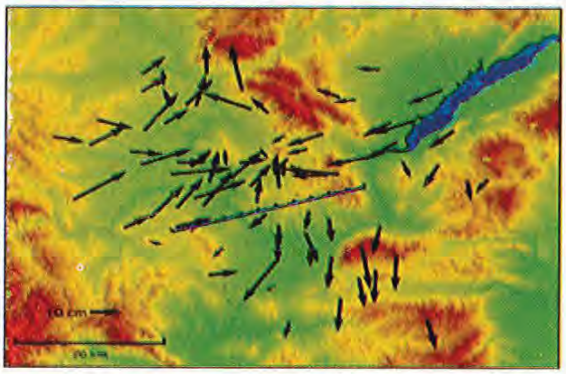

Fig. 5: Earth Quake detection using GNSS

3.10 Aircraft Landing

Now-a-days many airlines refuse the hand-held receiver landing system as it faces many complications [8]. GNSS are now used for landing and take-off which accuracy can be further more increased by the use of Receiver Autonomous Integrity Monitoring (RAIM) applications with GNSS.

3.11 Recreation

GNSS gives its foot print on the recreation sides like sports, climbing, racing, touring, hiking, skydiving and so on. It has tremendous growth in sports and fitness applications. Different types of sports cycles, swimming watches etc are examples of it, all of this needs proper mapping, location, position, safe place for landing and weather information for safety purposes. It also helps one to reach the destination with out facing jams by giving the correct information about roads.

4.0 CONCLUSION

The operation upon which GNSS relies is triangulation. For a good positioning and precision output at least signals from three satellites are required. To ensure continuous worldwide coverage, GPS satellites are arranged so that four satellites are placed in each of six orbital planes. Though GNSS has its own achievements in different fields of civil and military field in order to increase its applications, constellation and availability of satellites should be increased for more precise output. It can be done by the interoperability principle which includes the use of two systems together like GPS and GALILEO. But there is still scope for further augmentation in the system. The two other GNSS systems having global coverage as GLONASS and Compass can also be considered. New GLONASS-k satellites are intentionally designed to be compatible and interoperable with other GNSS systems. So, these two are high contenders to be added in the system. If GNSS receiver can be further improved and multipath obstacles can removed for interrupting signals this technology can take further away to make the globe more livable.

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