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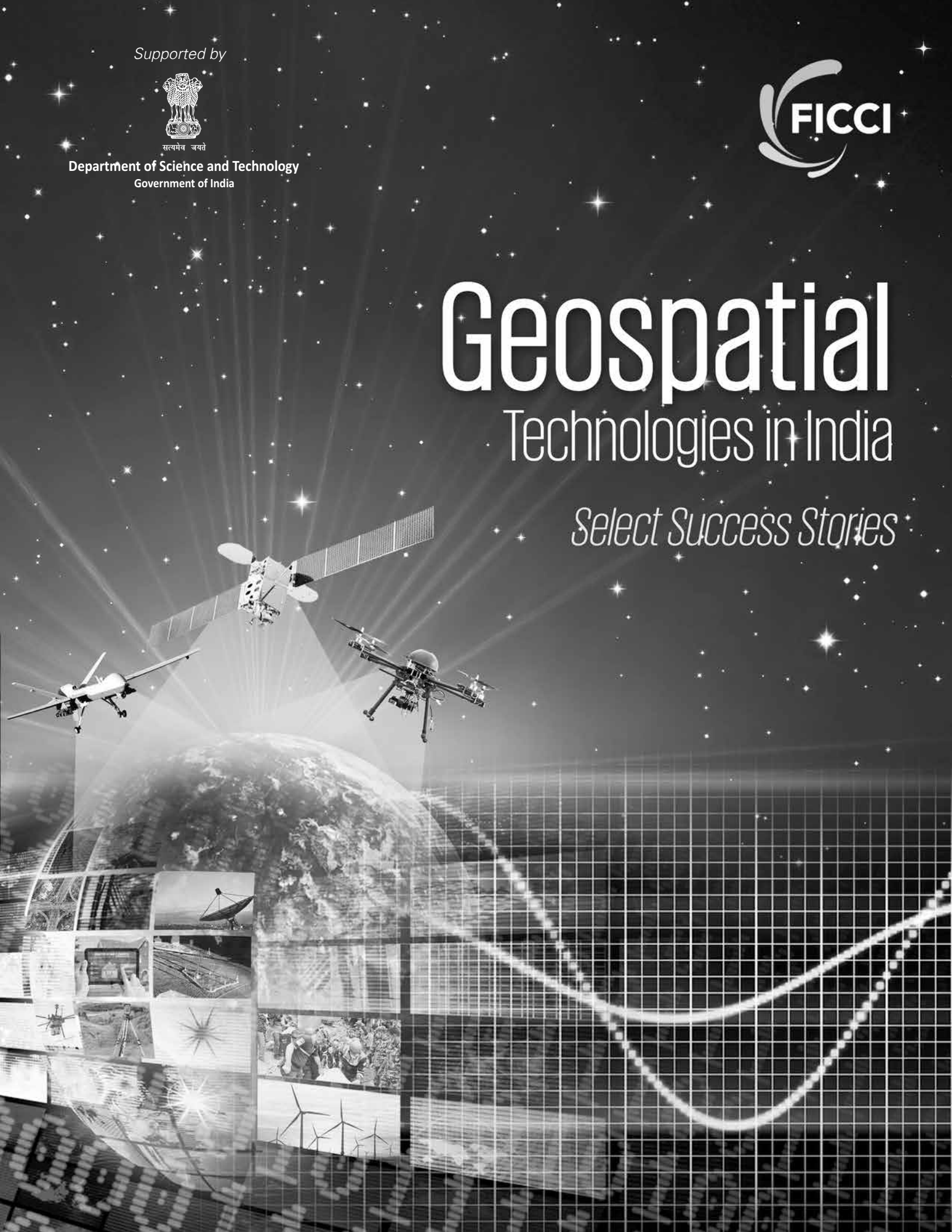

FOREWORD

Technological advancement is the key driver for economic growth and sustainable development. Geospatial Technologies are considered as one of the most powerful technologies that can effectively serve overall developmental needs of the modern world. Today such applications and tools are available and are being advanced for improved performance of a country towards all major verticals of economy like agriculture, mining, infrastructure, transportation, logistics, homeland security, disaster management, defence, urban planning etc. As India endeavours to achieve its developmental goals, the multifaceted and specialized capabilities offered by geospatial technologies will play a crucial role for information management in future.

Mainstreaming geospatial technologies for effective decision making and better governance is one of the mandates of FICCI. This publication is an effort in this direction. It is compilation of Indian case studies of successful applications of this technology, and showcases their immense potential as a tool for planning and management of resources by diverse stakeholders.

I am confident that this publication will help in propagating the adoption of this promising technology by various stakeholders from public as well as private sector.

A. Didar Singh
Secretary General
FICCI

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PREFACE

PREFACE

Year 2017 is a milestone in the journey of survey and mapping for India, a year when our national mapping agency celebrates its 250 years of glorious journey. In the recent past our remote sensing centre under ISRO has been raising the bench mark, with its recent successful launch of remote sensing satellites Cartosat2C (June 2016, 25cm) and Cartosat2D (Feb 2017). We have had ready availability of satellite imageries for the academia, government and industry, which resulted in prolific usage of satellite imageries in the geospatial domain over the last three decades. The present times can be clearly considered to be the time period wherein geospatial industry has become significantly relevant and matured. Long wait of over two decades is culminating with some of the trail blazing associated technologies and applications. With vehicle autonomy now hinged on maps, public transport through aggregators is supported on geospatial platforms, ubiquitous availability of geospatial data through multiple local and multinational portal clearly mark a dawn of new era. That a common man is using map data for his movement or government official is doing preliminary survey using maps and satellite imageries available on public domain and Internet, speaks more than the market size estimation churned out by consulting firms.

Emerging Technologies

It maybe worthwhile to take a look at some of the new technologies at horizon which could positively impact the geospatial market. Internet of Things (IoT) is here and we are inching towards the connected world. The prophecy of 50 billion connected devices by 2020 has been talked about for some time. We are nearing the landmark year 2020 for which an era of connected world was predicted and perhaps there would be number around this estimate. Topping this, humungous investment of over $60 Trillion is expected over next 15 years for industrial IoT (General Electric). Whats in store for geospatial community here? Many of the data being generated will have location information, though the device(actuators/sensors/communication device) may have fixed 'location', but this location info would be critical in overall analytics. Data from sensors embedded few feet below earth surface for moisture content would be futile, unless it is analysed in relation to its location. Similarly sensors for pollution level monitoring in industrial and urban areas would need the device location information for analysis. Connected car is round the corner and soon insurance telematics would be using route maps with other data for insurance discount on premiums.

The volume of data being generated and complexity in the ecosystem in terms of mobility and affordability, is making it difficult to keep updated about the business, offices, shops etc. even in nearby locality. Augmented Reality is another exciting technology round the corner which would be commodotized with geospatial technology as its enabling platform, taking the user experience in geospatial enabled search and information access to a next level.

Virtual Reality, Robotics, Block Chain, Big Data and Artificial Intelligence are some of the other technologies which could be affecting us.

Global Applications Going Beyond Traditional Usages

Globally the need for efficient land management has been key to the growth of geospatial industry. The rapid urbanisation taking place is increasing the complexity of planning the services while keeping the balance with natural resources like water, air quality etc. The shift to the usage of digital technology and geospatial tools can possibly result in reduced unlawful practices related to land. Geospatial technology enables the ecosystem to be transparent with improved information visualisation.

The transport sector has seen the growing usage of navigational maps by the goods and public transport operators for fleet management. The logistics and supply chain sector too has been looking at geospatial application for asset management.

For self-driving car, precise 3D geospatial data is a necessity, as the vehicle navigates on these map data. It is also important to mention about cutting edge concept of crowd sourcing of street navigation data based on LiDAR sensor data in self driving cars. Civil Maps, a startup in US (Co-founded by Indian) is processing LiDAR sensor data from vehicle having LiDAR sensors and updating the database of route about fixed asset on real time. In other words initiated by autonomous vehicle, it is a paradigm shift in the way crowd sourcing was looked at in geospatial sector.

According to Technvio, there is also an increasing adoption of geospatial data and tools in video games market segment which is expected to enhance the growth prospects. Though games have complex spatial components, but the proposition to have realistic world within the video games, makes it more engaging for the players.

Geospatial cloud data storage is likely to see moderate growth over the next 4-5 years with its adoption in BFSI, transportation, retail, healthcare, e-commerce, construction, marketing, sales, and real estate. It is foreseen that it will result in its augmented adoption in coming years (Technavio).

Cursory Glance of our Backyard

Over the last couple of years, there has been systemic push for improving the services to the citizens in urban through Smart City initiative where geospatial data has been the foundation on which many of the services are being planned. Similarly there has been continued support for the land record modernisation, which understandably will take time being an extremely complex subject to be addressed in short time frame.

The era of Digital India, driven by (1) telecom coverage providing Internet access and reasonable speed even in far off places and (2) availability of maps and high resolution satellite imagery for large part of country; is seeing increased usage of geospatial data.

Many of the leading geospatial companies in India have been engaged in geospatial data preparation, analysis and building solutions over it. The geospatial data industry for clients outside India(services export) has been driving force for many of the leading industry players for over two decades. The industry could boast of many prestigious clientele for whom data services has been provided to their satisfaction. Looking inwards the geospatial data services have been more or less, limited to the projects which called for such data preparation. Few of the industry players have been engaged in building pan-India geospatial data for navigation and route planning, but they are yet to hit viable business model. Though city maps (paper and digital), were emerging as business model in late 90s and early 2000, except for some pioneers who ventured in this space (Eicher, MapmyIndia) not many decided to provide digital map data services on Pan India basis.

We have seen the emergence of new surveying tools like LiDAR, which can capture data in large volume with precision in short time frame. Terrestrial Laser Scanners, Vehicle mounted LiDAR scanner or the mobile mapping system and UAV mounted LiDAR scanners are different ways in which the LiDAR scanners are being deployed for survey and mapping. LiDAR sensor data (Point cloud) overlayed with photograph from optical camera co-mounted on data capture platform is presenting a 3D model of real world which is measurable with precision.

Over the last few years we have seen growing usage of UAV based aerial survey. Through LiDAR sensor or optical camera or both can be mounted on UAVs for data capture tool. It presents a wide range of geospatial

data which can be captured. Starting from simple photographic survey which helps a planner or project executive with detailed picture of the area, it goes upto the level of survey grade data. It is expected to assist in data capture for linear features which are otherwise difficult to capture like- high voltage power transmission line, oil & gas pipelines, disaster affected area, mining, forestry and roads & highways. UAVs are increasingly becoming more robust with rugged and extended battery life. Low mobilisation cost and time, along with the feasibility for smaller area to be surveyed makes it a good option for survey in urban areas, forestry, mining, disaster management, land records and more.

Progressing on Policy Front

In a recently concluded workshop by National Geodetic and Geospatial Consortium (NGGC), it was opined that NGP-2016 could be superseding all other mapping policies, allaying the fear, that geospatial community will have one more policy to adhere to. Need to look at the geodetic policy for India is also catching up. Over the last couple of years there has been discussion to relook at the national mapping policy for India, as it is over a decade since we have had new Mapping Policy. Though in the meantime we had the Remote Sensing Data Policy-2011 and National Data Sharing and Accessibility Policy-2012, but the mapping policy remain unchanged. There were thoughts being echoed in the geospatial community that we might lose on the new technological opportunities if the government does not bring in changes in the existing mapping policy. Department of Science and Technology considering the need of the hour, released the draft National Geospatial Policy-2016. The NGP was released soon after the draft Geospatial Information Regulation Bill-2016 was released by Ministry of Home Affairs. Industry, through its representative bodies and associations have submitted their inputs on these policy and bill. It is expected that the new policy would enable the growth of geospatial industry while keeping in view the security concerns arising from the sensitivity of geospatial data.

Geospatial Success Stories- Covering Various Dimensions

The compilation of success stories is documentation of industry milestone. This edition is reflection of multidimensional usage of geospatial technology in India. (1) We are seeing the 'need based pull for usage of geospatial tools and data'. Over the last two decades and more, government programmes with geospatial component have been a 'push by design' to proliferate usage of such technologies. But when its usage are seen in far off places based on its utility to deliver value, one can safely assume that the 'pull' has begun. Usage of maps to help local communities access to water resources (Keystone Foundation) indicates 'the pull', which is further echoed in usage of maps for urban planning for improving sanitation (Shelter Associates). (2) We are going to capitalise the emerging technological opportunities. Often we hear industry people talk about missed technological opportunity, as we could have prepared large scale maps using aerial photography more than a decade ago. Possibly we may not miss the present technological opportunity through unmanned aerial vehicle (UAV/UAS) for preparation of survey grade maps or aerial photograph for project planning, as can be read from the experience shared by Skylark Drones and Airpix. LiDAR scanner with photographic camera has been complimenting the traditional ETSM/DGPS survey for sometime now, specifically the mobile platform (car/rail) based system, as it creates precise 3D point cloud model which can be measured with precision. An emerging application, as demonstrated by IIT Roorkee, has good scalability opportunity, which will serve the need to map the railway assets across the country and more. (3) Emergence of geostatistical analysis for governance. The usage of geospatial data for crime monitoring for railway passenger safety is a landmark application which combines historical crime data, real time telecommunication data and associated attribute data to provide a predictive model. This application can also be visualised as a mould for casting similar application for other state police functionaries across the country.

1

AGRICULTURE

Agri-business Solutions: Solving Tricky Problems of Over/ Under Estimation

Skymet, one of India's largest private sector weather station, provides end-to-end solutions for weather data collation, analytics and statistical modelling activities to predict short, medium and long term forecasting services. The organisation provides diversified and customised weather-based solutions to varied end users from all across the sectors.

They use their weather forecasting services to provide a wide range of services like crop estimation, agri-business solutions, crop loss estimation studies, crop cutting experiments and crop insurance. They provide mobile and web-based apps for weather information, customized solutions with accurate production forecasts for the agri-business community, as well as UAV-based solutions for precise yield forecasts and farm management.

Identifying Challenges

Agriculture and related industries are vital to the economy of India, accounting for 17% of its Gross Domestic Product and employing almost 50% of the workforce. While its importance to the national economy is so large, there remains no easy way to efficiently forecast crop yield and production. Measuring the amount of seeds sold by seed companies can give an answer, but farmers may not sow all of the seeds they purchased.

Spatially, the agricultural practice in India is quite varied, with differing plot sizes, irrigation schedules, and fertilizer applications. Even the sowing dates within a single season (like rabi) can vary by up to month. Variation in estimates also comes from double sowing of short duration varieties or re-sowing failed crop areas.

Where the data differs, fairly well established satellite image-based methods can provide a true reflection of on-the-ground scenario and can be used for review and refinement. Due to the wide variation in sowing dates, a single date imagery analysis at full crop vigor is insufficient, as there could be multiple peaks in single season.

Skymet wanted to explore and measure the multiple peaks within the growing period and reach exact acreages for three different crop ranges:

Early season: Sown in late October or early November and harvested in late January or early February.

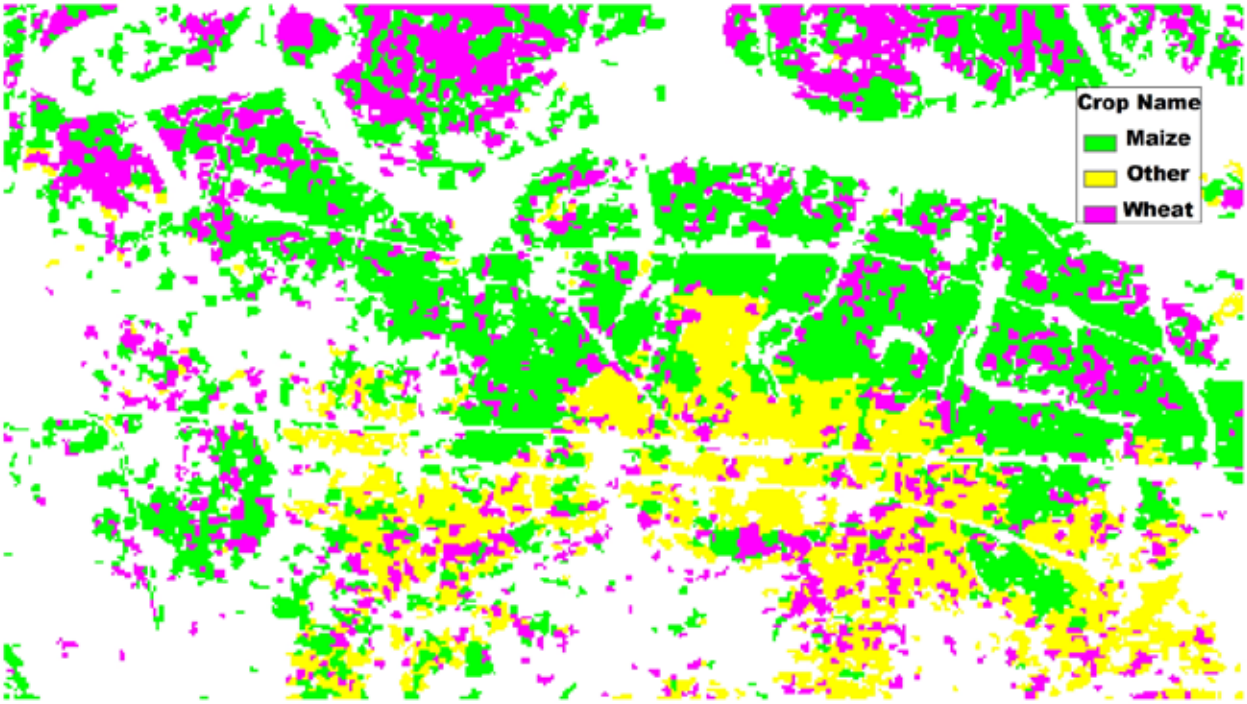
Regular season: Crops in the regular growing season are sown in late November or early December and harvested in March.

Late season: Fields which grew early season crops could be re-sown in February and harvested in April or May.

A more accurate forecast should take different growing seasons into account and reach to a more accurate crop yield/production market analysis, and alleviate confusion when estimating crops and setting prices for the season.

In addition, Skymet needed a way to quickly identify failed crops so that insurance companies could gather information on the extent of damage to calculate their liability and prevent the filing of false claims.

Figure 1: Classification output of multiple crops on one date



Setting Goals

- Use Landsat and Advanced Wide Field Sensor (AWiFS) imagery to identify the fertile lands prior to sowing the fields.
- Quantify changes that are the result of productive crop growth using the satellite imagery, to identify changes in crop patterns and any degradation that takes place in the crop.

- Perform multi-date image classification on satellite imagery of agricultural fields for the early season, regular season, and late season crops.
- Reduce number of fraudulent weather-related insurance claims.

Realising Results

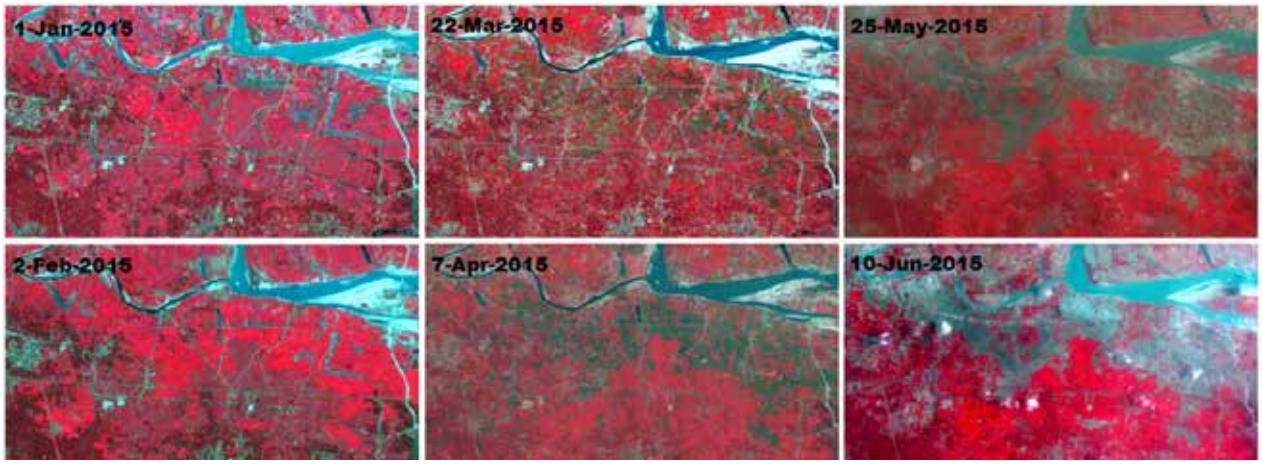
Skymet chose Hexagon Geospatial's ERDAS IMAGINE® to provide the advanced data processing tasks they required. They obtained Landsat and AWiFS satellite imagery from 6 or 7 dates across the growing cycle. All of this imagery needed to be accurately georeferenced, mosaicked, and subset to focus on the agricultural fields. ERDAS IMAGINE provides all the tools they needed.

They also made use of the advanced supervised classification techniques and tools in ERDAS IMAGINE Professional to classify the imagery. They established a baseline calculation by classifying fields in November, when all fields were in harvested state. They could then repeat the classification process and track the state of crop growth during the three growing seasons.

The IMAGINE Spatial Modeler was instrumental in allowing Skymet to distinguish differences between plants and differentiate crops which were growing during the overlapping growth periods. They performed Normalized Difference Vegetation Index (NDVI) calculations, and stacked the resulting images into the original data, providing rich resources for the classification routines. Once these customized spatial models are built, they can be used to process any new imagery that is acquired with minimal effort.

Because they used an empirical, formal, and repeatable process to achieve their estimation, they were able to produce a more accurate estimation of the actual acreage of crops right up until harvest. When crop damage was identified in the satellite imagery, they were able to use UAVs to fly over the damage area and capture images for more precise estimation. ERDAS IMAGINE provided tools for viewing and analysing the UAV data, establishing the extent of damage. They then also had photographic evidence of crops before and after harvest, reducing the number of false insurance claims.

Figure 2: FCC of Satellite Image of different dates showing multiple crop vigor peaks and harvested fields



Key Benefits

- Increase throughput in processing large volume of satellite imagery- by using ERDAS IMAGINE that has capabilities of processing huge amount of multiple satellite data and thus, providing efficient results for analysing the crop growth.
- Accurately estimate crop acreage in repeatable procedure.
- Streamline workflow through reusable spatial models.
- Easily incorporate multi-source data into single process thus making it convenient for decision makers to get optimised results in short span of time.

Skymet has successfully implemented crop yield estimation solutions by taking crucial data from UAV images as replacement to field inputs, and combining it with weather and other datasets for crop simulation models. Finally, the effort is towards arriving at farm field level yield estimates and to tell whether a particular farmer is likely to suffer or has actually suffered losses or not. Apart from that, Skymet derived very accurate acreage/undisputable estimates for fraud detection, connecting the farmer's data to cadastral information and a host of other new datasets like soil health card, etc., to improve upon precision.

Conclusion

Hexagon Geospatial's ERDAS software in general, and ERDAS Spatial Modeler have helped Skymet to develop algorithms which are able to segregate different crops in different phases leading to more precise crop yield estimates. The classification techniques are useful in crop classification by providing multi-date imagery analysis for sowing/harvesting trends, thus providing better results for efficient decision making.

Pritish Bisoyi, Sudhakar Manda & Vasudeva Rao

Better Nutrient Management on Standing Crop Using GPS Data Logger

In 2011, a research paper published in an international research journal: Agronomy for Sustainable Development had shown that it was possible to save up to 15% nitrogen in standing Rice and Wheat crops in the plains of northern India where the crop systems have most intense nutrition needs and often overdose of nitrogen is encouraged as the farmers compete to outdo each other in getting better crops. It is generally perceived that greener the leaves better would be the harvest. However, the scientists have been claiming that more than that, applying the correct doses at the time of requirement is the key for better harvest.

In order to understand the correlation of nitrogen application and yield of crop, a very elaborate research was undertaken over a period of three years in the Rice-Wheat cropping system areas of the north India. It was a joint effort of scientists working at the Punjab Agricultural University-Ludhiana, Directorate of Wheat Research-Karnal, Project Directorate for Farming Systems Research-Modipuram, Rice-Wheat consortium-CIMMYT, International Plant Nutrition Research Institute-Pune in association with scientists from the Oklahoma State University and Kansas State University.

It was a very ambitious project that tries to find solution to rampant use of nitrogen by the farmers that is causing soil degradation and underground water pollution.

The study was done using Trimble product Greenseeker that includes an optical hand held sensor and GPS data logger attached to it. It also has software from Trimble that allows receiving data in real time with location accuracy and provides

GreenSeeker Crop Sensor application System

- Each sensor emits and measures reflectance of red and near infrared lights
- The ratio of light reflectance is reported as Normalized Difference Vegetative Index (NDVI)
- The higher the index, the higher the level of biomass and vigor ranging from 0.001 to 0.999
- Map values only or variably apply nitrogen on the go based on sensor readings

(A) Evaluation of Greenseeker Based Nitrogen Management in Irrigated Wheat:-

- Blanket recommendation for N management in Wheat consists of applying 1/3rd to half of the total dose of 120 to 150 kh N/ha as basal at sowing and at crown root initiation stage which coincides with first irrigation event around 21 days after sowing. There also exist reports that application of all N as basal at sowing can be efficiently utilized by Wheat. Also because Fertilizer N application to Wheat has to coincide with an irrigation event, experiments on evaluating Green Seeker based N management in wheat was undertaken keeping in view the following:
- Green Seeker can be used to work out fertilizer N applications to wheat at Feekes 5/6 and Feekes 7/8 stages which almost coincide with 2nd and 3rd irrigation events.
- Moderate doses of N can be applied as prescriptive N management at sowing and at crown root initiation stages when Green Seeker cannot be used.
- Robust INSEY-GY relations were observed at both Feekes 5/6 and Feekes 7/8 stages of wheat.

Two experiments were conducted at Karnal and Ludhiana in the Wheat season. The results from these experiments are given in Tables 1 and 2. At both Karnal and Ludhiana, grain yield of wheat similar to that produced by applying blanket dose of 120 or 150 kg N/ha were obtained by applying 20 to 50 kg less N per hectare when Green Seeker was used to guide fertilizer N application after a moderate application of N at sowing and crown root initiation stage.

Table 1: Performance of GreenSeeker based N management in Wheat (Cultivar PBW 343) at Ludhiana, Punjab

Treat-ment	Fertilizer N applied ,(kg N ha^{-1}) at				Total N applied	Grain yield of wheat (t/ha)	%N in wheat grain	Total N uptake (kg/ha)
	Basal at sowing	Crown root initiation stage, 1st irrigation	Feekes 5-6 stage, 2nd Irrigation	Feekes 7-8 stage, 3rd irrigation				
1	0	0	-		0	1.52	1.47	32
2	60	60	-		120	4.35	1.75	103
3	75	75	-		150	4.41	1.81	110
4	60	0	17^{GS}		77	3.66	1.51	73
5	80	0	12^{GS}		92	3.80	1.67	88
6	100	0	10^{GS}		110	4.20	1.64	95
7	40	40	3^{GS}		83	3.81	1.65	89
8	50	50	0^{GS}		100	4.32	1.64	99
9	60	60	0^{GS}		120	4.39	1.73	105
10	60	0	-	29^{GS}	89	3.99	1.77	94
11	80	0	-	24^{GS}	104	4.13	1.72	98
12	100	0	-	21^{GS}	121	4.29	1.81	102
13	40	40	-	18^{GS}	98	4.27	1.73	101
14	50	50	-	12^{GS}	112	4.35	1.85	109
15	60	60	-	15^{GS}	135	4.40	1.92	115
LSD (p=0.05)			0.367				0.148	11

^{GS}GreenSeeker guided N application

Table-2: Performance of GreenSeeker based N Management in Wheat at Karnal, Haryana

Treatment	Fertilizer N applied (kg N ha^{-1}) at					Grain yield wheat (t/ha)
	Basal at sowing	Crown root initiation stage, 1st irrigation	Feekes 5-6 stage, 2nd Irrigation	Feekes 7-8 stage, 3rd irrigation	Total N applied	
1	0	0	-		0	2.03
2	60	60	-		120	5.33
3	75	75	-	-	150	5.69
4	80	0	16^{GS}	-	96	5.45
5	100	0	14^{GS}	-	114	5.50
6	40	40	16^{GS}	-	96	5.18
7	50	50	13^{GS}	-	113	5.41
8	60	60	8^{GS}	-	128	5.85
9	80	0	-	20^{GS}	100	5.05
10	100	0	-	12^{GS}	112	5.23
11	40	40	-	17^{GS}	97	5.19
12	50	50	-	13^{GS}	113	5.18
13	60	60	-	8^{GS}	128	5.87
LSD (p=0.05)						0.703

^{GS}GreenSeeker guided N application

Some salient outcomes of Wheat experiments can be summed up as below:-

- At low basal N application level, Green Seeker based N management is inadequate for all Feeks stages.
- With low basal N application supplemented with a low dose at Crown root initiation stage and coupled with Green Seeker based N use at Feeks 7/8 stage is most likely to significantly improve NUE (Nitrogen Use Efficiency) at higher yield levels.
- Using single basal N application and/or coupling it with a top dress with Green Seeker based N application can also lead to higher NUE.
- Sensor based N management helps in saving upto 20% nitrogen.
- Green Seeker based N application at Feekes 7/8 stage improves protein content and grain quality.
- These are significant outcomes of the study because on the practical side they allow to move forward in the direction of mulch based agriculture. Surface mulches retain the top dressed fertilizer nitrogen nutrient immobilizing it to release slowly subsequently. This implies that if 80% of the total N is applied as basal and the balance 20% N is applied using sensor, It may not only improve yield of Wheat and other crops but also improve protein content in the grain.

(B) Evaluation of Greenseeker Based and Management in Transplanted Rice :

Three Experiments were conducted at Ludhiana,Karnal and Modipuram to evaluate GreenSeeker based N management in Transplanted Rice. The details of treatment and Yield data are recorded in tables 3,4 and 5.

As Indicated, GreenSeeker guided N applications were made only after 40 DAT because upto this time standing water in the field interferes with the NDVI measurement. As it is well established that N should be applied to transplanted Rice in at least 3 split doses so as to curb losses via leaching, Ammonia volatilization and denitrification, in the reported experiments different combinations of N doses were applied at 0,7,21,28 and 35 DAT and GreenSeeker was used to find the third application of N at 42 or 49 DAT.

Table-3: Evaluation of GreenSeeker based N management in Rice (Cultivar PR 118) at Ludhiana.

	Fertilizer N applied (kg N/ha) days after transplanting									Total N applied (kg N/ha)	Rice grain yield (t/ha)
	0	7	15	21	28	35	42	49	56		
1										0	3.85
2	40			40			40			120	6.19
3	20			40			28^{GS}			88	6.23
4	20			60			12^{GS}			92	6.83
5	30			30			32^{GS}			92	5.63
6	30			50			14^{GS}			94	6.28
7	40			40			24^{GS}			104	6.34
8	30				50			29^{GS}		109	6.29
9		20			40			29^{GS}		89	5.97
10		20			60			19^{GS}		99	6.59
11		30			30			32^{GS}		92	5.66
12		30			50			17^{GS}		97	6.25
13		40			40			20^{GS}		100	6.50
14			40		40			20^{GS}		100	5.80
15			40			40			1^{GS}	81	4.97
16	50	50		50	50		50	50		300	5.73
LSD (p=0.05)											0.774

^{GS}GreenSeeker guided N application

Table-4: Evaluation of GreenSeeker based N management in Transplanted Rice (Cultivar HKR 47) at Karnal, Haryana

Treatments	Fertilizer N applied, kg/ha						Total N applied	Yield, t ha^{-1}
	0 DAT	7 DAT	21 DAT	28 DAT	39 DAT	50 DAT		
T1	0		0		0			5.63
T2	50		50		50		150	7.42
T3	20		40		13 ^{GS}		73	7.70
T4	20		60		4 ^{GS}		84	7.66
T5	30		30		22 ^{GS}		82	7.74
T6	40		40		9 ^{GS}		89	7.70
T7	25		75		3 ^{GS}		103	7.62
T8		20		40		21 ^{GS}	81	7.58
T9		20		60		12 ^{GS}	92	6.39
T10		30		30		13 ^{GS}	73	6.75
T11		40		40		18 ^{GS}	98	7.58
T12		25		75		28 ^{GS}	128	7.42
LSD (p=0.05)								0.722

DAT = Days after transplanting
^{GS}GreenSeeker guided N application

Table-5 :- Evaluation of GreenSeeker based N management in Transplanted Rice (Cultivar PHB 71) at Modipuram

Treat-ments	Fertilizer N applied, kg/ha						Total N applied	Yield, t ha^{-1}
	0 DAT	7 DAT	21 DAT	28 DAT	42 DAT	49 DAT		
T1	0	0	0	0	0	0	0	4.90
T2	40	0	40	0	40	0	120	8.85
T3	20	0	40	0	25 ^{GS}	0	85	8.23
T4	20	0	60	0	30 ^{GS}	0	110	8.18
T5	30	0	30	0	40 ^{GS}	0	100	7.92
T6	40	0	40	0	36 ^{GS}	0	116	8.75
T7	0	20	0	40	0	79 ^{GS}	139	8.23
T8	0	20	0	60	0	54 ^{GS}	134	7.71
T9	0	30	0	30	0	76 ^{GS}	136	8.94
T10	0	40	0	40	0	63 ^{GS}	143	9.06
LSD (p=0.05) for yield = 1.66								

The data in Tables 3,4 and 5 reveals that GreenSeeker guided N management always resulted in total N application less than the blanket dose of 120 or 150 kg N/Ha but in several treatment combinations it was possible to produce grain yields of rice equal to or more than that obtained with recommended doses. Fertilizer N applications guided by GreenSeeker were influenced by the amount and time of N applications already applied. For example at Ludhiana, in treatment 4 and 5 because of application of 30 and 60 kg N/ha at 21 DAT. GreenSeeker guided to apply 32 and 12 Kg N/Ha resulting in total N application of 92 kg N/ha in both the treatments. Obviously due to lower N dose at 21 DAT in treatment 5,GreenSeeker advised to apply more N than in treatment 4. However, the grain yield of rice in the two treatments was significantly different; perhaps a lower dose of N at 21 DAT adversely influenced tillering and resulted in low grain yield than in the treatment receiving 60 Kg N/Ha. Similar results were obtained when GreenSeeker guided N doses were applied at 49 DAT. Delaying the application of first N dose to 15 DAT also had a negative effect on the yield of rice and GreenSeeker guided N application did not help. As a matter of fact when second dose of N was delayed to 35 DAT, GreenSeeker did not recommend application of more fertilizer although the treatment yielded better only than the no-N control. It confirms that GrrenSeeker takes care of both the greenness and expected yield in guiding application of fertilizer N.

At Karnal (Table 4), GrrenSeeker guided N applications helped to achieve grain yield of rice similar to that obtained by blanket recommendations of 150 kg N/Ha but with total N application to the extent of almost 50%. These data convincingly proves that GreenSeeker results in need based N applications and can help avoid over application of fertilizer N. At Modipuram (Table 5), while application of first two doses of N at 0 and & DAT resulted in savings of fertilizer as compared to blanket recommendation (120 KG N/Ha). Only exception was when only 30 Kg N/Ha was applied at 21 DAT. But when the first two doses of N were applied at 7 and 28 DAT, GreenSeeker guided N application at 49 DAT always resulted in total fertilizer N applications more than the recommended dose of 120 kg N/Ha. These data suggest that more experimentation is needed to work out appropriate management of fertilizer prior to application fertilizer N guided by GreenSeeker at 42 DAT.

Trimble

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2

DISASTER MANAGEMENT

Countrywide Fire Hazard and Risk Analysis for Revamping the Fire and Emergency Services in India

SUMMARY

Growth of fire and emergency services in India is on ad-hoc basis without much scientific analysis of existing risk to different parts of the country, which needs different kind and types of equipment depending upon risk in the coverage area of Fire Station and its geographical location. As per analysis by Standing Fire and Advisory Council norms, the overall deficiency in the country was estimated more than 80 percent in Fire Fighting & Rescue Vehicles and more than 96 percent in Fire Stations & Fire Personnel, respectively, which is quite alarming. To address these and other related challenges, RMSI carried out unique kind of Geographic Information System (GIS) based comprehensive study for the entire civil Fire and Emergency Services to develop a roadmap for revamping the Fire and Emergency Services in the country.

Introduction

Fire service is one of the most important emergency response services in the country, which comes under the 12th schedule of the constitution dealing with Municipal functions. In India, at present, the fire prevention and firefighting services are organized by the concerned States and Union Territories (UTs), and Urban Local Bodies (ULBs). Directorate of National Disaster Response Force and Civil Defence (NDRF & CD, Fire Cell), Ministry of Home Affairs (MHA) renders technical advice to the States, UTs, and central ministries on fire protection, prevention, and legislation. Fire services in Maharashtra, Haryana, Gujarat, Chhattisgarh, Madhya Pradesh (excluding Indore), and Punjab fall under the respective municipal corporations of these states. In the remaining states, they fall under the respective Home Departments.

In India, there has been only an ad-hoc growth of fire-services without much scientific analysis of the existing risk in different parts of the country. The authorities have been neglecting the fact that different kind and types of equipment are required, depending upon risk category and coverage area of a Fire Station, its geographical location such as hilly-areas, coastal-areas, desert areas (water-deficient areas), and residential (high-rise, medium, and low rise-buildings), industrial, or commercial area or a

combination of these. Moreover, lack of knowledge management for future planning, institutional capacity and funds are also seen as major challenges in addressing improvements in fire and emergency services in the country[2]. As per analysis by Standing Fire and Advisory Council (SFAC) norms, the overall deficiency in the country in terms of number of Fire Stations is 97.54%, in terms of firefighting and rescue vehicles is 80.04% and in terms of fire personnel is 96.28%, respectively, which is quite alarming[1].

In consideration of this and the increasing fire risks from various hazards, the Fire Cell of NDRF & CD felt the need for a comprehensive GIS based study to identify existing gaps in the fire services of the country in terms of availability and requirement of fire stations, capacity-building both in terms of trained man-power and fire-fighting, rescue, and other specialized equipment. This comprehensive study was aimed to prepare a Perspective Plan for next 10 years for Revamping the Fire and Emergency Services in the country.

RMSI conducted a detailed Global Positioning System (GPS) based field-survey of India's entire civil fire-infrastructure and conducted detailed GIS based Fire Hazard and Risk Analysis to develop a Web-GIS based "Fire Decision Support System (FDSS)"[2]. This tool is helping Fire Cell of NDRF & CD as well as Fire and Emergency Directorates' of all the States and UTs of the country in revamping fire and emergency services.

Usage

Approach for Development of Comprehensive Roadmap

The primary goal of this study was to prepare a capital investment and institutional strengthening plan for accelerated development of fire and emergency services in the country. The key objectives of this study were:

1. Identify gaps in the existing fire services through conducting field investigations and interviews.
2. Assess the gaps and needs for future planning, up-gradation/ modernization of the fire service infrastructure in the country in a quantified approach.
3. Develop detailed 'Investment and Financial Plan' including Capital and O&M Investment plan for the next 10 years and the investment priorities.
4. Institutional Assessment and Capacity Building Plan.

In order to achieve these objectives, the following tasks were undertaken:

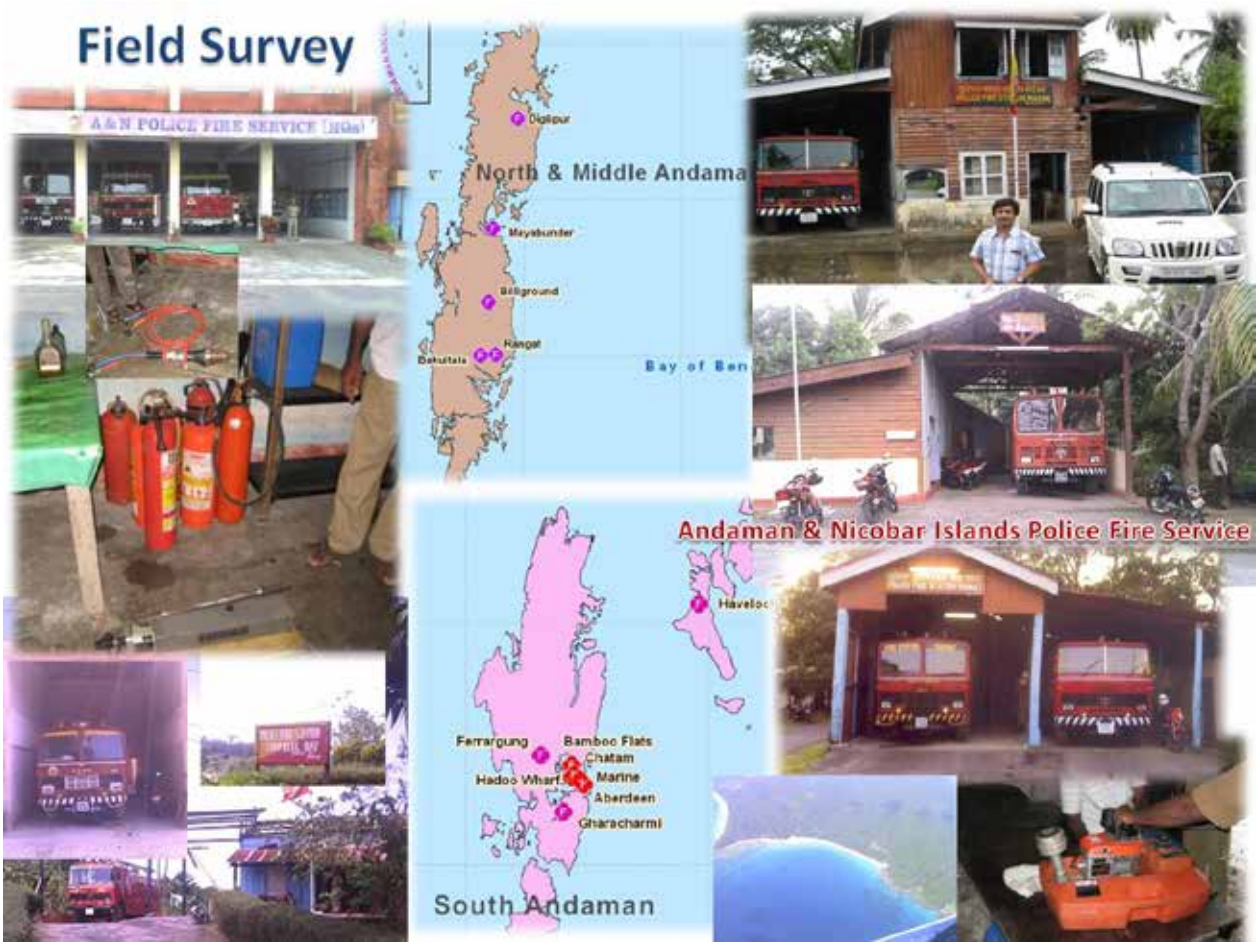
- Development of a questionnaire for Field Surveys of entire fire infrastructure and capacity reviews.
- GIS based Fire Hazard and Risk Analysis.
- Review of International and National Norms.
- Data Analysis to assess Gaps in:
  - o Number and locations of Operational Fire Stations
  - o Number of Firefighting and Rescue Vehicles and Specialized Equipment
  - o Number of Fire Fighting Personnel and Capacity of Fire –Infrastructure
- Summarise requirements by Fire Station, District, and State Level .
- Development of Fire Decision Support System (FDSS).
- Roadmap for Investment and Financial Plan for Next 10 Years.

I. Field Surveys for Fire Infrastructure Data

To collect and collate the information on Fire Infrastructure of all the States/ UTs, two detailed forms "Headquarter Data Collection Form" and individual "Fire Station Field-Survey Form" were developed. These forms were subsequently used for detailed GPS based field-survey of all the fire stations in all States/UTs for collecting detailed fire-Infrastructure information (Figure 1 and 2). The detailed information collected includes address of the Fire Station, name of the Fire Station In-Charge, emergency contact numbers, communication between Fire Station control room, public and headquarter control room; Fire Station building details including staff accommodation and barracks; fire fighting vehicles and specialized equipment; fire personnel, their duty pattern and pay-scales; water availability and water sources for fire vehicles, fire-risk in the jurisdiction of Fire Station and its geographical coordinates (latitude, longitude by using a GPS. All this information for each and every Fire Station has been digitally converted and is available through Fire Decision Support System (FDSS), which can generate a Fire Station report at the click of a button.

Figure 1: Field Survey of Jammu & Kashmir Fire and Emergency Services

Figure 2: Field Survey of Andaman and Nicobar Islands Fire and Emergency Services



II. GIS based Fire Hazard and Risk Analysis

In general, fire risk is defined as a combination of hazard potential, exposure, and vulnerability:

Fire Risk = F (Hazard potential x Exposure x Vulnerability)

The occurrence of fire incidents that constitute a threat for the population and exposed infrastructure of a certain region is associated with economic and human losses, always as a function of the exposure conditions and the vulnerability of the exposed assets in that particular region. While conducting a fire-risk analysis, different natural hazards such as seismic (earthquake), climatic, and wind are considered. Additionally, mountainous zones are also considered in risk analysis due to increased fire risk from wooden houses and heating provisions in cold regions.

