

Geoinformatics in Forestry Application of Geoinformatics for Working Plan Preparation

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Abstract

Forest Working Plan is a document that regulates wood production, silviculture and tending activities for a specific period of time through the application of certain prescriptions specifying targets, action and control arrangements. In this paper how geoinformatics was applied to prepare a working plan for Velhe forest Range in Pune district, Maharashtra state is explained. Geoinformatics was applied to get information on, vegetation type, density, slope, and peoples requirements etc. Based on the forest management guidelines the forests have been allotted to various working circles for scientific management.

Introduction

To manage the forests systematically, Under working plans, forest areas will be divided into blocks and compartments. Block is a main territorial division of the forest generally bounded by natural features. A block will be divided into several compartments which are territorial units of a forest permanently defined for the purpose of administration and record. For Silvicultural management, forests will be classified into Working circles. (W.C). A working circle is defined as a forest area organized with a particular object and subject to one and the same silvicultural system and the same set of working plan prescriptions.

Description of the Working Plan Area

Velhe Forests are situated in Pune district of Maharashtra state, India. It extends between 18° 25'

N to 18° 00' North latitudes and between 73° 25'E to 74° 03' East longitudes. The range has 26,147 ha of forest area scattered over a geographic area of 1,32,783 ha and includes 323 villages with a population of 1,13,761, as per 2001 census. The average annual rainfall in the subdivision is 2050 mm. The location map of Velhe Sub Division is shown in Fig.- 1.

General Objectives of forest Management are

- Conservation of forest cover on the steep slopes and lake catchment areas to check the soil erosion, soil and water conservation.
- To tend the immature growth to secure full growing vigor and size by carrying out proper silvicultural operations.
- To meet the requirements of fuel, wood, fodder, minor forest produce and small timber of the rural populations.
- Increasing the forest cover through afforestation works, on the degraded, barren, denuded areas in the forests.

Materials and Methods

The software used to prepare the working plan are Geomedia Professional 5.2, GRID 5.2 and Intergraph Image Analyst.

Topographical maps of 1:50000 scale were georeferenced. Transportation network, water bodies, settlements, contours, archeological structures, etc were digitized. Forest boundary, block boundary, compartment boundaries, beat boundary, were digitized from the forest topographic maps of 4 inch



Fig.1 : Location Map of Working Plan Area .

to 1 mile scale.

From soil maps, soil type polygons were digitized. A soil data base for each soil type polygon was created in MS Access with Soil polygon code number, Soil depth class, Particle size class, mineralogy class, soil pH class, Soil Drainage class, Surface texture, Slope class and Erosion class etc. as attributes. With these attributes a soil GIS layer was developed .

IRS, LISS III, PAN sharpened satellite image of Feb 2004 pertaining to the sub division area was used to get the forest type and density.

Using GPS hand set ground reference data was collected to classify the satellite imagery into various forest types, forest density classes etc. Sample plots were laid in the forest areas, following the stratified random sampling technique. Sample plots of size 25m x 25m size were laid in all forest types. In each sample plot, all trees were enumerated, and the tree species, height, girth, crown diameter, herbs, shrubs and natural regeneration status were noted. From these sample plots data a forest inventory was prepared for each forest compartment. From the compartment inventory a data base was created in the MS Access with the following attributes for all the 156 compartments in the sub division.

Compartment Number, Area , Village name, Legal status, Forest Type, Site Quality, Density, Principal species in the top Canopy, Second Story, Bamboos, Shrubs, Herbs, Grasses, Climbers, parasites, Epiphytes, Natural Regeneration Status,plantation year, species, survival percentage, illicit felling incidents, Encroachments, unauthorised Grazing incidents, Fire damage, Weeds, Research Plots, Preservation Plots, Plus and elite trees . Forest compartment boundaries were digitized from the forest territorial maps. Using the compartment polygons and these attribute values a Compartment

Village Name	Literates	Amenities available
House holds number	Main workers	land use
Total Population	Cultivators	Drinking Water source
Land less people	Agricultural labour number	Irrigation
Tribal Population	Marginal workers	Communication Facilities Construction workers

GIS layer was created.

Village boundaries shown on the taluka maps were geo-referenced and digitized. A village census GIS was prepared using the year 2001 census data for all the 323 villages in the subdivision, with 45 attributes consisting of the mentioned attributes.

