INTERNATIONAL TRAINING COURSE ON SATELLITE NAVIGATION AND LOCATION BASED SERVICES

JUNE 18, 2008 TO JULY 18, 2008

Conducted at:

SPACE APPLICATIONS CENTRE, ISRO
SAC Bopal Campus, Ahmedabad, India

COURSE REPORT

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CENTRE FOR SPACE SCIENCE AND TECHNOLOGY EDUCATION IN ASIA AND THE PACIFIC (CSSTEAP)

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FOREWORD

The "Regional Centres for Space Science and Technology Education" are established by the efforts of United Nations Office of Outer Space Affairs (UN-OOSA), to assist in the development of the indigenous capacity of each country of the region to apply space science and technology to enhance social and economic development. The first such Centre was established for the Asia Pacific region with India as host country – Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP). CSSTEAP holds regular nine month courses on Remote Sensing & GIS, Satellite Communication, Space Science, Satellite Meteorology and a number of short term courses on various applications of space science and technology. This training course on 'Satellite Navigation and Location Based Services' is organized by CSSTEAP to train middle level managers to get in depth theoretical knowledge and on the job training in applying Space Science and Technology for developmental activities using with particular emphasis on location based services.

I am happy that for the current four weeks course 18 scholars from 10 different countries could participate. Apart from the lectures by expert faculties from various institutions, within and outside India, the participants were given extensive hands on training on various aspects and types of Satellite Navigation systems and demonstration of location based services. On behalf of CSSTEAP I wish to thank Dr. R. R. Navalgund, Director of Space Applications Centre of ISRO, for organizing the course and Dr. K. Bandyopadhyay, Course Director and Mr. P. Satyanarayana, Course Coordinator for successfully conducting the course.

This booklet contains the details of the curriculum followed, the list of faculty, and the list of course participants and their plan to utilise the knowledge gained during the course.

I hope this booklet will be useful to others who wish to organize similar training course.

International Training Course on "Satellite Navigation and Location Based Services"

Report

1.0 Background

With increasing use of GPS receivers in various applications, satellite navigation is becoming part of everyday life. Global Navigation Satellite Systems (GNSS) provide three basic services: Position, Time, and Frequency. The GLONASS constellations, operated by the Russian Federation, are being modernized and upgraded to provide full fledged service equivalent to the GPS constellations, operated by the United States. The European Galileo system and China's COMPASS/BeiDou have also started launching their satellites. In addition to these four global systems, in next few years there will be three overlapping regional systems from India, China, and Japan in the region of Asia and the Pacific. With all these constellations the number of navigation satellites is expected to exceed 100 in the next five years. The worldwide investment in Global Navigation Satellite Systems utilisation is very high and is comparable to the investments in satellite communications or satellite remote sensing applications. Such new developments also lead to the establishment of the International Committee on Global Navigation Satellite Systems (ICG), inter alia, to implement recommendations of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III).

In addition to satellite based navigation, the location based services are useful to the public in many ways because it enables individuals to get information on nearest hospitals, police stations, emergency services etc. It is also very useful in disaster management. It is also used in tourism and sales promotions. Users of this service include common people, corporate, and the scientific community.

To provide this service, trained workforce is required in industry, manufacturing, sales and value addition. They should have basic knowledge in functioning of satellite based navigation systems and training in RF receiver and antenna, DSP and VLSI technology. In addition, trained individuals with basic knowledge is also required in related application and utilisation fields like GIS, remote sensing, aircraft and ship navigation, etc. where satellite navigation systems are used,. To meet this perceptible need, CSSTEAP organized an International training course of four weeks duration on Satellite Navigation and Location Based Services.

The overall objective of this training course is to make the participants aware of the potential of Satellite Navigation technology and its applications with an emphasis on location based services. The participants are exposed to relevant technologies, so as to get an in-depth understanding how these technologies can be used in an operational scenario. With the training received it is expected that the participants will have adequate skills to apply the knowledge acquired in their own country to support organizations/managers involved in providing value added services in addition to the basic satellite based navigation service.