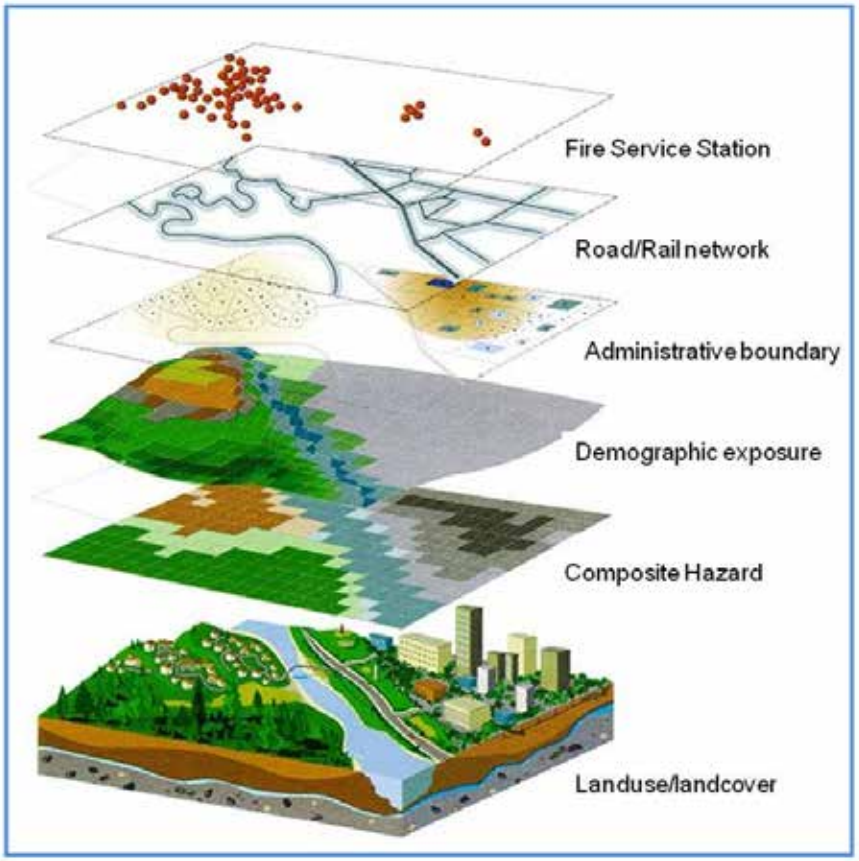
For estimating exposure and its vulnerability, detailed urban agglomerate classification maps generated from high-resolution satellite images have been used. With the help of remote sensing techniques applied on high-resolution satellite imageries, various types of urban agglomeration areas have been demarcated. These include urban, semi-urban, building blocks, and industrial & rural villages' built-up areas of different densities (high, medium, and low). For exposure vulnerability, four different layers such as population density, residential built-up areas, high-rise building block density, and industrial areas have been developed

individually at the district level. For assessing fire risk, both absolute built-up areas in sq km as well as built-up areas percent (ratio of built-up areas to the total area) are considered as important parameters. It is obvious that there are much higher percentages of residential built up areas as compared to industrial areas in various districts. However, presence of industrial areas in a district has a significant influence in assessing fire risk. Hence, industrial areas in absolute terms (sq km) have been considered in the risk ranking[2].

In order to assess the impact of each exposure to a vulnerability type, a vulnerability score/ ranking has been assigned to each layer at their base unit. The vulnerability score represents the level of vulnerability (very high to negligible) of a specific type of exposure in response to the occurrences of small and medium fire incidents. The natural breaks, in value distribution are considered for defining the ranking class. After developing ranking of individual units of hazard and exposure vulnerability, GIS layers have been overlaid on top of each other and a spatial analysis has been performed for integration in GIS environment. For combining hazard and risk, Weighted Factor Analysis (WFA) in GIS environment has been performed (Figure 3).

Weighted ranking scores have been used in the integration analysis and quantified risk distribution for each district. Values of weighted factors depend upon the importance of a particular hazard/ vulnerability class in risk analysis. For integration of hazards, equal weights have been assigned to wind, seismic and climatic hazards, while double weights have been given to hill zoning. This is because, in hilly terrain, wooden houses and heating provisions in buildings increase the chances of fire-incidences, and thus have been given higher weights.

Figure 3: Overlay Weighted Factor Analysis for Fire Hazard and Risk Assessment



After obtaining integrated individual weighted scores for hazard and exposure vulnerability, fire risk categories have been obtained in quantitative terms by further integration of hazard and exposure vulnerability. It is obvious that in the occurrence of the number of fire incidents in a given district, exposure vulnerability has more importance than the prevailing hazard. Hence, in quantified integration, higher weights have been assigned to exposure vulnerability. The quantified numeric values of district risk scores are again grouped into four descriptive categories of district level risk ranking (very high, high, medium, and low). As one can understand that fire risk is not uniformly distributed throughout the districts in both urban and rural areas. Considering this fact, GIS based risk analysis was conducted, based on distribution of population agglomeration by defining built-up areas into different risk categories, such as high-density urban, low-density urban, sub-urban, and village. Moreover, distinct demarcated industrial areas have also been considered in the analysis.

Review of International and National Norms

To estimate the gaps from the existing position in terms of number of Fire Stations and their appropriate location, the RMSI team followed scientific and innovative GIS based response time network analysis approach involving various norms and regulations. Various international and national norms on response time were reviewed. Response time is defined as "en route time (in minutes) taken by the fire fighting vehicle from the fire station to the fire emergency scene." Different countries follow different norms on response time such as:

- Germany: response time in urban areas varies from 8 to 15 minutes
- Japan: response time varies from 5 to 10 minutes, depending upon the location of the building
- USA: response time varies from (3-4) to 8 minutes
- United Kingdom: response time varies from 5 to 8 minutes
- India: Standing Fire Advisory Council (SFAC) norms recommended response time for first fire tender between 3 to 7 minutes respectively depending on risk category A, B, and C in urban area and 20 minutes in rural area. The norms also defined one Fire Station in an area of 10 sq km in urban area; and 50 sq km in rural area.

RMSI experts carried out a number of simulations using GIS based network analysis. With these simulations, it was demonstrated that SFAC norms contradict each other and suggested revised response time based norms for positioning a Fire Station, as response time will vary from place to place depending upon the road network as well depending upon the risk category, the recommended response time for first fire tender is 5 to 7 minutes in urban areas and 20 minutes in rural areas.

Summary Findings

As a whole, in India, there are about 3,000 operational fire stations spread over 36 States/UTs. Based on detailed demarcated built-up areas and GIS based network analysis (response time analysis), ideal jurisdiction boundaries were demarcated for all operational fire stations excluding areas served by other agencies, such as ports, airports, military cantonments, thermal/nuclear power plants, refineries etc. The remaining areas, not covered under ideal jurisdiction of operational fire stations, are also divided for ideal jurisdictions of new proposed fire stations. The requirements for firefighting and rescue vehicles and specialized equipment are based on ideal served population, population density, and built-up areas within ideal jurisdiction boundary.

Fire Station Gap Analysis

As per detailed GIS based analysis (Figure 4), as a whole in India, there is a requirement of about additional 1,300 Fire Stations in urban areas and about 4,250 Fire Stations in rural areas.

Hence this study found an overall gap of about 65% in terms of number of Fire Stations in the entire country (Figure 5). For this analysis, response time of 5-7 minutes in urban area and 20 minutes in rural areas was considered. With network analysis, ideal jurisdiction areas were delineated for all operating fire stations. In delineation of ideal jurisdiction areas, built-up areas such as various types of residential areas and industrial areas with estimated population were also considered. After delineation of ideal jurisdiction area, un-served areas (gaps) in urban agglomeration were identified. These un-served gaps were shown to be filled by new proposed urban fire stations. Similarly, rural areas of the country were covered with new rural fire stations. It may be noted that rural populations are sparsely distributed in various states/UTs. Hence, locations of rural fire stations were demarcated to the nearest relatively bigger village having population of more than 5,000 -10,000 or major roads intersection.

Figure 4: Overlay GIS-based analysis Response Time Analysis for Fire Station Gaps

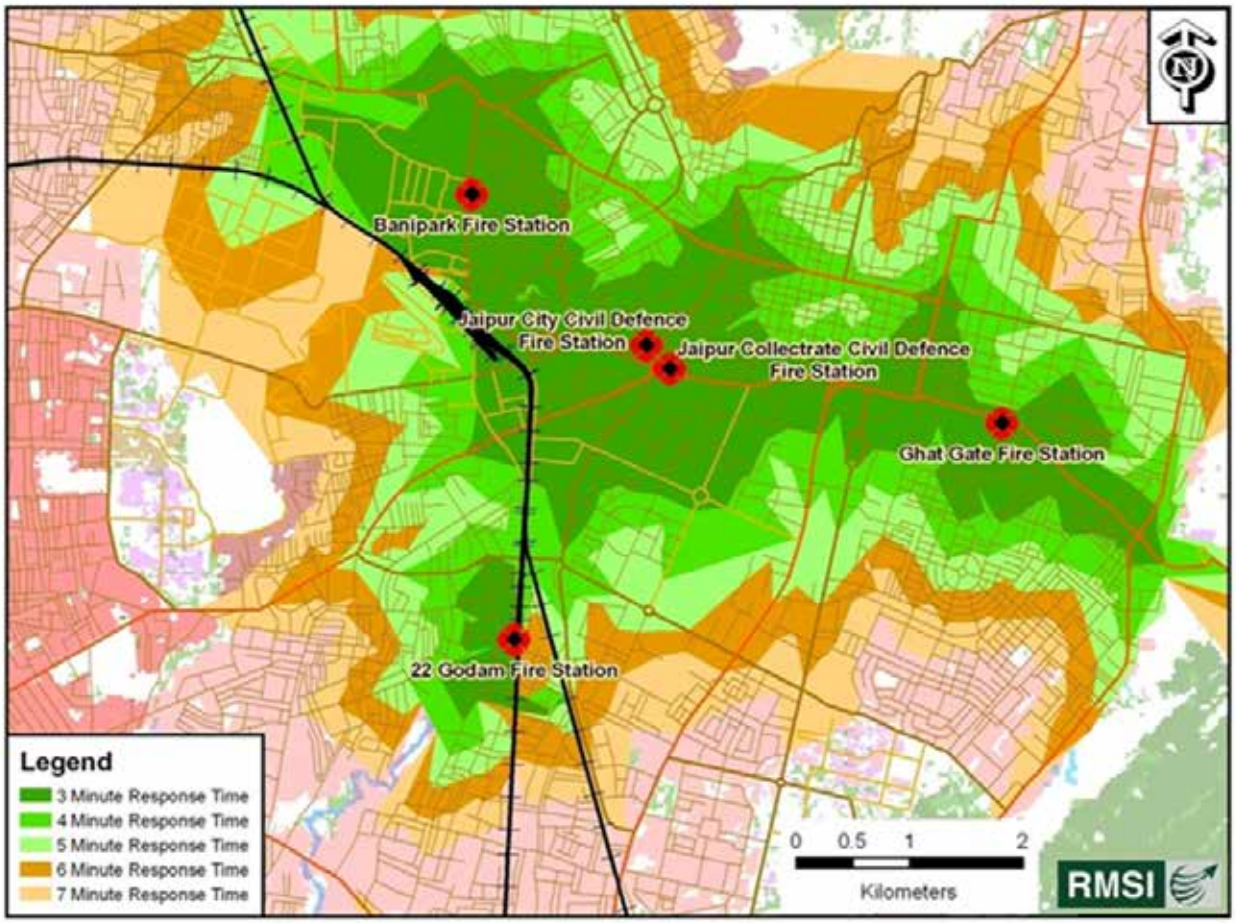
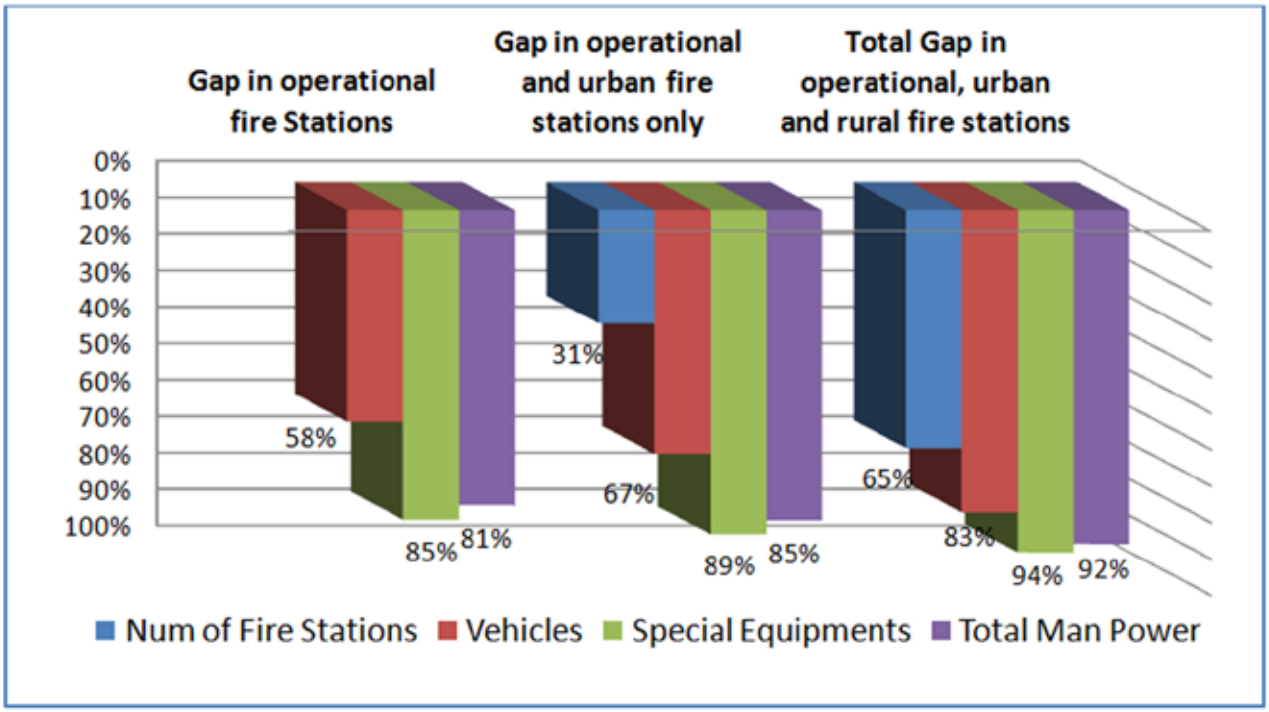


Figure 5: Gap analysis in number of fire stations, man-power, fire fighting vehicles and specialized equipment



Firefighting and Rescue Vehicles and Specialized Equipment Gap Analysis

These suggested modifications in SFAC norms helped in optimization of resources at district level of each States/UTs. This, study finds an overall gap of about 83% in the firefighting and rescue vehicles and about 95% in specialized equipment (Figure 5) for both operational and new Fire Stations in urban and rural areas.

Fire Personnel Gap Analysis

Administrative Reform Department (ARD, Delhi) norms based on duty pattern (double-shift) were used for optimization of the fire manpower requirements, which are different than SFAC norms. The duty pattern of fire personnel varies from state to state, i.e., from 8 hours, 12 hours and 24 hours. However, In this study, double shift duty pattern (12 hours) was followed for optimizing the fire personal gaps. Thus, as a whole in entire India, this study finds an overall gap of about 91% in fire personnel (Figure 5) considering double shift duty pattern[2].

Fire Prevention Wing

In addition to firefighting staff in State Fire Services, there is an urgent need for a dedicated and well-coordinated State/UT Fire Prevention Wing for inspection, awareness generation, and training in schools, colleges, hospitals, shopping malls, cinema halls, high-rise buildings, industries, govt. offices, public buildings etc. With the help of these the recurrence of the fire incidences similar to that at the Advance Medical Research Institute (AMRI), Kolkata, in terms of their magnitude and frequency can be reduced. Some of the states (e.g., Tamil Nadu, Goa, Delhi, and Andhra Pradesh) having a full-fledged dedicated Fire Prevention Wing and conducting awareness generation program frequently. As a whole, most of the states' fire services lack in awareness generation. Hence there is a need to develop a dedicated Fire Prevention Wing to make people familiar with common fire safety measures and their implementation[2].

Accordingly, to support the Head of Fire Services, additional officers at the levels of Director (Technical), Joint Director (Technical), Deputy Director (Technical), Chief Fire Officer (CFO), Dy Chief Fire Officer (Dy-CFO), Divisional Fire Officer (DFO), and Assistant Divisional Fire Officer (ADFO) have been suggested. It should be kept in mind that the number of officers suggested for above designations would vary from State to State or UT to UT depending upon various factors such as presence of urban agglomerations, industrial set ups including hazardous units, State's/ UT's current administration pattern etc.

Fire Station, District, and State Level Report Generation

The detailed report of Operational Fire Stations, District and State/UT level report for fire infrastructure and gap analysis is also available through the Fire Decision Support System (FDSS), which can generate reports for each Operational Fire Station, district.

Roadmap for Investment and Financial Plan for Next 10 Years

The other tasks include the development of Investment and Financial Plan, Institutional Assessment & Capacity Building Plan along with a dynamic web-based Fire Decision Support System (FDSS). The detailed investment and financial plan at State/ UT level includes estimation of capital cost for infrastructure, firefighting and rescue vehicles, and specialized fire and communication equipment. The recurring expenditure cost includes fire personnel cost depending upon pay-scales at various levels; staff uniform cost, and personal protective equipment (PPE); annual vehicle and specialized equipment maintenance cost, petrol, diesel, and lubricant (PDL); building maintenance; office and training expenses etc. The detailed roadmap and investment plan for the next 10-years include both capital and recurring expenditures.

Development of Fire Decision Support System (FDSS)

FDSS is a dynamic application, aimed at supporting decision makers take optimal decisions on complex tasks, such as resource prepositioning, gap analysis, prioritization, and resource optimization along with the day-to-day tasks. The most important aspect of FDSS is that it enables the apex fire management authority to provide the entire country's fire agencies' information on a single platform (Figures 6 and 7). Figures 8 and 9 present sample page of district infrastructure report and FDSS Gap analysis report.

Figure 6: FDSS Architecture - A smart client application

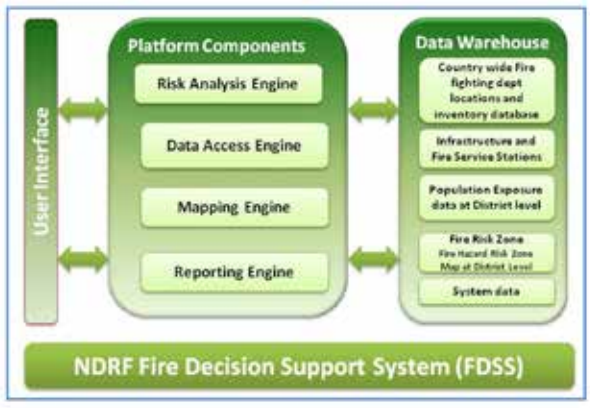


Figure 7: FDSS User Interface

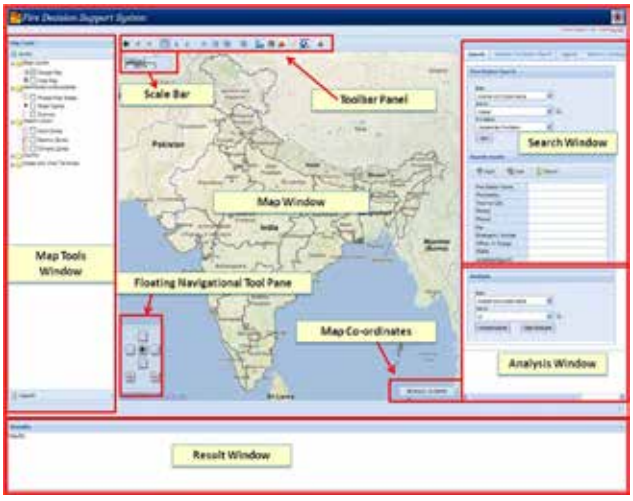


Figure 8: FDSS District Infrastructure Report

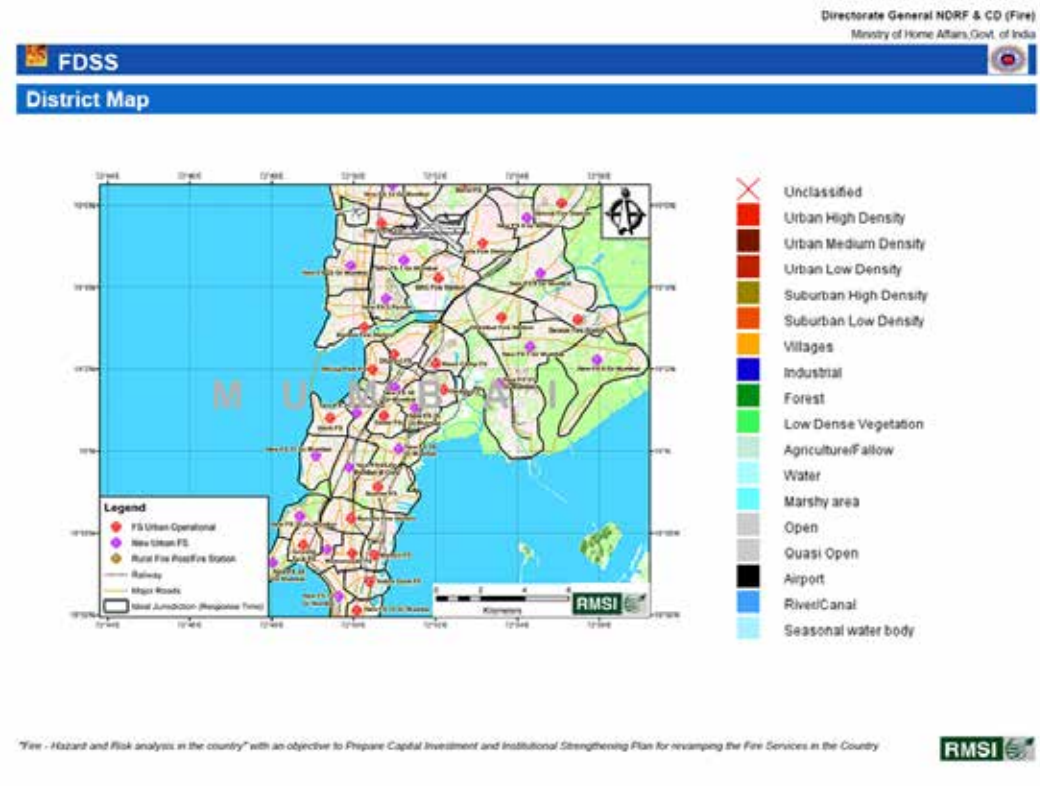
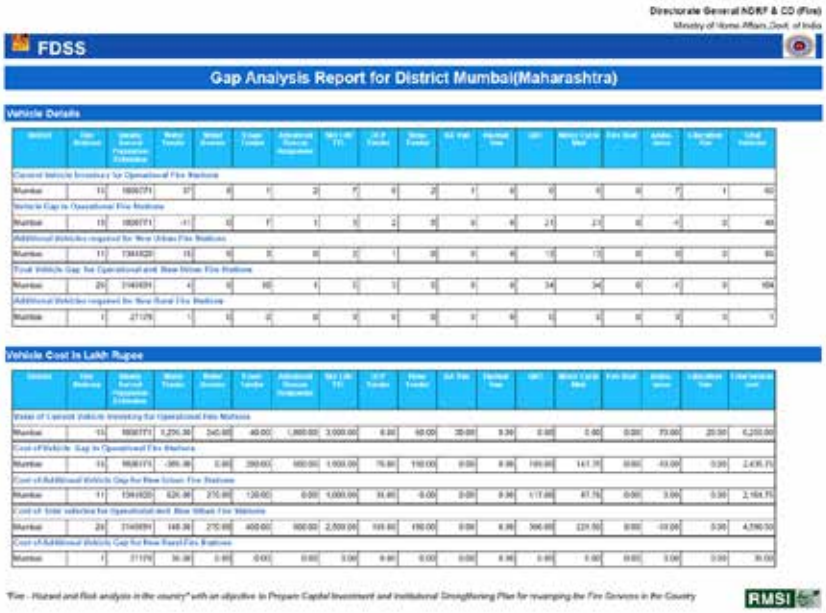


Figure 9: FDSS Gap Analysis Report



Benefits

The outcomes of this unique study are helping the Fire Cell in the directorate of NDRF and CD, MHA at the apex level as well as directorates of all the States and UTs, to:

- Achieve an inventory of fire infrastructure on a single platform for future development and growth of fire and emergency services in India.
- Understand the risk to people and infrastructure due to the growing vulnerability and the declining sufficiency of available firefighting infrastructure.
- Facilitate comprehensive financial analysis, automatic report generation at Fire Station, District, State/UT, Country level through FDSS.
- Identify comprehensive techno-financials requirements of each state/UTs.
- Know capacity building requirements both in urban and rural areas by prioritization of new proposed fire stations, and avenues for fund generation.
- Develop a National Fire Risk Management and Financing Strategy for revamping of fire services in India.

Way Forward

Despite optimization at each stage, there are significant gaps in the required number of new Fire Stations, trained fire personnel, fire-fighting vehicles and specialized equipment both in urban and rural areas. Specials efforts are needed to fill these gaps in all the Fire and Emergency Services in the country by implementing the recommendations of this study in all earnest both at the national (Directorate of NDRF&CD, MHA) and State/UT levels[2].

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2. Gupta Sushil (2012). National Report on Fire Hazard and Risk Analysis, Infrastructure and Institutional Assessment, and Key Recommendations, Final Report, submitted to Directorate General NDRF & Civil Defence (Fire) Ministry of Home Affairs East Block 7, Level 7, New Delhi, 388 pp. In total, there are 39 reports published as part of this study, which are available at http://ndrfandcd.gov.in/Cms/Firehazardandriskanalysis.aspx

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Sushil Gupta

Flood Inundation Modelling using UAVs at Guntur, Andhra Pradesh

SUMMARY

"The Government of Andhra Pradesh intends to utilize civil unmanned air craft systems, especially drones, for real-time governance to enable effective and efficient service delivery to the citizens. UAV technology will be deployed for various innovative applications in departments such as security, mining, agriculture, municipal administration and urban development, housing, tourism, survey, infrastructure and disaster management. It will also be used for monitoring the progress of projects / works on real-time basis"-Andhra Pradesh State Fibernet Limited

As part of this initiative, ideaForge was approached to engage its drone (UAVs), to provide end-to-end services for flood inundation modelling. ideaForge deployed its VTOL NETRAv2 drone above the town of Guntur in Andhra Pradesh to assess and simulate the damage that took place after the area experienced above average or heavy rainfall. The project's main aim: Produce a high-resolution photographic simulation of the town's surrounding geography and terrain at progressing levels of flooding, and asses the area of land that could be affected or would be inundated.

Introduction

ideaForge is equipped with two categories of UAVs; the VTOL (NETRA family) and the Fixed-Wing (SKYBOX family). For this mission, ideaForge decided to deploy the newly launched NETRAv2, which is equipped with best-in-class features. With an endurance of 50 minutes (on single charge of battery), Vertical Lift Off and Landing Capability in any terrain, and a 5-kilometer flight range LOS, this was the ideal UAV for the job.

Guntur Project Goals:

- Survey six surrounding areas of Guntur
- Map topography of the six areas
- Highlight sedimentation areas
- Demarcate damage of previous year flooding
- Outline streams and other water bodies
- Simulate possible routes or streams in case of flooding
- Simulate inundation of land at intervals of 1 & 5 meters
- Provide data that will assess possible crop damage

- Provide data that will help assess amount of sedimentation
- Provide data that might asses and provide solutions for other issues

NETRAv2 Vs a Regular Civilian Drone

NETRAv2 can be coupled with MAPPING PAYLOAD to make a fully automated and intelligent mapping platform for easy, fast and accurate aerial data acquisition.

1. **Quick**: Netrav2 can be assembled or disassembled within 10 minutes. Once assembled, it can be deployed in a single click.
2. **VTOL**: NETRAv2 does not need a runway as they rise vertically into the air, making them suitable for taking off and landing in uneven terrain and in a constrained area of 5m x 5m.
3. **Simple and hassle-free**: Netrav2 can be assembled and disassembled in a simple manner, without the use of specialized tools, thanks to its modular and robust design. The GUI is user-friendly. The UAV is integrated with multiple fail-safe modes, one touch take-off and land, dynamic flight plan adjustment amongst other features.
4. **Completely Unmanned**: Indigenously developed highly sophisticated Flight Control System or Autopilot makes the UAV easy to operate and less risky. The UAV can fly along pre-defined waypoints allowing the user to easily monitor the overall operation. This autonomous UAV makes use of GPS navigation and provides the most cost effective solution for GIS mapping.
5. **Endurance and range**: NETRAv2 has an endurance of 50 minutes. With a range of 5 km (Line of Sight), it allows for an inspection of a large area, suitable for construction sites, power companies and mines. It also allows the user to 3D map an area of 0.5 square km at an altitude of 100m at 1x optical zoom. If the altitude is increased, it can map an even larger area.
6. **Multiple payloads on Same UAV Platform:** The Mapping Payload is used to capture High Definition photos to be used for mapping and photogrammetry. Images are processed using specialized software and is capable of generating extra dense point clouds, high-resolution orthophotos and exceptionally accurate DEMs. The same platform can be fitted with a multispectral imaging payload for doing spectral imagery and assess crop health.
7. **Output**: By integrating above payload with NETRAv2, the system can be utilized for:
    1. 3D-measurement & creation of 3D-models
    2. Ortho-photos with high ground resolution
    3. Remote sensing and photogrammetry
    4. Vegetation & ground cover monitoring
    5. Surveying & mapping of catastrophes
    6. Geophysical mapping of industrial zones & excavation sites
    7. Statistical calculations
    8. Stockpile measurements & Mass determination
    9. Volume calculations, Stock measurements & Geological deposit models
8. **Time and Cost effective:** NETRAv2 provides an easy and cost-effective way of collecting a large amount of high resolution spatial data, with more frequency and detail than satellite imagery using Remote Sensing. From a delivery time standpoint, NetraV2 allows you to take to the skies virtually whenever you like – Survey the area, collecting the required geo-referenced images without the

hassle of booking and waiting for satellite imagery. Just plan, fly, download your images, and process your data the same day.

9. **Safety**: We can now survey areas remotely that perhaps have some environmental risks to them such as quarries, cliff edges, polluted areas, etc. Not only does NETRAv2 make things cheaper and faster for a surveyor, but they also make our job safer.

10. **Better returns**: NETRAv2 offers huge advantages over conventional methods, in every part of the mapping life cycle.

    a. A conventional aircraft would produce an inferior quality output for about ten times the cost. Conventional aerial survey aircraft require cameras with extremely high resolution (80MP and up) because they fly at elevations of 2000-5000ft above the survey area. NETRAv2 can fly at 100m with a 16MP camera and get better data.

    b. Topo mapping was previously produced by ground surveyors with an RTK/GPS rover. You would have to pay a survey crew to walk the entire property and collect GPS points to be used in a map. NETRAv2 can do this within fraction of the time and without the hassle involved in it.

    c. Output from Satellite imagery does not even come close to the quality of output data generated from NETRAv2, and the cost is exorbitant. You do not have to worry about cloud cover before surveying the area.

Sr. no.	Method of obtaining data	Ground Sampling Distance (lower the better)
1	Google Earth	65 cm/pixel
2	Satellite data	31 cm/pixel
3	NetraV2	Upto 2.5 cm/pixel

Background

Guntur, Andhra Pradesh

Guntur is an administrative district in the coastal region of Andhra Pradesh. It is the largest city in terms of population and area, and has a coastline spanning 100km. The city itself is situated right on the bank of the Krishna river, separating it from the Krishna district. The Krishna river empties into the Bay of Bengal.

Guntur cultivates and produces large quantities of chili, tobacco, paddy and cotton. It also produces a variety of oilseeds and pulses. The city is a business, textile, agriculture and industrial hub. Irrigation requirements of the area are fulfilled by the small rivers and tributaries that originate from the Krishna river and the Guntur Branch Canal (GBC). As a whole, the region is an agricultural hotspot with scope for diverse land use. Uplands particularly are best suited for horticulture and livestock rearing.

Geography:

Guntur spans across 11,391 square kilometers (4,398 sq miles) and is bordered by the Krishna River on the northeastern and eastern boundary. The southeastern border touches the Bay of Bengal and the south side borders Prakasam District. On the west lies Mahbubnagar District and the northwest is bordered by Nalgonda District.

Guntur geography consists of braided stream channels, extensive sandbars and broad floodplains, suggesting that the Krishna river flows across seemingly flat terrain and transports heavy amounts of sediment. This increases during monsoons.

Rainfall:

Guntur experiences an average rainfall of 864mm, which decreases from east to west. The rainfall is supplied by both the south-west monsoon and the Northeast monsoon. Rainfall ranges from nil rainfall in January to 160 mm in August. August is the wettest month of the year. The mean seasonal rainfall distribution is 547 mm in southwest monsoon (June-September), 235 mm in northeast monsoon (Oct-Dec), 8 mm rainfall in Winter (Jan-Feb) and 74 mm in summer (March – May). On the other hand, the district also suffers severe heat waves and scorching heat. The climate of Guntur can be divided into 4 distinct seasons:

1. December to February: Cool, Dry Winter Season
2. March to May: Scorching Summer Season
3. June to September: Southwest Monsoon Season
4. October Beginning to December: Northeast Monsoon

Rivers and Drainage Systems:

1. The Krishna
2. Gunglakamma
3. The Chandravanka
4. The Naguleru
5. Drainage systems: Romperu drainage basin, the Tungabhadra drain, the Bhattiprolu drain and the Repalle drain are the drainage facilities available in the district.

Problem

Guntur's Vulnerability to Flooding

- In Andhra Pradesh, 44% of the total area is vulnerable to tropical storms, with the coastal belt being the most vulnerable.
- Khammam district in Telangana region is most prone to monsoon floods, along with five districts in Coastal Andhra.
- Along the coast, area between Nizampatnam and Machilipatnam is the most prone to storm surges.
- Delta areas of the Godavari and the Krishna rivers, experience recurrent flood and drainage problems.
- Guntur district and Krishna District have collectively witnessed 18 cyclones till date.
- Guntur has witnessed disastrous flooding in year 2006 (Godavari Flooding), 2009 (Krishna Flooding), 2013 (Phailin cyclone), 2015 and 2016.

For many years now, Guntur has been at the mercy of heavy rainfall, flash floods and inundation. Speculations by scientists and locals suggest that environmental issues such as geography of the area (alongside the Krishna river), the weather pattern (sudden cyclones, storms) or the change in topography (sedimentation, loss of vegetation) are the cause of this disastrous annual event; or possibly a combination of all.

Year 2016 experienced the worst flooding so far, with damage and losses estimated to fall in crores. During a 24-hour period between 21 and 22 September, Machilipatnam in the state's Krishna District, recorded 117 mm of rain. Between 23 and 24 September Dachepalli in Guntur recorded 171 mm of rainfall and Pulipadu 155 mm.

The damage was so severe, that the Union Urban Development Minister, Mr. M. Venkaiah Naidu had to conduct an aerial survey of Guntur to get a real perspective of the devastation. Once in the helicopter, he was provided with an extensive view of Guntur district, submerged under brown, murky water.

The agricultural community of the area were the worst hit, with over 41,000 hectares of standing crops damaged. This included important staples such as paddy and cotton, along with spices such as chilies and turmeric. Due to the level of inundation, complete survey, mapping and research could not be carried out on foot. To get an idea of what future measures could be taken to stop this from happening, ideaForge was contacted for assistance in mapping and surveying the area using Unmanned Aerial Vehicles.

Solution, Detailed Methodology & Procedure

Traditional Approach

The traditional approach for surveillance or mapping involves manpower. Areas that are flooded or inundated are inaccessible at times or very difficult to survey. The traditional procedure of mapping also produces flaws, resulting in improper calculation of area. It also misses major topographical markers such as streams, vegetation and others.

Problems with traditional approach

- Manual mapping and surveying is inefficient
- Manpower involves huge additional cost
- Decision making is hampered

Pros with UAV approach

ideaForge's flagship product NETRAv2 offers huge advantages over conventional methods of inspection, monitoring, surveillance and mapping. It can be utilized in every part of geospatial studies including Exploration, Planning/Permitting, Mapping, Operation Inspection and Reclamation. NETRAv2 has a long endurance and long range. This allows the user to cover a large area at higher altitude. Images captured by UAVs span thousands of hectares of land in a single flight without the cost and hassle of manned services. The images produced are also of far greater quality than that of the satellite imagery.

Processing of Data

After processing the images, they are transformed collectively into one large 'geo referenced orthomosaic' image.

The generated Orthophoto Mosaic can help:

- Create efficient plans resulting in better decision making capabilities for Site planning engineers.
- Map steep inaccessible inclines.
- Generate detailed modelling and imagery of topography resulting in better management.
- Haul route design and optimization.
- Model geophysical & watershed/catchment areas.
- Monitor & report progress.

Table 1: Preparation of Orthophoto Mosaics is carried out using NETRAv2 in the above mentioned way

1. Pre-flight Survey:
• Choose the area to be surveyed and assess possible take-off/landing locations.
• Assemble NETRAv2 with mapping payload (time required: under 10 mins).
• Plan flight using GPS-enabled waypoint navigation in the indigenous ground control station software .
• Set required image resolution & photo overlap by selecting altitude and ground speed.
• Complete comprehensive pre-flight checks.
2. Flight
• Carry out a fully autonomous flight while monitoring the aircraft parameters in real time.
• The UAV is integrated with multiple fail-safe modes, one touch take-off and land, dynamic flight plan adjustment, user-friendly GUI amongst other features.
3. Post-processing:
• Retrieve High Resolution data from NETRAv2.
• Process the images.
• Generate Orthophoto Mosaic in required format/s.

NETRAv2 Flight Details & Duration:

Team: Magesh M Kumar, Lakshmi Narayan
Date: 26th and 27th September 2016

Total number of flights - 8 flights

Total number of days - 2 days

Payload/Camera used - Mapping Camera payload, HD Camera payload and multispectral Camera Payload.

Process Followed

- All flights were mapped by using data provided by local administrative representatives of government.
- The flights were conducted at an altitude of 100m.
- Mapping was focused on severely affected areas of past flooding (where streams joined larger water bodies).
- Important streams, tributaries and water bodies known locally were mapped.
- A virtual flood line was calculated using GPS coordinates by identifying the maximum level of water reached in past.
- Images were captured at different areas separately, stitched together and exported.
- Exported outputs were then processed with another software and analysed.

- Factors such as direction and flow of water body, highly vulnerable areas, positions of possible barriers for obstruction were analysed.
- Crops grown, extent of possible devastation, area-wise analyses were done for insurance purposes.

Along with the mapping of inundation, the project used the NETRAv2 drone to monitor the crops in the area. Using the drone fitted with sensors that can capture infrared spectrum, large expanses of field were monitored to estimate the effect the flooding had on the crop health. One of the prominently used indices is Normalized Difference Vegetation Index (NDVI), which measures the degree of vigor of the plant. This provides enough information to produce conclusions surrounding the soil quality, nutrition and other environmental factors. Once the map reflectance of NDVI is generated, analysis can determine areas that had severe crop damage due to the flooding, from leeching of minerals and soil erosion.

Key Challenges

1. Non-cooperative locals: The local people in the vicinity would crowd the take-off and landing zone along with their vehicles, out of curiosity. Despite repeated requests, they were reluctant to move away from the area, creating unnecessary commotion and a public safety hazard.
2. Clarity on the area to be mapped: Due to extensive flooding in the area, it was not possible to clearly demarcate the limits, which resulted in a larger area being mapped.
3. Weather: The rainfall in the area, though had subsided substantially, was still sporadic in nature, and was accompanied by heavy gusts of wind, making flights difficult. The weather conditions were challenging for the operating crew as well.
4. Lighting: Due to continued overcast conditions, the lighting was insufficient for capturing quality data. However, the highly-spec'd mapping payload deployed for the project, compensated for the poor lighting.

Results, Impact & Conclusion:

The project proved UAVs to be extremely successful and useful in completing aerial surveys for disaster-hit areas. NETRAv2 produced incredibly high quality data in a cost-effective manner, in a short span of time. The project also demonstrated the flexibility of aerial platforms, and specifically demonstrated NETRAv2's all-terrain performance capability.

The project produced the following results:

- The highly-affected areas were surveyed and recorded.
- Areas that experienced sedimentation, water logging and soil and land damage were identified and recorded.
- Mapping and analysis provided information on impact on residential, commercial and agricultural areas.
- The high quality and clarity of images helped identify possible rescue locations for future flooding rescue and relief operations.
- The agricultural community were severely affected and aerial survey helped in mapping impacted fields for insurance purposes.

- NDVI of crop health indicated that flooding had resulted in mineral leeching and soil erosion.
- Aerial images helped identify fields impacted for government authorities to plan for compensation.
- This information can be used by Agriculture Department of Andhra Pradesh to educate farmers about future flooding and preventive measures to be taken.
- The information can be used for effective water management.
- The processed images can be used for watershed, drainage basin & water flow mapping.
- The analysis of data over a period can help identify flood patterns and help the government plan future infrastructure projects, drainage systems, land allotment and others accordingly.
- Recording of flood patterns will also help agriculture, mining and other industries implement preventative measures in respect to cropping, mining and others.

KRAs of UAVs

Three of the most important KRAs of these types of applications is the range, endurance and versatility of the UAV. Since, by very nature, flooded areas will have very small land patches, few and far between, available from where flights can be operated, controlled and monitored by the UAV operators; the larger the area which can be covered in one flight from one place, the less challenging UAV operations will be. Longer range further aids the same purpose.

Further, weather conditions, the very reason for flooding, are almost never favorable. Thus, UAVs resilience to environmental factors like continuous drizzle and windy conditions is an important attribute to consider. With NETRAv2's IP 53 rated weather resistant build, the ability to reach a circle of 78 sq.km around the point of operation as its center, and an endurance of 50 minutes plus, it is the perfect platform for such large-scale projects.

Scalability and replicability of the solution

For a UAV based solution to be scalable, it is imperative that the operation of UAV be simple and user-friendly i.e. Doesn't require advanced skill set. Just like the Jawans in the armed forces, even secondary school pass outs can fly NETRAv2 successfully, with minimal training.

Another advantage with the NETRAv2 is that it doesn't require any external connectivity e.g. Wifi, external GPS, tower connectivity etc. This makes it the ideal solution for disaster management or mapping projects located in remote areas, mountainous regions, and other places that are out in the boondocks.

This removes major challenges of mobilizing scale UAV operations in areas with broken infrastructure in disaster areas.

Visual Results and Images

The team could map all the areas requested, and processed the most severely affected area, which was area 1.

Figure 1: Flood simulation was processed and created for area 1, at intervals of 1 and 5 meters respectively.


Area 1 – 1 meter


Area 1 – 2 meter


Area 1 – 3 meter


Area 1 – 4 meter


Area 1 – 5 meter


Area 1 – 6 meter


Area 1 – 7 meter


Area 1 – 8 meter


Area 1 – 9 meter


Area 1 – 10 meter


Area 1 – 15 meter


Area 1 – 20 meter


Area 1 – 25 meter

The APFSL, along with the Andhra Pradesh Government can now use the maps for urban planning. The data will also help pinpoint the areas in Guntur that require measures to prevent future flooding. The amount of detail will also assist government bodies in identifying suitable areas for the implementation of proper drainage systems. In a worst-case scenario, if the area faces future destructive flooding, the mapping will be a source of information for the government, in providing flood relief funding.

In conclusion, the flood inundation modelling proved to be a successful project, and will hopefully provide enough data for the government to act in respect to a future flood crisis.

Dhruv Shah, Lakshmi Narayan & Ciara Arora

GIS & GPS Based Emergency Response System for Smart Cities

SUMMARY

Geospatial tools and services integrated with Emergency Response Systems / Computer Aided Dispatch Systems are being extensively used for public safety. For better response, planning and preparedness to respond, this system provides location intelligence such as location of callers, response teams on the ground as well as the location of incidences which can be mapped. This has resulted in achieving a quick and accurate response to an emergency reported by a person in distress. Location of the caller or the incident on the GIS map together with the dispatch of the nearest response vehicle through the shortest path ensures reduction in response time. GIS based reports and analytics such as hotspots, crime forecasting etc. are very useful in deployment of constrained resources for the predictive and preventive crime control. The overall solution presented here could become one of the critical components of emerging Smart cities across the country.

Introduction

In the modern world, rapid growth in urbanization & population has led to increased emergency incidences like crime, accidents, riots, terror attack, flooding, earthquakes, landslide etc. In any of these situations providing quick and better response to minimize the damage is one of the major responsibilities of the various agencies like Law Enforcement, Fire & Emergency Medical Services. These agencies are required to respond to emergency situations in an effective manner with constrained resources in shortest possible response time. They are required to manage variety of emergencies arising from threats, protests, crowd control, domestic violence, fire, traffic disruptions, accident or any other unforeseen situations.