Contours were digitized, with contour value as an attribute .Using GIS software a digital elevation model (DEM) was prepared. From the DEM average slope map, aspect maps and stream network were derived. Using GIS functions from the streams watersheds were delineated. Watershed map is shown in Fig.-2



Fig. 2 : Watershed Map and Water bodies.

Analysis and Results

Keeping in view the, forest types, Biotic influences, Conservation of biodiversity, Site quality, Topography, Needs of the local people, forest compartments were allotted to the following working circles .

Forests on the slopes above 20° slope , 20 meter wide buffer areas along the steams, forests in the watersheds of lakes supplying drinking water to towns or for agriculture purpose, and compartments having rare, endangered, threatened flora and historical/cultural sites with a buffer of 50 meters around were placed under Protection Working Circle for management .

Tectona grandis (Teak tree) bearing Forest areas on below 10° slope, compartments with large number of stems in girth class 20cms to 45cms, forest density more than 0.6, and successful plantations were identified and allotted to Improvement working circle. Thinning and improvement felling was recommended in these areas.

Forest areas below 30° slope, having density

less than 0.4 were identified to take up soil and moisture conservation works. Areas where the soil erosion is severe were identified and prioritized to carry out soil conservation works. Soil type polygon features attribute data was used to know the erosion status .

For afforestation Working Circle potential areas for planting were identified by using criteria, forest areas having density less than 0.4, aspect and soil depth. Planting of different species was recommended in these areas depending on the soil depth, drainage, aspect, and rainfall. Light demanding species Teak was recommended on East and Western aspects .

To meet the fodder requirements of cattle in the village, forest areas within 2kms from settlement and, having soil depth upto 10cms were identified for fodder development. On these areas raising improved variety of grasses along with leguminous species was recommended in the working plan. These areas were allotted to the Fodder working circle for management.

Fuel wood is the major requirement for the local people. Forest compartments which are within 2 kms from settlements were identified and a buffer zone of 100 mtr was created and only fuel wood species were suggested for planting in this zone. Waste lands along the river with soil type equal to black cotton, and soil depth more than 30cms and are within a distance of 100 meters from the river banks were identified and planting of *Accia nilotica* which is a fuel wood tree with high calorific value was suggested to meet the fuel wood requirement of local people.

Forest areas newly acquired and the boundaries not demarcated properly were allotted to survey and demarcation work.

A buffer zone of 500 mtrs was created around settlements, roads and cart tracks, within this buffer zone falling on forest lands no water sources are allowed to be developed for wildlife, as the sites cause disturbance. Sites near habitat edges were identified for water source development.

Joint Forest Management (JFM) : Degraded forest areas were identified to take up regeneration of forests with people's participation, using the criteria, degraded forests with density less than 0.4, soil depth more than 30 cms, and are within a distance of 2 kms from village settlements, and in villages

where land less poor population is more than 30% of the total village population, were identified by running attribute and spatial query on Compartment, soil, and village census layers.

View shed analysis was done to identify ideal locations for watchtowers for fire and forest protection. The length and width of fire lines in the subdivision was extracted using GIS and appended the data to the working plan for executing these works.

After carrying out the GIS analysis forests in Velhe range were allotted to various working circles for management in working plan as shown in Table no1. Final Working Circle map is shown in Fig.-3.

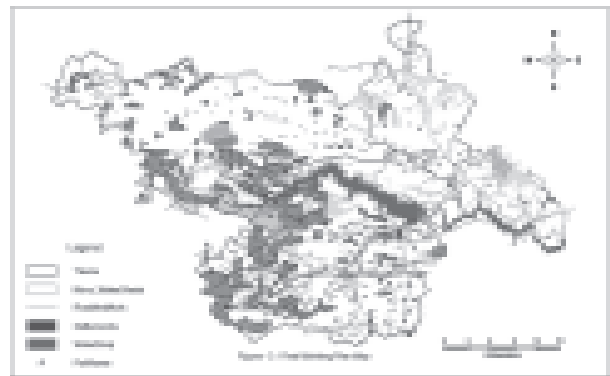


Fig. 3 : Final Working Circle Map for Management

Table No.1. Summary of Forest Area Allotted to Various Working Circles (WC)

Sr.No	Working Circle	WC Area in Ha
1	Protection WC	12169.06
2	Improvement WC	1454.36
3	Soil and Moisture Conservation cum Afforestation WC	5650.1
4	Fodder WC	2309.53
5	Bio-diversity Conservation (Overlapping)WC	Whole area
6	Survey & Demarcation works	1001.26
7	Fuel wood working Circle	3562.8
	Total Area in ha =	26147.08

Conclusions

Using Geoinformatics the Forest managers can prepare working plans in short time when compared with the conventional methods. As per conventional methods it takes 3 to 4 years to complete one working plan for a forest division, with geoinformatics the working plan can be prepared in one year and accurate classification of forests into various working circles can be done.