1. Familiarization with GPS Receivers and Coordinate System Conversion

Participants got familiarized with the single frequency hand held GPS receivers. They understood the operation of the instrument and its different features. They also observed the performance of these receivers in open space and under shadow. They also learnt how to convert the measured readings into different coordinate systems.

2. Experiment to demonstrate the operation of Dual Frequency GPS Receivers

This experiment enabled the participants to understand the operation of dual frequency GPS receiver and its advantages over the single frequency receiver. The required post-processing has been demonstrated to show the different capabilities of such kind of receivers like ionospheric delay estimation and estimation of scintillation index etc.

3. Familiarization with Standard GPS File Formats and their Use

The GPS receivers store the data in standard formats like RINEX (Receiver Independent Exchange Format). This experiment aims to explain the RINEX format for the Navigation and observation files. Furthermore, the participants in this experiment have estimated the satellite position, user position and the ionospheric delay utilizing the data in the file using MATLAB. They generated a scattered plot out of the derived positions to verify the accuracy of position estimation.

4. SATNAV Aided Precision estimation of distance

The experiment objective is to make the participants learn to use the DGPS receivers and understand its benefits and use. The participants in this experiment compared position differences between a single frequency GPS receiver and a DGPS receiver. The experiment also gave the participants a detail account of the post processing of the DGPS data using SkiPro software.

5. Combining Satellite Navigation with Satellite Communication: Fleet Monitoring application

This experiment demonstrates an interesting application using combined Satellite Navigation and Satellite Communication. In this experiment, GPS receivers integrated with MSS Reporting terminal has been demonstrated. These were mounted in a fleet of vehicle to transmit the position intermittently while moving in different routes to a central location via geosynchronous satellite INSAT. At the Central location, the locus of the movement of each vehicle was monitored on a GUI screen. Participants also verified the locations of the landmarks noted by them during their travel with the vehicles. The participants could see the real time transmission of the vehicle-mounted MSS Reporting terminal. They could observe the locus of the positions, interfaced on a map to see the movements as well.

ANNEXURE - I

List of Participants and their Details

Registration Number	Name & Country	Organisation Addresses	Photos
SSC-08-61	**Abdul Fatah Rahimy** Afghaninstan	S & CDMA Engineer. PMO – project Switch & CDMA deportment Afghan Telecom Corporation Ministry of communication information technology 4th Floor, Post Parcel Building Mohammad Jan Khan Watt. **Kabul, Afghanistan** Phone : +931-75-2030841 Email : fatah_rahimy@yahoo.com	
SSC-08-62	**Abdul Latif Sabqat** Afghanistan	MCIT, Kabul, Afghanistan Afghanistan Telecom Regulatory Authority, MCIT Building 19 th floor, Mahamd Jan Khan wat. **Kabul, Afghanistan** Phone :+930-700-205075 Email : latif.sabgat@atra.gov.af ablatifsabgat@yahoo.com	
SSC-08-63	**Murad Ahmed** Bangladesh	Asst. Communication Engineer, Communication Division, Bangladesh Meteorological Department, Agargaon, Dhaka-1207, **Bangladesh** Phone :+880-2-9118866 Fax : +880-2-8118230 Mobil :+880-1673106015 Email : murad.buet@gmail.com	
SSC-08-64	**Chhim Phalla** Cambodia	Bayon Earth Station, Ministry of Post and Telecommunications, Corner of street 13 and 102 Sangkat, Wat, Phnom, Khan Davn Penh, Phnom Penh, **Cambodia** Phone : +855-11-664-270 Fax : +855-23-427-998 Email : chhim008@yahoo.com	
SSC-08-65	**George Gugushvili** GEORGIA	Head Air Port Authority 0158, Internatinal Airport Sakaeronavigatsia, **Tbilisi, Georgia** Phone: +995-93-993229 Fax : +995-32-744235 Email : gushvil@gmail.com	

ANNEXURE - II

International Training Course on Satellite Navigation and Location Based Services