In order to address such diverse situations wherein response time is critical, firsthand (near real time) information of incident is of utmost importance. A technologically advanced multi-pronged approach is required to channel in as much information as available which involves spatially enabled information and its appropriate communication to the desired individuals/ agencies. Therefore, there is a need to establish an Emergency Response Centre through which the emergency situations can be handled in collaboration with multiple agencies/stakeholders. This is one of the critical components of emerging Smart cities in India.

State of art Emergency Response System known as Rolta GeoCAD has already been deployed in different parts of the country including Maharashtra and Uttar Pradesh. This system is also well known as Computer aided Dispatch or Dial 100 systems which is deployed in the modern police Control Rooms. The Geospatial Technologies constitute one of the important component of this system. Geospatial co-ordinates of an incident location, point of interest or the surveillance area provides the field responders and the control room operators in attending to the emergencies /surveillance effectively and accurately. The "Response Time" to attend to any emergency is the key performance index and is required to be achieved at all times.

This paper describes the success story of Rolta GeoCAD and applications of Geospatial Technologies in the Computer Aided Dispatch (Emergency Response Solution) deployed in the Modern Police control rooms at Lucknow and Mumbai.

Usage

The CAD solution deployed at Lucknow and Mumbai Police control rooms by Rolta is both desktop and web based for call taking, assessment of incidents, real time tracking of response vehicles, deployment of resources and efficient management of incident towards favorable resolution. The solution provides situational awareness of the incident on GIS enabled display for better visualization and management.

Mumbai Police

With a population over 12.5 million, Mumbai City covers just a geographic footprint of around 438 sq. Km. It is one of the densely populated area in India. From law enforcement perspective, this creates a challenge for Mumbai Police who is required to respond to emergencies as quickly and efficiently as possible.

Lucknow Police

The Modern Police Control Room was set up in the year 2014 serves population of 4.5 million spread over an area of 2000 sq km. The state of the art GeoCAD system operational at Lucknow police control room has many first time initiatives to bring in the efficiency and transparency in to the system. Provisions for real time exchange of information from the scene of incident to the control room, transparency through citizen feedback and seamless communication over various communication mediums has transformed the way policing is being done. The system has tremendously brought in confidence amongst citizens which assures help just in time.

This is an end-to-end Call Taking and Dispatching solution, from receiving & handling 'Call for Service' (CFS) to recommend, dispatch & initiate action through the response vehicles / 'Responding Units' (RU). The emergency events are generated based on CFS received through communication medium such as PSTN lines, Cellular, police radio, SMS, email and SOS calls. In addition, incidents are also created based on electronic information received from call triggered by an alarm in a premise. Based on the inputs received, the location of the incident is established and concerned agencies are activated for initiating necessary incident management/threat mitigation measures.

The 'Call Taking Functionality' provides an efficient method of entering and validating information received from a caller for assistance, to a computer assisted dispatch center. The 'Dispatching Functionality' provides operators with full dispatching capabilities allowing them to effectively monitor and track police vehicles & incidents on GIS map, and dispatch /control operations of the vehicles. All incidents and resource utilization information is time-stamped and recorded into mirrored databases for post incident analysis and training. The CAD work flow is depicted in Figure 1.

Figure 1: The Computer Aided Dispatch Workflow

The solution deployed is a fully configurable multi-lingual solution, which receives calls on 112 as well as 100 (Police), 101 (Fire), 1,073 (Traffic Helpline) and other help lines such as Women, Children and Senior Citizens. In addition, the system is configured to prioritize calls for selective landing at specialized consoles/operators. Further, the solution also supports facility to call up the complainant for feedback to ascertain the efficacy and satisfaction level of the citizens. The solution also provides various reports to the users for response analysis, crime mapping, hotspot analysis through graphical and dashboard representations. The Geospatial Technologies have been extensively used in achieving the functionalities essential for the operation of an Emergency Response System. Some of the uses of Geospatial technologies are described in succeeding paragraphs: -

Location Identification of Caller in Distress/Incident

The location of the caller or the incident is plotted and pops up on the GIS map as soon as the call is received in the CAD system. The Control Room Operator is able to see the location of the incident on the GIS map. The incident location, if different from the caller location is seen using the intelligent search operation and marked on the map as incident location. Vector maps of higher scale are made from the satellite imagery and enriched with different types of police specific layers, geographical boundaries and other attributes. Raster image or any high resolution satellite data of the area is also viewed in the backdrop, as required. This facilitates easy identification of location of incident and analysis of spatial distribution of the incidents across the city.

Automatic Vehicle Location & Tracking

The Responding Units (RUs) have been fitted with the locators (GPS devices). These devices continuously transmit their location at a pre-defined refresh rate. Locations of the vehicles received is dynamically plotted on the GIS map thus showing live position of the vehicle on ground which is continuously tracked. This enables identification of the RU in the vicinity of emergency incident and its location is visible to the control room operator for quick dispatch.

Mobile Computing Devices

Commercially available mobile computing devices and smart phones have been used by the field responders and senior officers on the move to respond to an emergency situation or monitor and control events. The available mobile computing devices with the field responders have inbuilt map or access to web based maps for display of their own/ incident location and also for visualizing the location of RU in the nearby vicinity. The shortest path with textual navigational facility to reach the incident location is automatically calculated and displayed on the map for faster movement. The integration of the Geospatial technologies with the ICT (Information & Communication Technologies) has dramatically helped in having the real time situational awareness at the field level and has enabled the senior officers/ supervisors to access control room operations.

GIS Based Patrol

Preventive policing is an important aspect of crime control. The visibility of the patrolling police vehicles or the foot patrols is a deterrence in itself. However, the deployment of constrained resources (man or patrolling vehicle) over vast areas is a challenge. The effectiveness, therefore lies in deploying the resources in crime prone areas. GIS maps and crime analytical tools have been provided in the ERS for planning of patrol routes within the constrained resources that are available in the crime prone areas. These tools have been effectively used for putting the Cops on the Dots. The Dots are the points or the stretches where the patrolling is required to be done. Various analytics such as hot spot, incident counts etc. have been made available for identifying crime prone areas. The Patrol route is planned by the supervisor in the control room or the police stations of the respective jurisdiction. The patrol routes are prepared using the hotspots or the incident counts displayed in the background. Areas which are relatively safer are left out depending upon the availability of the resources. The patrol routes thus prepared are based on the past crime records, seasonal and regional hot spots. The patrolling is scheduled and the patrol routes for each patrolling vehicle is transmitted on their Mobile Computing Devices for execution. The patrol route taken with time stamp is plotted on the GIS map at actual and compliances or the deviations are seen by the supervisors. This functionality is very useful and has been effective in crime control using preventive measures.

Be on Lookout (BOLO)

Be on Lookout (BOLO) function enables the control room operator in hot pursuit mode for a criminal or missing vehicle. The incident is raised as a CAD function or through other external systems like Crime and Criminal Tracking Network & Systems. BOLOs is created and maintained in a table in the CAD system. BOLOs may be entered by a dispatcher or may be created by anyone who has been given the required security clearance to create or maintain the table. Both CCTNS interface and a Mobile Data Computer support the creation and transmission of a BOLO back to the CAD system. Each BOLO is assigned an expiry date, either by the person who creates it or by the system, based on department policy and available system resources. A typical BOLO file includes the nature of the BOLO, priority, date, subject person information, subject vehicle information, risk involved, and contact information. There is a mechanism to search the BOLOs, to print them in a report and to automatically notify the originating source of the BOLO anytime it is

updated. Examples of a BOLO are: An unidentified male traveling in a white INNOVA car, bearing U.P. license plate may be in possession of stolen goods. This information is broad casted to all patrol units which will be on lookout for the described vehicle and identity.

BOLO is extensively used for tracking the lost or the stolen vehicles. A database of the stolen vehicles is prepared in the control room or published from the RTO with in certain time interval. Police vehicles on Patrol have this data access available on their Mobile Computing devices for verification against the abandoned or suspicious vehicles. The suspect vehicles are intercepted and checked.

Geospatial Information Updating

Field units/personnel with the inbuilt application for GIS data collection are able to capture the new developed/ missing GIS information (Point of Interest) and send to the Command & Control center for verification, approval and updating the GIS map. This ensures that the latest update GIS information is available at any time. The continual update of GIS data enriches the map with the current changes.

GIS Based Crime Analytics

Crime analysis plays a major role in preparing crime prevention strategies. GIS based crime analytics provides distribution of crime on GIS map enabling users to search particular type of incidences, classify and view the incident data, assess what is nearby associated with each crime, also allow users to identify crime patterns, forecast the crime and perform link analysis. Rolta GeoCAD Crime Analytics is a web based application where user filters incidents and mine the data for patterns and trends. Few examples of the GIS based analytics and its usage from policing perspective are described below.

Crime Forecasting

It has provision to predict likely location on the map, where the possibility of happening next crime is the most. It displays the cluster of incident locations on map based on selected criteria. The crime investigating team selects the specific area (Zone/Police station) and event type and sub type with specific date & time.

Suspect Analysis

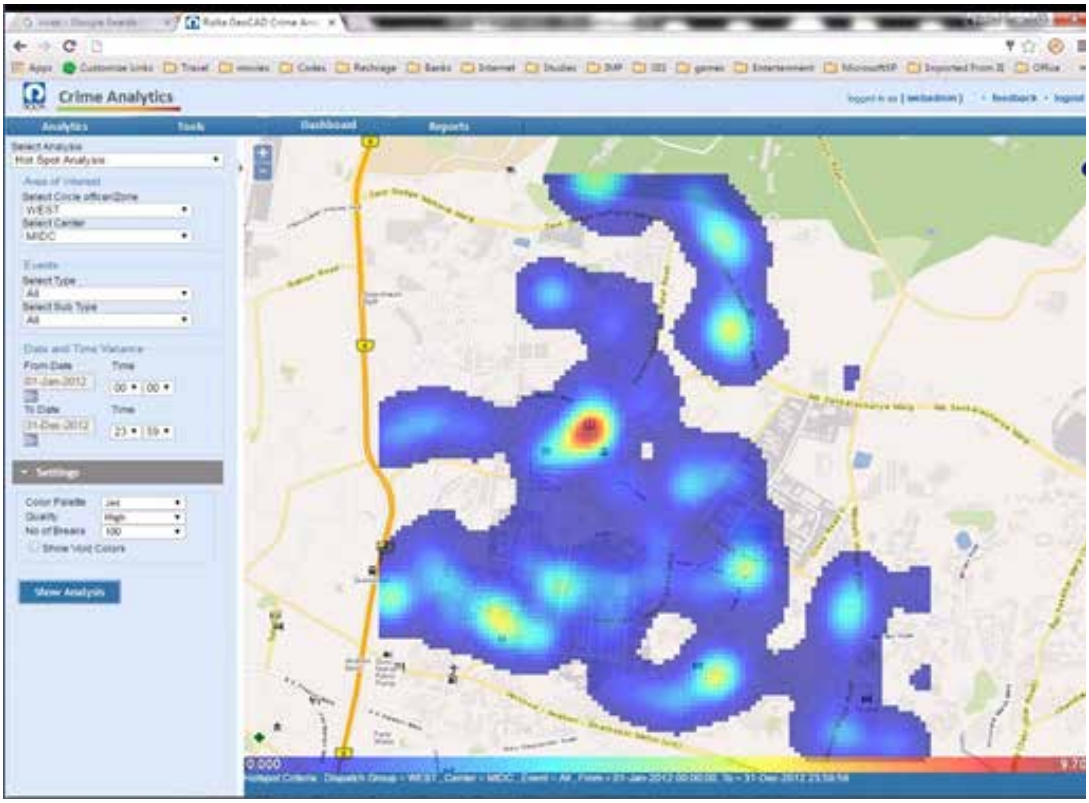
The Geospatial system integrated with GeoCAD enables the users to identify the possible offenders within the predefined vicinity of the crime location. Users select the specific area (Zone/Police station) and event type and sub type with specific date & time. On click of button, the location of crime and offenders in the nearby vicinity is displayed.

Crime Link Analytics

The GIS enabled Emergency response systems display common indicators of a crime by establishing association (groups of "events" that regularly occur together and linkages) on GIS map.

Similarly, Trend analysis assesses the trends of committing crime in a particular area, proximity analysis and network analysis finds shortest route between selected crime locations. Repeat incident count mapping and hotspot analysis (Figure 2) are best done using Geospatial tools.

Figure 2: Hotspot analysis of emergency incidences



Benefits

Benefits to the Police

The Modern Police Control Rooms at Lucknow and Mumbai have now become the nerve centre of the city for maintenance of law and order. The Geospatial system integrated with Emergency Response System or Computer Aided Dispatch systems have automated the entire operation of Call taking, identification of the caller and location of the incident on a digitized map. Now the response to an emergency is given by the nearest available resource or most appropriate resource. This has reduced the response time there by rendering timely assistance. The entire control room operations have been automated and redundancy provided for failover. Reports and analysis based on the MIS and GIS are used for preventive policing and allocation of constrained resource in the hot spots.

Senior officers are kept well informed about the entire control operations in general and of their respective jurisdiction in particular. They are able to access the current information on their personal smart phone, while on move. All police stations are linked with the control room and have access to the relevant information pertaining to their jurisdiction.

Benefit to the Citizens

Citizens can make a call for an emergency using any medium i.e. landline, mobile, SMS, e-mail etc. All calls are recorded from its receipt to its closure. The system ensures full accountability of the police to ensure that an appropriate response is given. Citizens are also informed about the receipt of their call for service

through SMS acknowledgement. They can check the status of their complaint online from police web site with provided user name and password. This makes the system transparent and accountable.

The solution provided to the Lucknow and Mumbai police is a new generation public safety solution, using latest technologies and is a leap forward in the public safety domain. These Control Rooms have become a trend setter in the public safety domain in the country.

Conclusion and the Way Forward

The use of Geospatial technologies in the Emergency Response System has revolutionized the way the emergencies are now being responded. Rich GIS maps and GPS technologies have enabled locating and tracking of the incidents, resources. The GIS based reports and analysis are an effective tool for the predictive and preventive crime control. The way forward is to ensure these systems provide spatial data both in 2D and 3D and have sophisticated tools to model the data from multiple sources for analytics. This will strengthen the crime prevention and crime detection for providing better safety and security to citizens. One of the most important issues in Crime Prevention and Crime Detection is the delivery of the right information at the right time to the right stakeholders. In operational terms this translates into information about the whereabouts, possible hideouts and known associates of a suspect, distress calls, information about crime in progress, crime hot spots, actionable intelligence etc. to be timely provided to stakeholders like investigating units, verification officers, patrolling staff, police vans and other field units etc.

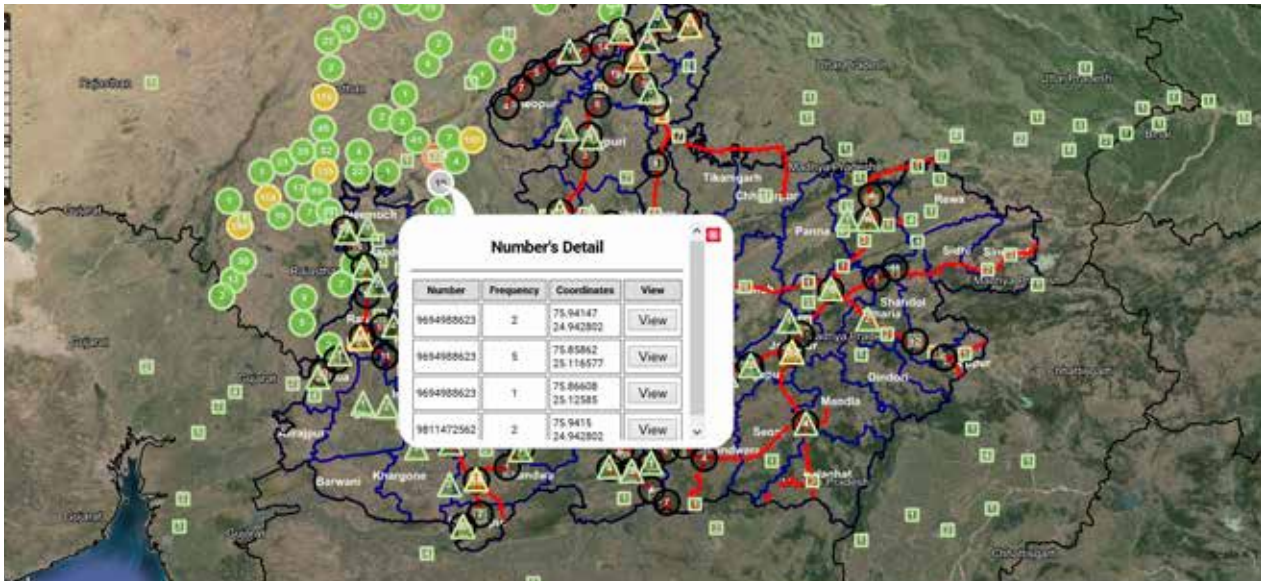
Since the system is modular in nature with logical partition between the user interface layer, business logic layer, and the data layer, the overall system is highly scalable. The system is deployable for geographic regions ranging from city, district to state levels both in a centralized and decentralized mode of operations.

C. R. Bannur

3

HOMELAND SECURITY

Integrated Web GIS based Crime Investigation System for Railway Passenger Safety



Vision

To make railway travel safe and to provide on board support to railway passengers.

Objective

Development of a comprehensive Integrated Web GIS based Crime Investigation System for Railway Passenger Safety to provide effective crime investigation.

Introduction

Railway Passenger Safety lies within the domain of the Government Railway Police (GRP) of the state through which the train is passing. Railway passenger safety is highly dynamic and requires a prompt and swift response. And so it is important that the victims should get the benefit of response while the train is within state jurisdiction. A majority of the railway crime takes place at night. By the time a victim passenger realizes the occurrence of the crime, usually the train already moves into the jurisdiction of another police station. Thus, railway crime investigation requires a high degree of data collation at least at a regional level.

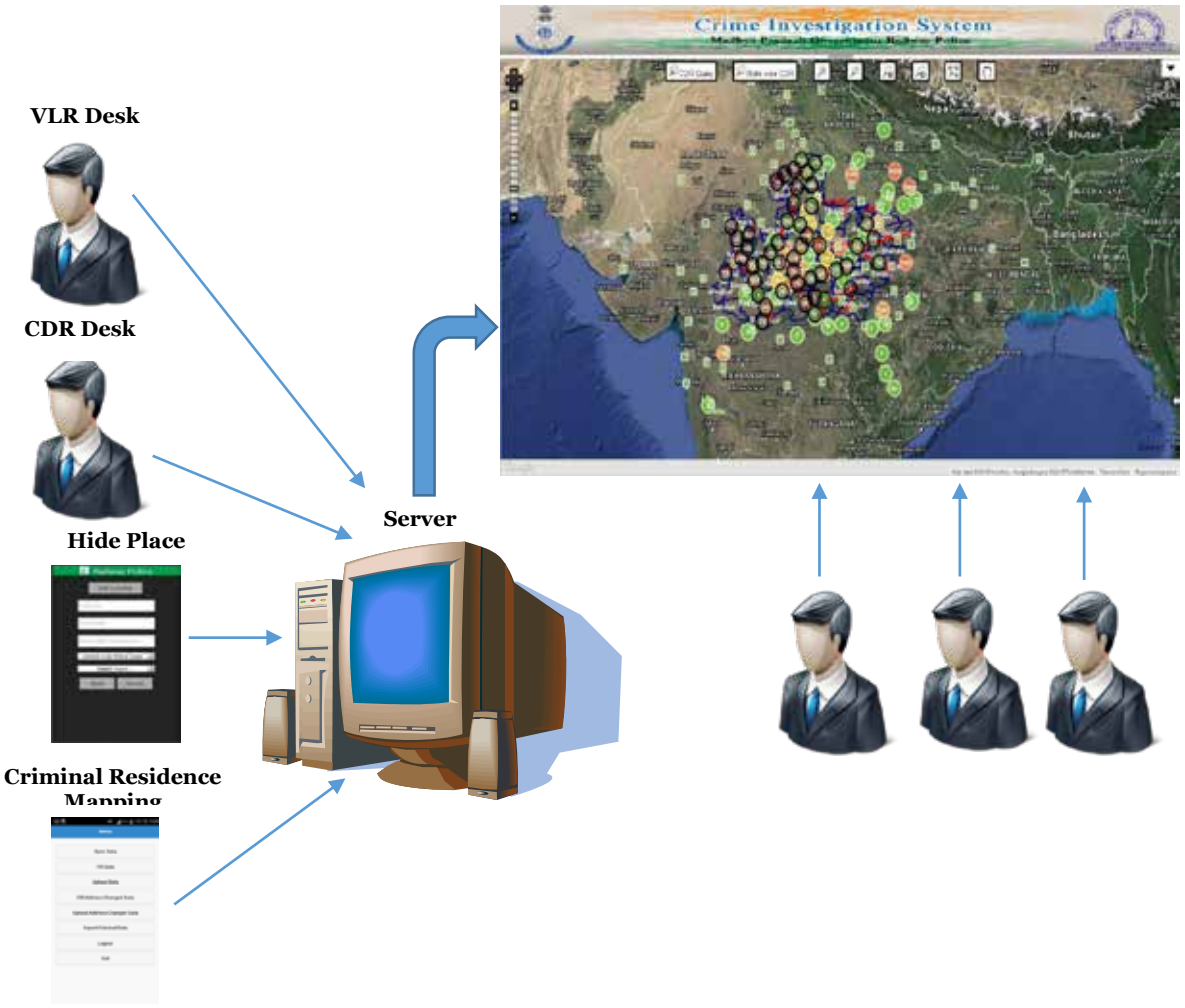
Criminal gangs usually operate in an organized manner. These gangs also involve a network of advocates and bail takers to get an easy release out of our legal system. It has been observed that whenever such criminals are caught, these lawyers contact the complainants and get it compounded out of court, thus effectively evading conviction. At times they even develop a good rapport with the railway running staff, vendors etc. which becomes a favorable factor for them to commit crimes. Such challenging circumstances necessitate the modernization of the response systems of GRP, so as to provide effective passenger security proactively by refocusing and readjusting preventive and detective strategies. Geo-Spatial technology has been effectively used to solve this complicated issue.

M P Council of Science & Technology (MPCST) and GRP is developing web GIS based applications for quick and effective crime investigation. It includes several modules such as Call Detail Records (CDR) analysis, Visitor Location Register (VLR) analysis, geo-tagged mapping of temporary hiding places of criminals along with the photographs of these places and attributes, digitization of criminal records of notified criminals and geotagging of their known residences along with ground photographs, passenger reservation dump data analysis, mapping of railway tracks, stations etc. All these tools are integrated onto a single platform known as Crime Investigation System.

Methodology and Approach

The approach taken to develop this system is to optimally utilize the features of geospatial analysis. Spatial data layers are the backbone of geospatial analysis; therefore, the initial requirement was to digitize the criminal profiles of notified criminals, followed by the collection of geotagged data of their residences and current status. It was also required to collect the information about places near the railway stations which are being used by criminals to hide temporarily after committing the crime. These places can be small tea or liquor shops, small hotels, lonely places in yards etc. Basic layers such as railway tracks and railway stations, layer of mobile towers with specified coding to towers in the range of railway tracks etc. were also created. The entire concept is shown in Figure 1.

Figure 1: Conceptual Diagram of Crime Investigation System



Digitization of Criminal Profiles

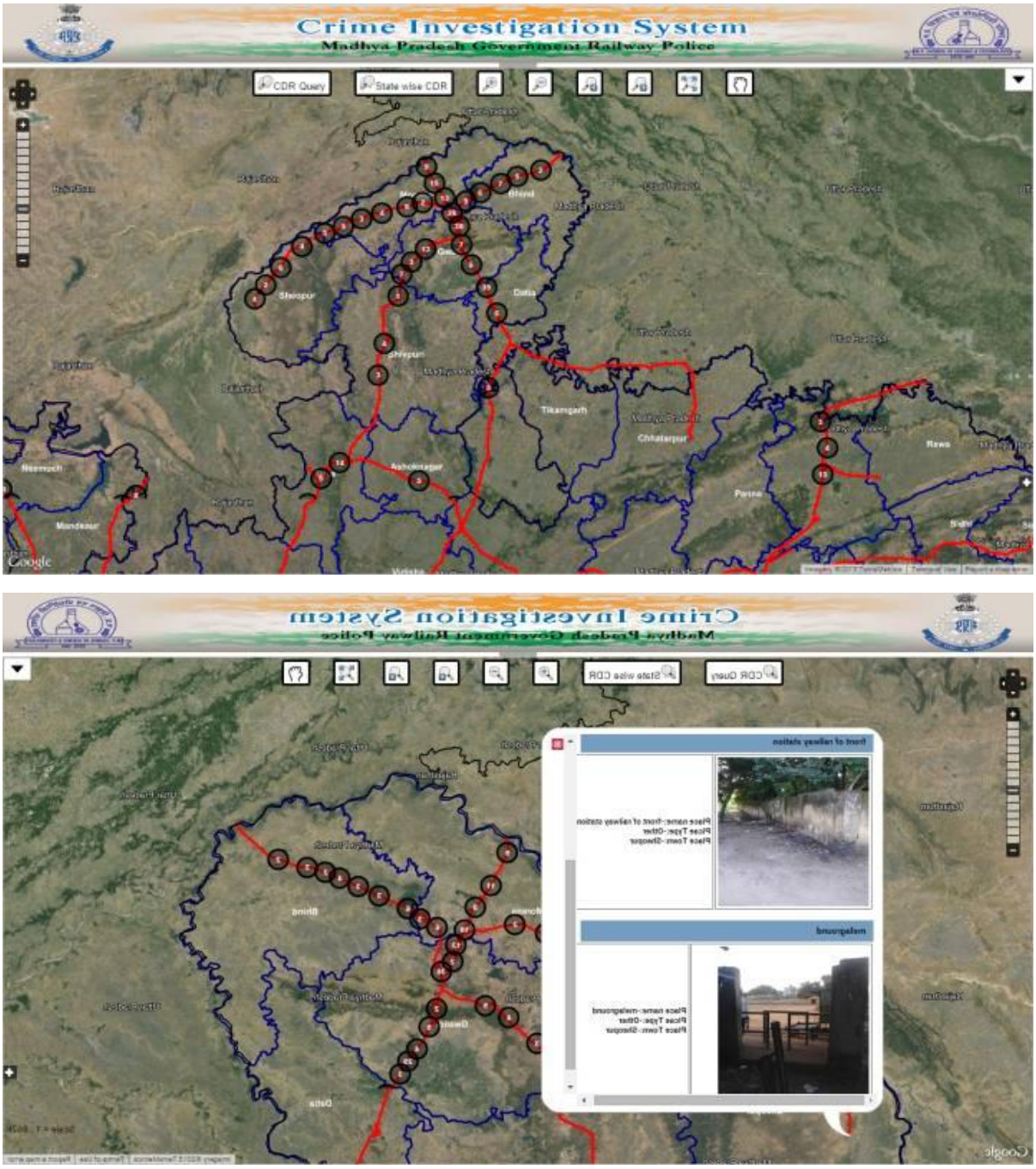
The criminal records were digitized and profiles were created including their crime pattern, operating area, family details, association with gangs, residence details, known mobile numbers etc. Each criminal was given a unique id in the database (Figure 2).

Figure 2: Digitised Criminal Profiles

Mapping of Hide Places and Criminals' Residences using the Mobile App

Spatial data collection in correct form is a difficult task. So to collect the required field data, a mobile app was designed. Different forms were designed for geotagging and photography of notified criminals' residences, mapping of temporary hide places near the railway stations where criminals may hide for few hours after committing any crime in a running train and then de-boarding after that. Madhya Pradesh GRP has done the mapping of criminals' residences and hide places using GIS based mobile applications. As soon as a police man logs into the app, the profiles of criminals of their area get synced with the app by querying the criminal ID. The basic details of the criminal become visible on the app. After verifying the details of the criminals, their residences were photographed and geotagged. In case a policeman finds a change during the enquiry, the app would provide the facility to update the new address and details. The entire criminal database is geotagged with the spatial information including photographs, family details, moving areas, crime pattern etc. The black circles visible on the screen shot are the number of hideouts in that area. Clicking on these circles the photographs and other details are displayed (Figure 3).

Figure 3: Mapping of Hide Places



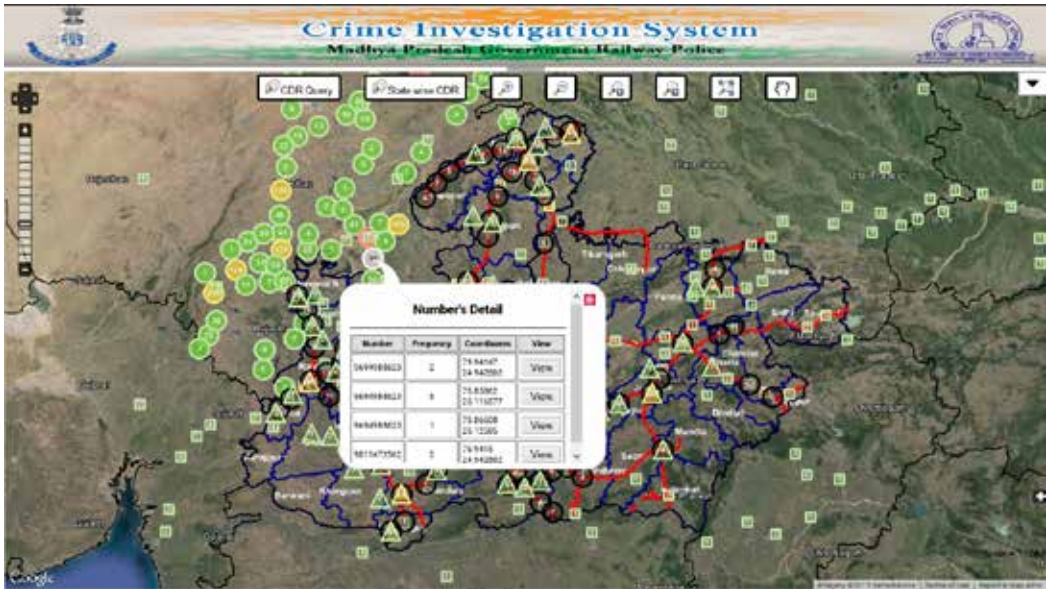
The criminal residence layer is visible by the symbol of triangle with the numerical value indicating the number of criminals in that location. As the layer is zoomed to a full scale, the individual location becomes visible. By clicking on the triangle the photographs of criminal's residence and other details are displayed in a pop up window. (Figure 4)

Figure 4: Mapping of Hide Places

Mapping and Analyses of Call Detail Records (CDRs)

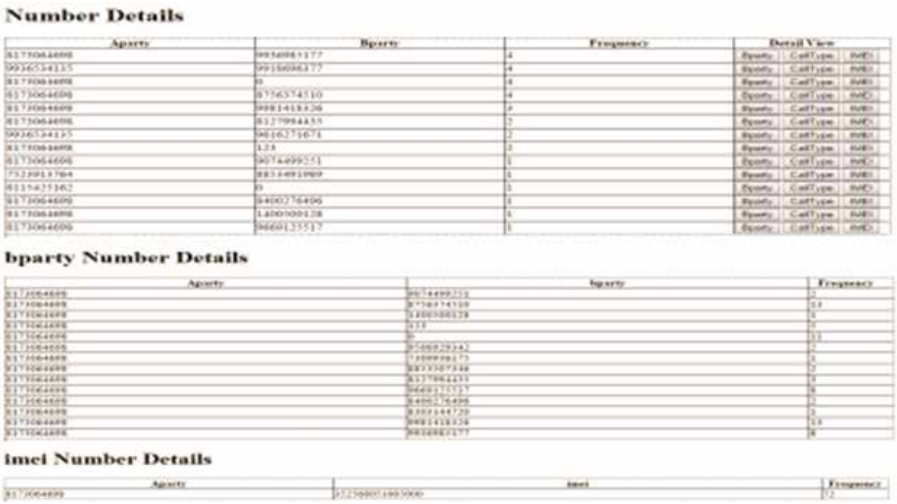
Mobile call details of suspected criminals are a big source of information for crime investigation. Mobile tower location information was gathered from service providers and a layer of mobile towers has been created in the system. The mobile towers in the range of railway tracks have been especially coded. As per the crime pattern, suspect call detail records have been collected from service providers and plotted geospatially in the system. As shown in the Figure 5 below, a screen shot displays by the symbol of light colored circles with the number of calls connected to various towers. As the layer is zoomed out the number of calls get added in the circle. As the number of calls increases the circle color gradually turns to red indicating the alarm. That indicates the movement of a large number of criminals in that area. At places many criminals have been observed within a single village.

Figure 5: Mapping of CDRs



As we click the CDR circle the suspect numbers are displayed in a popup window. Further clicking on the view details button shows the call details of that particular number along with IMEI number. The most important part in this is pivot analysis. In this, the system analyses the call detail records for A to B party calls, their frequency, incoming/outgoing and call duration, IMEI numbers of handsets etc. (Figure 6). Using the logics, the relations between these numbers and IMEI details are established. Based on this information even the gang formation and their movement can be tracked. The movement of these suspect criminals in a particular time period near and along the railway tracks can be easily established. This information helps in identifying the gangs and their movement around the incident location during the investigation of the crime conducted on the train.

Figure 6: A to B Party Pivot Analysis



Mapping of Visitor Location Register (VLR)

Visitor Location Register (VLR) is the information of last location of any stolen mobile or internet compatible gadget. This information is overlaid on other GIS layers to correlate the suspected criminal. The VLR layer is symbolized by small green colored square (Figure 7). By clicking the square the reported incident details with VLR is displayed (Figure 8). As the criminal residences and hide places are mapped, it helps in narrowing down the criminal's location and identity. In certain cases, this location is found in distant villages which helps in identifying the criminal based on available criminal profiles.

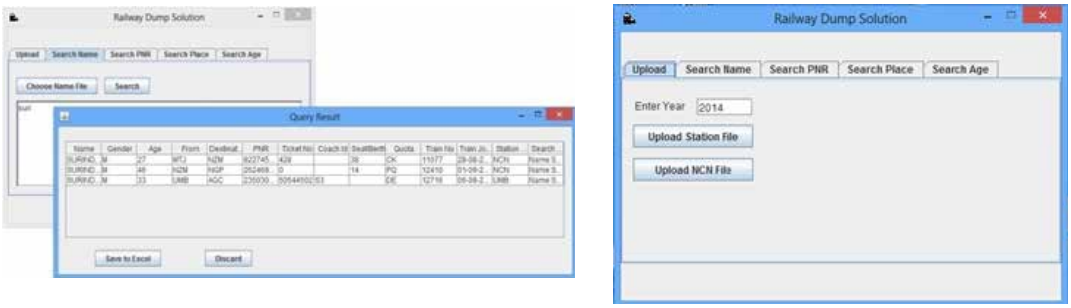
Figure 7: Visitor Location Register

Figure 8: Reported Incident Details of VLR

Analysis of Passenger Reservation dump

It is often observed that many criminals also travel using reserved tickets. A module is designed to analyze the passenger dump of the train in which any crime incident is reported. The reservation data of the train on incident date is requisitioned from railway department and uploaded onto the system. Based on the master list created by GRP, suspect names based on the previous records supported by other information such as boarding and ending stations, age etc., the system shortlists the suspected criminals who travelled in that train and provides clues for investigations (Figure 9). This information is passed through the CDR and VLR analysis modules for further pinpointing the criminals.

Figure 9: Passenger Reservation Dump Analysis



Results and Conclusion

The system is still under evolution and other investigative approaches are being built into it. The testing of the explained approach has been done in some cases and has been found very efficient and quick. It is found that Geospatial technology is a very powerful tool for carrying out spatial analysis and trend studies. Using this aspect in Crime Investigation is new and unique. M P Council of Science and Technology and Madhya Pradesh GRP are co-developing the methodology of an efficient geospatial enabled crime investigation system, which will help in providing a substantial support to railway passengers towards their safe travel. This system is being designed for scalability in other states to further improve its efficacy.

Sandeep Goyal & Maithili Sharan Gupta

4

INFRASTRUCTURE

Geospatial Data Modelling for Creation of Web-Portal Services for Industrial and Infrastructure Development under GOiPLUS in Odisha

SUMMARY

Land is one of the most important factors in economic development today and must be managed well to enhance socioeconomic conditions of communities. Government departments, industrialists and business communities are facing difficulties to implement their development plans because of shortage of appropriate lands.

In the present paper geo-informatics, ICT and space technology inputs used to create the Web-GIS based Odisha Land Bank for industrial development, and compensatory afforestation is elaborated. High resolution ortho-images, geo-referenced digital cadastral datasets, NIC Bhulekh RoR data, satellite derived spatial datasets and attribute datasets of industry department were seamlessly put together to create the Web-GIS based interactive portal for Odisha Industry information and Land Bank services.

A prospective investor can define preferred parameters such as the district, size of land required, facilities available in the vicinity, etc. based on which the portal identifies and returns information regarding the suitable and available land parcels in the State. It also provides a host of other information to enable an investor to decide on suitable location for investment based on the proposed business activities.

The system is of great use to state decision makers and being extensively used by officials of state besides, industry, academia and public.

Introduction

In order to implement the development plans for societal benefits and economic development, several government agencies are trying hard to create a pool of suitable lands for operational use as per the development need. In a bid to attract investment and ensure hassle-free land acquisition for major projects, the Odisha government decided to create land banks for industrial development. The state-owned Industrial Infrastructure Development Corporation of Odisha (IDCO), assigned to work for infrastructure development for different industrial projects, created land banks for 2.4 lakh Acres out of which 95,000 Acres are web-hosted for information of stakeholders. With land acquisition posing a major hurdle in rapid industrialization, technological interventions are made to identify 2.4 lakh acres suitable for industrialisation and to develop a land bank of 100,000 acres as a key initiative for development of industrial infrastructure in Odisha. The solutions provided on the context of above requirement are described in this paper. In the present paper, efficacy of technologies like geo-informatics, ICT and space imaging are elaborated to highlight the database management concepts for creation of Web-GIS based Odisha Land Bank for industrial development and compensatory afforestation.

High resolution ortho-images, geo-referenced digital cadastral datasets, NIC Bhu-lekh RoR data, satellite derived spatial datasets and attribute datasets of industry department are used to create the Web-GIS Odisha Industry information and Land Bank, which is web-hosted in public domain for use by all stakeholders interactively under GOiPLUS (Govt. of Odisha Industrial Portal for Land Use and Services). Revenue cadastral maps are used as base maps. The shape files of cadastral maps and digitised RoR data are used for identification of plots. Clustering was made considering its shape, size, landuse, location, physiograpghy, morphology, connectivity and contiguous nature. Ortho-rectified Cartosat 2.5m and World-View 0.5 m data are used to geo-reference the cadastral maps of the entire state. Land Bank cluster maps are prepared in revenue scale in digital dwg and shp format. Multisource data are used to generate data on infrastructure such as landuse, power supply transmission, electric Substations, transportation corridors, rail-road-port-air connectivity; social Infrastructure like schools, colleges, hotels, medical facilities, technical Institutions, police stations, fire stations and bank/ATM etc; physical themes like forests (RF/PF), habitations, surface water along with administrative zones and industrial activities.

Figure 1: Screenshot of GOiPLUS portal

Objectives

- Application of Geo-ICT, GIS, Space applications and web-technology to provide Land Bank related centralized database service to decision makers, administrators, investors, planners and common public.
- Creating digital database of "Land Bank" for investors information along with options of data supply about developed facilities, services, utilities, infrastructure and amenities around the identified land clusters.
- Provide information along with spatial and attribute data to potential investors for new ventures through GOiPLUS.
- To put industrial information in public domain in a spatial format for the access and appreciation of common citizen.

Scope of GOiPLUS Service

- GOiPLUS is a web enabled platform to provide investor friendly services. The portal is accessible through gis.investodisha.org
- Provides information on Land Bank of Odisha. It maps the existing land parcels and its status along with a query analysis that provide a glimpse of developed infrastructure.
- Database of industrial land use and infrastructure along with social infrastructure facilities.
- Provides a spatial relationship between industrial clusters and infrastructure and other amenities through an overlay of attributes that measures the suitability of industrial development.
- Creating inventory and prioritise industrial land utilization to provide strategic direction to industrial and economic development.

Database used

Component	Attributes	Source data
Land Bank Clusters	1. Geo-coded cadastral level plot boundaries,	1. Cartosat 2.5 and Wordview 0.5m/ Revenue maps
	2. Size of land parcels land bank clusters	2. 1:4000 cadastral maps
	3. Infrastructure/ amenities/ services around Land Bank	3. SIS-DP 1:10,000 maps
Infrastructure	4. Surface water	4. SIS-DP 1:10,000 maps
	5. Power supply- Transmission & distribution	5. SOI topodata 1:50,000
	6. Electric substations	6. SOI topodata/ Google image

Transportation	7. Transport Corridors National & State Highways/ Other major roads Rail Networks/ Rly stations Port connectivity	7. SIS-DP 1:10,000 maps/ 1:4000 ORSAC urban landuse maps
Social Infrastructure	8. Schools Colleges Hotels Medicals facilities Bank/ATM	8. ODISHA SAMPAD 1:50000 data/ Google image/ Wikimapia/ Bing maps
	9. Technical Institutions Police stations Fire stations	9. ODISHA SAMPAD 1:50,000 data/SOI topodata 1:50,000
Environmental attributes	10. Rivers/ Waterbody	10. SIS-DP 1:10,000 maps
	11. Forests (RF/PF) habitations	11. ODISHA SAMPAD 1:50,000 data/ SOI topodata 1:50,000
Administrative zones	12.Settlement locations/ village/ Gram Panchayat/Tahsil/Block/ District	12. ODISHA SAMPAD 1:50,000 data/ SOI topodata 1:50,000

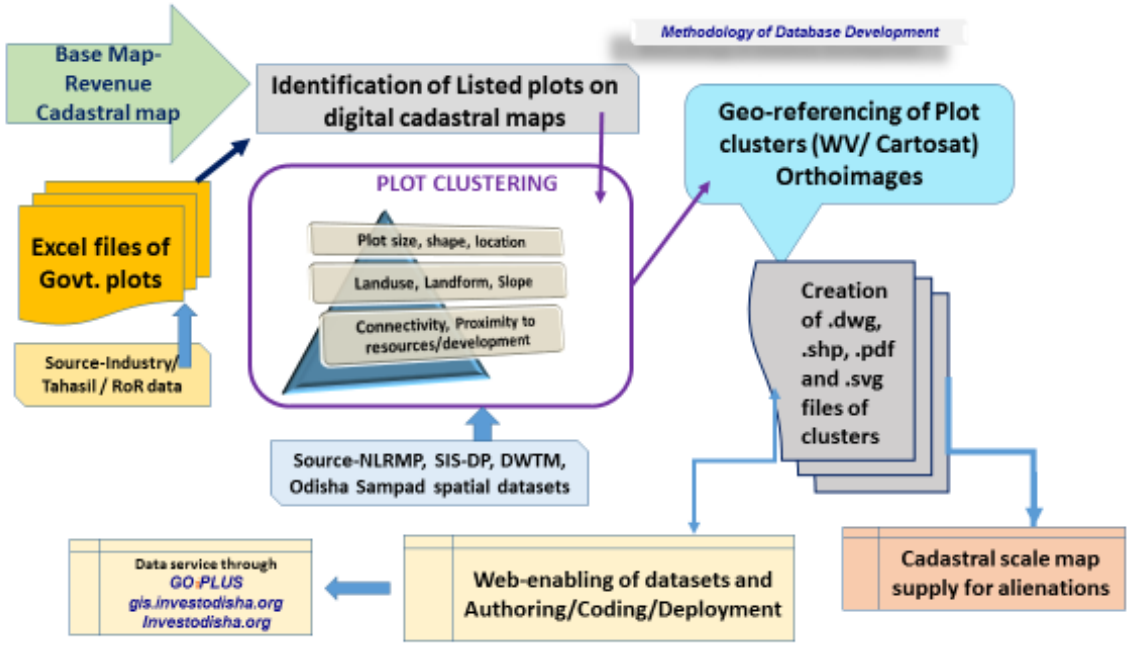
Methodology

Sequence of activities followed to develop the Web-GIS application is as follows.

Development of Land Bank maps and data tables

Revenue cadastral maps are used as base maps. Initially the plots are listed considering its government ownership as excel files by Tahasil/Industries Dept. The listed plots are identified on cadastral maps. The shape files of cadastral maps and digitised RoR data are used for identification of plots. Clustering was made considering its shape, size, landuse, location, physiograpghy, morphology, connectivity and contiguous nature. Ortho-rectified Cartosat 2.5m and World-View 0.5 m data are used to geo-reference the plot clusters. Land Bank cluster maps are prepared in revenue scale in digital dwg and shp format. Schematic diagram of the methodology followed is given in Fig below:

Figure 2: Schematic process diagram



Development Aspects

Map Authoring

The portal contains 37 layers of information in one geo-coded format which have facilitated creation of different types of maps catering to different types of user requirements such as IndustryInfo Map Document (.mxd), Administrative Map document (.mxd), Network Infra map Document and others.

Map Publishing

Maps Prepared are published in ArcGIS server, So that authored maps can be accessed via URL.

Database Preparedness

Industrial Data in Excel format entered in Oracle Database via Oracle SQl Developer software using Import tool.