Acknowledgements

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Further Readings

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Global Positioning System Studies for Dam & Crustal Deformations

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Abstract

With the recent major earthquakes in the South East Asian region, and the devastation caused by the tsunami effect, the importance of earthquake prediction and monitoring the safety of dams has been re-emphasized. Monitoring the Geodynamics, including the crustal deformations, and structural deformations of large engineering structures like dams, using advanced space geodetic techniques like the Global Positioning System (GPS), with the ultimate aim of predicting the disasters like earthquakes, dam failures, etc. is one of the greatest challenges faced by the scientists in this century. Many national organizations and institutions in India have taken up geodetic, geophysical and geological surveys for such studies. These efforts have now been augmented through the launch of an extensive National Programme on GPS and Geodetic Studies for Earthquake Hazard Estimation, by the Department of Science & Technology (DST), Government of India, since 1998. The programme, being implemented in a phased-manner by DST has now reached a significant stage. Several GPS research groups are engaged in studies of specific regions under this national programme.

The security of large engineering structures like dams, bridges, high-rise buildings etc., demand their regular periodic monitoring. These civil structures pose a risk to the economy if subjected to excessive loading. Therefore, monitoring the deformation pattern is often one of the most effective ways to understand the safety status of such structures. The IITB GPS research team has taken up such monitoring of the Koyna Dam. An overview of the recent developments in this field, along with the present status and future plans have been presented here. Some details of the research work being carried out by the IIT Bombay GPS research group, under this National Programme in the Koyna region of central India, are also briefly presented.

Introduction

Construction of large engineering structures such as dams, bridges, high-rise buildings, etc., is essential for the development of a nation. However, under excessive loading, they are subjected to deformation, thereby causing loss to lives and property. Hence, the safety of these works especially dams demands periodic monitoring of the structure and in-depth analysis of its structural behaviour, based on the monitoring of a large set of variables contributing to deformation. Thus, the deformation forms the most relevant parameter to be monitored.

Several factors contribute to the deformation of these structures. The most important of all is the result of the varying stress and strains developed in the structure due to the effects of local crustal movements. Crustal movements cause shifts in the relative location of points situated on the dam body and in the vicinity of the dam. Other factors may include type of the material, wind actions, temperature variations, settlement of soil, and fluctuations in the load due to vehicular traffic

(Manake & Kulkarni, 2002).

In India, Dam and Crustal deformation studies using GPS are being carried out in the seismically active region, Koyna, Western Maharashtra, by the GPS team of the Indian Institute of Technology Bombay (IITB), with the author as the Principal Investigator, under a research project funded by the Department of Science and Technology, Government of India (DST). This project forms an integral part of the "Indian National GPS Programme for Earthquake Hazard Assessment". A GPS network has been established for this purpose, and observed over nine epochs, from December 2000 to April 2004. The observations taken on the dam structure and the surrounding area have been processed, evaluated and analysed at IITB for the purpose of deformation analysis.

Indian National GPS Programme

In India, an extensive GPS-based national programme for earthquake studies has been launched recently. The Himalayan region is known to be seismically active, and needs to be monitored for

earthquake hazard. The Peninsular Shield of India also can no longer be considered to be seismically inactive, as shown by the Koyna, Latur and Jabalpur earthquakes, hence it is necessary to monitor the crustal movements in the entire country on a regular basis. This was also emphasized by the UN Experts Committee after the 1993 Latur earthquake. This committee recommended establishment of a dense GPS and also precise vertical control for this region, to monitor the seismotectonic activities. Based on this and the proposal to World Bank by the Department of Science & Technology (DST), a GPS programme was formulated for the peninsular shield, which is being implemented through many participating institutions, and major augmentation of resources, including instrumentation, manpower, training, budgetary allocation, etc. is being done. GPS surveys for Latur area and Koyna area have been taken up since 1995. However, in order to evolve a 'National Programme on GPS for Geodynamic Studies in India', by integrating the GPS control network for Peninsular Shield, and other existing GPS stations, to cover the entire country, DST set up a GPS Expert Group, comprising 14 scientists / experts from 10 Institutions, in 1997. The Expert Group has evolved an extensive 'National GPS for Geodynamics Plan', as described in the Report of the Group, compiled by the author, and submitted to DST in Feb' 1998 (DST, 1998). This National GPS Network for Geodynamics, recommended by the Expert Group, is now being implemented in a phased manner under a National Project by DST. The entire network consists of about 50 permanent GPS stations established for this purpose, a total of about 600 semi-permanent (campaign-mode) GPS stations in the Himalayan regions and the peninsular shield of India, and many more field GPS stations, being established and monitored for local campaigns. A National GPS Data Centre has also been established at Dehra Dun, under this project. The extensive geodetic data being generated through these networks will contribute significantly in understanding the complex earthquake phenomenon, and for monitoring the earthquake hazard in the country (DST, 2005).