TIME SCHEDULE

DATE/ DAY	09-45 to 11-15 Hrs.	11-30 to13-00 Hrs	14-00 to 15-30 Hrs	1545-1715 Hrs.
Wednesday 18.6.2008	***Registration and Administrative Formalities***		***Inauguration***	Prof. Hans Haubold meeting the participants
Thursday 19.6.2008	Overview of Satellite Navigation and its Applications **Dr. S. V. Kibe**		Principles of Satellite Communications **V. S. Palsule**	
Friday 20.6.2008	Coordinate Systems & Orbital Parameters **Dr. D. B. Rauthan**		Basics of Matlab : Part I **Priya Shinghal, Saurav Das, Bijoy Roy**	
Monday 23.6.2008	Introduction to Satellite Navigation Systems **Prof. A.D. Sharma**	Principles of Satellite Navigation (Position determination) **Prof. A. D. Sharma**	Basics of Matlab : Part II **Priya Shinghal, Saurav Das, Bijoy Roy**	
Tuesday 24.6.2008	Principles of Satellite Navigation (Time Transfer) **Prof. A. D. Sharma**	Satellite Navigation Primary Systems (GPS Architecture) **V. S. Palsule**	**Experiment # 1** Familiarization with GPS Receivers and Coordinate System Conversion **Dr. Ashish Shukla**	**SEMINAR**
Wednesday 25.6.2008	Satellite Navigation Primary Systems (GPS Signal Structure) **A. K. Sisodia**	Satellite Navigation Primary Systems (Other Primary Systems and Receivers) **V. S. Palsule**	**Experiment # 2** Familiarization with Standard GPS File Formats and their Use **Rajat Acharya**	
Thursday 26.6.2008	GLONASS System and Receivers and its Use in LBS **Dr. Sergey Karutin**			
Friday 27.6.2008	Errors in Satellite Navigation : Effects **R. Acharya**		Tutorial on fundamentals of Satellite Navigation **Dr M R Sivaraman**	

ANNEXURE - III

SEMINAR ABSTRACTS

1. Location Based Services for fishermen in sea

Today fishing is one of the important earning and employment generating sector. This sector not only provides export earnings but also provides source of living for millions of people. In most of the coastal areas two types of fishing is carried out i.e. Local Fishing and Deep Sea Fishing. The fishing trawlers used for deep sea fishing are generally well equipped with GPS receiver, VHF/UHF Trans receiver, and other emergency systems. In case of local fishing, the small fishing boats used are ill equipped to meet any emergency or to navigate safely at sea. The reason is that, these boats are generally owned by poor fishermen who cannot afford costly equipment like GPS receiver.

Many fishermen of coastal areas have incurred losses in the past due to cyclonic storm. However the fact is that modern technological tools such as GPS navigator has helped some of them in bringing down the losses to a considerable extent. The Marine GPS can be used to navigate safely, to track movement of shoals of fish, to relay position of boats and to advise best locations for fishing.

The basic requirements of fishermen are daily fishing for livelihood and information on weather forecast. The Location Based Services are the best solution to provide weather warning and PFZ (Potential Fishing Zone) forecast. Most of the fishermen use mobile for communication. More number of cellular towers on the coastline and powerful network would help them in better mobile coverage. They need to go for fishing in groups consisting of 10-12 boats per group. The fishing boats tend to go beyond VHF/UHF radio range in quest for more fishing. As a solution, some of the Mechanised boats equipped with GPS and high power VHF system could be placed at 50 Km from coast and can be used to relay the weather/PFZ forecast to fishing boats operating at 100 Km from the coast. Group Leader would pick up the warning and retransmit it to the fishermen of his group or nearest group by using VHF/UHF transreceiver. Further, to help poor fishermen and to popularize, the GPS may be provided at subsidised rates. A Fishing Regulatory body consisting of members from local administration, Meteorological Dept. Fishery Dept. and other regulatory agencies would assist in training and smooth fishing operations in the area.

needed and the type of route he needs and he will be given details of the nearest medical facility with the required feature, the route to the facility along with the details for contacting the hospital. During emergencies there will not be any requirement of authentication. An emergency button when pressed will send an SOS call to the Control Centre along with the users location. Evacuation will then be done by the fastest possible means. Simultaneously the government (police) authorities will also be informed.