Coding

Software used includes Visual studio, HTML 5, Dojo Libraries. The site is developed on widget Programming pattern. All the tools are developed separately from its interface design and finally bound together to work as a unit. Website is programmed in such a way that widget codes are hidden from the user.

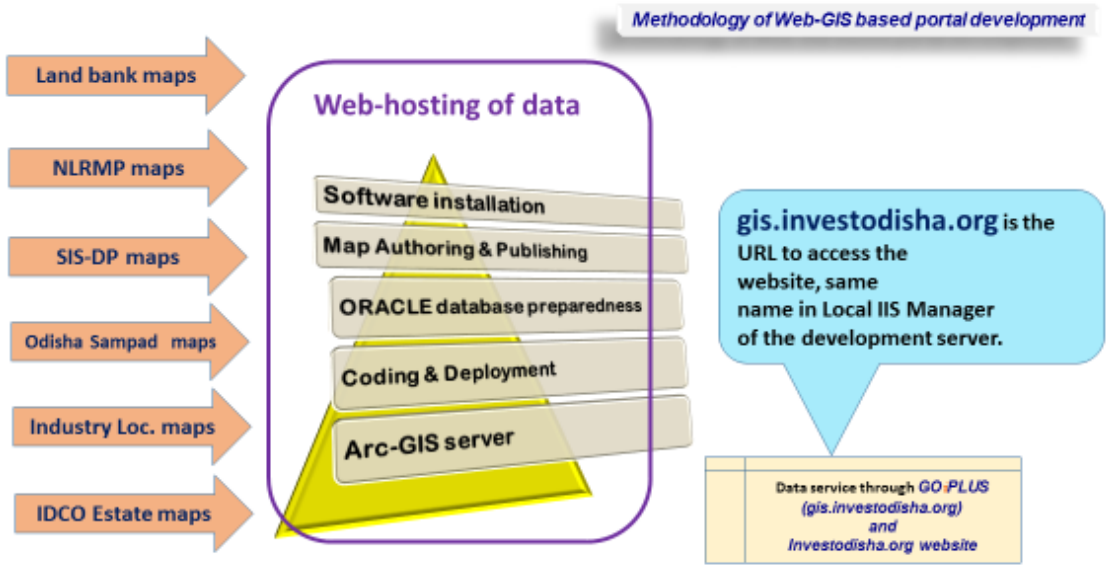
Deployment

As map services are accessed via URL, same public IP is used in URL in the code to make it accessible globally. Gis.investodisha.org is the URL to access the website. Therefore one directory with the same name has been created in Local IIS Manager of the development server. Domain name (gis.investodisha.org) is bound to the Public IP which is given to the development server. If user hits the gis.investodisha.org, it redirects the request to the public IP i.e. Development server, and to understand the request directory gis.investodisha.org has been created on Development server.

Navigation to GOiPLUS

The website www.investodisha.org is user friendly and assists with options in drop down menu and one can easily navigate to site under GOiPLUS.

Figure 3: Developmental methodology



Results, Developed database and Services

A. Outputs generated

- Land Bank clusters identified and mapped for 2.4 lakh hectares in 22 districts of the state.
- Land Bank map, data and land schedule for 95000 Acres are made available in public domain.
- GIS database of 106 industrial Estates, industry location maps and database of sector specific cluster development are made available.
- Information of industries inside and outside industrial estates are provided through the portal.
- Web-Based GOiPLUS is available in public domain and under operational use by various stakeholders.

B. Significant achievements

- To prepare outputs for the project, the cadastral maps of the entire state are digitised, coded, standardise and geo-referenced with ortho-images of the entire Odisha.
- Multisource data are used to generate data on landuse, network infrastructure and social infrastructure of the state.
- Integrating multi-source and multi-scale data in GIS environment starting from 1:50000, 25000, 12500, 4000 and 2000 scale.
- The system provides detailed information pertaining to land with regards to availability of industries, plots under land bank cluster and location specific attributes in terms of connectivity, linkages and availability of other utilities, amenities and services.
- Significantly under this project query based spatial and attribute search and information extraction is provided in web-portal in public domain for benefits of all types of stakeholders.

C. Data service through Website: some screen shots

Figure 4: Land Bank map/data services

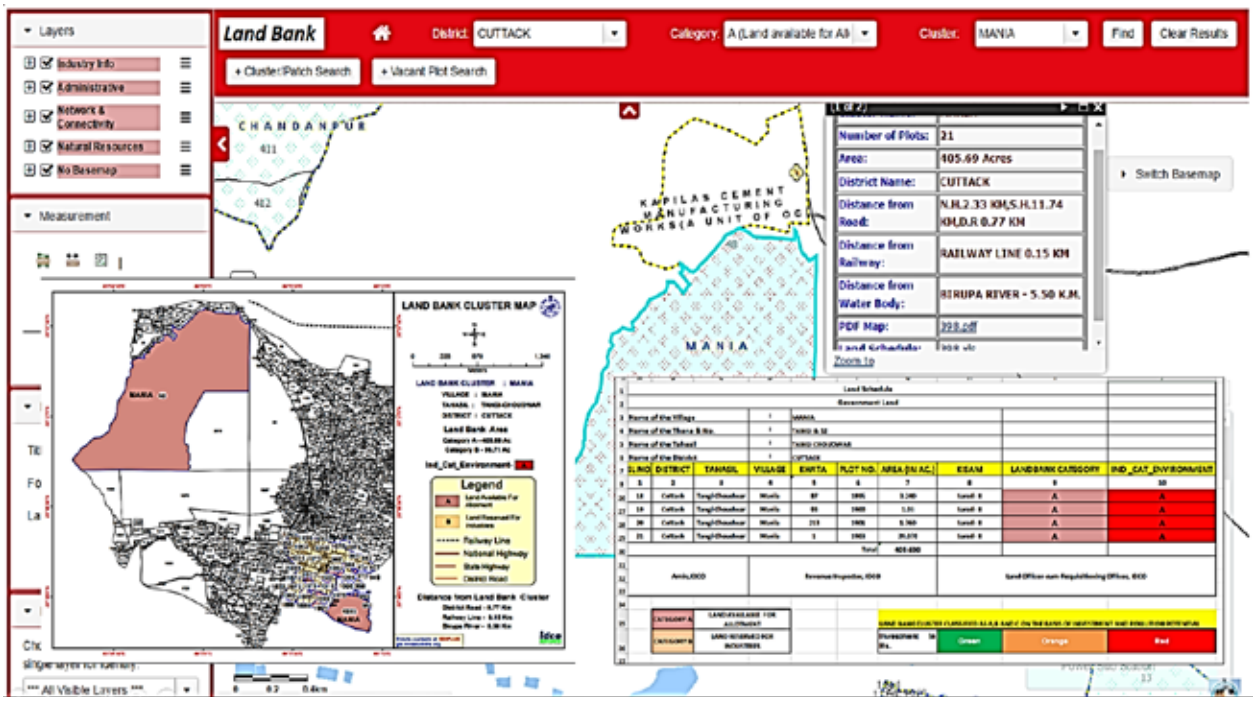


Figure 5: Utility search around Land Bank

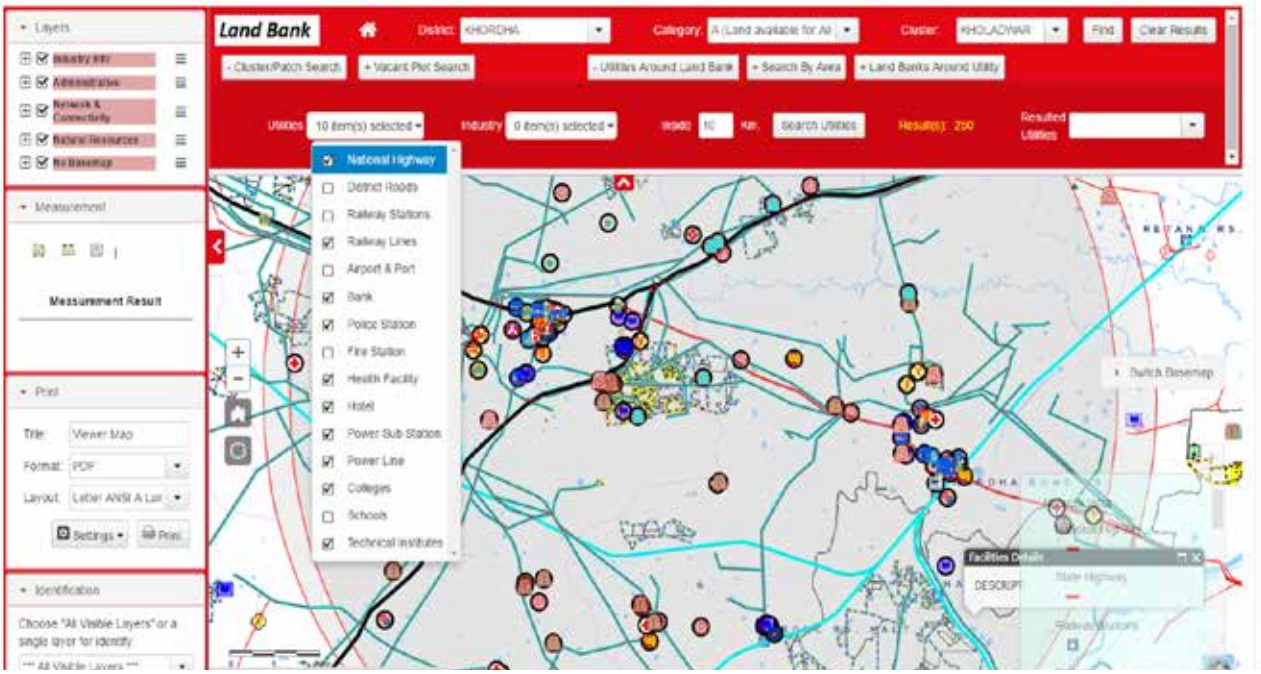


Figure 6: Land Bank search around utilities

Figure 7: Land Bank search in Industry cluster/sector zones

Conclusion

GOiPLUS developed using multiple geospatial datasets provides detailed information pertaining to land with regards to availability of industries, plots under land bank cluster and location specific attributes in terms of connectivity, linkages and availability of other utilities, amenities and services. Through the System, a prospective investor can get information not only about land availability but also the key attributes of existing industries operational in that area such as sector of operation, products, capacity, employment, raw material linkages etc. It provides a spatial relationship between industrial clusters and infrastructure and other amenities through an overlay of attributes that measures the suitability of industrial development. Web-based development is made to provide information through query mode on appropriate amenities and facilities close to the land bank cluster and proposed business activity which the investors can rely in deciding a particular location. It maps the existing land parcels and its status along with a query analysis that provide a glimpse of developed infrastructure and competitive efficiency in the movement of goods and products. It provides inputs for smart growth strategies and policy framework. The application is utilized in creating inventory and prioritise industrial land utilization to provide strategic direction to industrial and economic development. The database provides critical information in the decision making process and planning for future industrial developments in the state.

Acknowledgement

Project Team

Project Coordinator:- Dr. Debajit Mishra
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Sponsoring Agency/Advisor: –Sri Sanjeev Chopra, IAS, Principal Secretary
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Sri Kalyan Mohanty, GM; Sri Rajiv Dhal,DGM of IPICOL, Dept. of Industries, Govt. of Odisha
Sri S.Mohanty, CGM (Land), Sri P.Nayak CGM (MSME) of IDCO Dept. of Industries, Govt. of Odisha

Odisha Space Applications Centre and Department of Industries, Government of Odisha

Integrating UAVs in Social Research: Summary of a Successful Pilot Study

Introduction

A significant portion of Outline India's work is conducted in rural parts of India which are either unavailable on Google Maps or lack geo-spatial details. Intermittent or lack of connectivity along with outdated satellite images escalates the problem. The geo-referenced aerial and 3D maps, created with the help of drones offer a technologically advanced solution to aid social science research, implementation programmes undertaken by the government and other stakeholders. Moreover, this can be fed into the existing Google database to add value and improve our current understanding of the landscape and infrastructure.

To explore the potential of geospatial data and the use of geospatial technology in social research, a pilot study was undertaken at Bhora Khurd, a village situated in Manesar tehsil of Haryana. The intention was to understand the technical feasibility, scalability and gauge challenges that may arise in the process. While drones were used to produce detailed images along with elevation profile of the geographical space, a household level survey was conducted alongside to geo-reference granular-level information collected on-ground. Due permissions from the local Police Thana and the Village Sarpanch were taken for conducting the study.

Objectives of the Study

- To understand demographic and socio-economic profile of the village, spatially.
- To study the availability of and access to basic infrastructure services (including healthcare, education, water and sanitation).
- To establish correlations, between social stratification and access to basic resources, and infrastructure.
- To identify demographic variances spatially and identify priority intervention areas.

Research Methodology

The first objective was to profile the village spatially through transect walks, aerial mapping using UAVs while taking down the geo-coordinates of community infrastructure, resources, unutilized spaces, waste lands, disposal grounds and so on.

This was followed by mapping and identifying population distribution, demographic and socio-economic attributes along with other household level information to obtain granular data. An in-depth interview was conducted with the Village Sarpanch to gather an overall understanding of social governance of the community, with an emphasis on general issues.

During the survey, 107 household were selected through random sampling to assess the socio-economic profile of the members, their access to basic infrastructural services and their perceptions of major problems in the village.

The GPS coordinates of the surveyed households were also recorded using tablets to feed into the GIS dataset. One must note that the accuracy level of geo points recorded using tablets ranges between 0-30 meters, while aerially produced maps and KMZ (Key Hole Markup Language) datasets are accurate to the range of 5-20 cms.

Findings

Demographic profile

- Bhora Khurd village has 324 houses (Census 2011) and is divided into two residential clusters – Bhora Khurd and Dhani Khurd with a population of 1495 and 524 respectively. Schedule Caste (SC) constitutes 25.90 % of total population in Bhora Khurd village.

Figure 1: Ground images obtained through UAVs reveal on-ground nuances in comparison to satellite images

Figure 2: Complete UAV image reproduced on Google Earth

- Sampled households plotted on the geo-referenced aerial maps indicate that the households are distributed along caste lines. While upper and dominant caste households were scattered across the village, lower castes occupied a cluster commonly referred to as SC colony (SIC), in the south-eastern part of the residential area.

Basic Infrastructural Provisions

- **School**: There is a middle school in Bhora Khurd and a Primary School in Dhani Khurd. On an average, the households reported to have 1 child in the age group of 6 to 18 years, all of whom were enrolled in a school/college. Since there is no upper primary or secondary school in Bhora Khurd, the parents are forced to send the children to a private school after 8th standard. The middle school in Bhora Khurd is well maintained, with separate toilets for boys and girls and drinking water taps. Sidhrawali, located 3 km away from the village, has a degree college, secondary school and a private school.
- **Anganwadi Centre:** Both the residential clusters, Bhora Khurd and Dhani Khurd, have an Anganwadi centre each. However, in Bhora Khurd cluster, the building for Anganwadi has not been constructed and they operate out of rented premises. 73% of the children in the age group of 6 to 18 years in the sampled households have received vaccination such as polio, TB, hepatitis etc.
- **Healthcare**: There is no public dispensary or health centre in the village, and the nearest government hospital is in Sidhrawali which is 3 kms away. Consequently, 50% of the households reported that they consult an unqualified practitioner for primary health issues and 32% consult a private qualified doctor. Merely 16% of the households reported that they approach a government health facility.
- **Water**: 66% of the sampled households have piped water connection inside the household, and 18% collect water from pipelines/piped water points outside the household. 15% of the households use a mechanically or a manually drilled deep bore well for their water needs.

- **Sanitation:** At 86%, majority of households reported that they have a toilet within their household. Among those who do not have an individual household latrine, 80% defecate in the open, while rest use their neighbour's or relative's household toilet.
- **Solid waste disposal:** Household waste is generally discarded in pits lining the agricultural land, or designated areas in the agricultural land by households which own land. 21 out of the 107 sampled households reported disposing waste in open land, and out of those, most of them do not own agricultural land and belong to lower caste households (kumhar, harijan and valmiki). Animal waste is generally dried and used as fuel or fodder.
- **Electricity**: All households have government supplied electricity connection but have reported frequent power cuts. On an average, there is a power cut of 8 to 9 hours every day.

Problems Reported

- 71 households reported improper water drainage and 38 households reported lack of general cleanliness and unavailability of dustbins for waste disposal. These are some of the major problem faced by the village.
- The study also found that there is no dedicated building for Panchayat meetings since the land allotted is swampy, soiled with animal waste. This was visually evident during aerial mapping as well.
- Further, due to improper drainage leading to accumulation of waste water, the households reported to have suffered from common water borne diseases like Typhoid, Diarrhoea, Chikungunya and Malaria in the past three months.
- Lack of public transport from the village, unavailability of the public health center and frequent power cuts were some of the other problems stated by the village households.

Topographical Profile

The elevation differences in the village area, which are significant in geological terms, are crucial for understanding the drainage failure in the village, and for providing evidentiary explanations behind water accumulation at certain points.

Figure 3: Topographical Profile

Elevation Profile from Point A to Point B:
Depicts drop in elevation and clustering of lower caste households

Elevation Profile from Point C to Point D:
Depicts elevation gain in the centre by 2.75 m and distribution of dominant caste households

The elevation profiles of the Bhora Khurd residential area reveals the following:

- In general, the elevation around the perimeter of the residential cluster is 238-240 metres above sea level which is lower than that in the centre. For example, the elevation of the southern perimeter is 238 metres above sea level. The elevation gain from south-west corner to the centre of the village is 2.75 metres, with elevation at the centre ranging from 241 to 243 metres above sea level.
- As expected, the areas where drainage water is accumulated are at a lower elevation, ranging from 238 metres above sea level to 241 metres above sea level.
- The topographical profiles were also compared with demographic distribution of the households. The south-eastern part of the residential area where lower castes are clustered is at a lower elevation (240 metres above sea level) and witnesses frequent accumulation of drainage water, hinting at a more systematically-entrenched form of discrimination (Figure 3).

Significance of the Study and the Way Forward

As indicated above, absence of proper drainage system and failure of existing drainage lines due to uneven topography of the village area emerged as one of the most apparent problems in the village. The population distribution is based on the social stratification of the village and the location of the lower caste households is at a topographically disadvantaged area as compared to the upper castes or the dominant castes.

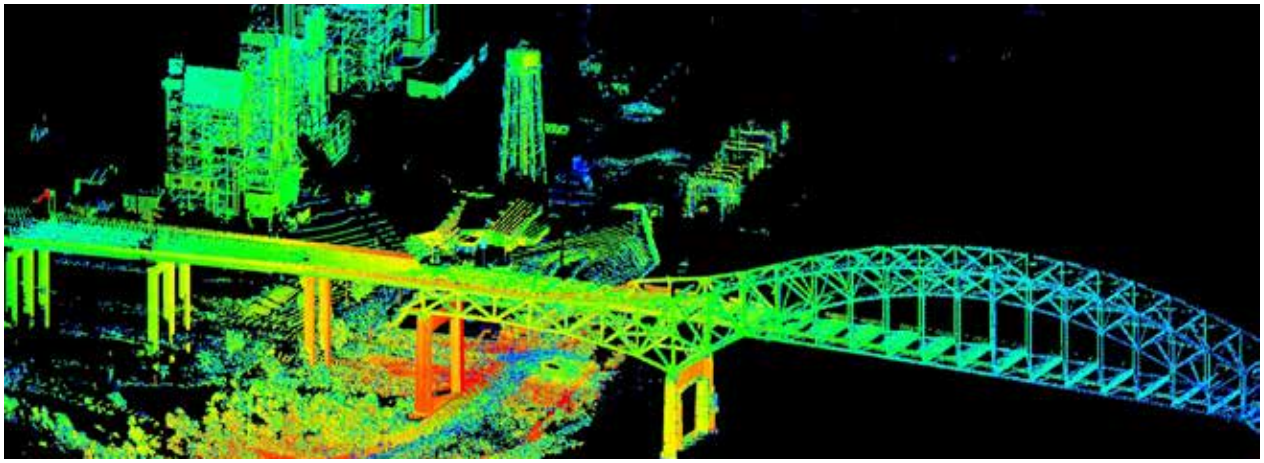
However, the Sarpanch had not been able to get a Gram Development Plan approved for fixing the drainage system or utilising the common land in absence of conclusive proof. The map provided by the Patwari which depicted land distribution in the village, did not include details on the elevation or the actual and real-time use of the land.

Evidentiary proof of failure of drainage system owing to the area's elevation profile which was captured through geo-referenced aerial maps (KMZ files) and orthophotos in this study was shared with the Village Sarpanch along with demographic distribution and analysis of data collected from households on access and availability of basic infrastructure resources. This helped the authorities in identifying and visualising priority areas for development plans. With the help of the compelling report and visual evidence the Block Development Officer would take the necessary steps such as levelling of land.

The intention of this was to work in partnership with local authorities and state governments in order to propel on-ground work through effective policy measures. The challenge remains in scaling the use of UAV technology owing to the ethical considerations and the legalities centred on gathering geo-spatial data. However, with the ability to integrate on-ground insights and operationalize the information through the effective use of geo-spatial technology will change the way evidence-based policy is current practiced. Inaccessible geographies which remain beyond the purview of door-to-door enumeration can now be gauged, mapped and produced on visual platforms to understand resource oriented gaps and eventually lead to better governance.

Mahima Taneja, Samayita Ghosh & Nishmeet Singh

Innovative use of LiDAR Technology for Smart City Surveillance



SUMMARY

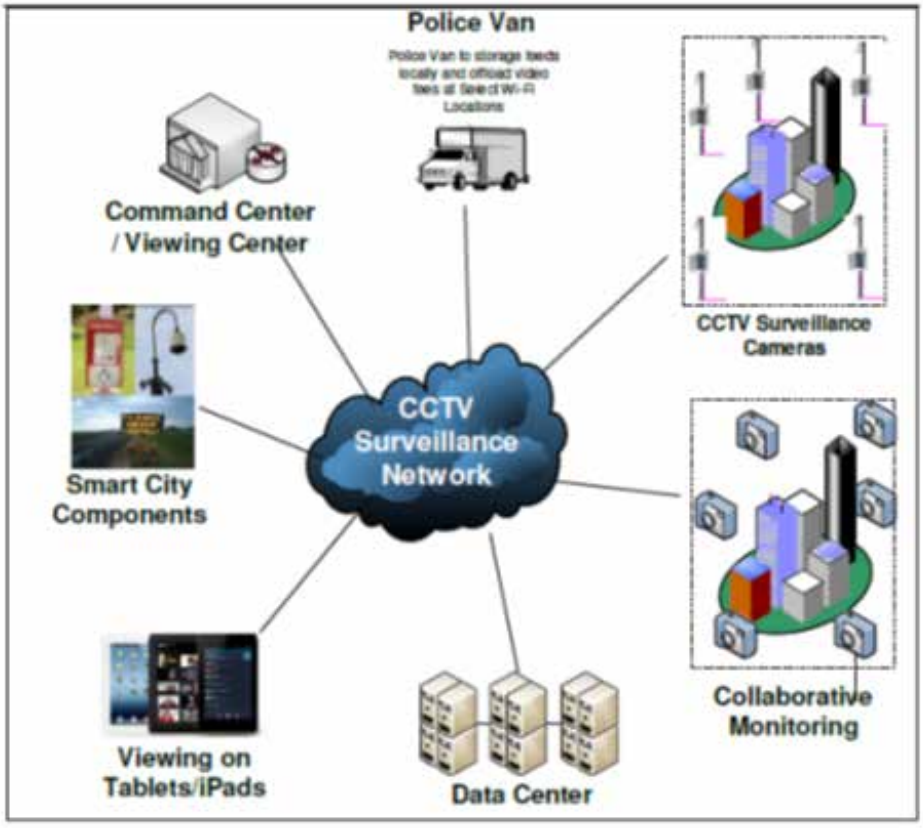
Genesys International developed innovative solutions based on LIDAR technology for safety and security planning in Smart Cities. As a part of the project implementation in one of the smart city in India which is implementing CCTV based surveillance system, Genesys provided the required feasibility tool with 3D models of the real-world objects. These models were derived from LIDAR datasets, for view-shed / blind-spot analysis with respect to various camera locations, positions and angles. Genesys International deployed advanced Mobile LiDAR technology to solve the problem with high spatial accuracy and executed the project faster than any conventional methods. The results are used not only for project planning but also for Project Implementation and As-Built Design updates. Besides, the spatial data comes as a base-line ground reality "As-is" for Smart City command and control center operations.

Introduction

In simplistic definition, 'Smart City' is a city equipped with basic infrastructure to give a decent quality of life, a clean and sustainable environment through application of smart solutions. The term 'Surveillance' relates to monitoring the behavior, activities, or other changing information, usually of people or any mobile assets for the purpose of influencing, managing, directing, or protecting them such as observation from a distance by means of electronic equipment (such as CCTV cameras). Surveillance is used by governments for gathering intelligence, prevention of crime, protection of a process, person, group or object, or for the investigation of any crime.

Traffic cameras installed in city road intersections plays an important role in accident reduction and accident prevention. The feeds from the cameras are normally viewed in the control and monitoring centers by traffic police personnel and operators. It helps to detect the traffic rule violators, identify the vehicle number and register complaints with time stamped documentary evidences for legal procession, if needed. Determination of the actual height and view angle of the cameras (for assessing Line of sight) to detect the pedestrians and vehicles plying in the roads is essential. Earlier the activity of ascertaining the view-shed of the CCTV cameras used to be based on the human judgment on the field. With the advent of the LiDAR technology this activity is done

Figure 1: CCTV Surveillance Network



scientifically. The present paper describes a real-world case study highlighting the methodology and its benefits.

Traffic cameras are normally installed in important Chowks, Traffic Junctions, Entry and Exit points of the City / Toll Nakas, Railway Station Entry/Exit, important road stretches (accident prone areas), entry/exit roads of schools and hospitals, key residential localities , market places, jetties and near other critical installations in the city. As industry standard practice, the coverage area per camera should be such that there is optimal number of cameras designed in a manner that the entire area be covered i.e. there should be no surveillance blind spots. The images captured by the cameras should such that the farthest point should be recognizable and all faces and objects are identifiable in the control centre.

Scope: Road junction survey using LiDAR technology for preparation of 2D Propagation Drawings in 250x250 meter grid with 50 meter inner grid for Junctions drawings in .DWG and PDF format.

Technology: Topcon IP-S2 Mobile Mapping Systems coupled with 360°spherical images registered with high-accuracy LIDAR Point Clouds

Methodology

Van Data Collection (VDC): In the process the vehicle mounted with the TOPCON IP-S2 LiDAR mapping system was used to collect the spatial features. Base station was set at an appropriate location from the

area of interest (junctions) to be surveyed. The surveyed/ captured data from LiDAR system had millions of point clouds and each point of the cloud data being represented with accurate X,Y,Z details w.r.t. base station. Among these cloud points appropriate point cloud data were considered as reference points. A plan was kept in place to finalize the region to be covered and therein defining the route that needed to be taken. Once the routes were defined, different vehicles were deployed across different regions in the city for data collection. The data collected was then sent to Genesys Production floor in Mumbai for bulk data processing.

Figure 2: Mobile LiDAR Mapping System

Data Processing: Verification and inventory of data received for Bulk Processing determines the completeness of the data. The received data was then added in a MDB to track all the trajectories received till date. Trajectories were splitted grid wise with a standard measurement of Intra 1.0 K.M. for allotment purpose. After completion of grid creation by cutting the trajectories, data processing team released the Grid & trajectory wise details to production team to initiate feature extraction.

LiDAR Feature Extraction: Feature extraction was carried out using customized softwares such as "Spatial Factory" and ArcGIS desktop tools. Features were extracted from LiDAR and Pano datasets only. Features which were obscured due to Parked Vehicles, Vehicular movement, Tree Cover could not be extracted. In this project process, no foot survey procedure was conducted to capture the data on field.

Deliverables: All the Junctions identified by the client were delivered in 250 Meter radius as per the shared Lat/Longs in AutoCAD & PDF formats. Accuracy of 10 to 25 cm for 1:1000 scale map / drawing has been achieved for the output. A GIS Application integrated with map data and 360-degree Pano data – Junction Viewer was provided along with the user manual.

Figure 3: CCTV Junction Viewer Tool

POINT FEATURES		
Airport	Electric Cabinet	Hospital
ATM	Electric Pole	Hotel
Bank	Existing OFC Marker	HT Tower
Bridge	Field Bund	Industry
BT Road (Asphalt)	Fire Hydrant	Kilometer Stone
Bus Stand	Fire Station	Manhole (Others)
Bush	Gasline Marker	Mosque
CC Road	Gate	Open Space
Church	Garss Footpath	Petrol Bunk
College/ University	Gravel Road	Pit (Others)
Culvert	Gurudwara	Police Station
Direction	Handhole (Others)	Railway Crossing
Railway Station	Telecom Tower (Others)	Tile Footpath
Road Devider	Telephone Cabinet	Tiles Path
Road under Rly. Bridge	Telephone pole	Traffic Signal Pole
Row of trees	Temple	Transformer
School	Theatre	Tree Guard
Trees	Water Bodies	Well/Bore

Usage

Road junction survey using LiDAR technology for preparation of 2D propagation drawings in 250x250 meter grid with 50 meter inner grid for Junction drawings in .DWG and PDF format is the requirement of every smart city wherein CCTV cameras are planned to be installed across different sensitive spots. Integration of data into a GIS based 3D visual platform combined with point cloud serves the operators with integrated picture. Genesys applied Mobile LiDAR Survey (MLS) for acquiring accurate street level building profile data to meet accuracy expectations and the acquired MLS data supplemented with high resolution panoramic imagery resulted in a rich GIS data set empowering the security planners, implementation engineers and contractors in their decision making and execution abilities via accurate drawings. The As-built data and underlying point cloud data along with street level panoramic images become the foundation as authentic visual data for command and control center operations. Data can measured in 3D, enabling users to experience and work directly in real-world conditions by viewing and planning on desktop based environment.

Accomplishments and Benefits

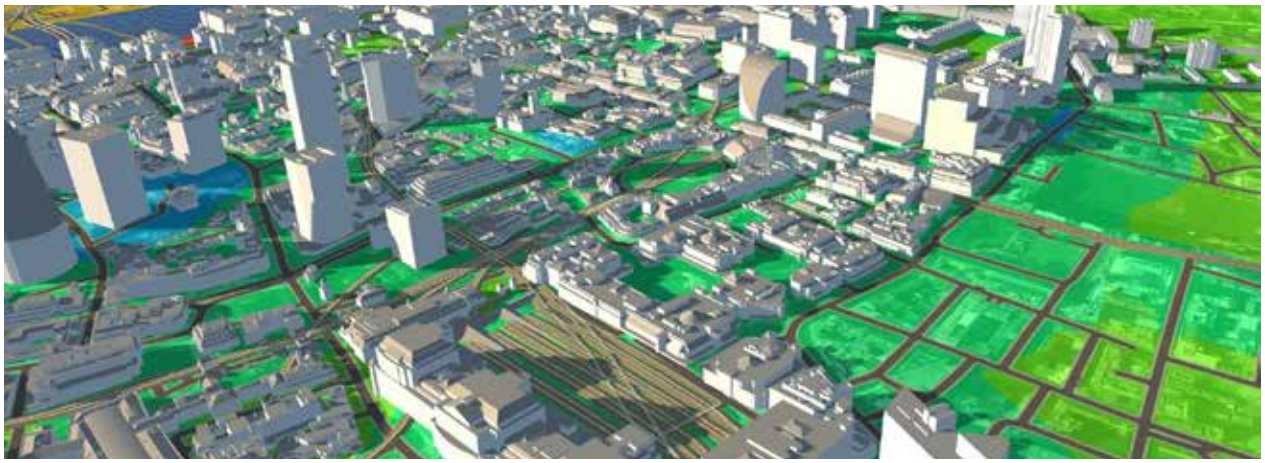
Genesys developed a scientific method for camera visibility analysis using LiDAR datasets. Feasibility tool for CCTV Surveillance helps in Iterative view-shed / blind-spot analysis for various camera position/angle. It is useful for effective analysis of CCTV system for complete coverage. The client can access 3D LiDAR point cloud + 360 degree panoramic data in both desktop and web environment. Additionally, As-Built drawings are used for planning and management. The visual data can be integrated into command and control system. It also brings fast turnaround time and costs saving in overall project execution

Way forward

The Smart city planners, decision makers, consultants and System Integrators can leverage the power of LiDAR data and Junction Viewer tools for mapping the Junctions in the city which will help them to place the CCTV cameras in strategic and optimum height and angle to derive maximum benefits. This will help also help them to execute the project faster in a cost effective manner.

Aniruddha Roy

eLoc: India's First National Digital Address System



Indian organisations and citizens are challenged with the inconsistencies of our address systems. This leads to frustration, wastage of time and resources in serving customers and citizens in both urban and rural India. Therefore, for any business, government or an individual to operate successfully, the identification of an address is critical.

Need for a Simple, Ready-to-Use and Precise National Digital Address System

India has an address system that identifies houses, building, places, government offices, businesses etc. but very few parts of our country have a formal address. And to add to this the varied dialects, languages, culture and other differences across India, the situation becomes mind-boggling – each individual reads and interprets an address differently. What is required is a simple, standardized and precise pan-India digital address system, what Aadhaar has done for the individuals identification, this system will do for the addresses. It identifies a place, building, business, apartment etc. and can be linked to various attributes (like floor, door number, etc.) as per the requirement as well as with Aadhaar.

Introducing eLoc by MapmyIndia

Wouldn't life be so much easier if you could say, "Come to, KYYJTG." Instead of, "436, Block Bd, Sector 1, Bidhan Nagar, West Bengal. From the yellow building come straight and take a right when you see…"

Now, there is an eLoc for every address across India. This overcomes the complexity and hassles of providing multi-line, often misspelled addresses across both formal and informal address systems.

eLoc – What is it?

eLoc is a 6 character code – a unique identifier that precisely locates any address. We have already generated more than 2 crore eLocs and this number is growing every day. These eLocs cover both urban and rural India and are ready-to-use.

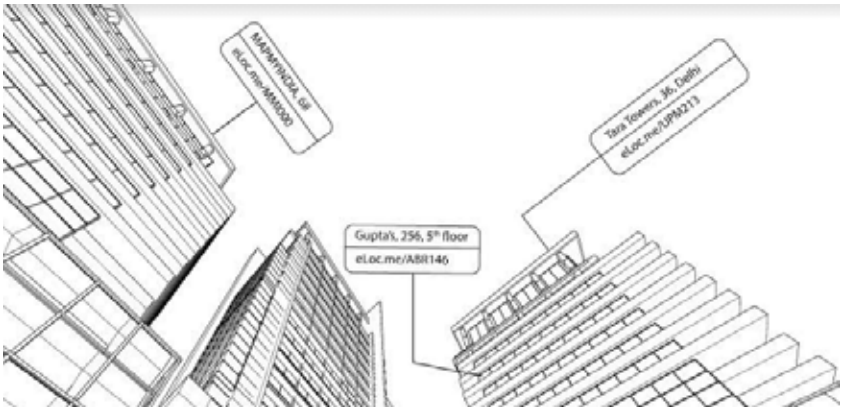


Figure 1: A business can have an eLoc, a building can have an eLoc and even a floor within that building also can have an eLoc

Why should you start using eLoc today?

There are 3 strategic competitive advantages to using eLoc over existing address systems in India.

1. It is simple

eLoc converts any address into simple 6 easy-to-remember characters. (Eg. MMI000) As a customer, you can gain freedom from having to remember, type, tell or search for long, complex Indian addresses and confusing naming systems. Sharing the location or map of any place, door-to-door navigation, doorstep delivery, taxi pick-up and drop, governance & administration down to property level is now easier and more powerful with India's first nationwide digital address system.

2. It is precise

Another game changing feature of eLoc is that it is precise to the doorstep or entry point. You can see any place accurately on the map, reach its doorstep without getting lost or needing to ask for direction in the last mile and get more information about the place, including reviews, neighbourhood amenities, photos, etc. While other businesses with higher inaccuracy let you down at the last minute leading to excessive wastage of time and resources. eLoc, on the other hand, will take you to the exact doorstep making you more efficient, smarter and happier.

3. It is ready-to-use and free

In line with its mission to make India better using maps & location technologies, MapmyIndia has taken the decision to make eLoc free for its current ready-to-use 2 crore and counting eLocs. The eLocs cover more places (properties, flats, buildings, residences, houses, offices, businesses, tourist points of interest, villages, localities, cities, roads, etc.) across urban and rural India than any other public or private provider. Use MapmyIndia's app, partner with eLoc and integrate MapmyIndia's APIs to enjoy the immense benefits of eLoc.

How can you find your eLoc?

1. Go to eloc.me
2. Search for an address
3. And find the unique digital address or eLoc

Use this to search for places, directions and great locations nearby.

If you cannot find an address or eLoc, create it at by adding a place!

What can you do with an eLoc ID?

1. Put it as a business card
2. Share it on your social & professional networks
3. Soon you might be asked to share for home deliveries
4. Soon you will be able to navigate to any eLoc using MapmyIndia App and NaviMaps (offline navigation app)

The Power of eLoc for Business

eLoc provides unprecedented input into decision-making because each eLoc unlocks 100s of attributes specific to an exact address. Each eLoc is a repository of rich location data that acts as a gateway for the most powerful location intelligence available in India. This provides hitherto unparalleled access to actionable intelligence and inputs into decision support systems for Smarter Businesses. eLoc is a critical input for decision support systems for businesses of any scale. This enables businesses to:

1. Provide quicker response times to customer requests;
2. Location based targeting;
3. Improve ease of reachability/ Doorstep delivery etc. – eLoc makes sure we take you to the entry points of the place, building, house-number, etc. It is a game-changing step when it comes to last-mile delivery and its implications are huge in terms of money and time saving.
4. Smarter Analytics.

eLoc for Government: Governance at your Doorstep

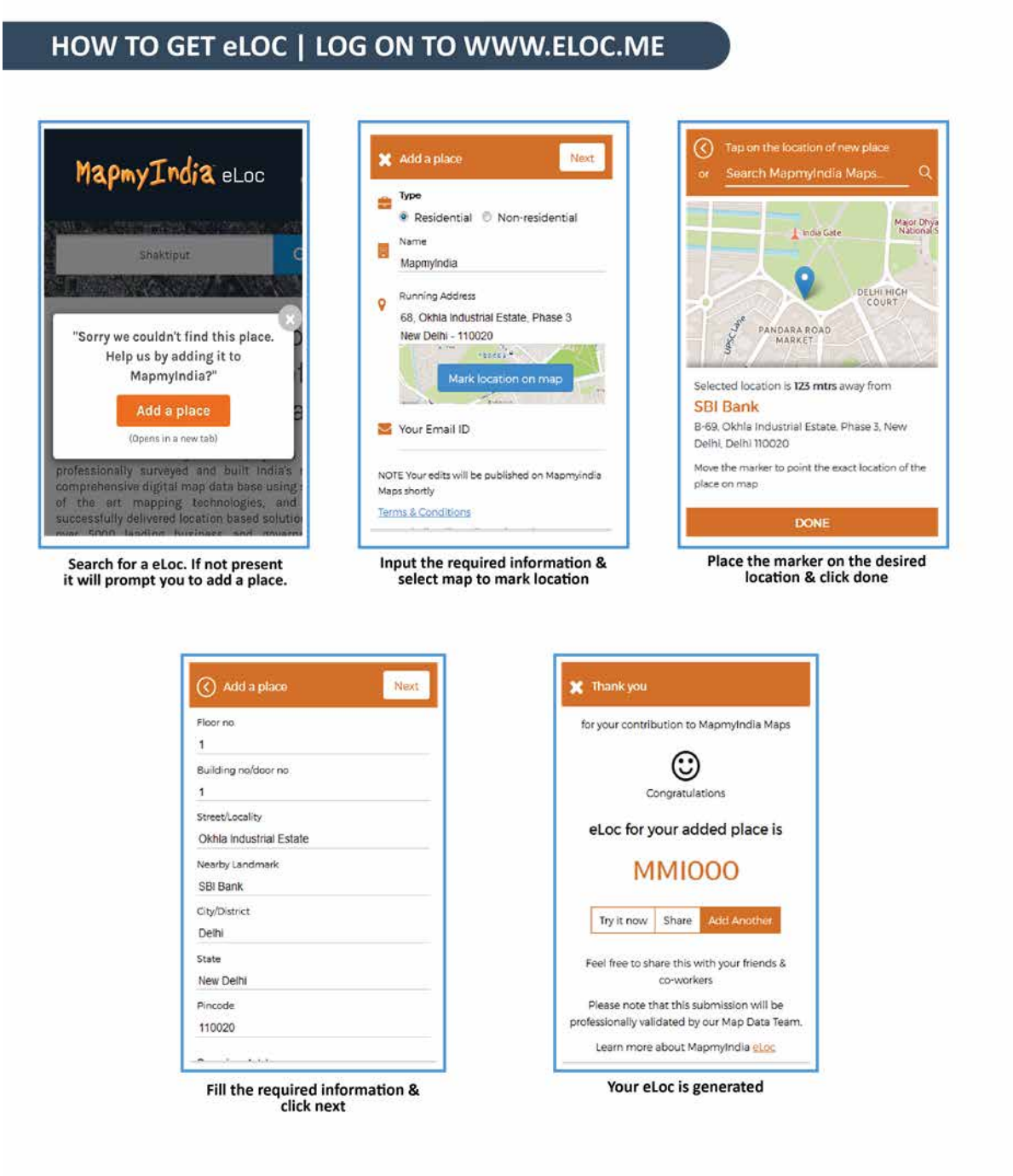
eLoc provides governments with unparalleled visibility and access to formal and informal addresses across the nation. This enables governments to

1. Provide quicker response times for disaster management & relief operations
2. Improve targeting and thereby improved delivery of citizen services -
3. Transform cities into Smarter Cities by providing better planning for amenities and properties - Combine powerful location information with contextual information for a successful property and other business compliances

As part of MapmyIndia's mission to make the world better through maps and location technologies eLoc is the latest offering from the company. Founded in 1992, MapmyIndia is India's leader in premium quality digital map data, APIs, GPS navigation, tracking, location apps, and GIS solutions.

Free eLoc APIs are available in the public domain to integrate this information and apply in various smart business apps, consumer apps, e-commerce apps, taxi aggregator apps, smart city apps with valuable information like Aadhaar, KYC, etc.

Figure 1: How to get eLOC



Rohan Verma

5

NATURAL RESOURCES

Mapping Technologies help Indigenous Communities Preserve access to Water Resources and Biodiversity

SUMMARY

Keystone Foundation's mission is to improve the lives of indigenous communities while conserving the natural environment and sustainable access to water sources. Achieving this mission requires detailed information about the communities served and the areas in which they live. Keystone uses Geospatial Information Systems (GIS), data and mapping to gather and analyse a library of information and build action plans to preserve water resources and biodiversity. It has used mapping technologies to support initiatives that protect springs and wetlands; promote sustainable livelihoods; help indigenous people gain title to traditional lands; and improve access to water for 4,000 families.

Introduction

Most people would not necessarily associate GIS with protecting water access, but in the Nilgiris mountain region of southern India, the former is helping preserve the latter. GIS and other mapping technologies are helping to ensure that indigenous people in the region have sustainable access to the water that has sustained their communities for generations.

Keystone Foundation is integral to this effort. Keystone is a non-governmental organisation (NGO) that works to improve the environmental conditions, protect access to water and biodiversity in the Nilgiris Biosphere Reserve, with the ultimate goal of enhancing quality of life for all who live there. A key focus of this initiative is access to local water sources, which has been a long-standing issue for indigenous communities. Changes in land use, dwindling forest cover, and the introduction of chemical fertilisers and pesticides posed a growing challenge to the local communities, their water supplies and the mountains in which they lived. Since 1993, Keystone has worked with an eco-development approach to improve people's lives while preserving the natural environment, in this case, with a special focus on the springs and wetlands in the Nilgiris Biosphere Reserve. Over the last two decades Keystone has adopted new technologies to do its work more effectively. Key among these tools are GIS data and mapping systems such as Google Earth.

Usage

Preserving indigenous communities, their ways of life and their access to water requires a deep understanding of the physical environment. It also depends upon recognising and respecting the differences of indigenous peoples from mainstream society. One of the most basic differences is the principle of land ownership. Many indigenous communities do not have a history of individually owned land and water resources. Due to historical factors, including life under colonial rule, the land and water near them may be owned and governed by a patchwork of government agencies and private owners. This often makes it difficult to launch projects aimed at preserving land, water resources and biodiversity. Keystone had to find a way to get a better picture of land and water ownership.

Conservation, protecting water resources and sustainable economic development require that you know in precise detail information about the land, water and biodiversity. For instance, a single habitation may have land under cultivation falling in forest, revenue or private ownership. However, there is neither an easily accessible dataset that has this data, nor is it shown on any map. On a national scale, some information of this type is available via India biodiversity portal. The data doesn't exist at the local level, however, and is particularly scarce when it comes to water resources. The toposheets of the Survey of India are the most commonly used data source, although at a scale of 1:50,000 these are not detailed enough for use at a village level.