Koyna GPS Network

The Indian Peninsular plate, one of the oldest continental blocks on the earth's surface, was traditionally referred to as a stable rock by geologists, which remained immune from any major seismic disturbance. But the December 11, 1967 earthquake at Koyna, with a magnitude of 6.9 on Richter Scale,

contradicted this belief and evoked interest on the part of geologists, geodesists, dam experts and engineers (Joshi & Kulkarni, 1986). However, the dam in the region withstood this significant seismic activity without much damage. This occurrence in the Central Indian shield has led to serious introspection among geo-scientists and led to various studies dealing with the stability of the dam structure and the surrounding regions [Manake & Kulkarni (2002)].

The Koyna Dam, a rubble concrete dam, is an 85 m and 800 m long rock-filled structure, with an 872 sq km of catchment area. The dam has been well instrumented for observations of structural behaviour, right from the design stage, and has proved to be significant, because of the continuing tremors in the zone, after the 1967 event. The instrumentation includes various gauges embedded in the dam structure or installed around the dam body like uplift pressure cells, thermometers, piezometers, stress and strain meters and coordimeters. Apart from this, the advances in technology have evoked the use of GPS for carrying out dam and crustal deformation studies. The main objective of the project described here is to study the seismologically disturbed region of Koyna area and the behaviour of the dam body, using geodetic GPS technique. It includes establishing dense GPS network in the identified seismically active area, its repeat observations, detailed GPS data processing using scientific software and to estimate parameters responsible for deformation.

In order to carry out structural and crustal deformation studies, an extensive GPS network comprising 34 stations has been established in the vicinity of Koyna Dam. The GPS network set up in order to monitor the complete area is given in Figure 1.

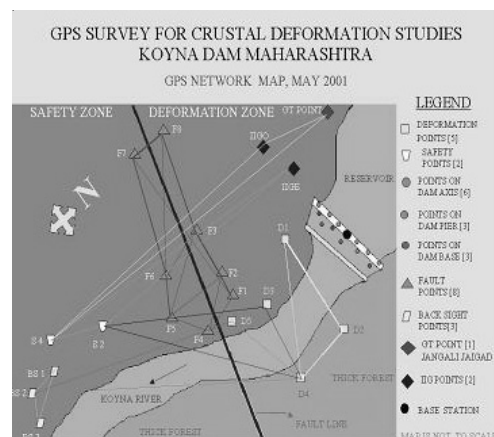


Fig.1. GPS Network established in the Koyna region. [Manake & Kulkarni (2002)]

The distribution of the GPS stations is one base station on the dam axis, established approximately at the centre and the top most point of the dam; Six stations on the dam axis (Three on either side of the base station); Three stations on the dam pier (Two on upstream (U/S) side & one on downstream (D/S) side); Three station on dam base (All on D/S side); One GT Station connected: Jangli Jaigad H.S. situated approximately 8 km north of the dam; One at IIG (Indian Institute of Geo-magnetism) Observatory and one at Evaporation Lab; Eight GPS stations (fault points) along the fault line D/S of dam; Three back site stations (All on D/S side); Two safety stations (All on D/S side); Five deformation stations (All on D/S side).

The observations at the selected points were taken using dual frequency geodetic GPS receivers: 4000SSi with Choke Ring antenna and 5700 with Zephyr Geodetic antenna. The data is collected for a period of 6-8 hours with a sampling rate of 15 seconds, and satellite elevation mask of 15°. Repeat observations over the entire network have been carried out starting from Dec 2000. This was decided keeping in the mind the possible effect of water table on the dam. Data was collected during the pre-monsoon or the drawdown phase (minimum water load) and the post-monsoon or refilled phase (maximum water load). Post-monsoon refilling generally starts by June/July and the maximum water levels is obtained by August/September. The water level remains close to maximum till December and then starts to drop. The period from March to June is treated as the pre-monsoon phase. Till date, 14 sets of observations have been taken since Dec. 2000, each fieldwork period spanning approximately two-three weeks. A permanent GPS station has been established at IITB, as reference (see Fig. 3).