4. Location Based Services for Urban and Suburban Development and Planning

A city is an urban settlement with a special administrative, legal, or historical status where as suburbs are residential areas on the outskirts of the city. Large, industrialized cities generally have planned central systems for sanitation, utilities, land distribution, housing, and transportation. The group chose Ahmedabad because its suburbs are getting redefined. Gujarat is home to some of the best institutes of urban design and planning and management. The state has drawn up a new Gujarat Integrated Township Policy with the objective of improving "the quality of the living environment by adopting town planning norms by providing for adequate open space, road network, density norms, and quality of building construction". Thus, Ahmedabad Urban Development Authority (AUDA) was established for undertaking tasks including urban agglomeration, draft town planning schemes, monitoring and control of development activities in accordance with the revised development plan and finally to develop infrastructure like road, sewerage, water supply and provision of basic civic amenities. As can be seen, for any city, the volume of developmental tasks is enormous. The project group firstly examined the major challenges for AUDA where the Location Based Services (LBS) could be exploited. These include redrawing of town plans using Geospatial Information Systems (GIS) and LBS, considering the conversion of farm land for commercial purposes and tag and map the plots using LBS technology, enhance environmental quality by planning for small lakes and gardens, re-forestation, ground water recharging, build public utilities, identify locations for layered/structured housing, shopping complexes, road planning, plan for a good public transportation system and disaster management for the city and its suburbs.

The study conducted by the group pertains to those aspects/areas where LBS have been utilized. Thus, three main aspects emerge; viz planning of Urban/suburban transportation, planning and monitoring of safety measures and planning for disaster management where LBS technologies could be used. In the following sections, we describe LBS technologies available that can be used to assist AUDA in achievement of its challenges pertaining to planning of urban transportation and disaster management areas. In the next two paragraphs, the proposals of the project group are brought out.

ANNEXURE - IV

Faculty addresses

S.No.	Faculty Name	Address
1	Mr V S Palsule	Head, ACTD, ADCTG/SITAA/SAC, Ahmedabad. Phone : +91-79-26912493 Email : vilaspalsule@yahoo.com
3	Dr S V Kibe	Programme Director, SATNAV, ISRO HQ, Antariksh Bhavan, New BEL Road, Bangalore - 560 094 Phone : +91-80-341 5281 +91-80-307 2312 +91-80 341 2141 (F) Email : kibesv@hotmail.com
4	Dr D B Rauthan	c/o Dr Amit Rauthan 311, RIFCO Santosh Apartment Wind tunnel Road, Airport Road Bangalore- 560017 Phone : +91-80-41266818 Email : drauthan@yahoo.com
5	Dr M R Sivaraman	B-31, Someswara Row Houses, Part-II, Opp. Star Bazar, Satellite Road, Ahmedabad Phone : +91-79-26921584 Email : sivaraman_55@yahoo.com
6	Prof A D Sharma	Director Research & Training Unit for Navigational Electronics, Osmania University, Hyderabad-500 007 Phone : (O)+91-40-27098066 (R)+91-40-27423086 (F) +91-40-27091762 Email : ad_sarma@yahoo.com
7	Mr A K Sisodia	Head, APDD, APSG/SPTA/SAC, Ahmedabad. Phone : +91-79-26912224 Email : anil_sisodia@sac.isro.gov.in
9	Mr R Acharya	SAC, Ahmedabad. Phone :+91-79-26912420 Mobile : 09426343901 Email : rajat_acharya@sac.isro.gov.in
10	Dr. P. Soma	ISTRAC,Plot No 12 & 13, 3rd Main, 2nd Phase, Peenya Industrial Area. Bangalore-560058 Phone : +91-80-28094583 Email : soma@istrac.gov.in
11	Maj. Gen. Dr. B. Nagarajan	Additional Survey General of India, GRB Survey of India, Karanpur, Dehradun-248001 Fax : 0135-2654528
12	Mr M. Irrulappan	GM, GNSS, AAI, Rajeev Gandhi Bhavan, Safdarjung Airport NEW DELHI-110003 Phone : +91-11-24610367 Mobile : 09868867331 Email : mirulappan@yahoo.com

ANNEXURE - V

Participants Response on Utility of This Course
(Unedited)

Abdul Fatah Rahimy (Reg. No. SSC-08-61), AFGHANISTAN

1) Briefly explain in 10 Lines your nature of work in the organization.