Keystone set out to solve this problem with a new innovative approach, as previous solutions were imprecise at best. In the past, staff gathered the information by hand. They went into the field to interview local individuals, then manually built maps on chart paper. Someone who lived in the area might draw a map on the ground using sticks, and a staff member would transfer the drawing to a slightly more sophisticated hand-drawn map. This process, though suitable in a context of low literacy, resulted in errors. It relied on people's interpretations of the geography and the free hand drawings were not to scale, making it difficult to integrate with other thematic data.

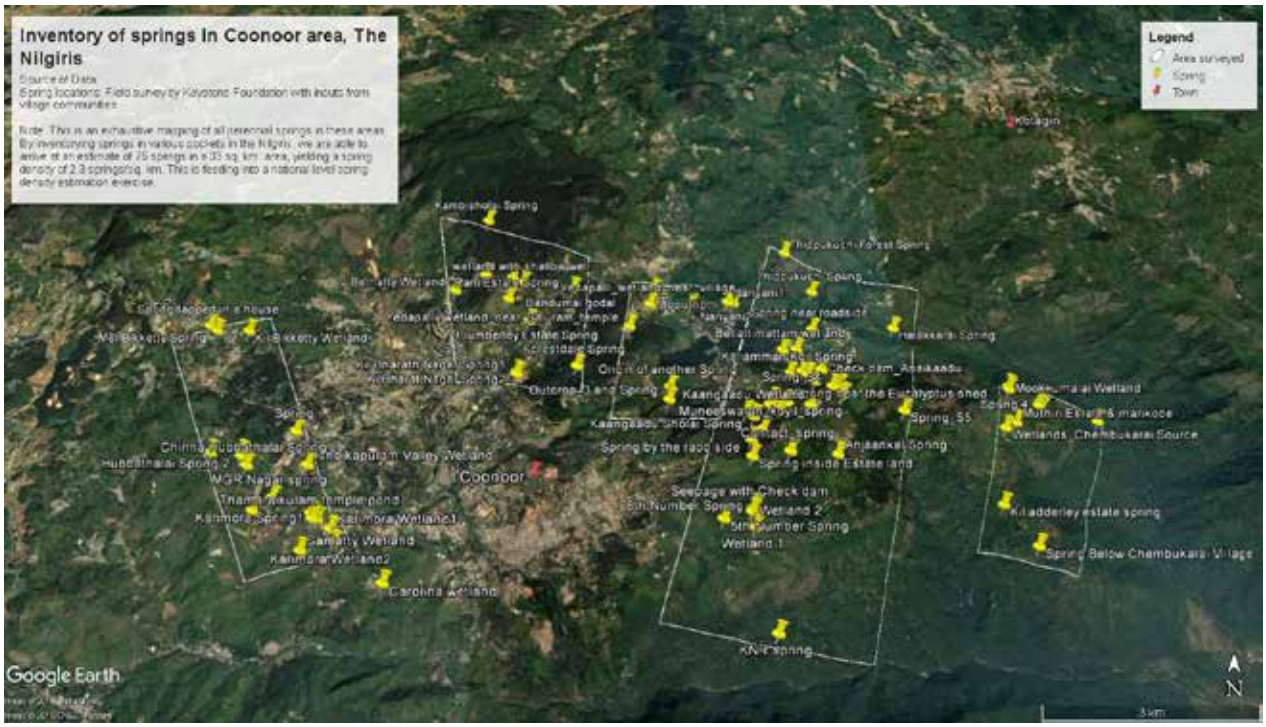
GPS and GIS mapping changed this manual approach and introduced a level of precision to Keystone's mapping efforts. Keystone now uses GPS capabilities of Android phones and tablets as well as handheld GPS units to create highly detailed and localised maps. Community members and volunteers are trained to use GPS and Open Data Kit forms to gather data about their surroundings. The team uses GIS to layer data onto those maps, including information about water resources, land use and ownership, biodiversity, wildlife movement and human wildlife interactions. The data is still generated by the community, but is leveraging the accuracy and convenience afforded by technology.

Using the maps and the data they display, Keystone launches projects for a variety of campaigns related to water access, biodiversity, conservation and land & water use. For example, Keystone is one of the groups involved in 'Save the Western Ghats movement'. The Western Ghats is a mountain range that runs parallel to India's western coast, a UNESCO World Heritage Site and one of the most biologically diverse areas in the world. The movement aims to stop deforestation and protect the Western Ghats' unique ecosystem, including its rivers and reservoirs.

In 2010, Keystone created a map to support discussions and interactions around the state of development and environment in the Western Ghats during the meetings of the movement members. The map included national, state and district boundaries, state capitals, major rivers and reservoirs, mining projects, major power plants, populations of tribal people and protected areas, crowdsourced from partners in the movement and other open sources. The foundation also built a 3D flythrough of the Western Ghats that helped in visualisation of ecological issues in the region. The maps and flythrough were designed to highlight the environmental threats faced by the Western Ghats, as well as the geopolitical and social influences on the area.

Keystone relies on these types of maps and GIS for one of its largest water-resources projects, under the Springs Initiative. Supported by the charitable foundation Arghyam, with technical support from the non-profit Advanced Center for Water Resources Development and Management (ACWADAM), Pune, this initiative is designed to conserve springs across India and protect local communities' access to water. India has more than a million springs that serve as safe sources of drinking water for rural and urban communities. Springs are the sole water source for many people in the hilly regions of India. As one of the partners in the Springs Initiative implementing this idea in the NBR, the foundation, with support from community volunteers, mapped these springs and is creating a first-of-its-kind atlas of the region that includes details about each spring in the region.

Figure 1: This map shows an inventory of springs in the Coonoor area



The Springs Initiative promotes awareness of the importance of springs, and protects 'springsheds', the ecosystems around springs, across India. Protecting springs can help ensure water security and improve the management of land and water resources. Changing land use, ecological degradation, exploitation of natural resources and climate change are cutting down on the number of springs and the amount of water that flows through them.

Although many Indian communities rely on springs, they have no inventory of water resources. As a result, the springs are not always properly monitored and protected. Springs do not exist by themselves; they are intimately tied to the surrounding countryside and wetlands.

Keystone creates maps that show, in detail, the ways in which springs are endangered by changes in the countryside near them. For example, a spring may dry up when new developments nearby pump too much groundwater from wells. In other instances, Keystone's maps have illustrated how sewage upstream endangers springs and wetlands downstream or how agricultural runoff pollutes groundwater that feeds springs. Based on these maps, communities and government can take actions to protect the springs.

By mapping springs and their surrounding areas, Keystone is working with communities to improve their shared understanding and management of springs. From policy analysis and social surveys, to collection of flow data and research, they are building a unique knowledge base for these vital resources, which in turn will lead to their protection. Undertaking these activities as part of the Springs Initiative helps Keystone gain from the experiences of other partners as well as providing scale to this effort for a national level impact.

Keystone has spent years studying, mapping and preserving water resources in the Nilgiris while better understanding the connection between local communities and the water that sustains them. Traditionally, villages and families have cared for and maintained their water resources.

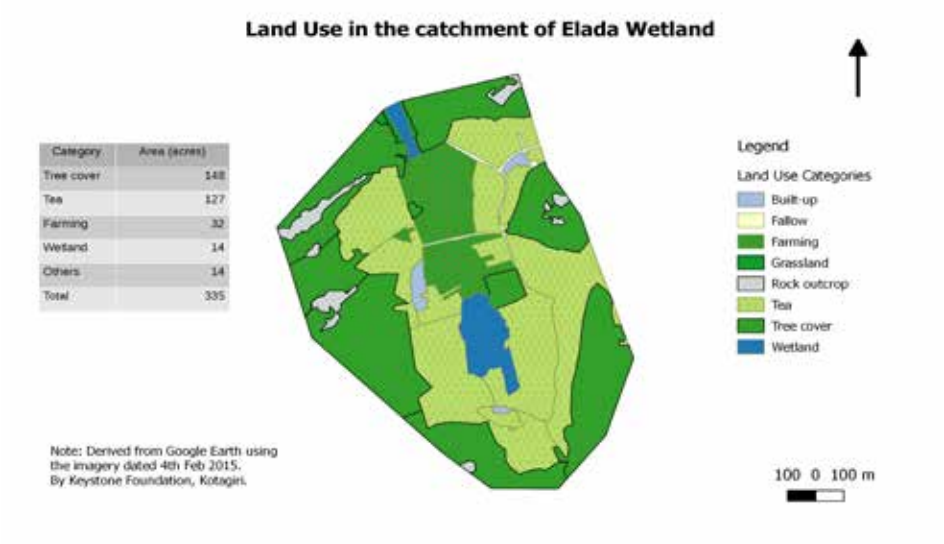
The Badaga settlements, mainly on hill tops, have depended on upper spring sources, which are considered pure. They are protected and worshipped once a year in a ritual called the Halla Paruva (Water Worship), done before the Northeastern monsoon in order to get abundant rainfall during the season. In most Badaga villages, water underground has been protected for drinking water. It is a sacred place where outsiders are not allowed. As the springs dried up and demand for water increased, Badagas have had to depend on sources below them in the valley for their drinking water. Indigenous communities in the region have had traditions linked to water, and each community worships or practices rituals linked to water sources such as springs, wetlands or streams.

Throughout Nilgiris, families had maintained water channels between sources and settlements by removing blockages and desilting. It was a community effort in which everyone took responsibility for the water system. But the government introduced piped-in water, and took control of the water channels. Now only a few people do the work, not the entire community. Today, the government water supply is often insufficient in summer.

The communities' traditional connections with water sources has eroded over time as the government took responsibility for the water supply. As settlements grow and demand for water resources grow, there is a disconnect between people and their sources of water. Bottled water and tanker water are increasingly used. But overuse of water resources combined with uncertain rainfall is making that unsustainable.

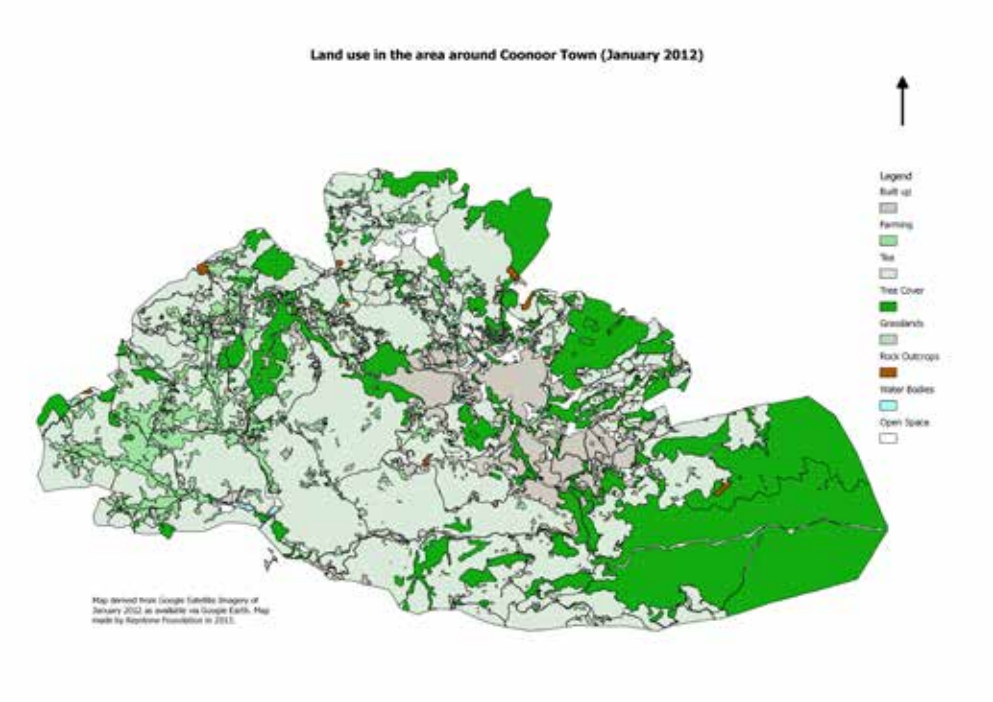
Using mapping technology and Google Earth, Keystone has been working to provide better access to sustainable water resources. The foundation is currently studying the Elada wetland, an important source of water for Kotagiri, a town in the Nilgiris. In 2016, as the wetland dried up and the water supply dwindled Keystone investigated the problem. It mapped the wetland area as well as its catchment, and examined historical satellite imagery to see changes over time. Doing so, we uncovered the cause of the problem. Another wetland in the catchment that feeds the Elada wetland and dam has not been managed properly and may be gradually shrinking because of the encroachment of exotic plants, among other factors. This wetland is within a private tea estate. Armed with that knowledge, the community and local government can undertake eco-restoration as well as soil water conservation measures in order to conserve their water source.

Figure 2: This imagery, based on mapping data, shows land use in the Elada wetlands



Maps created by Keystone show that land management and water supply affect one another. The foundation created maps for the Coonoor region in the Nilgiris on which it overlaid crucial data such as land use patterns and the watershed boundaries of small streams. It used that data to run models that show how land use affects water quality. The information is being used to better plan land use.

Figure 3: A map of land use around Coonoor



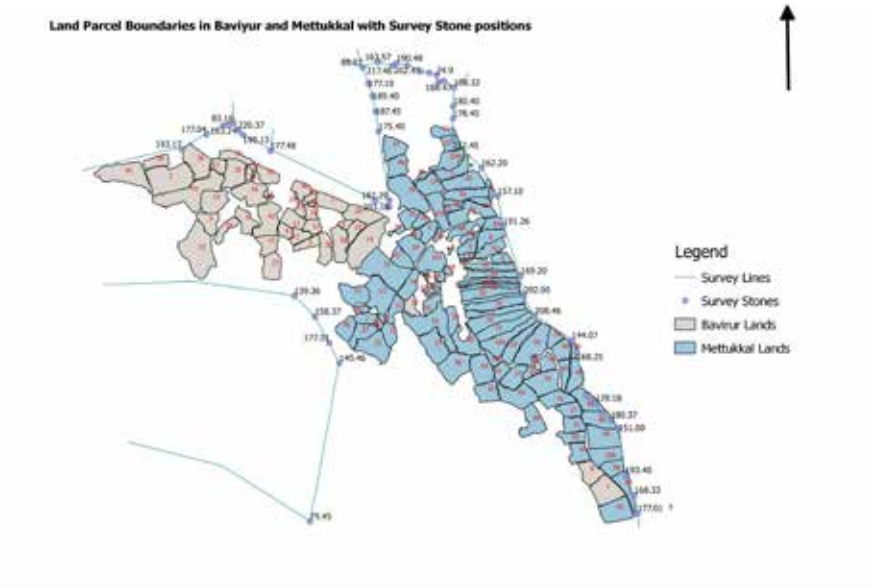
Keystone is also helping with one of the most serious problems facing indigenous communities. Many do not have undisputed titles to their land. These Particularly Vulnerable Tribal Groups, as they are classified, have traditionally accessed large areas of forests to gather non-timber forest produce and other items for their needs. Much of the land in the Nilgiris is owned by the government or private businesses that own tea and coffee estates. In many cases, it is unclear who owns the land the indigenous people have been accessing for generations, and the only record that exists is in the fading memories of elderly indigenous people who live there, knowledge which would have been passed down to them by their parents.

Until a decade ago, many of the indigenous communities were considered encroachers on the lands they had been using for centuries. The Forest Rights Act changed that by providing for titles to indigenous communities and forest dwellers to land they had been individually cultivating and using collectively. Before any claims could be filed, however, the land had to be surveyed and accurate maps prepared marking the boundaries of land parcels.

The matter of filing was complicated by the fact that land names and landmarks referred to by indigenous communities do not match those used by the government. Even more challenging is that the official boundaries cannot be found in a single government office and are instead spread out among multiple departments.

Keystone tried to solve this problem by using geotagging to demarcate government boundaries. The staff then combined those geotags with scanned-in government maps and high-resolution satellite imagery. They created a map with a layer showing government boundary markers. Community volunteers then used handheld GPS devices to record the boundaries of every indigenous plot claimed under the Forest Rights Act. The result is an accurate map that can be used by indigenous communities to file claims for their land.

Figure 4: Maps like this can be used to help indigenous communities file land claims



Keystone has worked with two villages to prepare claims in this way. The claims were filed in 2015 but the titles have not yet been awarded as there was a long standing stay in the High Court that prevented this. With the lifting of the stay in 2015, if the claims succeed, the foundation will use the same technique to help other communities claim land under the act. This model could be used across India to help indigenous communities file claims for their ancestral lands.

Keystone uses GIS for a number of other purposes to support indigenous communities. They map incidents in which people have lost crops, livestock, housing, and even their lives in conflicts with wildlife. These maps help people understand wildlife behavior patterns, mitigate incidents of conflict and support people's claims for compensation from the government by documenting the damage they have suffered. Keystone has also mapped the sacred groves of local communities, including individual trees of species considered holy. This helps increase awareness about the status of the groves and trees and helps monitor their health over time. There are a group of barefoot ecologists, community volunteers who are trained in the scientific method of assessing biodiversity, who are collecting this data periodically and helping their communities and other stakeholders in conserving the forests.

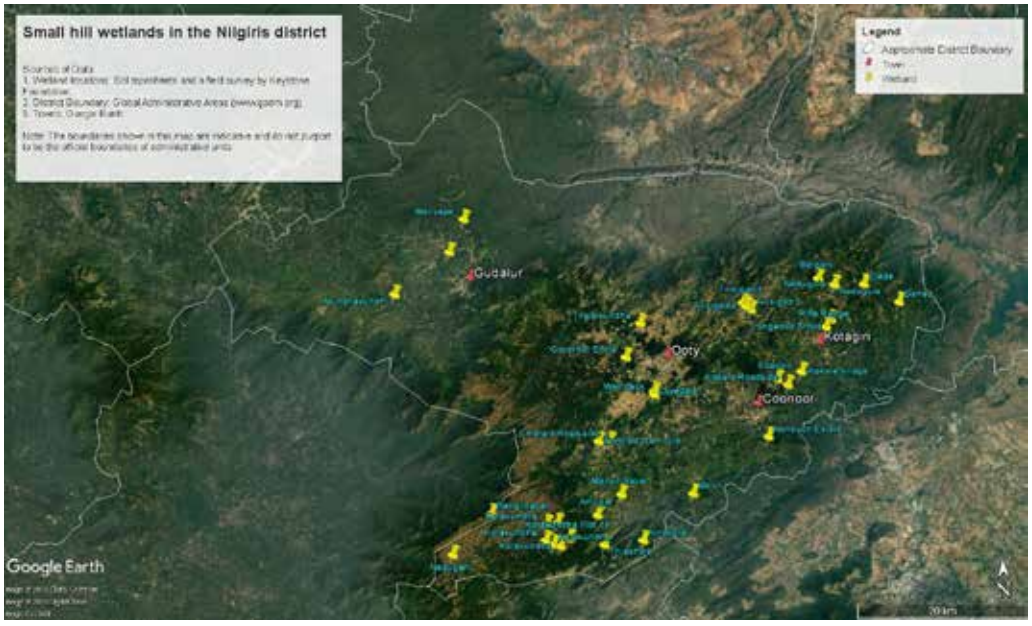
In addition, Keystone uses maps to identify fallow lands and support farming there to strengthen traditional organic millet cultivation. Mapping the land helps analyze aspects such as why it went fallow, whether there is available water nearby and the movement of wildlife across it. Using that information, Keystone can help communities turn the land to productive use.

Results and Benefits

Keystone has achieved significant results, including saving springs, protecting wetlands, and is helping indigenous communities gain title to their traditional lands. There have been other benefits as well. In a number of communities, testing water samples from springs has shown the presence of faecal contamination. Mapping the nearby wetlands and springsheds revealed the source of contamination and is helping the communities mitigate health risks. In several instances, the Springs Initiative found that one village's sewage or septage had contaminated the spring of downstream villages. Open defecation, a common practice in some regions, is a major contributing factor to this contamination. Mapping open defecation areas helps highlight the pathways to contamination and stop them.

Beyond the Springs Initiative, in the Nilgiris 40 important wetlands were identified and information about them mapped. Water management plans based on the maps were recommended for several wetlands and shared with the district administration. As a result, key wetland water resources were saved from hazardous developments.

Figure 5: A map of the wetlands in the Nilgiris district



Keystone has also partnered with the Kotagiri Town Panchayat to undertake eco-restoration efforts on one acre of common land, based on its mapping efforts. Over the last decade, the patch of land has grown into a small native forest that improved water availability and purity in the area. Even during times of water crises, the spring continues to provide safe drinking water to thousands of families living downstream.

The Way Forward

Keystone plans to continually expand its use of maps. It is looking at using mapping and data to improve urban sanitation, protect forests and agricultural and water resources. Over the last two decades, Keystone has invested significantly in building the capacity of community volunteers and leaders to handle various aspects of ecodevelopment. It has bought Android tablets and trained community volunteers to use the devices' built-in GPS and cameras to collect data from the field and create maps. Keystone hopes the communities themselves can monitor their environment by proactively using mapping tools.

Keystone is planning to use Google Earth Engine to document changes in land and water use and land cover over time to examine the impact of its sustainable forest use initiatives. This will help the foundation better gauge its effectiveness and make changes to improve its work. Keystone is also developing a resource center to train and support other agencies, institutions and individuals to use mapping tools to better understand their surroundings. Keystone hopes to popularise the use of Google Earth, ODK, QGIS, and other free tools and open data formats among civil society as well as the government in India.

Countless problems, particularly those revolving around access to water, can be solved using mapping information. In many countries, including the United States, the availability of mapping data is taken for granted because the government, non-profit organisations and watchdog groups are involved in it. But that information is harder to come by in India. The government has only recently embraced an open data policy and hopefully this will ease the data availability situation in the coming years. Keystone has found that maps, GIS and data are liberating tools, and they are trying to make them available to everyone. Keystone hopes to use maps to protect access to water, indigenous communities, the environment and biodiversity, so that India and the whole world will be better for it.

Acknowledgements

The author would like to acknowledge the Indigenous and other communities in the Nilgiri Biosphere Reserve with whom Keystone has been working in partnership since 1993 and which forms the basis of the stories being shared here. We are also indebted to many agencies and individuals in this journey including The Swallows, Department for International Development (DfID), Winrock International India, International Union for Conservation of Nature (IUCN), Critical Ecosystem Partnership Fund, Taru Leading Edge, Sálim Ali Centre for Ornithology and Natural History (SACON), Cornell University, Arghyam, Advanced Center for Water Resources Development and Management (ACWADAM), India Natural Resources Economics and Management Foundation, Springs Initiative, The Save Western Ghats Movement, Google Earth Outreach, the state government of Tamil Nadu, District administrations in the Nilgiri Biosphere Reserve, Municipality of Coonoor and Town and Village Panchayats. Acknowledgements are due to colleagues at Keystone who have been involved in the work which formed the basis for these stories, particularly Pratim Roy, Founder Director, Keystone Foundation, the inspiring presence driving our work on water, among other programmes. I would also like to acknowledge the work of Mohan Raj, Senthil Prasad and Gokul Halan in applying mapping technologies within Keystone over the last two decades. Thanks are also due to the Bateman Group for their assistance in writing this case study.

This case study is dedicated to the memory of B Babu, who worked with us on many of the interventions shared here and who passed away in November 2016.

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- http://nilgiriswaterportal.in and its archived version at http://nilgirihillswater.pantoto.org/nilgiri/
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T. Balachander

Sujal - NRW Management for Jalgaon Municipal Council

SUMMARY

Maharashtra Sujal Nirmal Abhiyan (MSNA) is a reform led program. The program aims at achieving 24x7 water supplies as per the central government guidelines with a focus on water conservation. It includes a scope of accountability mechanism like theft, leakages and to promote the judicious and equitable distribution of available water to all consumers while extending the access of water to all the residents in the ULB. Parameters for improvement include the intra-city equitable distribution of water with desirable level quality, Non Revenue Water (NRW) within acceptable limits, optimal cost of service provision, improved service level and functionality of metering etc.

Jalgaon Municipal Council called for tenders to conduct audit of system, to know the present technical & commercial efficiency of the existing water supply system. This includes various sub-works i.e. carrying out consumer survey, water audit, energy audit providing and installing flow meters, Geographic Information System (GIS) development & mapping, hydraulic modelling and computerized water billing & collection system for towns in the state.

Introduction

Potable water is not available in plenty and becoming scarce in nature; making it more demanding. More energy is required to pump water to long distances and from deeper depth in the ground. This is an alarming situation and ever increasing population is a warning to everybody to conserve & optimally use the available water resources.

Water as a resource, is an essential commodity, and has to be looked upon from demand as well as supply side. The urban local bodies, which are from the supply side, need to play a vital role in managing this scarce resource. As urbanization continues on a wide scale, it gets difficult for the local bodies to cost effectively while providing water to keep the cities operational. Further in the process of improving overall water system efficiency, energy & water consumption have to be viewed as associated inputs rather than viewing them as separate and unrelated. On the other hand, the demand side consists of consumers who have to be made aware of the present situation of the available water resources, the necessary habitual changes required to be made by adopting various means of water conservation, optimal use of available water, re-use and re-circulation of waste water for some activities.

Govt. of Maharashtra (GOM), which provides grant–in–aid and stands guarantee for the loans to the Urban Local bodies (ULBs) in the state for the water supply schemes, decided to take a close review of urban town water supply schemes on an emergency basis. Review of these potable water supply schemes revealed an unsatisfactory situation. In most of the water supply schemes, the expenditure is mainly on establishment and the activities like operation & maintenance, billing recovery, improvement to existing system had not been done properly resulting in heavy water losses due to water leakage, illegal connections, theft of water and loss of revenue. Moreover, Local bodies also lack requisite expertise in operation and maintenance of water supply schemes. In many cases the major cause in revenue loss of ULB is believed to be unaccounted water / energy losses in entire water supply system. GOM therefore decided to take urgent steps for improving the efficiency of the water supply system and the process took up "Sujal–Nirmal Abhiyan" project. The project basically aimed at up-gradation of water systems of small & medium towns in Maharashtra. This ULB improvement program included funding to various Municipal councils in the state to increase serviceability of the system.

Objective

- Achieving 24x7 water supplies as per the central government guidelines with emphasizing the focus on water conservation.
- Identify physical & revenue losses in system.
- To identify the action with cost benefit analysis.
- To ensure the end result & providing same to the end user while reducing operating costs, energy used per capita consumption.
- To advise concerned authority in the tendering process for procurement of equipments/machinery requirement in the pumping stations.

The project was designed considering 30 years (as design periods) to include three phases

Table 1: Phases under Jalgaon Water Scheme

PHASE I	PHASE II	PHASE III
Consumer Survey	24X7 Pilots	24x7 Systems
GIS Mapping	80% Metering	100% Metering
Water Audit	collection efficiency 80%	collection efficiency 100%
Energy Audit	Creating MIS	100% O&M
Flow Meter supply and installation	Tariff Framing	
Hydraulic Modelling		
PPP in O& M		

Overview of Jalgaon Water Scheme

Primary source of raw water for Jalgaon City is Waghur Dam on Waghur River. The Waghur dam site is located near village Raipur @25 Km from Bhusawal & 21 km from Jalgaon. Quantity of water daily supplied to city from this source is @ 65 to 80MLD. It comprises of one raw water pumping station, one water treatment plant, two booster pumping station and one pumping station for supplying water to ESR's.

Waghur raw water pumping station is the major raw water source for Jalgaon city. Waghur scheme have 6 Nos. pumps (4 working+2 standby) which were installed in 2007.

Table 2: Overview of Jalgaon Water Scheme

Name of City	Jalgaon
Class of City	"D" Class Municipal Corporation
Tahasil & District	Jalgaon, Tal. & District: Jalgaon
Region	Nasik
Coordinates	21°0'52"N 75°33'52"E
Population	1991: 242193
	2001: 368618
	2011: 460468 (As per preliminary census data)
	2013: 522406
Municipal Council Area	68.24 Sq.km.
Average Rainfall (mm)	730 mm
Average altitude (mtr)	578 to 611 m above sea level
Nos. of Wards	69
Present water supply source	Waghur Dam
Existing supply	@ 90 -100 MLD
Existing storage	MBR = 26.0 ML, ESR/GSR =(33.60 + 10.50)= 44.10 ML
Water supply connections	Domestic 66887 + Non Dom. 391, Total = 67298 Nos
Exiting Transmission Main	33.788Km [Dia ranging from 200mm to 1500mm]
Exiting Distribution piping	564.350 Km [dia 25mm to 600mm]
Whether covered / likely to be covered with sewage?	Yes

Usage of GIS based services

1. GIS MAPPING

GIS mapping involves the feature extraction and creation of base map.

- ADCC provided high resolution satellite imagery (World View-2) for digital data extraction.
- Photogrammetric technique was used to extract digital data from high resolution satellite imageries for the development of water supply system of Jalgaon Municipal Corporation.
- Topographical details were obtained with Hydrological features along with Roads and Railway Network.

Figure 1: Usage of GIS based services

STEREO Pair Imagery Purchase

Image Procurement has been done through NRSC, Hyderabad. World View-2 (0.6m Colour resolution) Stereo-Pair was supplied and distributed by Digital Globe, Singapore.

DGPS, GCP Collection

A single GPS receiver from any manufacturer can achieve accuracies of approximately 10 meters. To achieve the accuracies needed for quality GIS records from 1 to 2 meters up to a few centimetres requires differential correction of the data to improve accuracy.

The collected GCPs through DGPS survey is used for geo-referencing the satellite imagery data.

The tie-points pattern is used to clear the Relative orientation error or parallax. This will create a relation between all the images, reducing the Y-Parallax and X-Parallax. Out of 109 tie points including 20 GCPs collected the RMSE (pixel) was 0.0017.

ADCC introduced the Ground control points i.e. Absolute Orientation. This orientation will refine our images from orbit information to real assigned co-ordinate system.

Aerial Triangulation

Aerial triangulation is applied to determine X, Y and Z ground co-ordinate of individual points on measurements from photograph.

DTM and Feature Extraction

After completion of the Arial triangulation reception, the Digital Terrain Model can be extracted. It includes all the morphological features along with break lines and mass points.

DEM

ADCC performed digital stereo compilation to collect the morphological features along with break lines and mass points for the generating Digital Elevation Model (DEM).

Contour Generation

Digital Elevation Model is suitable for generating 1meter vertical interval contours for 50 cm resolution stereo images. These contours are used for hydraulic modelling.

Orthophotos (50 cm resolution) was generated in Erdas Imagine with the help of stereo environment using Digital Elevation Model.

All data (mass points, spot height points, break lines etc.) are represented by digital surface model (DSM).

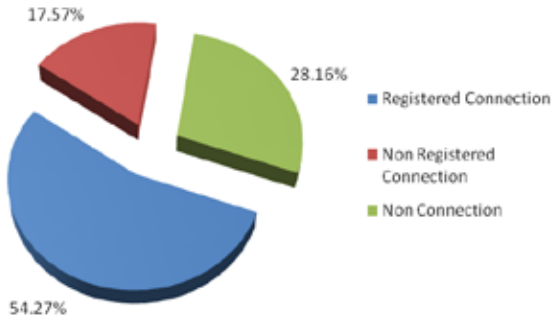
Base Map Creation

Base map can be created using different sources as per the accuracy and details desired for the particular kind of application. Base map was created by interpretation and digitization from the rectified satellite data.

2. Consumer Survey and Indexing

Survey was carried out for property details. The activity of property survey involves door to door survey, thus there was interaction possible with the property owners / tenants. Consumer survey data is useful in Hydraulic Modelling, Water Audit, and Demand Supply Analysis. Ward wise Connection Details as per their connection use and size. After updating the survey data, it was matched with JMC details.

Figure 2: Connection Statue



3. Energy Efficiency Calculation

The purpose of energy audit is to understand up to what extent simplifications are possible. The overall energy consumption of Jalgaon water supply scheme comprises of energy consumption of five pumping stations i.e. Waghur raw water pumping station, WTP At Umale, Girna Pumping Station, DSP chowk booster pumping station & Raymond chowk booster pumping station. Detailed analysis of energy efficiency involves walk-through analysis, input data collection, site visit, and field observations (equipment test, equipment energy performance).

Input data is collected in the form of electricity bill (last 2 years), log book, scheme detail, flow diagram, pumping machinery details etc.

Table 2: Existing Pumping Station

Sr. No	NAME OF PUMPING STATION	Motor Rated Power KW	Overall Pump & Motor Combined Efficiency %	Average Power factor
1	PUMP-1 WAGHUR RAW WATER	375	70.09	0.97
2	PUMP-2 WAGHUR RAW WATER	375	55.89	
3	PUMP-3 WAGHUR RAW WATER	375	61.17	
4	PUMP-4 WAGHUR RAW WATER	375	60.62	
5	PUMP-5 WAGHUR RAW WATER	375	73.15	
6	PUMP-6 WAGHUR RAW WATER	375	66.92	

Sr. No	NAME OF PUMPING STATION	Motor Rated Power KW	Overall Pump & Motor Combined Efficiency %	Average Power factor
7	PUMP-1 GIRNA PUMPING STATION NEW	55	69.99	0.97
8	PUMP-2 GIRNA PUMPING STATION NEW	55	68.17	
9	PUMP-1 GIRNA PUMPING STATION OLD	37	38.82	
10	PUMP-2 GIRNA PUMPING STATION OLD	60	80.75	
11	DSP CHOWK BOOSTER PUMPING	55	68.76	1

The overall electrical energy consumption of the Jalgaon water supply scheme is 1, 10, 04,422 kWh/annum.

1. Installation of Flow Meter

Flow measurement includes quantum of flow released from the service reservoirs and measurement of flow of water from the selected water connections. Assessment of Bulk water supply systems is done for operational hours & flow patterns. However, simultaneous measurement of inflow, outflow at various components of system are recorded for operational hrs during study period. DMA study includes inflow to DMA; water consumption at consumer end in DMA/Sub-DMA is measured and recorded for the study period. Flow readings are taken at these locations for regular intervals as required during the study period.

Measurements of night flow into sectors of the distribution system prove to be extremely useful for rapidly identifying the presence of new unreported leaks, which can then be located and quickly repaired. This technique can be used irrespective of whether customers are metered or un-metered.

Whenever actual metering is not possible, for example in activities such as stand post, etc., every effort is made to estimate each component of water use accurately to determine realistic quantities for the water balance.

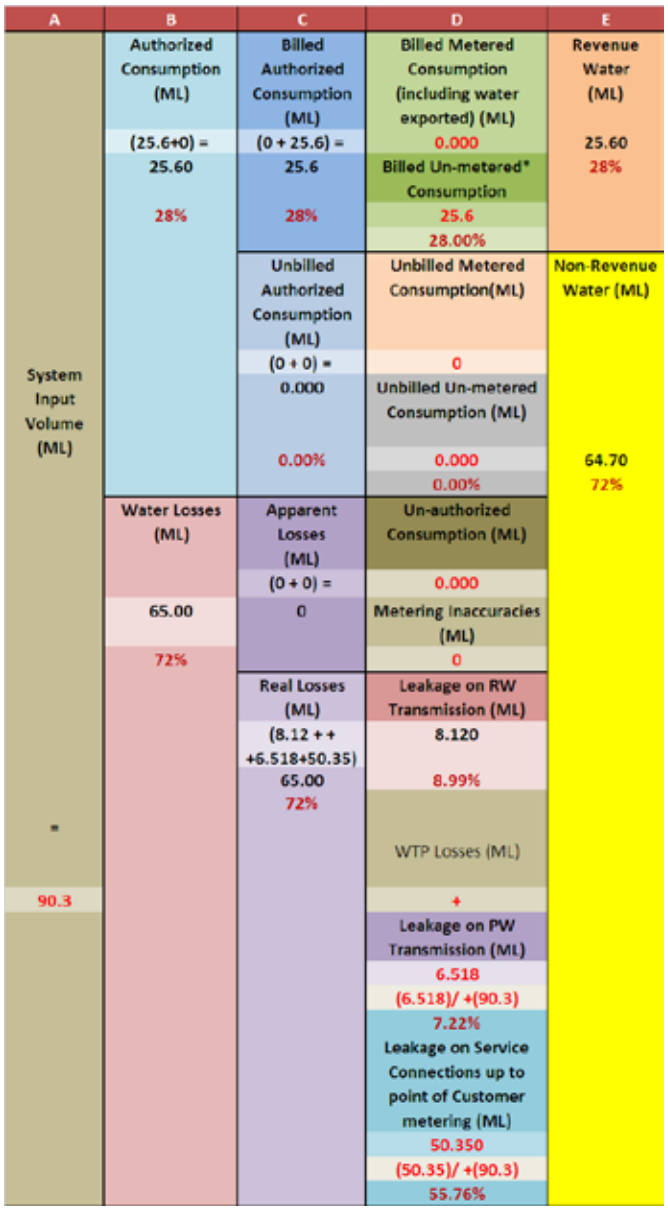
2. Water Audit

The main objective of water audit program is to quantify Physical losses & NRW. For Jalgaon this is applicable to verify variation in consumption, as all consumers of similar category & billed as per tap size on Flat rate basis and not on actual consumption.

Data recorded daily, is sent for further analysis using in house software prepared based on AWWA water audit sheet. Volumetric readings were taken, for those connections, where it was not possible to install consumer meter in sub DMA. Suitable measures of rehabilitation are identified & suggested for improvement of system.

Table 3: Details as Per DMA Study

Average Measured Raw Water Input	90.30 MLD
Average Losses measured From HW to ESR	14.64 MLD
Average Distribution system Losses	50.35 MLD
Water available for distribution @ ESR	75.66
Total popn of town as per consumer survey	490320 Souls
Water available at consumer End	25.60 MLD



6. Hydraulic Modelling

Hydraulic modelling rationalizes the distribution networks, there by leading to savings in capital as well as operational cost.

- Suitability for continuing their use in future.
- Possibility to increases their serviceability by renovation / rehabilitation.
- Possibility to increases their capacity with suitable renovation / rehabilitation.
- Addition of proposed component in parallel, to augment it for desired capacity.
- Replacement with revised parameters & capacity.

7. Population Forecasting

Population forecasting, demands projection and demand allocation in various stages as per the norms of water supply in CPHEEO manual.

The population for these stages is projected by using population projection methods.

Table 4: Population Forecasting

Year	Arithmetic Increase Method	Incremental Increase Method	Average	Avg. as calculated By PMC MJP
2018	520238	528972	524605	524650
2033	648832	700498	674665	674700
2048	777425	905051	841239	841250

Existing Network Mapping

The hydraulic analysis of distribution network of existing networks was carried out using "Water Gems V8i, By Bentley as per the TOR. Layer of existing pipe network from Updated Base map in A Cad file format is imported as pipe network for analysis.

Demand Projection and Demand Allocation

Preparing and running base scenario of each DMA, running the base as well as child scenario, allocating the demands to the nearest node and allocating the demands by these in polygon method, checking the demand and supply of the zone.

The demand allocation is done by using the LOAD BUILDER wizard (Bentley).

Table 5: Demand Projection and Allocation

Particulars	%	Immediate stage	Intermediate stage	Ultimate stage	Unit
Design year		2018	2033	2048	
Population (Jalgaon City)		524848	675088	841687	souls
Population (3 nos of Fringe Village)		-	33837	51320	souls
Demand calculations					
City Water demand @135 lpcd rate		70.85	91.14	113.63	MLD
Fringe Village demand @70 lpcd rate			2.37	3.59	MLD
Fire demand		2.29	2.60	2.90	MLD
Bulk demand		4.21	5.34	6.65	MLD
Railway demand		0.41	0.49	0.59	MLD
Net demand		77.76	101.94	127.36	MLD
Losses calculations					
Distribuition Losses	10%	8.64	11.32	14.15	MLD
Total demand at consumer end		86.40	113.26	141.51	MLD
Transmission Losses	2%	1.76	2.31	2.89	MLD
Total demand at Storage reservoir		88.16	115.57	144.40	MLD
WTP (process) Losses	2%	1.80	2.36	2.95	MLD
Total demand at WTP		89.96	117.93	147.35	MLD
Raw water Losses	1%	0.91	1.19	1.49	MLD
Total Raw water demand		90.87	119.12	148.84	MLD
Say		91.00	120.00	149.00	

The network balancing & alternative hydraulic model for existing distribution lines are analysed considering peak demand.

Results/Impacts

MSNA is an activity oriented program in which measurements in terms of savings (water, energy consumption, expenditure, monthly billing) for 30 years design period by converting existing intermittent water supply system into 24x7 water supplies @135lpcd at desire pressure with 100% coverage, metering and monthly billing.

Conclusion

As per the observation from the extensive water program, the following works are envisaged for improving the service levels to consumers of Jalgaon. The project designed considering 30 year as design period.

The improvement programs are under three phases-

1. Immediate stage (Yr. 2018)
2. Intermediate stage (Yr. 2033)
3. Ultimate stage (Yr 2048)

The sustainability of existing components is checked for the year 2018, and suitably rehabilitated / augmented is proposed in phase manner in intermediate phase (year 2018-2033) & ultimate phase (year 2033-2048).

ADCC Infocad

6

RAILWAYS

Drones, Data and the Indian Railways

SUMMARY

Indian Railways with an aim to introduce technological solutions for project management and monitoring, employed AIRPIX to avail UAV solutions for their 25 km long Seawoods-Belapur-Uran project. The solution included data capturing using UAVs and data analytics to derive insights about the project status. The data acquisition was completed within 2 days and processed outputs were generated including orthophoto, DEM and overlay of design data on the base processed imagery for observing the status of completion at different locations of the project, inventory at site and bottlenecks. Indian Railways are further planning to implement this solution in projects all across India.

Introduction

India has the largest railway network in Asia. Millions of people travel every day by train and it is at the heart of connectivity for a lot of cities. With the growing industrial development and population, the role of railways in transportation is going to be crucial for the coming years. The network has to be further spread across to improve connectivity for both passenger and freight transportation and with the increasing demand, comes the need for better safety. Keeping this in mind, Indian Government is constantly looking for means to introduce new technology and modernize Indian Railways to meet the challenges of economic growth, the aspirations of the common man, and the expanding market to facilitate faster and safer travel.

This could be the premise that encouraged the Indian Government to explore the various solutions that could be achieved using Unmanned Aerial Vehicles (UAVs), or more commonly known as drones, and announced in the rail budget 2016 that drones and geospatial based satellite technology will be used to monitor the physical progress of the various railways projects. Honorable Minister of Railways in his Railway Budget Speech 2016-17 has emphasized on Leveraging Technology for project management. As per item No. 107 of the Railway Budget Speech, Honorable Minister has stated that, *"In line with international best practices, we rely on technological solutions for project management and monitoring. It is intended to use the latest drone and Geo Spatial based*

satellite technology for remotely reviewing the physical progress across major projects. In the next financial year, this would be operationalized for monitoring the progress on Dedicated Freight corridor."

One of the bottlenecks in expanding the railway network in the country has been the slow progress of the projects due to hindrances at site such as delay in land acquisition, illegal encroachment etc. Such problems are better discussed and resolved when you have visual data. UAVs come with an inherent advantage of easy & quick data collection. In addition, the fact that the imagery collected using an UAV is up to date and unaffected by cloud cover, unlike satellite imagery. The high resolution imagery and the accurately processed outputs help to capture & measure the actual status of the project without having the site visited physically . The periodic data capture also helps to monitor the changes at the project site and highlight any major hindrances to the project.

Background

One such project is the Seawoods-Belapur-Uran project under the Central Railway. The 25-km long project will connect residents of Jawaharlal Nehru Port Trust (JNPT), Uran, to Mumbai and Thane by rail. The trans-harbour town Uran and its surrounding areas have seen rapid development since the Jawaharlal Nehru Port came up and hence the project is critical for their connectivity. The line is expected to cut down travel time to Uran, which is 95km from Mumbai. The project consists of 25 km of double line with 9 proposed and 3 existing stations. Central railways wanted to expedite progress of the project. For the same they approached AIRPIX, Bombay based UAV survey solutions provider, to explore potential solutions using UAVs.

Figure 1: Existing status of a ROB along the Seawoods-Belapur-Uran project

Methodology

AIRPIX team first carried a site reconnaissance along the entire alignment with the railway officials to understand the site conditions & feasibility and to identify the take-off and landing zones. After the preliminary visit, missions for autonomous flight were planned so as to ensure 70% or more forward overlap and 30% or more side overlap while capturing the aerial imagery.

Figure 2: AIRPIX Team at site during project execution

GCPs (Ground Control Points) were laid at every 250m interval. Reliable GCPs in the correct intervals are crucial for precise Orthorectification[1] i.e. geometrical correction of the aerial images. Based on the site observations, the AIRPIX team decided to deploy their multi-rotor UAV with a 16MP camera. The UAV's computer was fed with multiple Way Points as per the planned missions to autonomously fly exactly above the laid track route and capture data at 3.1cm GSD (Ground Sampling Distance). The autonomous flights ensured that the desired overlap was achieved and the entire data collection (including GCP laying & coordinate recording) was completed within 2 days.

Data outputs

The captured data of the entire alignment was then processed by 3D triangulation and stereo reconstruction to produce dense point cloud, high resolution Ortho-photo and high resolution DEM. The data was orthorectified and Geo referenced[2] using the GCPs laid. Design data of the project were overlaid on the exact coordinate of the location and Google Earth compatible files were generated for ready reference.