Data Processing and Analysis

The objective of the work was to identify the factors responsible for deformation of the dam and their impact on the dam points and the surrounding region. The major factors that have been identified and studied were the plate motion and varying reservoir water table. The data was processed using Bernese v4.2, which is a scientific software developed by the University of Bern. All the changes in the coordinates and baseline lengths between the subsequent repeat observations (campaigns) were established.

In order to study the deformation of the dam

due to continuously fluctuating water table, the base station on the dam axis was analysed. Continuous observations were taken for the base station throughout all the campaigns. The change in the coordinates of the point between the successive campaigns was estimated and the deformations thus obtained were studied to understand its pattern of deformation.

Results of Deformation Analysis

The change in the coordinates obtained from GPS yield the global deformation of the points, which include two components, namely the local deformations and the plate deformation (of the Indian plate). In order to understand the deformation pattern of the dam, it is necessary to exclude the plate deformation from the global deformation to give the local deformation. For this purpose, the coordinates of IGS station IISc was used to compute the plate motion between the successive campaigns. Since IISc and Koyna are on the same plate (Indian plate), the deformation reflected in the Koyna points with respect to IISc would yield purely the local deformations. Thus, the local deformations calculated were plotted against the campaigns as given in Fig. 2.

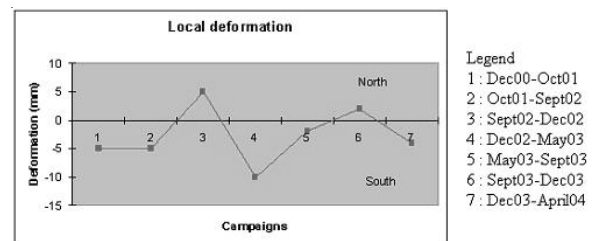


Fig. 2. Local Deformations versus Campaigns



Fig. 3. IITB Permanent GPS Station

It is observed that during Dec02-May03 and Dec03-April04, the dam shows a negative deflection indicating that the dam shifts in the southern

direction. This sudden decrease in the water pressure during the drawdown phase reduces the load on the dam structure thereby inducing a bending moment on the base of the dam, due to which the entire dam structure tilts or rotates considerably, resulting in displacement of the top of the dam towards the D/S side.

During the refill phase from May03-Sept03, it is observed that the deformation is negative indicating that the dam shifts in the southern direction. This may be because of the sudden increase in the water level by about 24 m. This high water pressure induces a bending moment on the dam that it tilts in the D/S direction. From the figure, it is observed that Sept02-Dec02 and Sept03-Dec03 give a positive local deflection indicating that the dam tends to shift in the north direction. This is the phase where water is retained for a longer period of time.

Conclusions

An extensive network has been set up at the Koyna Dam and the surrounding region to carry out deformation studies using GPS. GPS proves to be a very effective tool to carry out deformation studies due to its high precision and accuracy. It was observed that in order to understand the displacement of the dam due to the effect of local parameters like water table, it is necessary to separate out plate motion from the global deformations. The results indicate that the deformation of the dam is mainly because of the water table fluctuations, and these water level changes may be inducing the seismic activities in the area. The regional GPS network has been useful in estimating the crustal deformations in

the area under study.

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Dr. Madhav N. Kulkarni, Lt. Col. (Retd.), is presently Professor of Geodesy & Remote Sensing Division in the Civil Engg. Dept., of Indian Institute of Technology, Bombay, after taking voluntary retirement from Army Engineers. An Alumnus of I.I.T. Kharagpur, Dr. Kulkarni served in Survey of India, where he executed and supervised extensive Geodetic survey operations from the Himalayas to Kanyakumari, for diverse applications. He did his Masters and Ph.D. in Space Geodesy at The Ohio State University, USA, in a NASA-funded project, on study leave, and received two international awards. He is a member of several international and national committees, including the National GPS Expert

Committee of Govt. of India. His areas of specialization include Space Geodesy, Satellite-based Surveying & Mapping techniques, and Global Positioning System (GPS).