Technical survey of erecting tower for mobile and installation of feeder and sectors of it. Hardware and software installation of digital warless switch and fix line telephone switch installation and operation. Operation and installation of Mobil, digital wireless fixed line telephone switch and relevant equipment. Troubleshooting of technical problems in Mobil and Digital wireless, fixed line telephone switches. Test coverage for all erecting tower of mobile systems. Technical survey of positioning, transportation, and installation of all above-mentioned equipments which are planned for provinces where require these systems. Provide training for the human resource.

2) Briefly explain in 10 Lines your plan to utilize the knowledge gained from the course.

As I previously described, I am working in Afghan telecom. Accordingly after getting knowledge of Global Navigation and Position based services here I hope I can apply gained knowledge from this effective and advanced scientific knowledge and bias Navigation based services in Afghanistan and develop this kind of services which are essential and vital in the era of development of Afghan telecom around the world. This technology is not still introduced well in my country and our people are not familiar and aware of services this advanced and complex technology can provide to government and people. In addition, it is important to indicate that I get this knowledge in the country the people of which have friendship, from several decades with people of Afghanistan.

Chhim Phalla (Reg. No. SSC-08-64) CAMBODIA

1) Briefly explain in 10 Lines your nature of work in the organization.

My nature can be described in following manners:

- **Operation & Maintenance :** I am working at Radio Coast Station, Installation, Operation and Maintenance Equipments in Transmitting and Receiving Station in Sihanouk Ville.
- **Managerial Activities :** I look after and coordinate day to day activities of my division. I also prepare report of my section for the head office.
- **Providing Training :** I provide training on wireless communications to the technical persons in my organization.

2) Briefly explain in 10 Lines your plan to utilize the knowledge gained from the course.

The International Training Courses on Satellite Navigation and Location based Service in Ahmedabad, India, is very important and will provide me great benefits. This course would help to improve my knowledge in Location Bases Services.

After finishing this course I would be able to:

- Understand the satellite Navigation technology and location based services.
- Understand the process related between Communication and Navigation satellite system.
- Transfer the knowledge to the technical perssonels of the organization human resources development.
- Train other personnel on GPS which is extensively used in the organization.
- Create awareness and promote utilization of GNSS systems in various fields.

Piyush Agarwal (Reg. No. SSC-08-67), INDIA

1) Briefly explain in 10 Lines your nature of work in the organization.

I am in the government service. Presently, I am looking after policy and training related issues. It involves developing and vetting training philosophy including on space related subjects.

2) Briefly explain in 10 Lines your plan to utilize the knowledge gained from the course.

I would like to utilize the knowledge gained on the course as follows:-

Refine the training philosophy developed with the help of better understanding gained.

Assist in developing location based service using GNSS for the various users and requirements in my organization.

Train other personnel on GPS which is extensively used in the organization.

V Shanmugavelan (Reg. No. SSC-08-70), INDIA

1) Briefly explain in 10 Lines your nature of work in the organization.

I am a systems manager responsible for the induction and maintenance of GIS systems. My work involves analysis, system study and coordination of development of the GIS systems and GIS based applications for a particular region. I coordinate generation, fusion, issue and maintenance of GIS data. I am responsible for the establishment and functioning of the regional Geo-Int Centre as part of the Defence Spatial Data Infrastructure. We also analyse the HR requirement and train them with help of renounced train institutions like the Centre for Development of Advanced Computing (CDAC). I also manage the website and the web portal of our organisation.

2) Briefly explain in 10 Lines your plan to utilize the knowledge gained from the course.

This course will enable better understanding of GNSS technology. This will lead on to better contribution in development of GIS systems. This will also enable me to give better advice to senior level decision makers. GIS system is the end product through which users will Location Based Services of GNSS. Since my primary job is GIS, this course will enable me to make the users utilise the GNSS / Satellite Navigation technologies in a better manner.

Miss. Muratalieva Seidana Janybekovna (Reg. No. SSC-08-73), KYRGYZSTAN

1) Briefly explain in 10 Lines your nature of work in the organization.