The outputs included:

- Dense point cloud
- Orthophoto
- Digital Elevation Model
- 3D Reconstructed model of the entire project with volume and distance measurements
- Google Earth compatible file with project design data overlay

[1] Orthorectification is the process of removal of distortions in the aerial images caused due to topographical variations in the surface of the earth. This equilibrates photo units with real life distances thus enabling accurate measurements.

[2]Georeferencing is the process of assigning real-world coordinates to each pixel of the raster data.

Figure 3: Orthophoto capturing details of the construction status, inventory at site and the existing track

Figure 4: Digital Elevation Model of a section of greenfield alignment

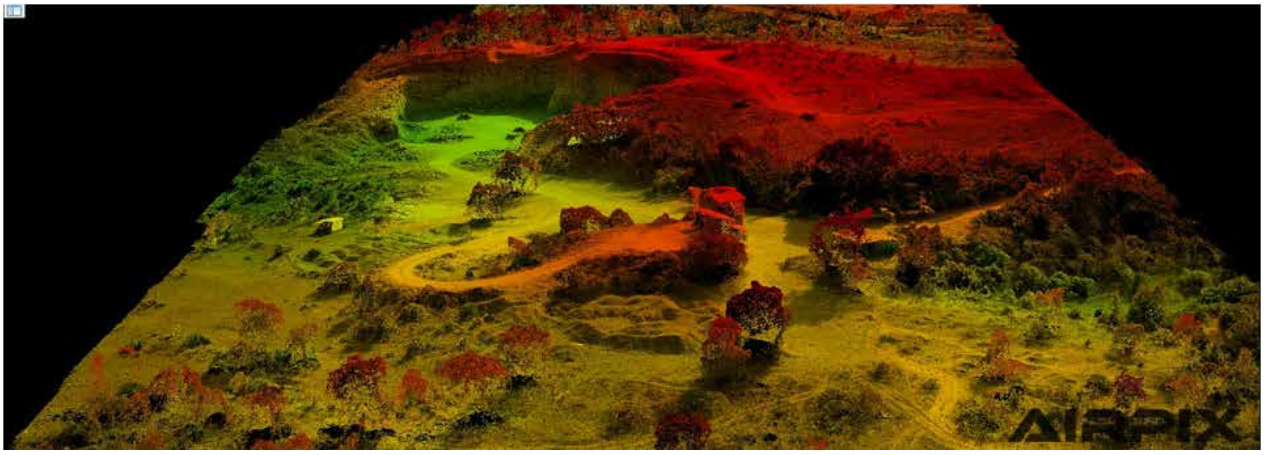


Figure 5: Screenshot of Google Earth file with design data overlay on base layer of processed aerial data

Benefits

The processed outputs helped the railway officials to present to their higher management the exact status of the project without having them to visit the site physically. The imagery could provide details of even sleepers and other inventory present at the site. The data overlay on Google Earth file helped them access the complete design data (such as curve details, gradients, RUB, ROB and bridge specifications, station details etc.) without having to refer to the hard copy of their project data sheet. The base layer of imagery helped them to relate to it better since the information was overlaid at the exact position on ground as the model was orthorectified and georeferenced. Apart from this project, Indian Railways have utilised drones in other projects also such as Dedicated Freight Corridor to record videos of the existing status of the construction and other details on ground.

Table 1: Drawbacks of Conventional Method Vs Ddvatages of using UAVs

Drawbacks of conventional method to monitor project progress	Advantages of using UAVs to monitor project progress
No visual record of project progress	Project status can be visually recorded and also archived for future reference
Need to visit site physically to see the project progress	No need to physically visit the site
No recorded data available in cases where there have been illegal encroachment	Data collected using drones are dated documents to track illegal encroachment
Have to refer to the large project sheets and reports	Easy and quick access to project progress updates
No visual data available for checking volume of work completed	Orthorectified & georeferenced 3D model provide visual details with measurements about the volume of work completed
Comparison of planned and as-laid alignment is difficult	Comparison of planned and as-laid alignment is convenient with the orthophoto
No visual record of on-site inventory	On-site inventory including sleepers are recorded

Conclusion

The solution provided by AIRPIX using UAVs will contribute in establishing a system that will facilitate a better way to monitor project progress of railway projects. Currently, there is no provision of visually recording the project status and the current report formats also do not have provision for taking out measurements from them. The data collected by UAVs and the processed data help derive such insights those are critical in identifying bottlenecks and pace up project completion. Comparison of progress (such as the amount of earth work done, number of sleepers laid, status of bridge / station construction) at specific exact locations along the alignment is possible since the model is georeferenced. Such data acquired across all the projects in India over a period of time will help generate trends in project progress and bottlenecks in all the railways projects in India. These kinds of insights will help in predicting hindrances at a much earlier stage and take proactive steps to overcome them and help reduce project completion timelines drastically. UAVs can also be used in surveying greenfield alignment for designing routes of new tracks and help reduce timelines by as much as 50% as compared to conventional survey techniques; in hilly terrains, the time & money savings could be even higher and results much better. Levels can be determined in intervals as required and feature extraction on the base layer will help take decisions quicker.

Factors influencing future usage

To what extent drones can aid the Indian Railways in the future will be governed majorly by two factors:

(i) Technology

Technology enables UAVs to complete a job without human intervention, which in turn creates efficiency and accuracy for a broad spectrum of industries and applications. The arrival of the smart, miniaturized autopilot technology and LiPo (Lithium-Ion Polymer) batteries has played a significant role in driving the drone market forward, allowing us to create intelligent automated drones with flight times of up to 45 or even 50 minutes depending on weather conditions. Further advancement in the autopilot and battery technologies, will enable development of more robust systems that can carry a range of sensors simultaneously and cover longer lengths of track alignment. The combination of different kinds of data collected using different sensors will help to quickly understand the green cover, soil type and obstructions on alignment so that decision making regarding fixing the alignment, land acquisition and designing the track layout can be accelerated. The data collected by UAV can also be archived and accessed on cloud by any railway official any time. It will not be required any more to carry around the large printed copies of design sheets and discussions between different teams at different parts of India can happen just over a video conference. Drones can also be used for inspection and maintenance of tracks. Visual data will provide data for observing visible flaws such as track erosion, warpage and also monitor illegal encroachment in to the railway and if sophisticated sensors are used then, laser based profiling of tracks can help even identify hair-line cracks on tracks. The laborious job of walking along kilometers of track can be replaced by flying a few drones completing the task in a fraction of time.

(ii) Regulations

Regulations are going to be another hurdle in the complete implementation of drones. In the industrial applications, one of the main reasons to use an UAV is to reduce the time involved in carrying out a task by the conventional methods. If the regulations take away that advantage then the whole purpose gets defeated.

Processes should be in place to apply for and get permissions to use UAVs in a short span of time without much red tape or multiple levels of approvals. Licenses should be given only to well-trained pilots and recognized agencies so that security of the country and safety of the people are not compromised. The DGCA had recently issued draft guidelines related to using UAVs and invited suggestions for changes in the

draft. It is a welcome move by the DGCA and we completely appreciate it. They have tried to address a lot of points however, since it is a preliminary draft, a lot of improvements are definitely possible.

We hope to come across a set of regulations that promotes the technology at the same time ensuring country's security and public safety. With favourable advancement in regulations and growth of technology, AIRPIX looks forward to developing a lot of applications for the Indian Railways to enable faster execution of projects and contributing towards development of the Indian infrastructure.

Way forward

Going forward, Indian Railways should plan to use a combination of UAV solutions that can be used for planning, designing and monitoring of projects. Capturing photos or videos only help achieve visual data, but do not derive many actionable insights. When these photos are processed to derive the right type of data such as orthophotos & DEM and integrate them with ground data, that is when the complete potential of aerial survey using UAVs be realized. For constructing & laying tracks in difficult terrains such as hills, conventional surveys are difficult to conduct, time consuming and do not capture complete data. Aerial survey using UAVs and LiDAR will not only complete the work in a fraction of time but also enable the designers with visual data and high resolution topographical data for better planning. The three dimensional data and the photographs will give a complete sense of the project with the freedom of measuring distances & volumes and also give an idea of the context of the site with respect to the surroundings or obstacles along the alignment thus aiding them in taking decisions without having to visit the site. Capturing data of the on-going projects with UAVs in fixed time intervals will also be an effective tool to monitor progress and ensure faster elimination of bottlenecks & completion of projects.

Shinil Shekhar

LiDAR Scanning for Railway Infrastructure

The importance of having the right equipment for a job cannot be underestimated. In a surveying and mapping project, the access to advanced 3D laser scanning technology can make a world of difference to the study outcome. A group of researchers from the Indian Institute of Technology Roorkee (IIT Roorkee), honored by the India Government as an Institute of National Importance, experienced this first hand when conducting a study on India's railway infrastructure.

The research project was initiated at IIT Roorkee, for providing Ministry of Railways with insights on India's current railway infrastructure and recommendations for improvements on the tracks, signaling, and stations and terminals. There is a huge potential in shaping the country's future railway infrastructure, and it is imperative that results of such projects is presented accurately to facilitate future scalability.

The First Step

One of the first and most crucial steps in carrying out the research was to select a reliable and effective surveying solution, including comparing traditional photogrammetry with modern laser scanning solutions, and it was clear that the success of this project would require a high-precision and high-speed device.

Figure 1: Scan data acquired by the FARO Laser Scanner Focus^{3D} X 330.

Scanning an entire railway platform can be a time-consuming activity as complex calculations are involved. Additionally, the research team had to take into account several considerations, including overhead power lines, entities on the railway platform (e.g. escalators, shops, and information centers), diversions on track, and the frequency of arriving and departing trains.

For these reasons and for the fact that a large area of study was involved, it was decided on utilizing laser scanning technology. The proejct team at IIT Roorkee used FARO Laser Scanner Focus^{3D} X Series.

FARO's Focus^{3D}

The Laser Scanner Focus^{3D} X 330 opened up a world of possibilities for the research team at IIT Roorkee. Featuring an extra-long scanning range from 0.6 m up to 330 m, the Focus^{3D} has a distance accuracy of up to 2 mm, which was exceptionally useful for the team's application, given that they needed to capture minute details for the railway research.

The research team was able to completely scan the Roorkee Railway Station and its surrounding areas in 10 days. In order to capture as-built documentation on all aspects of the railway system, scans had to be taken from different angles, and the Focus^{3D} had to be constantly repositioned. In total, the team obtained nearly 50 scans that covered a distance of over eight kilometers, with each scan taking only 30 minutes from set-up to completion. In a typical day spent onsite for data collection, the research team conducted six to seven scans, concluding the scanning process within 10 days.

Figure 2: Dr Kamal Jain Scans the Railway Infrastructure using the Focus^{3D}

Establishing the Benchmark

As the Government contemplates doubling existing railway lines, the research results will influence future railway infrastructure strategies for India. Knowing the urgency and importance of this research, the project team strived to depict a most accurate presentation of our current railway situation. Apart from the added advantage of providing point cloud data simultaneously with every scan, the Focus^{3D} also offered IIT Roorkee with a complete, stitched 3D map. When shared with the Government, this data can be easily integrated into a 3D smart city data file for the country.

Figure 3: Point cloud data of the railway platform

FARO Business Technologies India (P) Ltd.

7

ROADS & HIGHWAYS

Road Asset Management System for National Highways

Indian Road Scenario

India has one of the largest road networks of over 52.32lakh km. It comprises National Highways (1,00,275 km), Expressways (200 km), State Highways (1,48,256 km) and Other Roads (49,83,479 km). Roads carry 85% of passenger and 70% of freight traffic. National Highways constitute only 2% but carry 40% of the traffic on Indian roads.

The development of National Highways is the responsibility of the Ministry of Road Transport and Highways (MORTH) which is entrusted with the task of formulating and administering, in consultation with other Central Ministries/Departments, State Governments/UT Administrations, organizations and individuals, policies for Road Transport, National Highways and Transport Research with a view to increasing the mobility and efficiency of the road transport system in the country. Over the total length of 1 lac km of National Highways approximately 50% (48,000 km) of network is with NHAI and the work is going on in seven phases of NHDP in all over the country.

MORTH has launched major initiatives to upgrade and strengthen National Highways through various phases of a National Highways Development Project (NHDP) which is being implemented through NHAI. Approximately 40,000 km of National Highways improvement contracts comprises widening and strengthening of existing intermediate,2 lane to 2 lane paved shoulders or 4 or 6 lane highways with rigid or flexible pavement. This also includes construction of major and minor bridges, culverts, road over rail Bridges, flyovers etc. The works are executed either on item rate contracts or hybrid PPP model. Most of the contracts under NHAI are being executed on PPP Model. Remaining National Highways (over 56,000 km) are the direct responsibility of MORTH with maintenance and improvement works being executed by the state governments on an agency basis using public fund.

Road Asset Management system

To manage the National Highways assets National, Highways Authority of India (NHAI) had received financing from the International Bank for Reconstruction and Development (IBRD) in the form of a loan towards the cost of NHAI Technical Assistance Project. As an implementation agency NHAI applied a portion of the

proceeds of this loan to strengthen Asset Management Capacity of NHAI and Ministry of Road Transport and Highways (MORTH) after open global tender to M/s HIMS-SATRA (JV). NHAI awarded the consultancy services contract entitled, Consultancy Services for Technical Assistance to Strengthen Asset Management Capacity of NHAI and MORTH. The project commenced on 31 October 2014 with an expected completion date of 30 October 2017. The project is on schedule and completed two years of data collection of the pilot road network.

The development of RAMS for National Highways (NHs) is a flagship project. RAMS is developed for the entire National Highways in India bringing both public funded and private funded roads under one umbrella. The outcome of this project is to assist in accurate and scientific maintenance planning, enhancing road safety measures and planning of development of the NH network in India. RAMS has been developed using the international best practices.

NHAI has associated with Indian Space Research Organisation (ISRO) for optimal use of the Geo Spatial Technologies for National Highways Planning and Management. NHAI has planned to use the indigenous Bhuvan maps for monitoring encroachments and projects progress.

Objectives of the Project

The specific objectives of the project:

- Sustainable Road Asset Management System (RAMS) for National Highways in India. Single Road Database for NHs supported by analytical tools
- Institutionalization of NHAI and MORTH for Road Asset Management system for planning, programming and budgeting for road maintenance and upgrading works;
- GIS capability of the RAMS to form publicly accessed Traveller/Tourist Information System providing road users with information on road conditions and location of hotels and tourist sites etc.

Project Highlights

The specific tasks included the following:

1. Data collection for GIS, road inventory, condition, pavement strength, traffic and other data using automated, semi-automated and manual procedures over 3,000 km of NHs;
2. Developing of data collection plan that allowed the RAMS to fully populate with current data required for planning, programming and budgeting of road works;
3. Upgrading hardware and software to provide a RAMS which meets the objectives;
4. Develop analytical tools which allow the RAMS data to support the formation of plans and programmes for road network preservation and development;
5. Institutional framework for the RAMS to ensure its sustainability and development over the long term;
6. Recommendation of strategy for commercial use of relevant parts of the RAMS as a Traveller/Tourist Information System.

Major Deliverables

NHAI and MORTH attempted in the past to adopt modern and computerized road information system and pavement management system. Although the business processes and technology used were somewhat acceptable but a major drawback which saw systems become redundant was the institutionalisation of the systems within NHAI and MORTH. Therefore, the focus was not only developing a software tool which , but place higher emphasis on its sustainability. The following were deliverables:

- Road Asset Management System (RAMS)
- Data Collection Framework.

Project Team

For developing the system, a team of experts form NHAI, MoRTH and Consultant were presented. By devoting the valuable inputs the system is developed. The key personnel were Sh. Atul Kumar (CGM), Sh. P K Mohapatra (GM), Sh. Raj Mallela (TL), Sh. Narinder Pal Singh (STE), Sh. Raj Shekar (IT Expert), Sh. BalaMurli (Data Collection Expert).

Use of High Resolution Satellite, UAVs and Geospatial Technology in Highways

- Prefeasibility/feasibility studies of new alignments, upgrades/road widening
- Monitoring of Road segments under Construction
- Road Asset Management
- Land Use situation for development of National Highways
- Issues of Width available along the road (Width of RoW)
- Study of congestion/traffic jams/ junction arrangement planning etc.
- Road safety including identification of Black Spots
- Traveller information

NHAI initiatives as below

- Signed MoUs with ISRO and NECTAR
- Development of Road Asset Management system
- Use of LiDAR technology
- Development of Mobile app for road safety

Road Asset Management System (RAMS)

NHAI has taken up Road Asset Management System (RAMS) project with the World Bank assistance. Under this project the software is being developed to collect the Location Based data for more than 200 attributes of the road.

This system has been developed for the whole of National Highways. This is a web based system with comprehensive Asset Register capable of providing a variety of information to wider stakeholders, both internal and external with a click of a mouse. Further, users are able to drill down the map to audit and extract information available within the system. The system has facilities for determining the maintenance needs

The RAMS is being populated with 3000 km of data to test the software. First year data has already been collected and being uploaded into the system.

Pilot Road Network

After thorough review of the pilot road network stretches given in the TOR, it was decided to include more relevant stretches to reflect current situation of NHs and also to include stretches from the road network entrusted to the Ministry. The pilot road network is given at the end of this article:

Data collection Items:

- Road type
- Pavement surface type
- Pavement width
- Shoulder type
- Shoulder width
- Median width
- Topography
- Road furniture
- Side Land use
- Median Type
- Wayside Amenities

Data Collection Framework

A comprehensive data collection framework for the whole of NHs has been developed, considering:

- What data to collect;
- When to collect;
- How to collect;
- Who should collect these data?

The data collection framework considered the current practices adopted by MORTH and NHAI for NHs development and maintenance including, EPC (Item Rate), EPC (Lump sum), DBFOT, DBFO, BOT, OMT and etc. The annual and other regular reporting requirements of various stakeholders including Concessionaries and State PWDs have been considered.

Institutional Framework

The institutional framework included the following criteria:

- Who should own and manage RAMS;
- How frequently it should be updated;
- How to source and collect data for updating;
- What measures required to use within NHAI/MORTH/NHIDCL;
- How to disseminate its outputs.

Earlier all decisions about planning, programming and implementation of new road construction or maintenance & rehabilitation work of existing roads were based on priorities set by departmental officials and availability of sanctioned budget for the work. It was an earnest need to move towards a more scientific approach for maintaining road assets; which is on the basis of road conditions as per the data collected and priorities are set on condition data analysis.

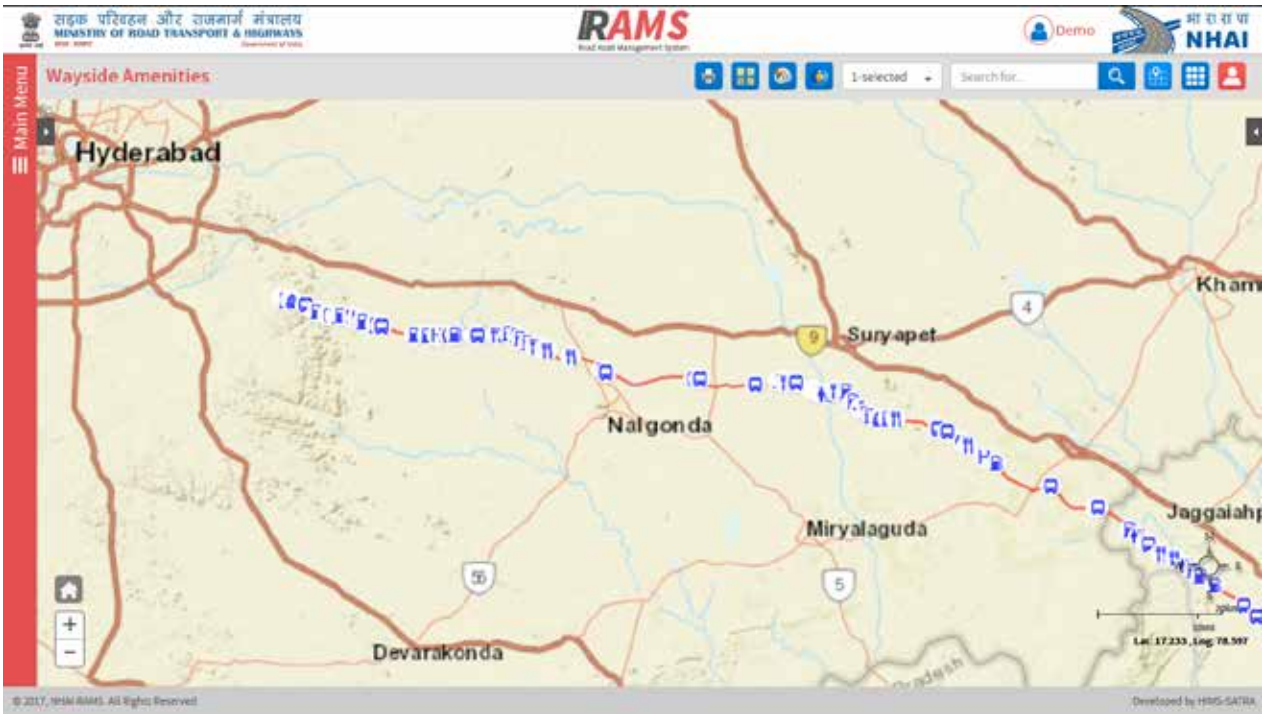
From the beginning, the focus was on managing the complete asset lifecycle of planning, development, operation and maintenance. Asset management is also being delivered more and more through public–private partnerships. This included development, delivery, management, and operation, with the investor acting as an active participant in all stages.

Until now, our engineers have developed many systems for road condition data collection as well as for monitoring of road maintenance, but a uniform system was needed to take any decision regarding their planning and the fund requirements for that work. It is important that this unique system is accepted by all, it was institutionalized for better performance in maintaining our road assets.

The World Bank provided advise and valuable input on the international best practices for development of RAMS.

Output

Figure 1: Screenshot of RAMS' Portal



Uses

- Planning and Development
- Road Maintenance Management
- Integration with Linear Chainages with Spatial Locations
- Road Alignment
- Attributes with Spatial Coordinates
- ROW Management
- Encroachment Monitoring
- Wayside Amenities Management
- Online Tracking of Road Projects
- Real time Tracking of Defect and Liabilities
- Traveller/Tourist Information

Progress so far

The RAMS is being populated with 3000 km of data to test the software. First year data has already been collected and being uploaded into the system.

Conclusion

The outcome of this project is to assist in developing an accurate and scientific maintenance planning mechanism, finalising road safety measures and development of the National Highways network in India. The data collected has been stored and managed through a web based application, which is hosted in the public domain. The application can also be accessed by smart phones. Information collected from this project are useful for Transport Ministry, Finance Ministry, NHAI, State PWDs, Police Departments, Funding agencies, Developers and Citizens. The software is equipped to interface with the indigenous Bhuvan satellite images.

Table 1: Project Related Information Accessed through RAMS Web Application

S No.	Stretch Name	State	NH No (New)	Survey Length (Km)	Entrusted to	Lanes
1	Pimpalgaon Baswant - Nasik	Maharashtra	60	30	NHAI	6 lane
2	Indore - Dhule	Madhya Pradesh/ Mahrashtra	52 & 60	249	NHAI	4 lane
3	Madurai - Tirunelveli-Pangudi-Kanyakumari	Tamilnadu	44	242	NHAI	4 lane
4	Tirunelveli - Tuticorin	Tamilnadu	138	47	NHAI	4 lane
5	Pune - Sholapur	Maharashtra	65	212	NHAI	4 lane
6	Hyderabad Vijayawada	Andhra Pradesh	65	181	NHAI	4 lane

S No.	Stretch Name	State	NH No (New)	Survey Length (Km)	Entrusted to	Lanes
7	Haryana Border -Dabwali - Fazilka -Indo/Pak Border	Punjab	9 & 7	107	MORTH	2 Lane
8	Pathankot to Mandi	Punjab/Himachal	154	207	MORTH	2 Lane
9	Madrui - Tuticorin	Tamilnadu	38	126	NHAI	4 lane
10	Rajasthan Border - Vadali - Palanpur (NH-27)	Gujarat	27	160	MORTH	2 lane
11	Betul - Indore	Madhya Pradesh	47	277	MORTH	2 Lane
12	Nagpur - Sanver - Badchicholi (Mah/MP Border)	Maharashtra	47	57	NHAI	4 Lane
13	Badchicholi (Mah/MP Border) - Pandhurna - Multai - Betul	Madhya Pradesh	47	117	NHAI	4 lane
14	Jalandhar to Mandi	Himachal Pradesh	3	148	MORTH	2 Lane
15	Jalandhar - Nakodar - Patran -Haryana Border	Punjab	703, 52	146	MORTH	2 Lane
16	Beawar-Pali-Pindwara	Rajasthan	25, 162	244	NHAI	4 Lane
17	Nimbahera to Dahod	Rajasthan	56	265	MoRTH	2 Lane
18	Baran to Aklera	Rajasthan	752	94	MoRTH	2 Lane
19	Baran Shivpuri Jhansi	Rajasthan/ Madhya Pradesh/ Uttar Pradesh	27	196	NHAI	4 Lane
20	Pathankot-Jammu	Jammu & Kashmir	44	19	NHAI	4 lane
	Length Managed by NHAI of Pilot Survey			**1701**	**55%**	
	Length Managed by MoRTH of Pilot Survey			**1404**	**45%**	
	Total Length ToR (km)			**3105**		

Atul Kumar

Integrating Disruptive Solutions with Traditional Survey Tools for Efficient Project and Stakeholder Management

SUMMARY

Consultants enlisted by Karnataka Public Works Department were entrusted to manage and oversee the road rework and repair projects taking place across Dakshina Kannada district.

The challenges of dense vegetation and need for efficient project management prompted the consultants to opt for an integrated approach of utilizing conventional theodolite, Differential GPS and Unmanned Aerial Vehicles.

Each element in this trinity served to compensate for the other's drawbacks across different terrains and conditions to give a dynamic method of project and stakeholder management.

A total of 253 km of Major District roads have been surveyed and managed using the tools and methods highlighted in this case study.

Introduction

Karnataka is a blessed state of the Indian subcontinent that is endowed with a variety of natural resources ranging from a long useable coastline to dense evergreen forests. In order for these resources to be fully utilized for economic growth the state has undertaken a comprehensive development drive to improve the road network, especially in it's less urbanized and resource rich district regions of Kodagu, Mandya and other surrounding areas, with the help of state, national and international funding.

The roads in Karnataka are divided into national highways, state highways, Major District Roads (MDR) and village roads.

Of particular interest is the use of Major District Roads that are used to transport resources from various parts of the state to/from the coastal shipping areas of Mangalore. Shipments of Iron ore from the mines located in the eastern region is heavily dependent on the road network for transporting ore, at the same time it is important for the roads to be able to handle the heavy loads transferred by these carriers and others while transporting goods to/from the different regions of Karnataka engaged in manufacturing.

The region of interest in this case study is the region of Dakshina Kannada which has the second highest GDP in the state but also with a road density (road length per 100 sq. km) that is lower than the state average. Karnataka also has the lowest rail and broad gauge densities as compared to other Southern States of India but the region of Dakshin Kannada has a relatively better developed railway network due to the presence of the Konkan and South Western Railway network, meaning that the scope for development of the railway network in this region is not as important or as vast as compared to other regions of the state.

The average traffic density in the region has increased by an average of at least 8% year on year over the last three decades as per the official economic survey of Karnataka reports, with a large amount of the traffic increase caused due to increased goods carriers and domestic four wheelers.

Hence, taking into account all the above listed factors, this region has a significant scope for economic and social development with the provision and maintenance of better roads. The major portion of the work undertaken to achieve the objective of better road connectivity is being done by Karnataka Public Works Department (KPWD). KPWD has been concentrating a significant portion of their work to rework and repair existing MDRs in the region.

The main objective of KPWD was to transform a cumulative length of about 200 kms of MDRs located in the Dakshina Kannada region to State Highways as per specifications laid out by the Indian Road Congress as per documents such as the IRC:SP:73-2007 entitled, "Manual of Standards & Specifications for two laning of state highways on B.O.T. basis".

In order to manage and monitor the development of these roads, a number of tenders were floated with each requiring the services of a vendor to provide for the betterment of the road in various disjointed but stretches of road in close proximity that have been spread across the region.

Problems Faced

The officials from the SHDP soon realised a consultant is needed to perform the following functions:

1. To ensure that the work takes place in the most efficient manner possible by prioritizing high traffic density roads having rapidly deteriorating surface features.
2. To ensure that the vendors who have won the tender are following the necessary quality measures specified in the tenders such as the Indian Road Congress.
3. To ensure that work progresses without producing botched and unreliable results that do not reflect the reality of the work done on the ground.
4. To simultaneously and regularly monitor the progress and work rate in different stretches of the MDRs in the region.
5. To validate claims of losses and deferment due to unavoidable reasons and unforeseen circumstances.

The consultants employed by the SHDP realised that the combination of different technologies is needed to fulfill the above objectives and tackle the problems posed by the regions such as:

1. Dense tree and vegetation cover over large parts of the road network.
2. Rapid change in elevation.
3. High probability of equipment being damaged due to unsighted vehicular traffic.

The consultants explored the possibility of integrating Unmanned Aerial Vehicle (UAVs) with existing tools such as Differential Global Positioning System (DGPS) and Theodolites.

Two cases were tested and only through a combination of trial and error, it was understood that all the three components in conjunction were needed to achieve the objectives set forth by the KPWD and to overcome the geography related problems posed by the region.

The unique shortcomings of the three cases that were first tested have been listed below:

Case 1: Only UAV

Only using Unmanned Aerial Vehicles as a tool for data collection brought about shortcomings in the data acquisition as well as data analysis phases, the following shortcomings were faced:

1. UAV based geolocation system did not provide the required accuracy on it's own and needed a more accurate georeferencing system (by at least 50%) to locate assets of interest such as utilities (powerlines and cell towers), trees and settlements to within 5-10cm of tolerance in all directions.
2. Visual sensor based photogrammetry cannot identify and capture information about features located under heavy vegetative cover.
3. The same limitation was observed for areas that required widening and repair to be done that were under the cover of existing culverts.

Case 2: DGPS and UAV

The use of DGPS along with the UAV increases productivity and positional accuracy, however the dense tree cover over significant stretches meant that the DGPS equipment could not relay signals effectively which in turn decreased accuracy of the measurements of the markers laid on the ground.

Case 3: Total station and UAV

The nature of the topography meant that the roads changes direction over short intervals that leads to a very short sighting distance.

This meant that the manual labour input for Total Station increased to an extent that the progress was less than a 3 to 5km per day.

Over stretches with vertical cuts across gorges and hill sides, the total station method becomes impractical and offers little or no data due to the inaccessibility of the terrain.

Common shortcomings over both cases are as follows:

1. Utility information such as the presence of powerlines and pipelines cannot be adequately captured using Total Station or DGPS theodolites. Information about the nature of the utilities such as the voltage rating of powerlines and the right of way requirements are essential to the project.
2. Manpower and equipment are put under considerable risk due to regular vehicular movement and lack of facilities to warn incoming traffic.
3. In areas where an intensive amount of effort is involved in taking measurements where there is also a high volume of light and heavy freight vehicles, the traffic flow needs to be diverted or constricted. This leads to an increase in backup as well as delay in measurement taking.
4. Road widening of sections near and over culverts require data that takes into account structural information such as the height and length of culvert sections and members. Since every culvert has some structural variances from the prescribed norm, the necessary changes to the structure need to be done for every culvert based on measurements provided.

After prior experimentation it was decided

1. To use the UAV with DPGS theodolites for regions with
   a. Lesser tree cover and obstruction to signal transmission
   b. Heavy vehicular movement
   c. Regions with steep vertical cuts
2. To use UAV and Total Station based theodolites under conditions
   a. That have increased overhead vegetative cover
   b. Culverts
   c. Rail over bridges
   d. Rail under bridges

Figure 1: Methodology to integrate all the technologies used

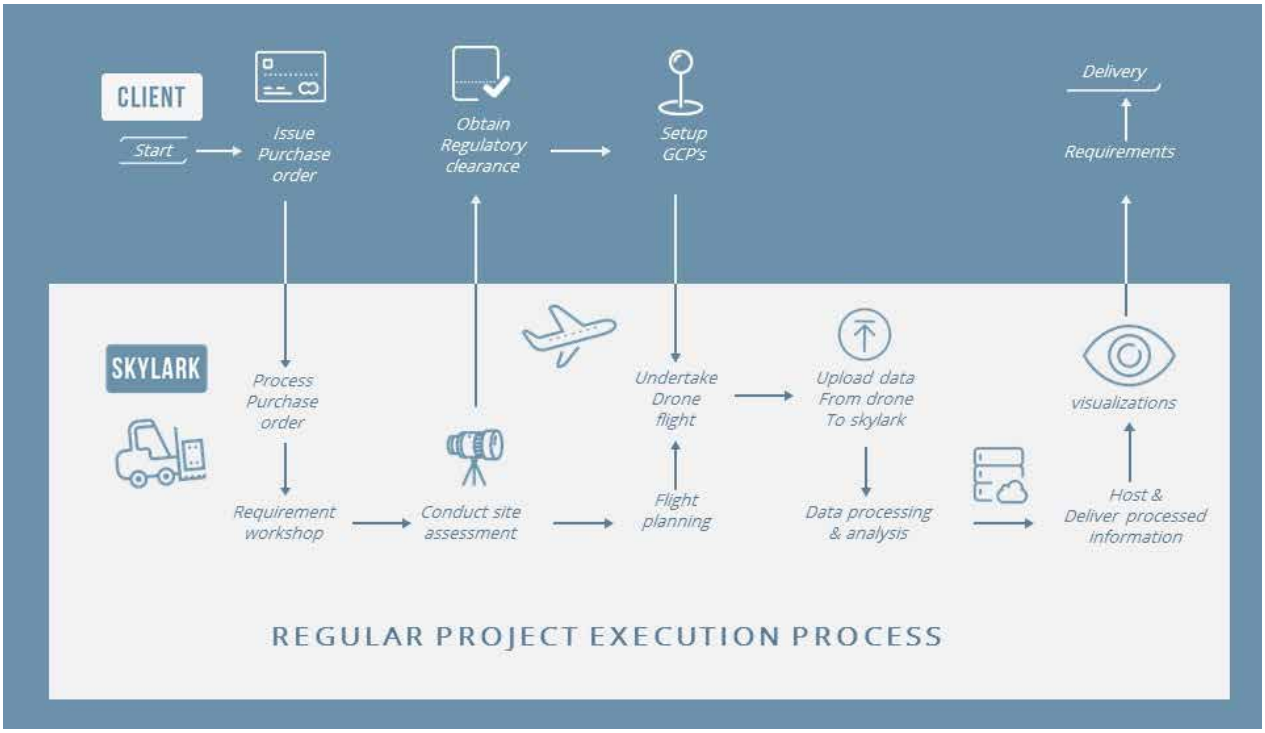
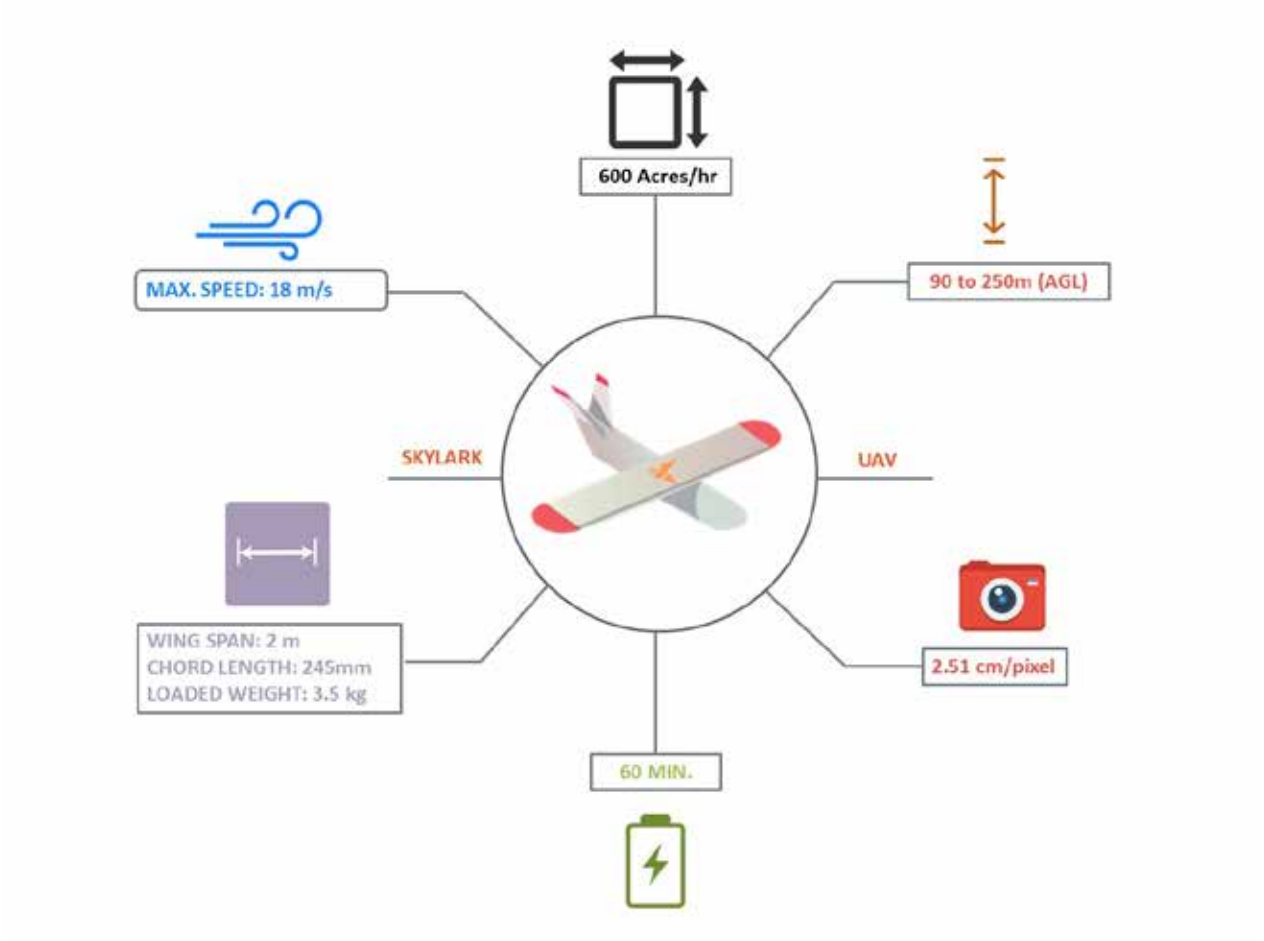


Figure 2: A brief illustration of the drone system



Stage wise explanation of the project

A detailed workshop with the consultant was conducted to understand the client's needs, expectations and requirements for the land survey project in detail over every major stretch. The workshop typically lasted half-a-day to one-full-day session (depending on the complexity of the stretch), and was mostly conducted in a face-to-face meeting/setting. The workshop was driven by experienced professionals from all sides, and was intended to unearth / identify all major requirements, expectations, risks, assumptions and dependencies.

Site Assessment

This step was undertaken with support from the all stakeholders. A preliminary site assessment was conducted to understand the environment in which the UAVs will have to operate in order to deliver the solution to the consultants.

The objectives of the site-visit were to:

- Understand the topography, weather conditions, and general environment in which the land-survey needs to be undertaken.
- Know obstructions and hazards posed by natural, or man-made structures for UAVs to fly in the survey area.

- Plan for contingency measures to deal with the hazards.
- Gather inputs for detailed flight planning of the UAV taking into consideration the topography, weather conditions, general environment, obstructions, and hazards.
- Determine the logistical needs, and time-frame required for conducting the land survey in the given area.
- Plan the project execution from start to finish accurately so as to meet the customer's timeframe without delays.
- Collect the X-Y/Lat-Long and elevation co-ordinates of existing Ground Control Point (GCP), if any and ascertain whether additional GCPs are required to be laid.
- The GCPs were laid out as specified in the following section.

Project Planning Process

Regulatory Clearance

This step will have to be undertaken by the customer.

The consultant undertook suitable steps to get necessary regulatory clearances from relevant regulatory authorities (such as DGCA, nearby Airport management, Police, etc.) before Skylark personnel could begin the project execution.

GCP Setup Using DGPS

This step was undertaken by Skylark Drones Private Limited in association with an approved third party for laying out DGPS This step will not be required as per Site Assessment procedure described above.

Placement of GCPs

One GCP for every 500m for the length of each corridor was laid out using DGPS equipment in a diagonally symmetric pattern. An extra number of GCPs were allotted for regions that required an extra area of land to be surveyed such as intersections with other district roads and minor roads.

UAV Flight Planning

The detailed requirements defined earlier, along with the information gathered from the site assessment was used to create the UAV flight plan. The flight plan defines how, when, and where the UAV will fly and what data will be gathered by the UAV in the process of surveying the land.

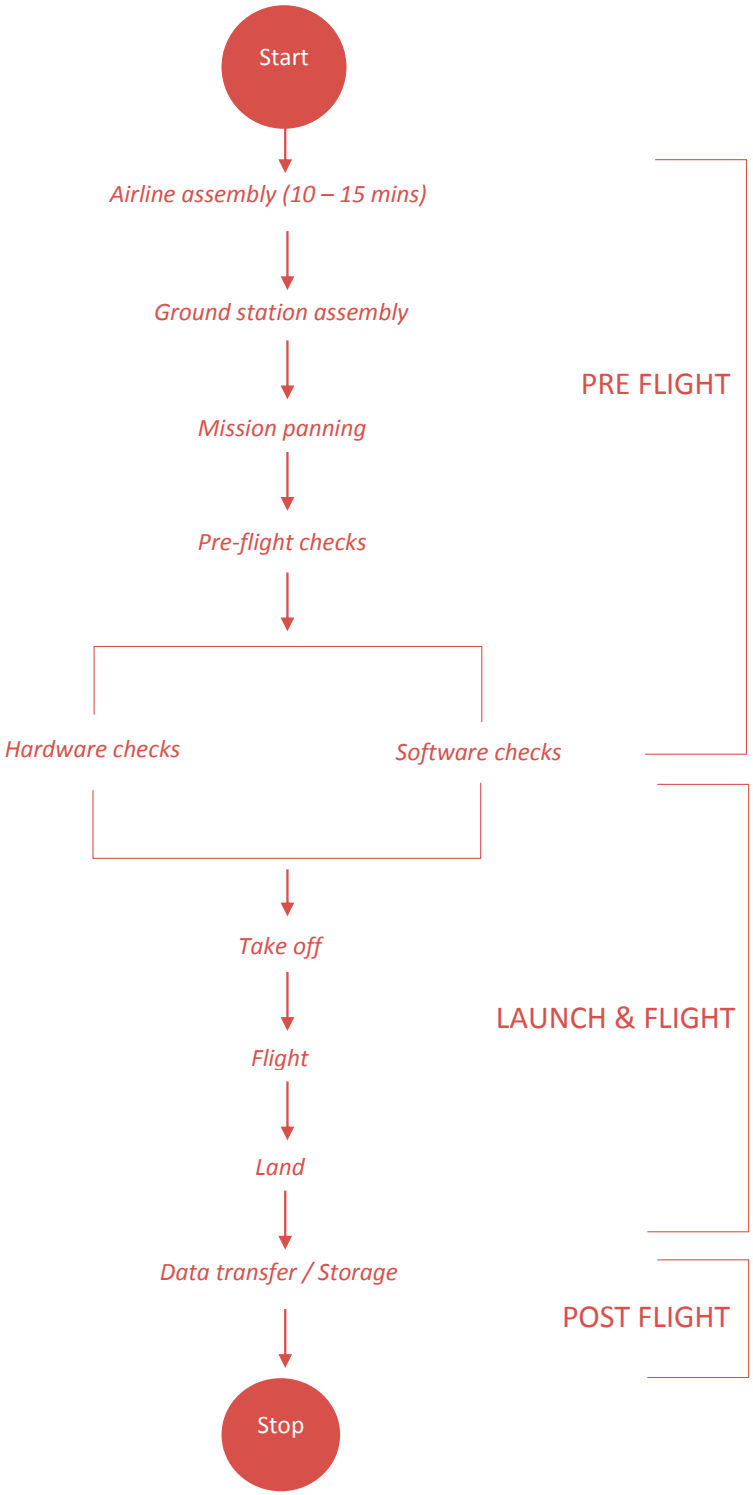
Project Execution Process

The below steps will be undertaken by Skylark UAVs.

UAV Flight

Skylark UAVs undertook the responsibility for flying suitable UAVs with required sensors to survey the land as per consultant's requirements. The day(s) and time for flying the UAV were communicated by Skylark UAVs to the consultants per the project schedule outlined in the next section such that the Ground Control Points are placed in their right position at least a day before the flight of the UAV takes place. On their part, the consultant ensured that the necessary regulatory clearance were available well before the flight day(s), and suitable logistical support was provided to Skylark UAVs' personnel on the ground.

Figure 3: UAV Slight Plan



Data Collection and Transfer

On site operations involved data collection on board the UAV. Transfer of data for further processing and analysis was done as and when data connectivity was available to the onsite team.