Mumbai Police Now A Part of GIS Community

Mr. Shikant D. Joshi

DCP (Wireless), Bruhan Mumbai Police

Mumbai Police has always been a front runner in adopting latest technologies. We were the first to adopt latest communication technology in the year 1997.

Mumbai Police have an uphill task of maintenance of Law & Order across the length and breadth of Mumbai city measuring about 438 Sq.K.Mtrs. with population of cosmopolitan nature of about 1 crore 40 lacs.

Being commercial capital of India, any serious incident taking place has immediate repercussion in the state as well as in the country.

Mumbai Police have Main Control Room situated at the office of the Commissioner of Police Mumbai, working round-the-clock for the immediate assistance of general public. We have 100 No. facility where common man can seek the help of Police whenever required. Other numbers like 1090, 103 Alert Citizen & Elderline, CFC (Citizen Facilitation Centre is also available for General Public) are also available. This is one step forward in the same direction. Mumbai Police, for last 3-4 years were thinking of acquiring the detailed map of Mumbai city. After continuous efforts for last 4 years, we are now able to install a Geo scaled map in our Control room. The map has a scale of 1:1000 and has different layers required for the working of Police department. There are 73 layers viz. roads, lanes, by lanes, hospitals, Rly. Stations, public places, religious places, blood banks etc. The map is still in the stage of upgradation and the required data is being fed in. The sensitive areas from the point of view of communal tensions, areas from election point of view will be also high-lighted, e.g. hyper sensitive, sensitive booths etc. Vital installations from the point of view of security will also be high-lighted.

Initially, with the help of GIS at Control room & the GPS Module with modem for connectivity installed in the Police vehicles, efforts are being made to ensure quickest help to the caller. Earlier it was experienced that many times Police help could not reach the caller for lack of correct address. The caller

in distress is unable to give correct address and the patrolling van is unable to contact the caller though in vicinity.

Work flow of the system

The system has two parts comprising of the call taker part and dispatcher part. General public in distress or requiring help of the Police dials 100 No. There is a digital telephone exchange with automatic call distribution facility connected to 25 hunting lines of MTNL with 25 call takers handling one line each at the Police Control room. All call takers have a GIS map on monitor. After receipt of the call, a pointer blinks on the place /building with a telephone No. and address from where the call has landed. There is no need for a caller to give his detail address to the call taker.

The patrolling van can be directed to the spot due to the correct location of the event. The call taker on receipt of the call transfers the same to the dispatcher instantly. The dispatcher is in control of Wireless patrolling mobiles installed with the GPS. Once the call is transferred from call taker to dispatcher, the call dispatcher has a window showing the address of the landed call, nature of call and its priority. There are five priorities pre-decided, like-bomb blast, fire, weapon, murder, accident, dead body, injured person, kidnapping, fighting, robbery, shop looted, riots etc. There is also a window showing the nearest location of the patrolling mobile which is nearest to the place of incident. The nearest patrolling van is directed to the Place of incident. There are 412 wireless mobiles installed with the GPS. They include divisional patrolling mobiles, vehicles of Senior Police Inspectors of various police stations, vehicles of divisional Asst. Commissioners of Police, Dy. Commissioners of Police of Zones and Traffic mobiles. The GPS connectivity of a mobile is through GPRS net-work and the location of the mobile is upgraded every second. The dispatcher will immediately dispatch the vehicle which is nearest to the place of incident. There is also a provision that patrolling mobiles which are already busy with some

other call are indicated by separate colour, so that busy mobile is not dispatched. Timing of all the actions, right from receipt of call, transfer of call from call taker to dispatcher and the dispatch of patrolling mobile is recorded as per the computer time. It is noticed that the response time of Police has decreased after the system is installed. The average response time in Mumbai is about eight minutes. GIS/GPS is

a step in the direction of reducing the response time further.

The use of GIS is also envisaged in future for use of Traffic Police, VVIP bandobasts and Crime Statistic data also. The implementation of the system is still in progress but a beginning is done.

About Author



Mr. Shrikant Digambar Joshi presently, Deputy Commissioner of Police Wireless, Mumbai. He is responsible for the Wireless Communication of entire Mumbai Police. He joined Police Force in July 1970, as Asst. Police Sub-Inspector Wireless. He worked in different capacities on different Networks of Police Wireless including State Police Network. He has been trained in operation and maintenance of TRUNKING System of M/s ERICSSON in U.S.A. He has been awarded INSIGNIA by the Director General of Police Maharashtra State and PRESIDENT MEDAL, in the year 1997 for Meritorious Service.