I am a specialist of Radio electronic, Division of Registration Department. In our organization under Government of Kyrgyz Republic.
The work activities in our department that I have responsibilities performance as follows:

- To check the technical parameters of application for radio stations systems in all types services.
- To check the technical parameters of all types application stations of satellite communications.
- To contact and coordinate of these stations with /Outside Countries.
- To apply the registration for radio stations systems in The International frequency register of International Telecommunication Union (ITU).
- To provide the practical applications such as designing radio equipment of various types.

2) Briefly explain in 10 Lines your plan to utilize the knowledge gained from the course.

First of all, participating in this International Training Course on Satellite Navigation and Location Base Service will give me the opportunity to improve my knowledge and skills in Satellite Communication and SATNAV use technology together related to technology for implementation and development programme work projects in my country, to optimize the utilization of this International Training Courses on Satellite Navigation and Location Based Services and support our efforts to achieving our goal for using the monitoring agricultural crop development, the satellite to monitor and forecast weather, the use of satellite helps farmers plan, remote sensing or development in rural areas other activities to support by SATNAV. my career and gain qualification as engineer in this developing area.

Battulga Batkhuu (Reg. No. SSC-08-76), MONGOLIA

1) Briefly explain in 10 Lines your nature of work in the organization.

I am in charge of operational tasks of geophysical stations including permanent ground GPS stations as well as maintenance and technical security on satellite communication for certain number of remote geophysical stations. Actually my work devotes in the type of jobs like field engineer, station operator and technician. As I am field engineer I deal with installation, calibration and maintenance of geophysical stations throughout Mongolia. Also decision making on technical issues for field deployments and testing and benchmarking equipments before utilization is one of my duty. As station operator: monitoring geophysical stations and their management of operational tasks, checking the overall status of the data flow, ensuring data quality and completeness through established procedures, maintaining data base and preliminary data analysis as needed.

2) Briefly explain in 10 Lines your plan to utilize the knowledge gained from the course.

The knowledge gained through the course might be helpful for my job especially for the business on permanent GPS stations and its data analysis. Any geophysical data without having time stamp is useless. Therefore broad knowledge on GPS operation and its signal structure is strongly helpful in most of geophysical fields. Recently we have built Mongolian National Data Center (Geophysical), the main goal of the center is to give an alert to the government agencies (Decision makers) in case of Earthquake disaster. It is pleasure and helpful to understand the philosophy of the Location Based Services. Also to know current technologies and its trends on LBS is useful for future development of the alert system at the recently built NDC.

ANNEXURE – VI

GPS Glossary

Accuracy : A measure of how close an estimate of a GPS position is to the true location.

Acquisition Time : The time it takes a GPS receiver to acquire satellite signals and determine the initial position.

Almanac : Coarse satellite orbital data used to calculate satellite position, rise time, elevation, and azimuth. This is transmitted by all GPS satellites as part of its Navigation Data (Subframes 4 and 5). By acquisition of any one GPS satellite signal and demodulation of the received signal, the almanac of all GPS satellites in the constellation can be obtained. Any GPS receiver initially obtains this data by tracking any one GPS satellite, computes all the visible satellites using the almanac and tracks only those satellites, to compute position fix.

Ambiguity : The unknown integer number of cycles of the reconstructed carrier phase contained in an unbroken set of measurements from a single satellite pass at a single receiver. It is the initial bias in a carrier-phase observation of an arbitrary number of cycles; the uncertainty of the number of cycles a receiver is attempting to count. If wavelength is known, the distance to a satellite can be computed once the number of cycles is established via carrier-phase processing.

Anti-Spoofing : Encryption of the P-code (to form the Y code) to protect the P-signals from being "spoofed" through the transmission of false GPS signals by an adversary. It is the process of encrypting the P-Code modulation sequence so that the code cannot be replicated by hostile forces. When encrypted, the P-Code is referred to as the Y-Code

Atomic Clock : A very precise clock that operates using the elements Cesium or Rubidium. A cesium clock has an error of one second per million years. GPS satellites contain multiple cesium and rubidium clocks. Atomic Clock is a clock whose frequency is maintained using electromagnetic waves that are emitted or absorbed in the transition of atomic particles between energy states. The frequency of an atomic transition is very precise, resulting in very stable clocks. For redundancy purposes, GPS satellites carry multiple atomic clocks. GPS satellites have used Rubidium clocks as well as Cesium clocks. The GPS Master Control Station uses Cesium clocks and a Hydrogen Maser clock to maintain GPS Reference Time.