Data Processing & Analysis

The data collected by the UAV was processed to generate primary outputs such as orthomosaic, digital surface model and digital terrain model. Additional information for tree counting, canopy area mapping, electric pole location with height of each pole, roads with center distance, height, length and area of man-made structures such as buildings/bridges/railway lines/side and cross drains was also provided

Data processing: After the data has been cleaned the various data sets have to be integrated into one volume of smooth and consistent body of information that can be analysed for various inferences and results. For the integration of the data set into one single orthomosaic map or DSM by the software the following steps have to be done:

1. The GCPs are used as primary reference points to start processing and demarcate the boundaries of the study area. (The GCPs were selected so that they represent assets which were clearly visible, permanently rigid and could be determined with a very high degree of accuracy from the images during processing).
2. The CPs are then used as a point of reference to see the deviation from the Surveyor's CAD report. (These are points that were first marked and surveyed using a Total Station with respect to an arbitrary coordinate system).

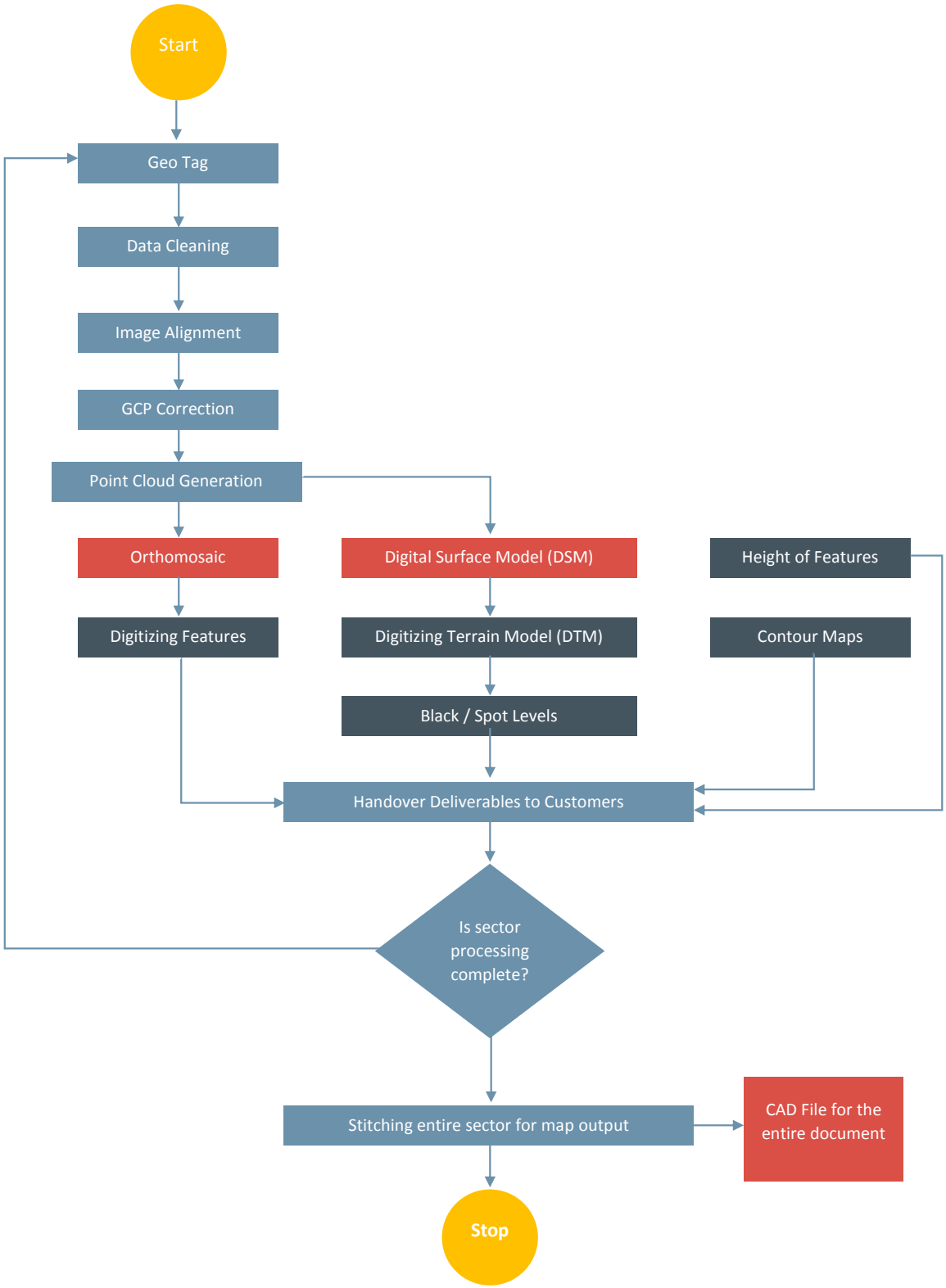
Once the GCP and CPs are assigned other points of interests (keypoints) are identified which are characterised by parameters such as high contrast ratios. Each image is treated as a data set consisting of points and the keypoints are now used to refer to the data set.

The number of keypoints identified per data set depend upon the camera used, it's parameters such as megapixel, focal length and exposure characteristics. The number of keypoints that can be extracted from an image also depend on the amount of visual details present in the area being photographed.

These keypoints are then described using binary descriptors which gives them a definite identity instead of being referred based on arbitrary parameters. The X, Y and Z measurements of keypoints are determined by triangulating the same keypoint using two different images from different locations. The difference in perspective and area gives a relative depth to each keypoint by taking two different images with significant overlap of keypoints (orthorectification).

The relative positions of neighbouring keypoints on the map are then related using software that uses state of the art aerial photogrammetry techniques which include keypoint correlation and matching among the visual imagery. This is then repeated over the entire data set to produce a 3 dimensional orthorectified map. Once this is done, the orthorectified map with all the keypoints is then overlaid with the corresponding geo-reference positions from the flight log for further processing using GIS.

Figure 4: Data processing



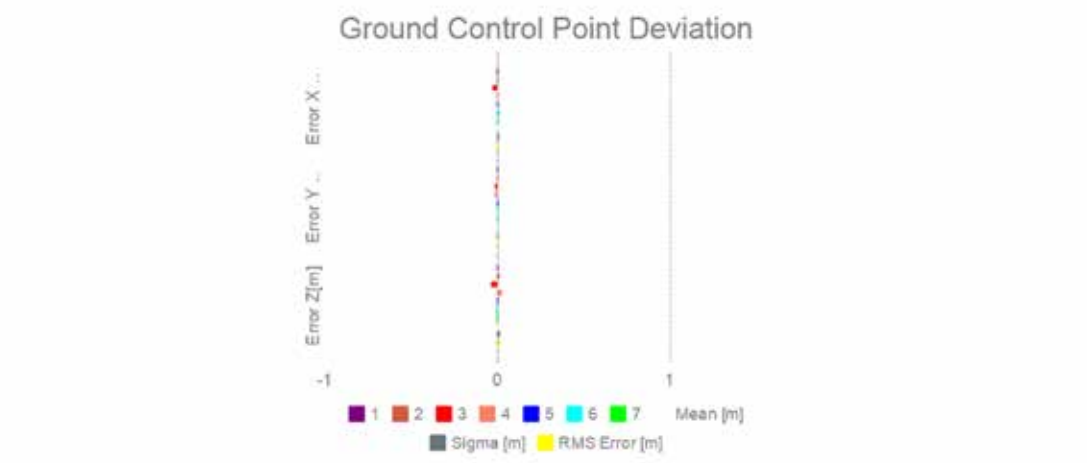
Project Management

Skylark UAVs was to be responsible for complete project management of all phases of project. Project management activities would include project planning, scheduling, monitoring and tracking progress, risk management, quality management, change management, communication with consultant and ensuring that deliverables are provided to the consultant in a timely fashion and ensuring the closure of the project, meeting project objectives and consultant satisfaction goals.

Accuracy Assessment

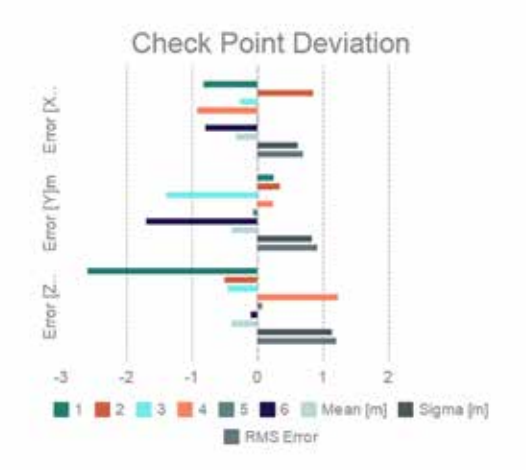
The deviation in the coordinates of the Ground Control Points identified for setting up the arbitrary coordinate system should ideally be zero. However a negligible deviation was observed.

Figure 5: GCP deviation



A sample of 6 check points assigned to corresponding points on the Orthomosaic map and DSM. The deviation from the surveyor's CAD report is shown below:

Figure 6: deviation from the surveyor's CAD report



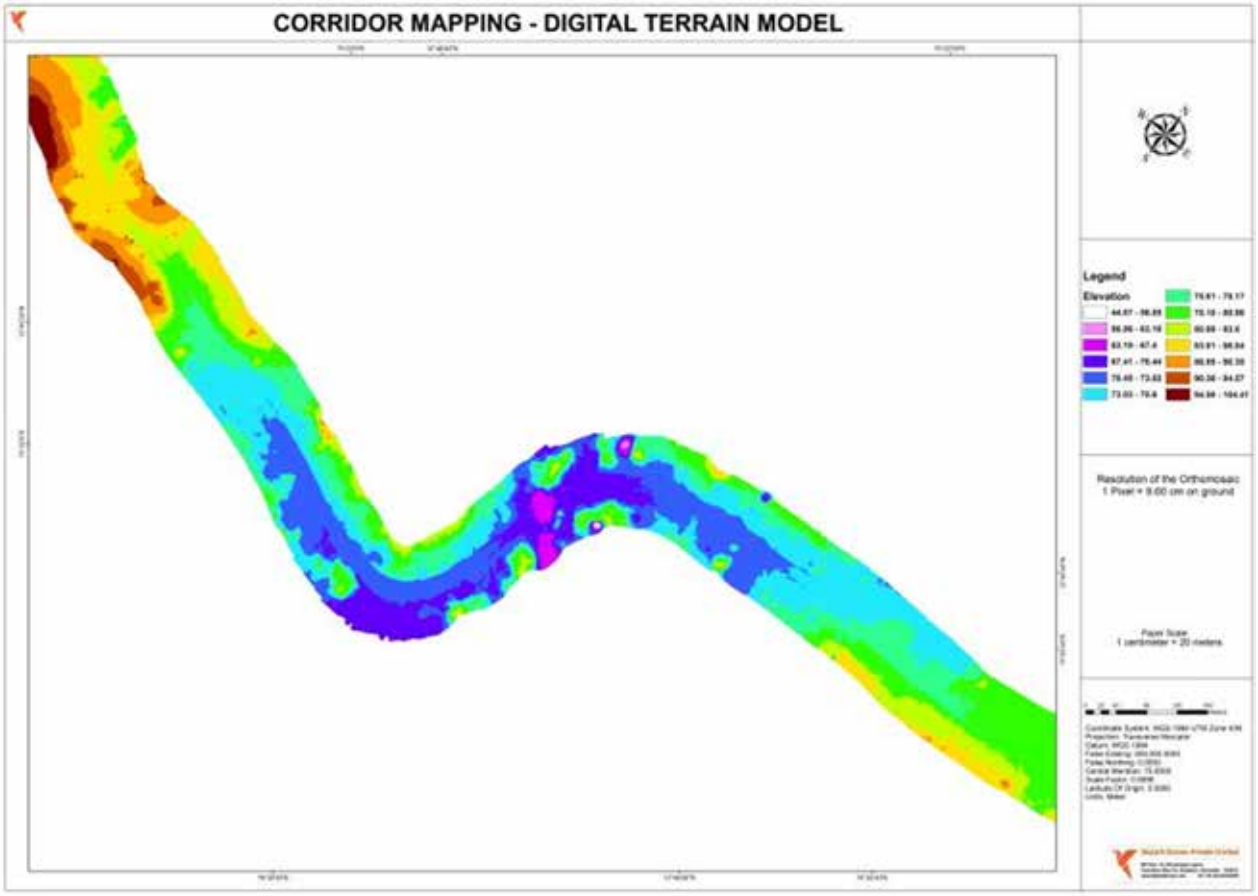
Project Delivery Process

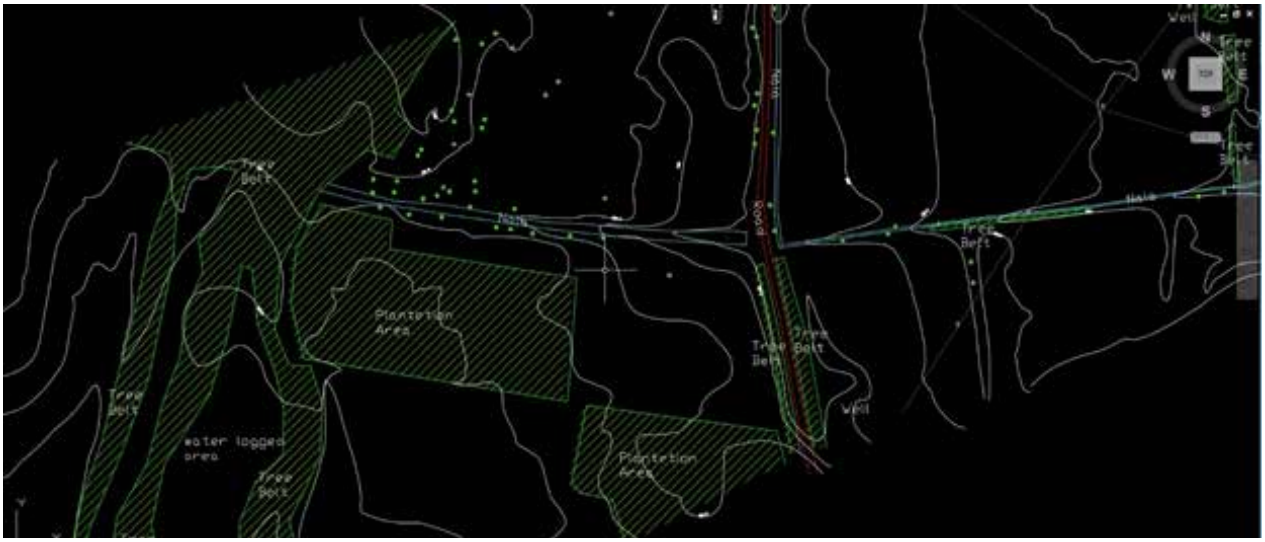
Hosting and Delivery

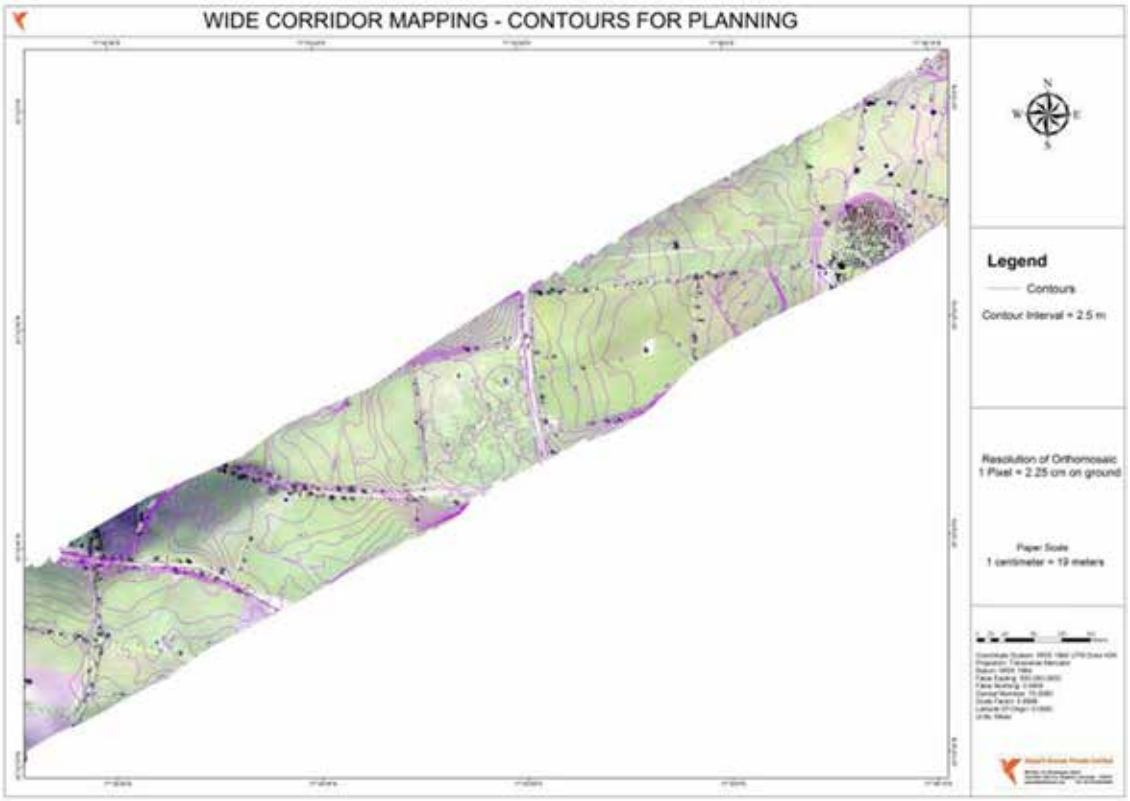
The processed and analysed data was made available at periodic intervals.

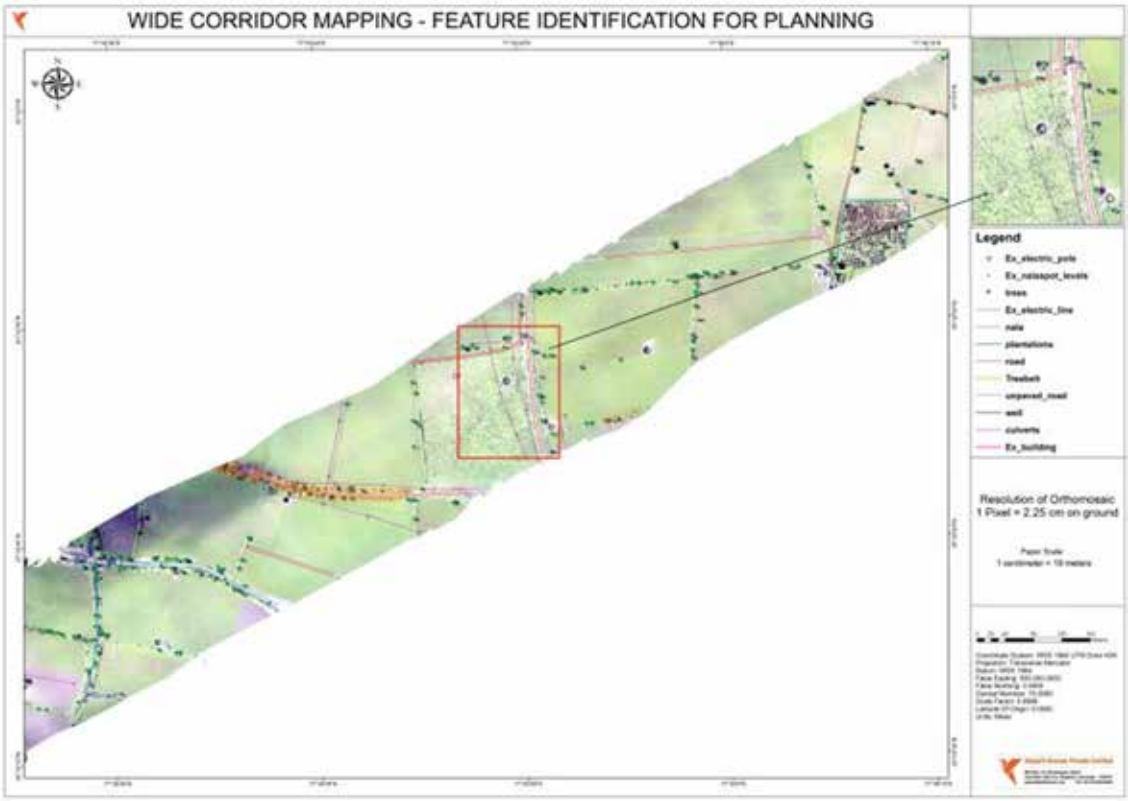
Figure 7: A preview of the outputs

Figure 8: CAD preview of outputs rendered above






WIDE CORRIDOR MAPPING - CONTOURS FOR PLANNING
Legend
Contours
Contour Interval = 2.5 m
Resolution of Orthomosaic
1 Pixel = 2.25 cm on ground
Paper Scale
1 centimeter = 19 meters


WIDE CORRIDOR MAPPING - FEATURE IDENTIFICATION FOR PLANNING
Legend
Resolution of Orthomosaic
1 Pixel = 2.25 cm on ground

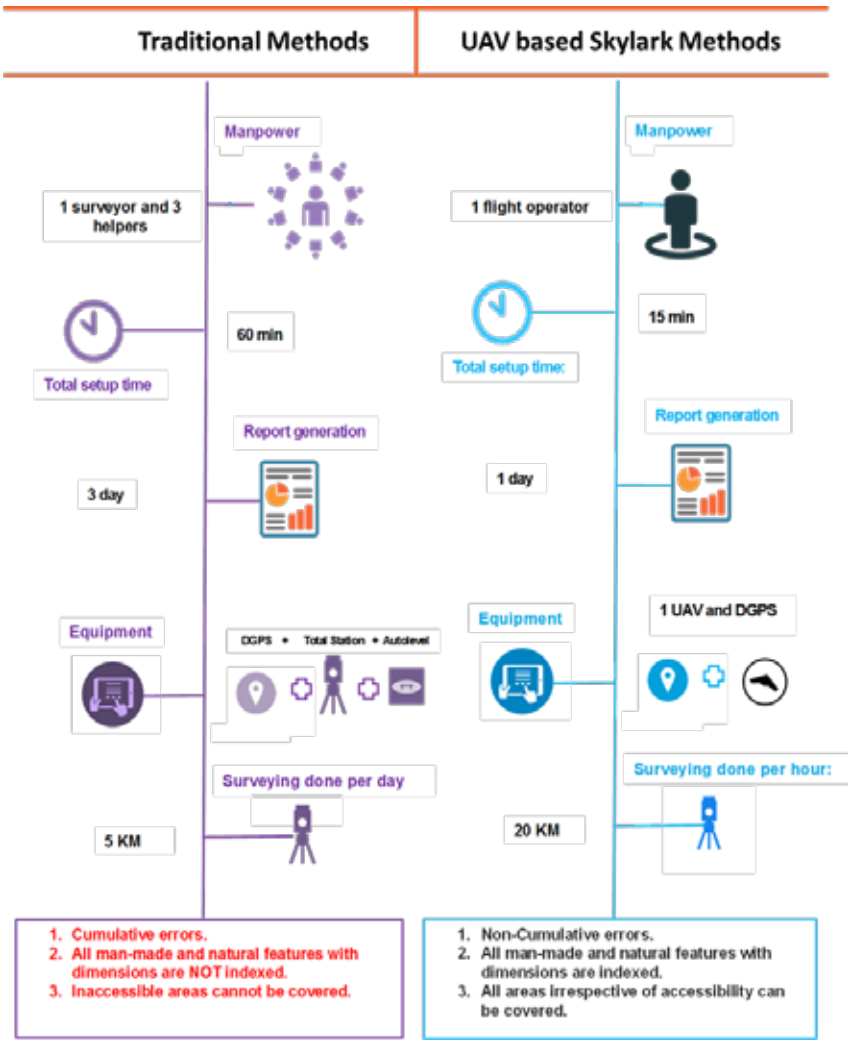
The above process was implemented once to give mapping data as output for civil engineering and planning purposes.

However a complimentary project wherein only video data was acquired twice over for the four major stretches and the datasets from each stretches were compared to give the following insights

1. Progress of road widening and repair work over every individual stretch from an elevated perspective
2. Qualitative assessment of work being implemented that was used a primary filter for work quality verification procedure.
3. Cross verification of manpower and equipment deployed as against promised values as required by tendering process

The project was being implemented with a total team of 10 comprising both aspects of data acquisition, data processing and data delivery.

Benefits



Scalability of UAV enabled surveying and mapping

Time and cost savings observed were significant

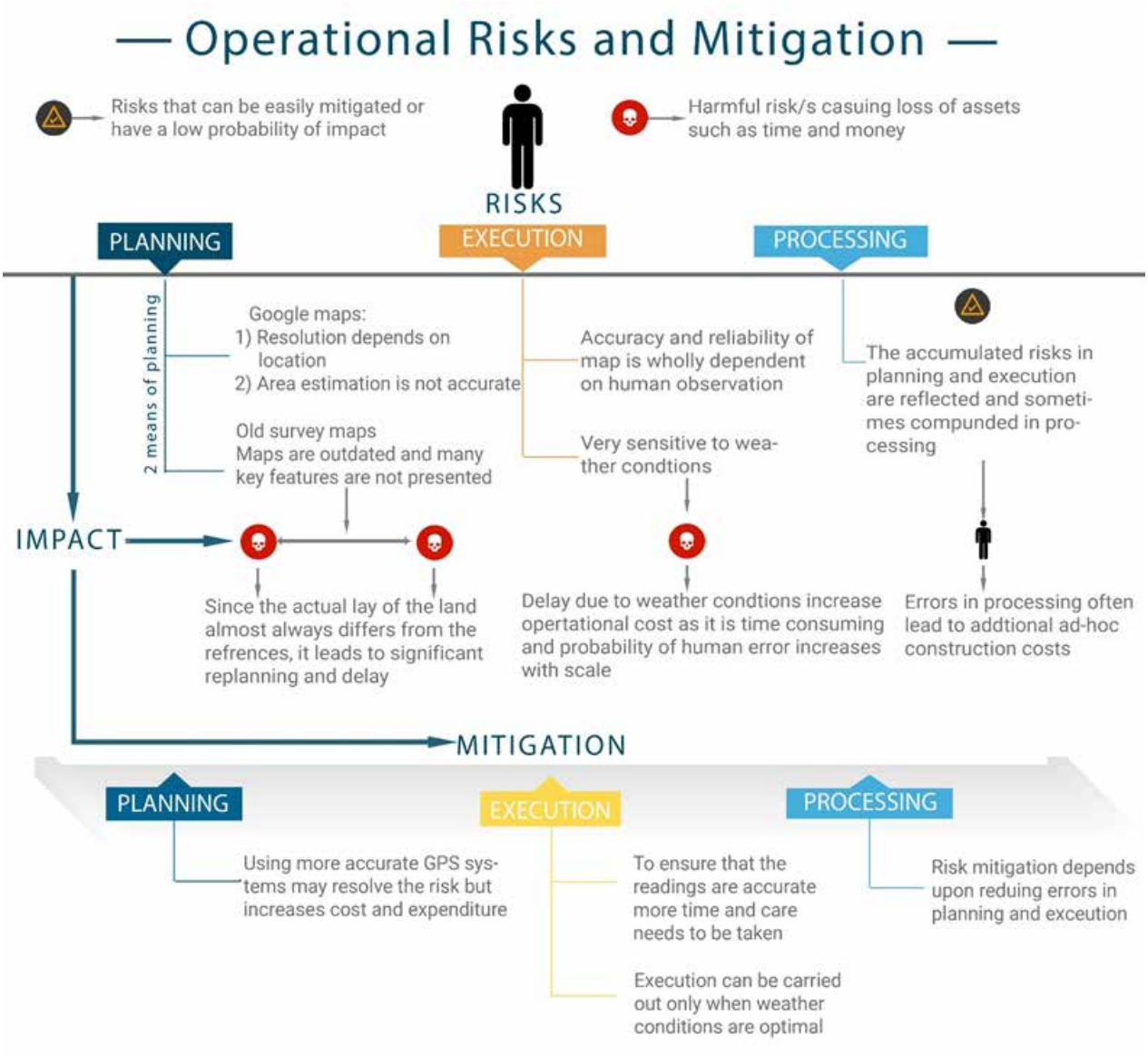
1. On field data collection was about 4-5 times faster than normal methods
2. Project management costs have been reduced through reduced field visits and better data for verification
3. The survey and mapping was implemented at costs comparable to the traditional methods
4. Activities on the ground were not disrupted which led to a simultaneous increase in productivity and public inconvenience
5. Resources including personnel and equipment had to be marginally increased (2-3 times) to observe an increase in productivity by about 8-10 times
6. Inaccessible terrain did not prove to be a hindrance while conducting operations
7. About 200 times more data was collected per unit volume of land that provided additional details such as utilities and nature of vegetation

There is a significant time and labour advantage observed while adopting UAV based survey over traditional mode of survey.

Officials from the government have expressed positive reviews with respect to using the combination of technologies for project management. Future course of action is to make the above service available on a web platform and reduce the size of files and system requirements for handling the data provided.

Future plans also include the use of thermal cameras to continuously monitor the laying of bitumen based tarmac for better quality management and oversight.

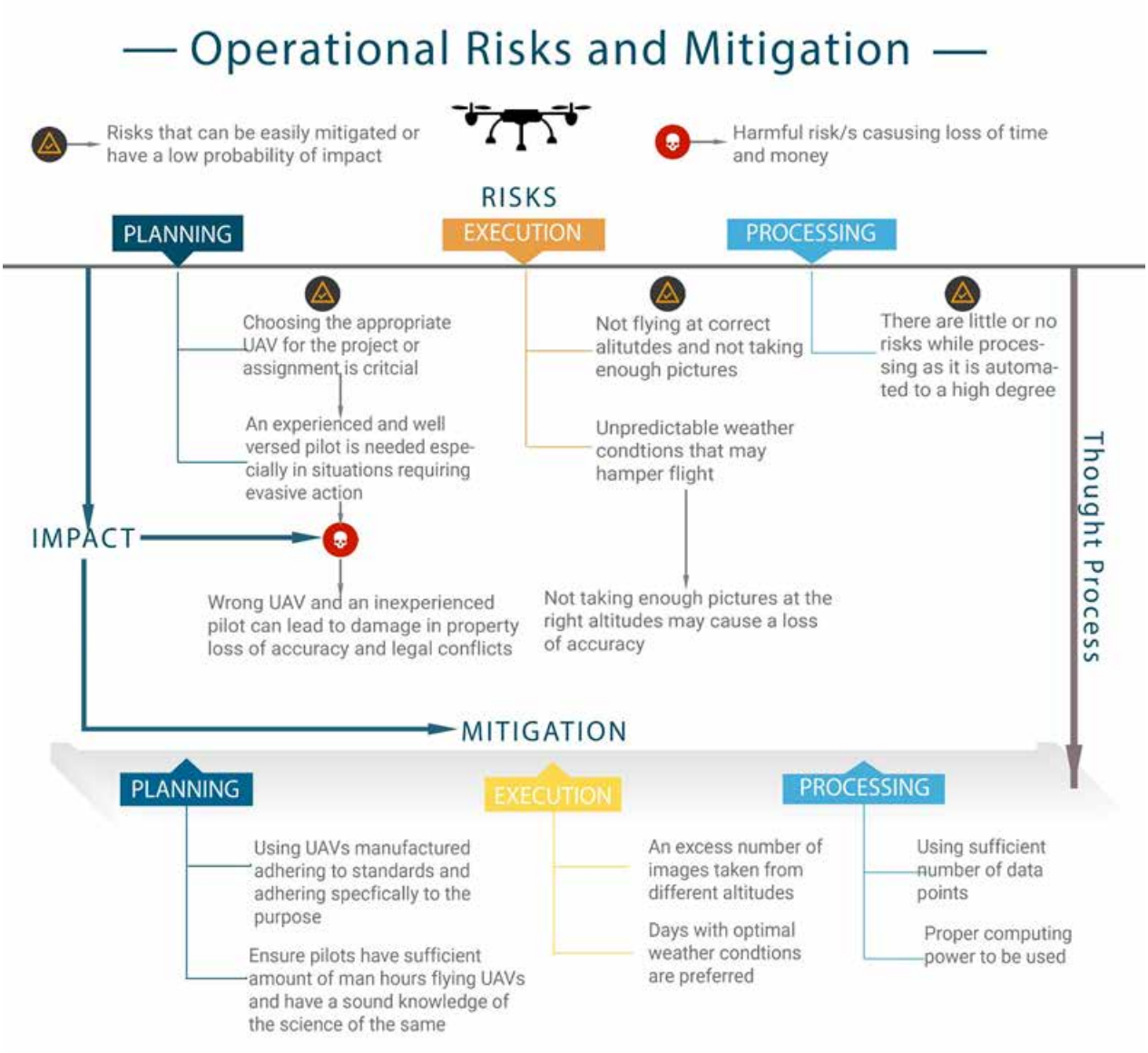
Figure 9: Risks and Mitigation Schematic 1: Traditional Practice



Mitigation Score:

Liability Score:

Figure 10: Risks and Mitigation Schematic 2: UAVs



Mitigation Score: **Risk/ Liability Score:**

Conclusion and the Way Forward

Officials from the government have expressed positive reviews with respect to using the combination of technologies for project management. Future course of action is to make the above service available on a web platform and reduce the size of files and system requirements for handling the data provided.

Future plans also include the use of thermal cameras to continuously monitor the laying of bitumen based tarmac for better quality management and oversight.

K.Gokul

Tamil Nadu Highway Department to Take the High Road to Success

Introduction

In the state of Tamil Nadu, the transportation network acts as the central component of every developmental activity. The exponential growth in the number of vehicles hitting the roads of Tamil Nadu has increased the need for better roads and related transportation infrastructure. State's vast road network needs continuous monitoring and management to make quick, reliable and rational decisions on its upgrade and maintenance. Road network management and maintenance are complex tasks influenced by variety of factors, and include diverse activities in their purview such as assessment of current and future needs for maintenance, upgrade, and improvements.

The task of setting a realistic criterion to decide which roads to repair on priority has today become more difficult with limited funds for road maintenance, an ever-increasing road network and the related voluminous data. The Tamil Nadu Highways Department (TNHD) is primarily responsible for the construction of new roads and maintenance of its vast existing road network. In order to keep abreast with technology and maintain its voluminous transport infrastructure data, TNHD established a web-based Road Maintenance Management System (RMMS) consisting of a database to store road condition data collected through special data-collection vehicles. RMMS consists of a web-enabled Road Information System and PMS - a planning system for prioritization of roads to suit the budget. Although RMMS generates a variety of reports related to road & bridge data, it lacks visualization capabilities.

TNHD wanted an application which would provide them with visualization capabilities to better allocate resources for the road sector. Geographical Information System (GIS) was a befitting solution to provide visualization and enhance the analytical, problem-solving, and decision-making capabilities of TNHD, as it is rightly said, *"a picture is worth thousand words"* and that, *"maps speak a subtle and surprising truth."* A GIS map with data on roads & bridges can help decision-makers in planning, monitoring, and maintaining of roads and related assets effectively. A web-enabled GIS system can take the decision support system to the next level by providing secure access to information over the world wide web, and also ensure timely and accurate decisions related to planning, monitoring and maintaining of roads and related assets

at anytime from anywhere. TNHD deployed a solution, centered around Esri's ArcGIS Server technology, a web-based GIS road and bridge information system (based on the client-server architecture) under e-Pathai (Electronic Project, Administration, Traffic, Highway Assets and Information Management System) program, that integrated the GIS solution with RMMS and Project & Finance Management System (P&FMS).

Usage

- TNHD envisioned e-Pathai as a web-based GIS, to assist them to rationalize decision making in planning, programming, funding, procurement and in the allocation of resources in road sector in order to make the best use of public funds in preserving the road networks at an acceptable level of serviceability. The system improves the technical capacities, skills and management capabilities of TNHD and other related agencies associated with road management and maintenance, thus improving the ability to manage efficiently and cost-effectively road maintenance and improvement activities.
- e-Pathai GIS help to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends. The system is a mix of digital base maps for Tamil Nadu consisting of several layers (spatial data) compiled from different sources, such as Survey of India (SOI) and attribute data (non-spatial data) on roads, bridges etc. from RMMS database besides other attribute data of interest such as demographic details from Census of India, average annual rainfall data from India Meteorological Department.

The Web GIS based Road & Bridge Information System developed for TNHD under e-Pathai GIS is a web based system for;

- Accessing relevant and valid information on the road network and related infrastructure.
- Effective decision making in planning, programming, funding, procurement and in the allocation of resources in road sector.
- Effective prioritization of work as well as reporting on its condition.
- Improved support for decision-making through GIS analytical tools.
- Easy evaluation of the roads and related infrastructure for planning purposes.

Client Server Model

e-Pathai GIS is based on client-server architecture that helps distribute data and process chores across a network. The main part of the application runs on a centralized server, to ensure that any user across the globe is able to access the server application.

e-Pathai GIS Components

The Web GIS built using ESRI® ArcGIS® for Server Microsoft® Silverlight and Microsoft .NET framework is supported by a set of powerful customized query and analysis tools.

Spatial & Non-Spatial Data in e-Pathai GIS

Several spatial and non-spatial data from various sources have been integrated into e-Pathai GIS. The key sources for spatial and non-spatial data are Survey of India (SOI), Open Series Maps (OSM), and RMMS. The SOI layers in e-Pathai GIS are available only to departmental users (TNHD) due to sensitive nature of data. Spatial data for 20,000 Km (SH and MDR) based on GPS data stored currently in RMMS has been used to create a graphical representation of the roads in e-Pathai GIS. The spatial layer thus created has

been linked with the related non-spatial or attribute data in RMMS after cleanup of the various graphical data inconsistencies. In addition to the OSM digital data from Survey of India, several other spatial and related non-spatial data have been compiled as additional layers (MLA, MP constituency boundaries, soil boundaries, District wise Annual Average Rainfall (i.e. Normal) for Tamil Nadu etc.) from various sources, after taking appropriate undertaking and permission, in the e-Pathai GIS.

e-Pathai GIS: Overview of Key Features

e-Pathai GIS is a web-based application written in .Net / Silver light technology which is a cross-browser, cross-platform technology. It runs on all popular web browsers including Microsoft Internet Explorer, Mozilla Firefox and Google Chrome. The Web GIS built using ESRI® ArcGIS® Server, Microsoft® Silverlight and Microsoft .NET framework has a set of powerful customized query and analysis tools developed specifically for TNHD. Some key features of the Web GIS application listed below have been developed based on the data currently available with the department:

Locate Spatially locate various elements on the GIS map such as Boundary (District, Taluk, MLA, MP etc.), Road, Bridge, Culvert (Quick locate and by TNHD Circle, Division and Sub Division).
Query Roads, Bridges and Culverts Query Roads by CW Surface Type, CW Width, Drain Condition, Pavement Composition, Category, CBR, IRI, Inventory Details, Shoulder Type, Shoulder Width, Soil type, Terrain Type, Work History, Traffic (ADT & AADT) etc. Culverts can be queried by Culvert Types & Condition and Bridges by Bridge Condition & Type.
Thematic Maps A thematic map is a GIS map that focuses on a specific theme or subject. Users of TNHD Web GIS can create thematic maps for roads using the Query->Roads functionality. The web GIS application will automatically paint or re-color the road stretches based on any of the road characteristics such as CW Surface Type, CW Width, Drain Condition, Pavement Composition, Road Analysis, Category, CBR, IRI, Road Inventory Details, Shoulder Type, Shoulder Width, Soil type, Terrain Type, Work History, Traffic (ADT & AADT) etc. Similarly, thematic maps can be currently generated for Culverts by Culvert Type and Condition and for Bridges by Condition and Type attribute. Reports can also be generated for these maps.
Bing Maps A web mapping service provided as a part of Microsoft's Bing suite of search engines and powered by the Bing Maps for Enterprise framework is also available in the application as a backdrop layer besides Open Series Maps of Survey of India. Bing aerial view overlays satellite imagery onto the map and highlights roads and major landmarks. Using Bing services made it possible to locate a point or address of interest, find shortest route between two places by distance or travel time.
Bi-Lingual Interface Web sites and web applications in local language have become the order of the day. The Web GIS for TNHD currently has a bi-lingual interface allowing users to switch between English and Tamil.
Identify Selected Features Hidden attribute information pertaining to the selected features is only a mouse click away. If the feature belongs to more than one layer, user can select the desired layer from the 'Identify From' tool bar.
Mouse over info Hidden attribute information can be quickly accessed for a user defined layer such as taluk, district, road, culvert, bridge etc. by just moving the mouse over the feature after selecting a layer of interest.

High Resolution Map Printing Generate high quality PDF files of GIS analysis/ maps for most common paper sizes or to download them for sharing.
ROMDAS Video ROMDAS video has been integrated with the Web GIS. Camera icon is displayed at locations where ROMDAS video is available. Clicking on the camera icon at the required location plays back the ROMDAS video for the selected location.
Vehicle Damage Factor (VDF) VDF tool provided can be used to switch on the census stations having VDF information. When the VDF tool is clicked census stations will display the VDF icon on the map. When the VDF icon at a census station is clicked the relevant VDF information is shown to the user.
View elevation profile along a road This is a handy tool to understand the elevation or profile of the terrain along a selected road stretch. It is also possible to generate longitudinal profile along the user defined alignment, which is useful for route planning.

e-Pathai GIS: Snap shots of the Web GIS

Snap shots of some of the key features of the Web GIS application have been illustrated below:

Figure 1 – e-Pathai GIS Home Screen

Figure 2 – Identify Selected Feature for SH

Figure: 3 Mouse over features (State Highways) for Information

Figure: 4 Thematic for Query on Bridge Condition

Figure: 5 Thematic for Query on Road by IRI

Figure: 6 Report for Query on Road by IRI

Figure: 7 Thematic for Query on Road Work History

Figure: 8 Thematic for Query on AADT

Figure: 9 Thematic for Query on Road Drainage Condition

Figure: 10 ROMDAS Video integration

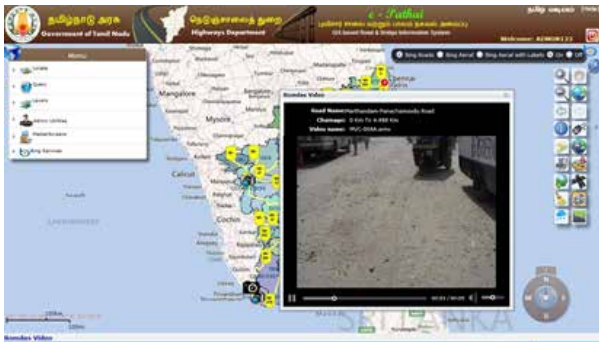


Figure: 11 Routing by Criteria by Shortest Time/ Distance

Figure: 12 Bing Geocode / Locate

Results/Benefits/Accomplishments/Impact

The Esri India GIS solution enabled TNHD to:

- Retrieve and analyse the roads and bridges data visually to help decision makers in planning, monitoring and maintaining of roads and related assets
- Take well timed and appropriate decisions from anywhere by accessing the system through Internet
- Access a common integrated platform (RMMS, P&FMS etc.) for road management and maintenance, thus efficiently and cost-effectively managing road maintenance
- Provide an interface for the public to access details about roads, bridges and other projects implemented

Conclusion

The ArcGIS platform's extensive capability helped TNHD to rationalize their decision making in planning, programming, funding and allocation of resources. e-Pathai GIS has been programmed in such a way that the public can also access details about bridges, roads and other projects implemented by the highways department. It comes as no surprise that this new, robust and holistic initiative has been appreciated by the World Bank for making the best use of public funds in preserving the road networks at an acceptable level of serviceability.

Esri India Technologies Ltd.

Gayatri Projects Improves Grading Productivity

SUMMARY

Gayatri Projects Improves Grading Productivity by 42%, Cuts Fuel Consumption by Almost Half for NH215 Highway Expansion in India.

Grade Control System improves grading accuracy, reduces the number of passes, machine runtime and eliminates rework and wasted material.

Overview

Gayatri Projects Ltd. is the flagship company of Gayatri Group that has interests in infrastructure, power, hospitality, real estate and industry. Established in 1963 as a partnership firm specializing in irrigation construction projects, it has now established itself as one of India's leading infrastructure companies with expertise in construction and infrastructure assets.

Challenge

Gayatri was hired for a highway road widening project in the state of Odisha, India. The 163 kilometer (101 mile) stretch of road (NH215) was being widened from two lanes to four lanes. The Project was delayed due to land acquisition, forest diversion and environmental clearance from the government. The process for handover of land is still on. The National Highway road is considered to be the economic lifeline of the mineral- reach Keonjhar and Sundargarh district of Odisha State of India. To address the delay in the project, Gayatri turned to its technology partner SITECH® and Trimble for help.

Solution

Gayatri equipped its motor grader with Cat® AccuGrade™ Cross Slope Grade Control

Benefits:

- Gayatri was able to stay on grade and improve productivity by 42% compared to conventional methods.
- This includes 36% fewer passes required and 44% less machine run time
- Cut fuel consumption by 47%
- 100% accuracy; met tolerance for grade of +/- 20 to 25 millimeters with fewer passes Gayatri has a strong presence in the engineering, procurement and construction of road, irrigation and industrial projects across India. In fact, over the last 50 years, the company has repaired and built 5,094 kilometers (3,165 miles) of roads and 1,200 kilometers (746 miles) of irrigation canals. Its subsidiaries are also producing power and infrastructure projects that will generate over 5,000 megawatts (MW) of power.