Azimuth : A horizontal angle measured clockwise from a direction (such as North).

Bandwidth : A measure of the width of the spectrum of a signal (frequency domain representation of a signal) expressed in Hertz.

Cold Start : The power-on sequence where the GPS receiver downloads almanac data before establishing a position fix.

Compacted data : Raw data compacted over a specified time interval (compaction time) into one single observable (measurement) for recording.

Conformal Projection : A map projection that preserves angles on the ellipsoid after they have been mapped onto the plane.

Control segment : Ground-based GPS System equipment operated by the U.S. Government that tracks the satellite signals, determines the orbits of the satellites, and transmits orbit definitions to the memories of the satellites

Coordinates : A set of numbers that describes your location on or above the earth. Coordinates are typically based on latitude/longitude lines of reference or a global/regional grid projection (e.g., UTM, MGRS, Maidenhead).

Coordinated Universal Time (UTC) : Replaced Greenwich Mean Time (GMT) as the world standard for time in 1986. UTC uses atomic clock measurements to add or omit leap seconds each year to compensate for changes in the rotation of the earth.

Cutoff angle : The minimum elevation angle below which no more GPS satellites are tracked by GPS receiver to track and compute position. Typical values are 15^0. This is to reduce the errors due to Troposphere and Ionosphere.

Cycle slip : A discontinuity of an integer number of cycles in the measured carrier beat phase resulting from a temporary loss of lock of a GPS satellite signal.

Data message : Also known as Navigation Data. Data transmitted by GPS satellites, which is used to compute satellite's location and satellite clock Corrections.

Datum : A mathematical model which depicts a part of the surface of the earth. Latitude and longitude lines on a paper map are referenced to a specific map datum. The map datum selected on a GPS receiver needs to match the datum listed on the corresponding paper map in order for position readings to match.

DGPS : Differential GPS. The term commonly used for a GPS system that utilizes differential code corrections to achieve an enhanced positioning accuracy of around 0.5 - 5m.

Deflection of the vertical : The angle between the normal to the ellipsoid and the vertical (true plumb line). It is usually resolved into a component in the meridian and a component perpendicular to the meridian.

Geodetic Coordinates : Coordinates defining a point with reference to an ellipsoid. Geodetic Coordinates are either defined using latitude, longitude and ellipsoidal height or using Cartesian coordinates.

Geodetic Datum : A mathematical model designed to best fit part or all of the geoid. It is defined by an ellipsoid and the relationship between the ellipsoid and a point on the topographic surface established as the origin of datum. This relationship can be defined by six quantities, generally (but not necessarily) the geodetic latitude, longitude, and the height of the origin, the two components of the deflection of the vertical at the origin, and the geodetic azimuth of a line from the origin to some other point.

Geographic Information System (GIS) – A mapping system which combines positional data with descriptive information to form a layered map.

Geoid : The particular equipotential surface which coincides with mean sea level, and which may be imagined to extend through the continents. This surface is everywhere perpendicular to the direction of the force of gravity.

Geoidal Height : See Geoid separation

Geoid separation : The distance from the surface of the reference ellipsoid to the geoid measured outward along the normal to the ellipsoid.

Geosynchronous Orbit : A specific orbit around where a satellite rotates around the earth at the same rotational speed as the earth. A satellite rotating in geosynchronous orbit appears to remain stationary when viewed from a point on or near the equator.

GPS week : GPS time started at Saturday/Sunday midnight, January 6, 1980. The GPS week is the number of whole weeks since GPS time zero.

Glonass : The Global Orbiting Navigational Satellite System, the Russian Counterpart to the United State's GPS.

GPS : Global Positioning System

GPS time : A continuous time system maintained by US Naval Observatory.

NMEA : National Marine Electronics Association. Defined a standard (NMEA 0183) to enable marine electronics instruments, communication and navigation equipment to communicate. This standard is used to get time and position data out of GPS instruments in many applications.

Navigation messages/ Navigation Data : data modulated onto the satellite's signals. The navigation data is transmitted at 50 bits per second and contains ephemeris and clock data for that particular satellite, other data required by a receiver to compute position velocity and time and almanac data for all NAVSTAR satellites. The data is transmitted in 1500 bit frames, each requiring 30 seconds to transmit. A complete set of data to include all almanacs, timing information, ionospheric information and other data requires 12-1/2 minutes to transmit.

Observing Session : A period of time over which GPS data is collected simultaneously by two or more receivers.

Orthometric height : The distance of a point above the geoid measured along the plumb line through the point (height above mean sea level).

P-code : The Precise GPS code - a very long (about 10^{14} bit) sequence of pseudorandom binary biphase modulations on the GPS carrier at a chipping rate of 10.23 MHz which does not repeat itself for about 267 days (about 38 weeks).. Each one-week segment of the P-code is unique to one GPS satellite, and is reset each week. Access to the P-code will be restricted by the U.S. Government to authorized users only.

PDOP : Position dilution of precision. See Dilution of Precision

Phase observable : See Reconstructed Carrier Phase

Point Positioning : Determination of Position (Latitude, Longitude and height above Spheroid), using Pseudorange observations.

Post processing : The process of computing positions in non-real-time, using data previously collected by GPS receivers.

Precise Positioning Service (PPS) : The highest level of point positioning accuracy provided by GPS. It is based on the dual-frequency P - code.

Pseudolite : The ground-based differential GPS station which transmits DGPS Corrections on a signal with a structure similar to that of an actual GPS satellite.

Pseudo Random Noise (PRN) code : Any group of binary sequences that appear to be randomly distributed like noise, but which can be exactly distributed.

ANNEXURE – VII

Some Simple Articles on GPS available in Internet

1. www.trimble.com/gps/index.shtml - All About GPS
2. http://www8.garmin.com/manuals/GPSGuideforBeginners_Manual.pdf - GPS guide for beginners
3. Http://www8.garmin.com/manuals/UsingaGarminGPSwithPaperLandMaps_Manual.pdf - Introduction to using a Garmin Receiver
4. http://www8.garmin.com/aboutGPS/manual.html - about GPS
5. http://www.colorado.edu/geography/gcraft/notes/gps/gps_f.html - Global Positioning System Overview by Peter Dana
6. http://en.wikipedia.org/wiki/Global_Positioning_System - Global Positioning System
7. http://www.gps.gov/ - Global Positioning System – This US Government Web site has been developed by the US National Space Based Positioning, Navigation and Timing Office. It is hosted by US Coast Guard Navigation Centre.
8. http://www.howstuffworks.com/gps.htm - How GPS works ? It contains videos also
9. http://geography.about.com/od/geographictechnology/a/gps.htm - GPS - Eight things you should know about GPS
10. http://www.faa.gov – Navigation Services – Global navigation Satellite System
11. http://tycho.usno.navy.mil/gps.html - US Naval Observatory GPS Timing Operations
12. http://www.aero.org/education/primers/gps/GPS-Primer.pdf - GPS Primer
13. http://www.gmat.unsw.edu.au/snap/gps/gps_survey/principles_gps.htm - Principles and Practice of GPS Surveying By Chris Rizos
14. http://telecom.tlab.ch/~zogg/Dateien/GPS_basics_u_blox_en.pdf - GPS Basics by Jean-Marie Zogg
15. http://gge.unb.ca/resources/glonassconatellationstatus.txt - Provides Glonass status
16. http://gge.unb.ca/resources/glonassconatellationplot.pdf - Provides Glonass constellation plot
17. http://www.surveyingsupplies.com/surveyingsupplies/pdfs/gpsbasics.pdf - "Introduction to GPS " - Leica Company's article on GPS for Surveying
18. http://www.cmtinc.com/gpsbook/index.htm - Inroduction to the Global positioning System for GIS and Traverse.
19. http://www.gps-basics.com/faq/ - Frequently asked questions on GPS and their answers
20. http://www.the-gps-place.com/downloads/BasicsofGPS-V18.pdf - The basics of GPS