In 2013, Gayatri was selected by the National Highway Authority of India (NHAI) for the widening of the Panikoili to Rimuli section of the NH215 highway. This highway is considered an economic lifeline of the mineral-rich area. In addition to widening the road from two lanes to four, the project requires building facilities including flyovers, underpasses, bridges, bus bays, rest areas and service roads. The project will also include Highway Traffic Management Systems, Highway Patrolling Service and Accident Vehicle Recovery Service. Scheduled to be complete in 2016, this project was broken into two phases: Panikoili to Rimuli, which is 163 kilometers (101 miles), and Rimuli to Rajamunda, which is 106 kilometers (66 miles). Project manager Venkat Reddy consulted with Gayatri's technology partner SITECH India North & East and adopted the Cat AccuGrade 2D Cross Slope system for its motor grader. The system uses sensors on the machine to control the slope of the blade during operation.

In order to widen the road, the Gayatri team had to lay each layer of material precisely, starting with the subbase course, base course and finally the surface courses. To prepare the subbase course, Gayatri conditioned the soil, mixed material and loosened up the hard layer of material so subsequent material can bind properly. There was a 250 millimeter layer of soil and the next layer was embankment top layer at 70 millimeters in thickness. Five full time surveyors surveyed the NH215 site initially.

Traditionally, road building projects require this initial survey plus ongoing subsequent grade checking of the project site. Not only is surveying, running and re-setting stakes costly, it is time consuming and means the motor grader is often running but not being utilized. This burns fuel and adds wasted time to the project.

With the grade control system, only the first pass requires a grade stake and checker. The rest of the passes reference the first pass, using auto mode. The machinemounted sensors calculate necessary blade position to achieve the desired cross slope of the subbase course and surface layers.

"We do not need a senior operator to operate it, even a junior operator can understand how to operate it," said Duryodhana Saahu motor grade operator. "Once a cam bar is set, then even a junior operator can operate the equipment easily and prepare bed."

The system makes automatic adjustments to the left or right lift cylinder as the operator runs the grader. It delivers all of the information to the in-cab display so the operators can quickly spread material or cut at the correct cross slope, which reduces manpower utilization. Real time cut and fill data and in-cab guidance give the operator the opportunity to work more confidently and achieve greater accuracy with fewer passes using less material.

To monitor the effectiveness of the technology, Gayatri tested the system laying material for a 140 meter long (459 feet) by 15 meter (49 feet) wide bed. The surface course layer material was 250 millimeter aggregate and had to maintain a tolerance of +/- 25 millimeters; slope was approximately 2%. With the grade control system on the motor grader, the operator made 21 passes in 50 minutes, compared to manual grading, which required 33 passes and took 89 minutes. The result was 36% fewer passes required and 44% less machine run time. In addition to decreasing passes and run time, accuracy improved by 25%.

Solution

"With the sensor we are getting accurate tolerance limits +/- 10 millimeters, and because of that we require less man power," said Nagraj Chowdary, senior civil engineer for Gayatri. "Once the peg marking is done, it runs automatically by auto sensors of hydraulic systems so no man power is required later, which means we can utilize that manpower somewhere else."

Overall, Gayatri was able to stay on grade and improve productivity and accuracy by 42% compared to conventional methods. Further, they were able to increase accuracy and decrease both fuel consumption and grading time, while building a better road that is expected to have a longer life and overall lower long-term maintenance costs. With less rework, Gayatri saved costs on the final embankment layer material. Fuel consumption for that same embankment layer went from 19 liters (5 gallons) to 10 liters (2.6 gallons), which is a 47% increase in fuel efficiency.

The team also used the motor grader to cut and maintain the road ditch slope when building the road drainage systems. This was needed to remove material from the bottom of the ditch. With a slope of 2.5%, the operator can create a crown by depositing the ditched material. By reversing the cross slope, the operator can move the material across the crown and down toward the other ditch if needed.

Trimble

8

TRANSPORTATION

Ground up Approach for Solving Local Transportation Issues

Introduction

In the first decade of this millennium, India underwent some massive demographic changes. We witnessed a major urbanisation drive, as more and more people moved to the cities to seek better life prospects. If we look at numbers, urban population, as a percentage of total population, went up from 17 percent in 1951 to 31.8 percent in 2011. In the 2000s, we saw a formidable 91 million people move to cities and join the already swelling population of urban dwellers.

As a consequence, the number of metropolitan cities (i.e. cities with a million plus population) rose from 35 in 2001 to 50 in 2011 (Source: Census of India, 2011). Since then, this number has only grown bigger. Out of these 50 cities, eight of them – Mumbai, Delhi, Kolkata, Chennai, Hyderabad, Bangalore, Ahmedabad, and Pune – reported a population of over 5 million.

Of course, this rapid urbanisation did help with the growth and development of our economy. Urban areas were contributing more than sixty percent of India's national income. It was also quite obvious that with this growing urbanisation, cities would continue to play a critical role in sustaining high rates of economic growth.

But this sustained growth was possible only if an important caveat was addressed – the availability of good urban infrastructure. For cities to function efficiently and for residents to enjoy a good quality of life, mobility is a huge factor. Effective transport systems, that can efficiently move people and goods through the city are crucial. A sub-par transport system can not only seriously stifle economic growth and development, but it directly affects the competitiveness of a city, in terms of its ability to attract commerce and talent.

Existing Infrastructural Constraints

Public mass transport was carried out primarily through urban rail services, buses, trams (in Kolkata). Only four cities - Mumbai, Delhi, Kolkata and Chennai had functioning suburban rail systems and these were simply not enough. In the other cities too, commuters had to deal with buses that were overcrowded, unreliable, and often had long and unpredictable waiting periods.

This demand for personalised transportation was being fulfilled by intermediate public transport modes such as auto-rickshaws, tempos, taxis, hand-pulled rickshaws etc. Their availability was sketchy and largely unreliable, especially in suburbs and during off peak hours. Additionally, hand-pulled rickshaws, besides being uncomfortable, also posed ethical issues due to the poor quality of life they offered to the rickshaw-pullers.

Call taxi services were few and far between with inconveniently long lead times and quite unreliable for day-to-day needs. Organized personal transportation was almost non-existent.

With millions of consumers travelling point-to-point every day for various purposes, there was a crying need for innovative transport solutions that could meet the needs of the growing urban population.

Emergence of Geospatial Technologies

A parallel, although unconnected, trend was the growth of geospatial technologies including Global Positioning System (GPS) or Geographic Information Systems (GIS) which offered the potential to transform local transportation. The technology made it possible to create extensive near real-time maps that could provide valuable on-ground information. Traditionally, Geospatial technologies are built for mature markets like the US where there is easy availability of structured map data, lower density of population and broader roads.

In India, on the other hand, digital maps are not available readily. An inaccuracy of 20 metres in the GPS signal can be the difference between one side of the road and another. Densely packed residential and commercial buildings can become difficult to resolve.

Personal Transportation Solution in India

It was these insights that prompted us to launch Ola as a way to aggregate the highly scattered personal transportation offerings into a single system that was efficient, reliable, scalable and affordable; through the use of geospatial technologies.

The technology application sounds simple in principle. When the cab drivers install an app and login, their position is tracked using GPS in their smart phone and their coordinates, date, time and speed are recorded, which gets stored on the company server. We use an exhaustive mapping system and complex algorithms that work to determine cab availability, shortest distance etc., and to communicate with customers; through software installed on the back end.

One important factor was that we chose to build our solution ground up and scale it up using technology. This meant that instead of taking an existing solution and trying to force-fit it into the Indian context, we were able to build a solution that was tailored to meet the very unique requirements of Indian passengers.

We created hundreds of thousands of entrepreneurs and brought on board tens of thousands of traditional mobility service providers like black and yellow taxis, autorickshaws etc. to bring efficiency into the process of hailing a taxi through the power of technology. People could now book cabs, autorickshaws at very short notice through our call centers or website.

Most of our driver devices cost ~$150 as compared to that of drivers in the US or Europe who predominantly use devices which costs upwards of $800. Our software addresses the challenges around poor quality of location signals from these low-end devices and the unique challenges due to existing mobile data infrastructure in India. By accounting for these structural problems we've removed barriers of entries for our driver partners to earn a decent livelihood

Through all of this, our singular focus has been to ensure that we are always conscious of ground realities and limitations of existing infrastructure. We constantly work to make the experience as convenient and accessible as possible, for both our drivers as well as commuters. Here are some examples of this:

Mapping technology

Given that our entire platform draws on the power of geospatial technologies, getting accurate maps that accurately reflect on-ground situations was crucial. Local nuances including one-ways, short-cuts and unmapped terrains make for a challenging ground reality. Add to that diversity in culture, languages and demographics, which makes India a very unique place. Therefore, we put some amount of effort to enhance the efficiency of Google maps and work with local norms.

Ola Hotspots

We worked to identify popular "Hot Spots" i.e. high demand areas such as tech parks, housing colonies, malls, public spaces etc. which have multiple entry and exit points. Commuters waste a lot of time in locating drivers while booking their ride from such public spaces. So, through our Ola Hot Spots, our App proactively suggests 'Hotpots' closest to the customer's location and send this information to the driver in the form of text, instead of displaying a geographical location, which might not always be 100% accurate. To identify these Hotspots, Ola had its on-ground teams survey these places and identify common names for popular pickup points, one of the most unique use cases of localisation.

Snap to historic pick-up

One of the main things Ola has done is personalise customer's pickup spot to their preferences. Some people prefer getting picked up in front of their homes, others prefer calling a cab across the road to save time on detours. This feature allows Ola to customize customers' pickup location based on these preferences. Essentially, this feature uses a customer's past rides as a reference point when triangulating the user's historic pick up point vis-a-vis booking point

Share Directions

Digital maps in India still do not capture the local nuances that are used by commuters to describe their location. Understanding the challenge of navigating through the many lanes and bylanes of the Indian cities, we developed the 'Share Directions' feature which allows user to feed in the landmark closest to their pick-up location that will be communicated to the driver instantly. This feature allows customers to identify prominent features like an ATM, Super-market, police station, etc. to help the driver pin point the customer's location with accuracy.

It can also be used to give specific instructions to drivers - like knowing which apartment to ask for at the entrance of a gated society!

Low or no Internet

Internet connectivity is often a challenge in Indian cities. Although over 46 crore people in the country today have access to internet, it still only accounts for 34% of the population. A vast majority of the populace even today, struggles to get adequate data connectivity at all times. In India, users are more inclined towards prepaid mobile service, making them more vulnerable to running out of data. Spotty 3G and 4G coverage also account for a fair amount of data connectivity issues, even in Tier 1 cities. It was this reality that prompted us to come up with a feature that enables customers to book a cab even without Internet on their smartphones. We've piloted the feature in smaller towns and cities since last June.

Auto-Connect to Wi-fi

Wi-Fi hotspots that are available publicly today, are cumbersome to use with login credentials and unique passwords to be input every single time, give a broken connectivity experience on the move. Also, the need for seamless connectivity is extremely important in a local market like India which is seeing a massive growth in the user base of smartphones that is upward of 40% year on year. This prompted us to launch Ola Wi-Fi, a feature that allows users to auto connect to Wi-Fi in an Ola cab without having to enter credentials every single time. Users with a one-time authentication on their phones, can use Ola Wi-Fi on their devices without having to key in login credentials and passwords in subsequent rides, staying connected with Ola's secure network whenever they take a ride.

Language barriers and communication modes

Right from the beginning we understood that Indians are not comfortable communicating either through a computer or an IVRS system, especially in emergency situations. Therefore, we have always maintained 24X7 Call centers for customers to provide the much-needed human touch.

Also, recognising that a majority of our drivers are not necessarily comfortable communicating in English, we made sure that our Driver app supports eight regional languages across India, making it extremely convenient and user friendly for local drivers to use. We also have 24X7 walk-ins at our call-centers for drivers to ensure that their businesses run smoothly.

Shared Mobility

To tackle the twin challenges of congestion and pollution, as well as to make commuting more pocket friendly for users, we launched Ola Share, which allows users to car pool when they are travelling in the same direction. Using complex algorithms that are developed right here in India, we have been able to ensure minimum deviation as well as optimum wait times.

To sweeten the deal even further, we launched services such as 'Share Pass' that offers fixed fares per ride, and a predictable and consistent fare for regular Ola Share users. We also launched Share Express rides that only operate on fixed routes and offer unbelievably affordable commutes.

The use of Geospatial technologies has brought several benefits. We have been able to:

- Optimise routes
- Use real-time information
- Enable analytics to accurately predict demand and traffic flow
- Route cabs more efficiently based on demand patterns instead of traffic patterns

Transforming Urban Transportation

The cab aggregator market is developing at a fast pace in our country. On an average, there are over 300 million rides happening in India on a daily basis. These include auto-rickshaw and taxi rides and with a large working population, this is increasing by the day. The market is estimated to be over $12 bn and is a rapidly growing industry not just in India but on a global scale.

Upskilling

The convenience, ease of use and availability of our app in 8 local languages has enabled us to upskill several rickshaw pullers as well as auto drivers to help them climb up the economic ladder. Although the entire

operation is based on highly sophisticated technology, the fact that it has a simple, intuitive user interface makes it completely accessible.

Digital India Vision

We're not only helping our driver-partners become a part of our PM's Digital India vision, but, also ensuring increased connectivity and mobility at all times. Besides, by encouraging the use of digital payments through incentives and convenient payment options, we are taking them towards a cashless economy.

Driving entrepreneurial spirit

Our driver associates are not employees, but entrepreneurs in their own right. They have all the opportunity to manage their schedules, grow their income and earn a decent living. On our part, we have focused on building a holistic ecosystem for our driver partners, professionally as well as personally, allowing them to grow as entrepreneurs. We have rolled out a number of initiatives like driver Melas, health check-ups, educational loans, family support initiatives, etc. that are aimed at ensuring a better quality of life for our driver associates.

What the Future Holds?

Reskilling and Upskilling

The mobility sector in India is seeing phenomenal growth and has the potential to empower aspiring individuals from all walks of life to become micro-entrepreneurs. Skilling and promoting entrepreneurship has been at the center of our business strategy since inception. Aligned to PM's vision of Skill India, we are committed to skilling at least 50 lakh driver-entrepreneurs in the next 5 years, and also help meet the growing demands of urban mobility within the existing infrastructure, with smart solutions.

Better transportation facilitated by mobile Internet

With smartphone usage picking up in rural India, the country will be better connected on mobile phones. With an inclusive approach towards addressing the mobility challenges in India, we are driving a significant behavioural change in semi urban India. End-to-end integration of transport not only in Tier 1 but in Tier 2 and 3 cities as well is what we look to accomplish in the near future.

Inclusive Growth

Because our mission is to provide mobility to a billion Indians, we seek to bring existing and new modes of transport under our ambit; making it that much easier for a commuter to access all these mobility options in one place. Apart from the existing taxis and autos, we will also need to look at:

e-Rickshaws – Because they are battery-operated, e-Rickshaws offer an excellent eco-friendly alternative to petrol/diesel/CNG-driven vehicles, thereby helping to curb pollution. They are also easy to ride, making them a convenient means of livelihood for many.

Shuttles – Point to point shuttle services can be a convenient and affordable option, especially for daily commuters. They can also help ease traffic congestion in large cities.

Bikes – Bike taxis can be a convenient option for commuters travelling alone, as they offer faster commutes within the city. Overall, they can also help ease traffic congestion.

Partnering with Government for Road Intelligence

Given the enormous amount of data that we harness on a daily basis, we believe that we are in a good position to share rich insights with government authorities in order to bring positive changes to our cities' transportation landscape. Road closures, accidents, traffic movement etc. are some examples of such data.

Conclusion

Technology is at the core of what we do at Ola and it will play a telling role in the evolution of the transport system in India. Services cannot restrict themselves to only providing point-to-point services anymore, the process needs to be completely integrated. The real game-changer will be the wholesome experience provided through the journey, seamless payment mechanisms and technology to help them keep connected.

Ola

GIS Based School Bus Tracking

SUMMARY

Consciousness and concern of safety of their children among parents is increasing in urban India. Most school students travel to school in designated public or private school buses. At most times, these are ill-maintained and thus follow irregular routes and timings. Increased city traffic has added to this uncertainty.

Smart Bus has been a concept being talked about for a while but we still need to see its usage in India. School Transport is a sector which affects everybody on day to day basis and requires measures to ensure safety and security of students in transit. How can we ensure buses run on time, like in foreign countries? To do that, we need to track them and make driver conscious about the importance of running on time and safely. Writing telephone numbers to contact if driver is driving rash was only a small first time.

Application of Mobile and location based technologies provides capability to monitor and track the school buses from anywhere anytime. Mobile as a channel has become so strong that in India we may find households not having computers but everybody has mobiles. Information Alerts about arrival and departure of school bus and exact geo-location and ETA in mobile app is a boon for parents when they go out to drop and pick up their little ones early morning and late afternoons. These technologies not only add to the convenience of parents but also provide a safety cover in terms of drivers being conscious of being monitored for rash driving and over speeding. School Transport has a geospatial dashboard to monitor the status of buses and take corrective measures in case of violations. Mobile technologies also ease communication between parents and school leading to continuous improvements through feedback and comments. In an unwanted situation of an accident or injury to any child, real time tracking, monitoring and status update helps action by parents or teachers to bring medical aid early, saving precious time. Business Intelligence and Analytics add further dimension in providing reports and models which helps school transport in optimizing maintenance and fuel cost, reduce speed and route violations and overall monitoring of fleet movement based on historical location data.

The Need

There is constant pressure on School Transport to provide a safe, secure and reliable transport service to the students and also to be cost effective and ensure profits for the fleet providers. The rate of increase in transport related incidents are really worrisome and alarming for school administration and parents. School Transportation has been a non-organized sector and despite the fact that it deals with school going kids there are only few measures taken by the schools and transporters to ensure safety and security of the kids. In some cases, transport is outsourced by the school to a transport company wherein buses, drivers and attendant staff is provided by the transporter itself. In some states, government has mandated installation of GPS devices in the buses but the usage is only limited to getting the vehicles passed by Road Transport Department. Every morning parents wait on pickup points for arrival of school bus. If they reach early at pick up points, they have to wait endlessly, if they get late, they miss the bus. Parents are also concerned about over-speeding by the driver during the commute which could be fatal at times as there are no seat belts in buses and small kids might get hurt during speeding and sudden breaking of the vehicle. There is no alert if the bus takes detour. If there is a break down or long halt, school transport and parents do not have a clue on the whereabouts of the bus. Often drivers/attendants do not pick up the phone during such incidents. Our geo-spatial and mobile technologies have potential to address the problems faced by parents, school transport through real time monitoring of school buses. These technologies enable the school transport managing their fleets in terms of daily runs, speed violations, routes violations, and transport misuse. Parents will have the peace of mind while sending their kids to school as they are aware of the location of the bus and will get to know about over-speeding and breakdowns as and when it happens. Following are the key Challenges faced by School Transports and Parents:

a. Lack of a reliable solution to track the school bus on anytime, anywhere basis.

b. Manual dependency in managing school transport, route assignments and communications.

c. Lack of business intelligence and efficient analytics for location data analysis and inferring results.

d. Time-consuming maintenance processes.

e. Schools considering transport as an additional responsibility and not concerned about providing adequate measures for safety and security of students.

f. Schools not investing in quality software & services and rather going for cheap unreliable services to meet regulatory requirements.

And here is the Solution

Usage of GPS tracking technology helps transforming school buses into smart buses. Schools enforcing such systems are preferred by parents for offering such needed services which are becoming critical for ensurings safety of students.

We use geospatial and mobile technologies to give visibility to parent who can track the location of the vehicles in real time on map. Location based services help parents /schools to be aware of bus location and plan for pick and drop of students. This adds to safety of students as absence of parents for pick up/drop or school attendants for boarding/de-boarding students, at school has led to incidents in past.

Safeplanet Innovations has built a mobile based application for parents, schools for receiving the information, alerts and location updates of the school bus in real time. While the parents can see the exact location of the bus on map and expected time of arrival, they also have the provision to mark kid as absent in case child is not going to the school that day. This prevents unnecessary delays for students who are going to board on subsequent pick up points. Parents can send their feedback to school using mobile app. Schools can manage their entire fleet through a geospatial dashboard and online reports like fleet travel summary, long

halt, over-speeding reports and features for mass communication like email and SMS.

Following are the key features of the applications:

On the tips of parents:

a) **Pick/Drop Alerts/SMS:** Real time alerts for arrival and departure of school bus. Prior intimation through SMS/Mobile App Notification to students/parents that bus is approaching pickup point.

b) **Live Tracking**: Live view of bus route on map. Track the school bus on real time on map and expected time of arrival for the pickup/drop point. Parents can plan their time to receive their children on return from school.

c) **Long Halt/Breakdown Alert/SMS:** Information about Long Halts and Break Down of Bus.

d) **Absent Notification:** Parents can mark the student absent saving wait time for other students.

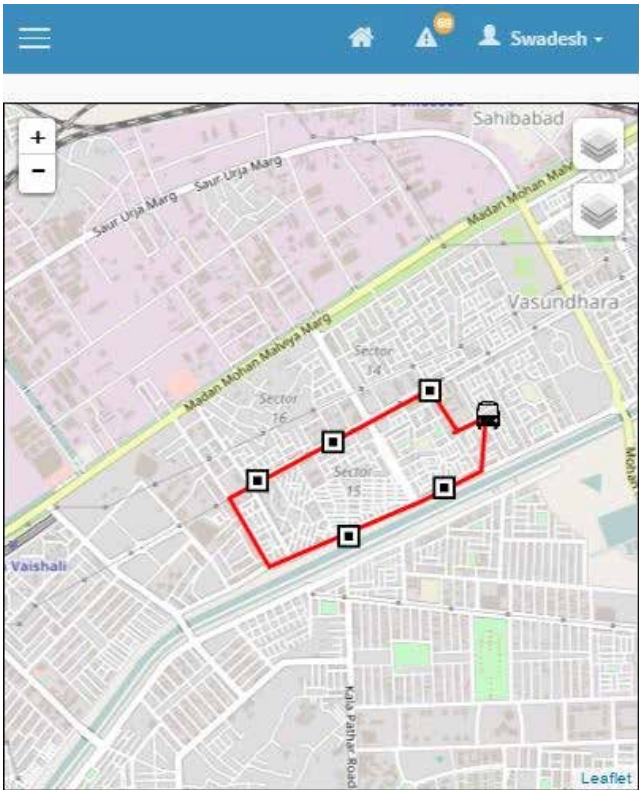
e) **Bus Staff Information:** Driver, Attendant and School Information on tips.

f) **Feedback/Complaints to School:** Parents can register complaints /feedback with school using the app.

g) **Complete Information:** Information about the Routes, Pick up, Drop Time and facility to update the address information etc.

h) **Secure data:** Your account is password protected. Only Authorized and approved parents/guardians can see the students' details and tracking information.

Figure 1: The parent mobile view (map source: OpenStreetMap)



Power to the School:

a) **Route Management:** School Transport can manage routes, parents and students pick up/drop information.

b) **Live Tracking:** Live view of all buses on map. School Transport personnel can see all the buses in real time on a geospatial dashboard.

c) **Historical Reports:** Transport department can see history of trips done by school buses.

d) **Driver Analysis:** School Transport can also see Long Halt and Over Speeding incidents of School Buses. Total distance and total time travelled.

e) **Message Broadcast:** School Transport can send information about transport issues through mass SMS/Email System.

f) **Downloadable Reports:** School Transport Admin can view/Download multiple reports, some of the key reports are as follows:

- Student attendance
- Bus location
- Over speeding
- Stoppages
- Fleet summary
- Position summary
- Halt summary

Figure 2: School admin dashboard

g) **Economical:** Fleet tracking reduces speeding, excessive idling and unnecessary vehicle usage — thereby reducing fuel consumption and carbon emissions. Case studies report an average fuel savings of 15% per vehicle. With vehicle tracking, what's good for business is also good for the environment.

Table 1: Facts on average wait time for any pickup point for students

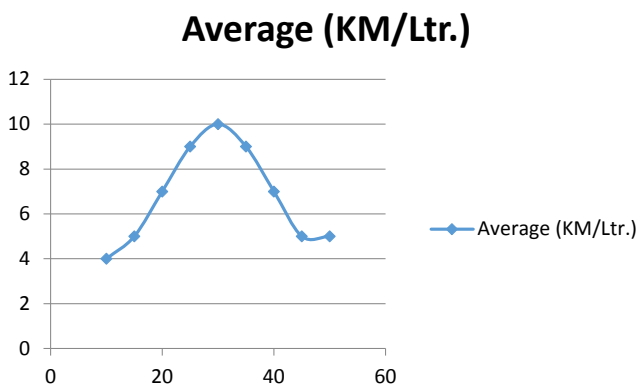
Average Wait Time per Stop	Total wait Time for a Round Trip	Additional KM due to Key on Bus Waiting	Fuel Wastage %
0.5	5	2.5	8%
1	10	5	16%
1.5	15	7.5	25%
2	20	10	30%

**Assumptions: - Average speed of bus is 30KMPH/ Average distance per day 30KM/ 10 Pickup points per route/ 50% probability of waiting per route.*

h) **Reputation**: Convert your ordinary transportation service into a high-tech, technology enabled services. The schools deploying such technologies are preferred by parents for providing such unique, reliable and safety services. It also establishes the modern IT infrastructure outlook of the institution.

i) **Cost Optimization**: Transport Management Systems bring accountability, which improves driver behavior, reduces fuel cost and undue overtime billings. When vehicles are not misused in off-hours, overall maintenance and fuel costs decrease. Driving with constant speed will be more cost effective and not only save time but tear of the vehicle.

Figure 3: X-Axis Speed, Y-Axis Avg.



j) **Discipline**: With vehicle tracking, drivers are more punctual and speed conscious. Pick up and drop time shifts are started and completed on-time. Transport Dept. always know where the vehicles are, where they were, and for how long. Over-speeding & detours are identifiable. In the event of a dispute, vehicle tracking provides irrefutable proof-of-work.

Figure 4: Admin Geospatial Console (Map Source: OpenStreetMap)

The Utility for Driver/Attendants:

a) The SMS facility and Mobile App notification avoid the need of calls from/to driver/attendant and helps the driver concentrate on driving rather than diverting his attention towards dialing/receiving the calls from parents.

b) As the students/staff are on time at the bus stop, the driver can maintain the time schedule for the next pickup points and thereby reaching the school on time. This eliminates the general concern of over-speeding to make up for the lost time.

c) The driver/conductor is relieved of the stress of communication which they undergo currently, but are unable to express as they have unwillingly accepted the communication as part of their duty.

Scalability & Replicability

Considering the scale, application has been designed as a set of loosely coupled components. Application is multilayered by design with each layer addressing specific aspects. It is a highly configurable product having plug n play features and components. Application is deployed in Cloud and can be accessed any-time from anywhere with flexibility to scale up on demand. Cloud infrastructure provides failover and load balancing capabilities for uninterrupted services.

As the application is componentized, it can be repurposed for any other domain like public transport, corporate and commercial transport. Application model is flexible enough to accommodate any domain specifics requirements.

Positive Impact

iSafeTrack - School Transport Management System from Safeplanet Innovations addresses school transport issues without adding any complexity in the process. The system has been deployed on a cloud platform and accessible as a service to both schools and parents. Mobile Interface along with real time availability of location on map makes it highly convenient to use. It is as easy as using OLA or Uber and hence has high acceptability. The system has been deployed in schools in NCR and being used by parents, schools and gaining further traction through word of mouth. Roll out of mobile based transport management system has led to sense of safety and satisfaction among parents using school transport. This has significantly reduced number of calls to school transport department and has given them a better control in terms of management of routes, students and users information. School transport can easily figure out route violations and monitor speed violations. In case of long halts school transport can arrange alternate transport and arrange required mechanic/ help to fix the issues. Based on the feedback received during parent teacher meetings, parents are really looking forward to use this kind of services based on Geospatial technologies and expects many more features to further enhance child's safety during travel between school and home. End-to-end service including device, application and connectivity, means greater accountability and lower cost of ownership for the schools. Access to scalable and future-proof services means you need not invest up front in the IT infrastructure. Quick and seamless deployment helps you getting started at the earliest. Following are the key benefits for all the stakeholders:

- Safe
- Simple
- Geospatial tracking of the bus, just as Uber and Ola
- Better brand building for the school in the eyes of parents
- Save on fuel or removing the chance of fuel pilferage
- Saving in manpower cost at School transport desk

What Lies Ahead!

In the era of high speed internet and mobile being the most popular gadget, parents want to doubly sure about safety and security of their kids. Getting real time information about location of kids makes them feel secure and adds to child's safety and security. As a next stage of this application, students can be given wearable devices which will help parents track their locations even after they leave school bus and track daily activities while in school and out for play. Mobile DVRs and vehicle mounted CCTV cameras also provide real time surveillance of vehicles and provide parents real time footage of vehicle while their kids are travelling to and from school. For School Transport, Smart Buses concept adds lot of value in terms of cost, effort and reduction of transport issues. There are instances when a safe transport becomes one of the key criteria for school selection and adds to school reputation. Application of leading mobile technologies will go a long way in reducing issues related to child safety and security and make this planet safe and secure for our future generations.

Learnings from the Case Study

Following are the key learning from case study:

1. GIS technologies have potential to address safety and security of the children and women in transit.
2. Though the adoption of these technologies is slow due to the non-awareness and privacy concerns, it is gradually getting popular among the masses with the increase in mobile penetration and bandwidth explosion.
3. Parents are concerned about the safety and security of their children but they do not have much options except school provided or contractual buses.
4. Regulatory enforcements like mandatory GPS in school bus will help increase penetration of the GIS /GPS technologies in transportation domain.
5. The application can be further enhanced by usage of wearable devices which will enable child activity monitoring even after de-boarding the bus.

Nirupama Dixit

Transportation: A Successful Geospatial Solution Case Study

SUMMARY

IOCL transports large quantities of petroleum products between its supply depots and retail outlets. To better manage the transportation process and costs, it has undertaken to automate the process of identifying the shortest transport routes on all-weather motorable roads for delivering its products. This activity is now undertaken successfully using geospatial technology which enables the Company to identify alternate routes between start and end points and automatically calculate the distance between them. The solution also provides digital tools for managers to verify and approve the selected routes. Early assessment of the implemented solution indicates cost and time savings, better management and increased convenience to the Company.

Introduction

Indian Oil Corporation Limited (IOCL), a `Fortune 500' Corporation, is India's largest commercial enterprise, with a net profit of ₹103.99 billion for the financial year 2015-16. It is engaged in the business of refining, transporting and marketing of crude oil and petroleum products. In its pursuit to provide best customer service of global standard, IOCL envisaged the application of Geographic Information Systems (GIS) technology to digitize and upgrade several internal work processes.

In the years 2015 and 2016, IOCL published tenders calling for IT/GIS services relating to route mapping and road distance determination; and developing a server based map solution for verification and approval of these routes by IOCL officials. These tenders were floated separately for different states and regions. ML Infomap has been given contracts to undertake the project in several states. As of now, some states have completed design, development, testing and deployment of the solutions. In other states, work is in progress. IOCL also requires the maintenance of the implemented solution for a period of five years.

Transportation is an important cost component in any industry where physical products are distributed over large geographies. This is more so in retail distribution

where the product requires to be replenished often. This is an aspect that has drawn much attention among managers who have used geospatial digital solutions to reduce cost of delivery. However, our experience in undertaking the above project has shown that using a well designed IT/GIS solution has many more advantages.

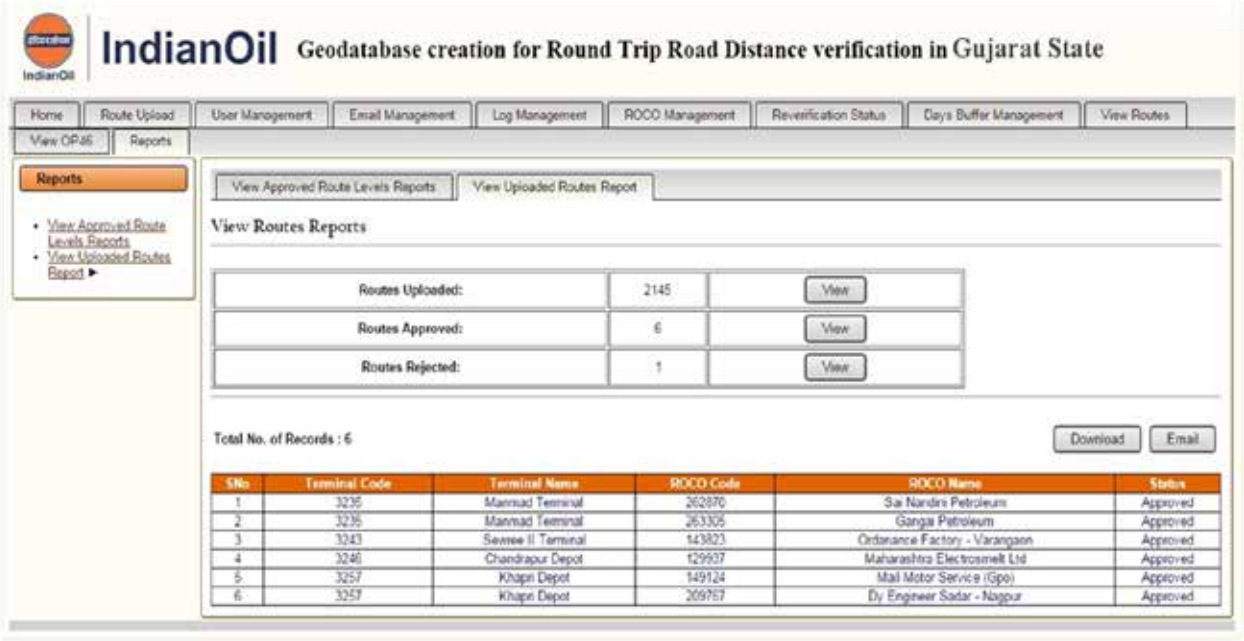
Usability

IOCL required identifying the shortest route on all-weather motorable roads for transporting oil and petroleum products from their supply depots to retail outlets and other end points. Further, it planned locating company assets relating to its distribution network entities on digital maps. This would lead to optimizing IOCL resources across large areas and also identify the most suitable routes between loading depots and supply destinations. The activities could only be possible within a geospatial environment and be provided on a GIS platform.

This project was planned for use by several different departments of IOCL in all states of the country, which would benefit IOCL in multiple ways. Distribution of products is a critical part of IOCL's business and the solution would streamline the logistics of transportation and lead to smooth supply to petrol stations and other outlets. Managerial staff required to maintain better control over all business processes which would happen through controlled access to the Web based system. Internal administrative processes required approving each route at several levels of administrative hierarchy and making routine reports. The accounting departments required information to make payments to transport contractors, without disputes arising on the bills. And several other less obvious reasons included discouraging deviation from approved routes by transporters and complete transparency in the approval process.

The core of the solution was to create multiple routes on all-weather motorable roads between supply and delivery points. For each route their total distance from start to end was recorded. All these routes were created on accurate high resolution digital maps on a GIS server platform. These routes were then made available to each manager responsible for giving approval through controlled access on the IOCL intranet network. Automatic mails were triggered to concerned persons if there was a delay in the approval.

The shortest approved route was used by IOCL for paying out to transport contractors, on the basis of price calculations made through the solution. If there was disruption on the route for any reason, the next approved route was used by the transporter to deliver the products.



As retail and commercial outlets are included or excluded in the transportation network, or motorable roads are constructed in the area, these changes will be introduced into the system. It follows that new routes can be approved for these areas.

Weekly and monthly analytics of transportation related data is created into reports and available to managers. These reports are made by geography and aimed at multiple hierarchical levels of managers.

Benefits and Impact

The IT/GIS solution developed and implemented for IOC has already demonstrated the benefits that were expected of it, and more. Some of these positives are as follows:

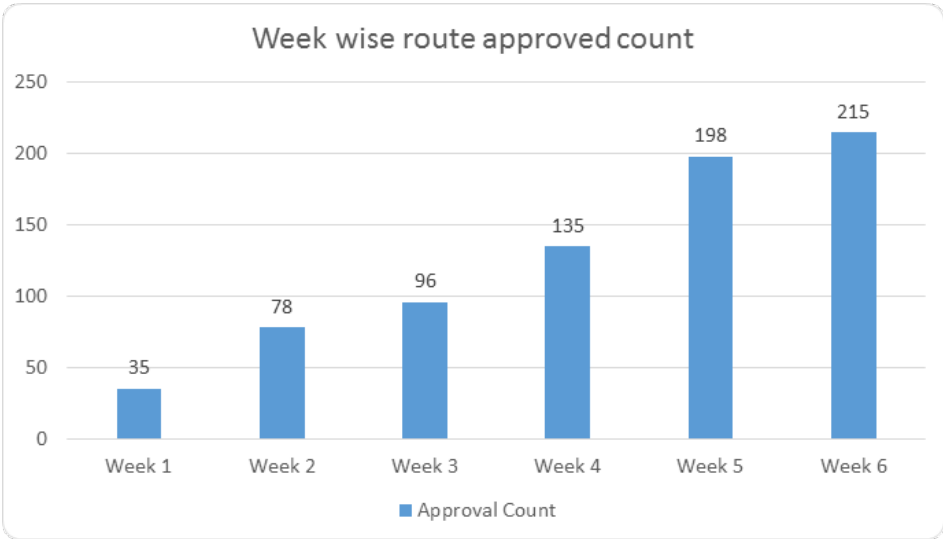
Return on Investment

The distances of the routes between terminals/supply depots and retail outlets recorded in the past, often vary from those suggested by the newly implemented solution using geospatial tools. This is usually because the distance measurements were earlier made from small scale paper maps or reported by drivers on the route. As the digital routes were identified and calculated from high resolution maps, the results compared favourably with ground distance.

Using the current method, in one state, IOCL has on an average reduced road distance by 2.6 km. per route. This has resulted in a saving of approximately Rs 12.5 lakhs per month or Rs. 1.5 crores per year in this state alone. So, the saving on distributing petroleum products, as a consequence of implementing this project across the country, would conservatively be Rs 35 crore per year. This has clearly established the cost saving to the company as well as the fact that such projects are cost effective, when compared to the cost of undertaking them. IOCL will recover cost of the project within one year and financially benefit for a much longer time.

Time Saving

As explained above, a route selected by the software is approved by several officials before it is incorporated into the system and finally used for pricing and payment for transport cost. The approval process can be completed within a very short time now, while it was a month long process earlier. As retail outlets cannot be supplied except along approved routes, this has greatly reduced the possibility of their not receiving supply because of delay in approval. The developed approval process, now fully digital, has dramatically reduced the time taken to approve a new or altered route.



Alternative Transport Routes

At times of emergencies, for example, during concentrated heavy rainfall that renders sections of roads unmotorable, or unexpected closure of roads, or temporary diversions along approved routes, the alternative routes proposed in the system can be used without delay. As these routes are already available within the system as approved routes, there is no disruption of supplies.

Virtual Environment

Sitting at one's work desk, employees of IOCL can now view digital maps, approved transport routes, all assets and related information in graphs and tables. On the digital map, operators can see the complete route at single glance, which was not possible on paper sheets. Officials no longer need to access paper documents or unwieldy map sheets that also require safe storage. Results of analytics and routine daily, weekly and monthly reports are generated speedily and sent to the designated recipients. Thus virtualization of maps, documents and activities has proved immensely convenient.

Better Management

On the whole, as a result of employing a well integrated Web based GIS solution, the management of the logistics of transportation of petroleum products has improved a great deal in the states where the IT/GIS solution is now being used. Today, the system proposes shortest available motorable route which was not necessarily the optimal ones chosen manually earlier. As stated above, this has translated into substantial cost savings.

There is no longer need for physical availability of any person for approval of routes and documents. All stages of approval can be tracked and reminders sent to those whose approval is pending. This frees persons to perform other duties without wasting time on work undertaken physically, in person, earlier.

The change in work culture too is taking place. Moving from a manual and slow process, it is changing to a digital, transparent and efficient system. Management is able to look into the system and know the exact status of activities at all times.

The ultimate impact of the systems to IOCL will be evident once all the states of the country have implemented the IT/GIS solution.

Way Forward

ML Infomap has undertaken this project successfully in three large and two small states of the country as a vendor to IOCL. Our experience suggests that large organizations require geospatial tools and map data to maintain standard information and processes across the organization. This is especially so in cases such as the one described above where decisions are made on the basis of calculated distances along roads, identifying alternative routes fulfilling defined conditions, finding locations of assets, etc. Besides, all changes on the ground, as they happen, are updated in the digital system quickly for management to see.

It is our observation that several employees initially resist computerization of manual processes. However, on familiarization, and insistence by senior management, they do begin to appreciate the convenience offered by the digital systems for operational purposes. Therefore, the move from manual to digital systems may not always be simple, and indeed can be over an extended period, before its full advantages can be experienced by the company.

Finally, it is an important learning that standalone GIS solutions performing as a silo will no longer suffice in an operational environment within business enterprises. It requires to be integrated to ERP, CRM, supply-chain, payment systems and other modules. System integration is what gives the ultimate benefit to the end user. Rapid changes in the IT environment require intensive users of geospatial technology to interface with other hardware, software, data, tools and methods to get the most benefits out of their GIS platform.

Manosi Lahiri

9

UTILITIES

Mapping Technologies Utilised For Urban planning to Improve Sanitation for India's Urban Poor

SUMMARY

In India, more than one in six urban citizens live in poverty, often in slums. Many of the urban poor lack access to a basic sanitary resource: a toilet. In 2013, Shelter Associates launched its One Home One Toilet initiative to solve this problem. The project combines data and Geographic Information Systems (GIS) to map slums' infrastructure, showing the homes which do not have individual toilets or access to communal ones. Shelter Associates works with government agencies and community members to facilitate installation of household toilets, improving sanitation, health and quality of life. The organisation has facilitated more than 7,500 toilets in slums throughout 5 cities of Maharashtra.

Introduction

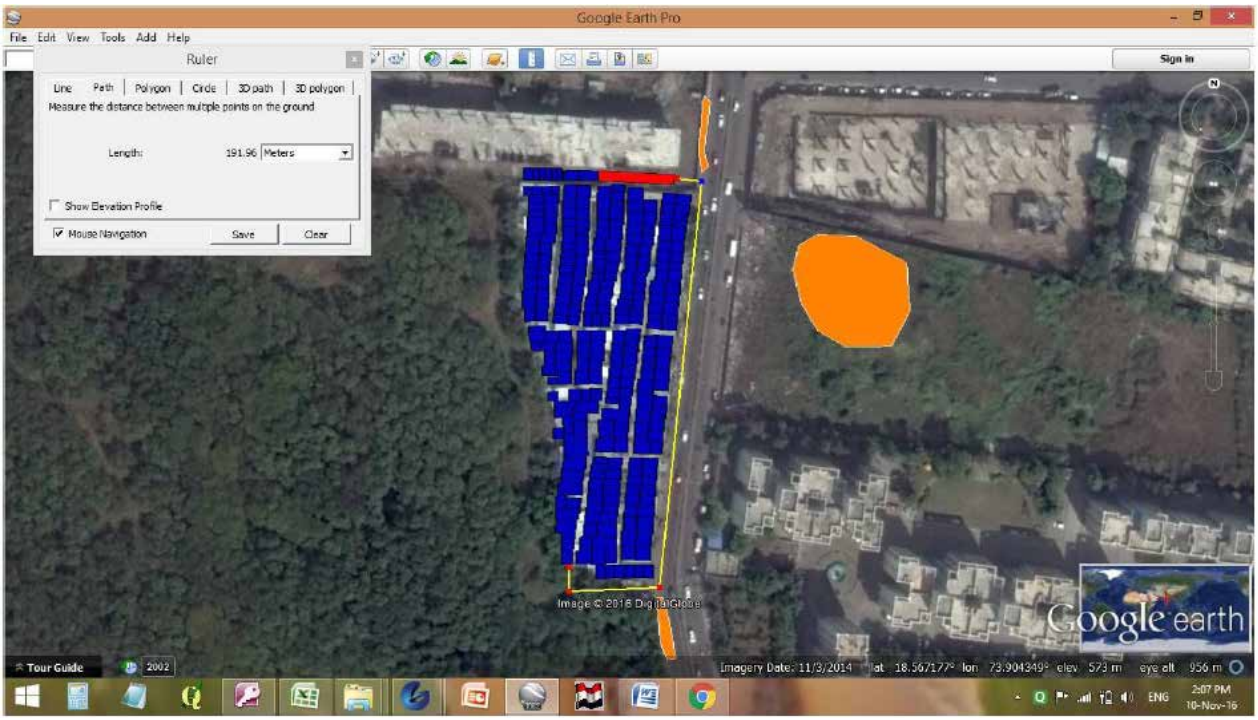
Shelter Associates (SA) is an Indian civil society organisation founded in 1994 to ensure access to basic infrastructure and housing for the urban poor. The organisation works in slums and informal settlements across Maharashtra to provide technical support for, and facilitate access to, housing and essential services. The organisation is using GIS, data and Google Earth mapping technology to realise this vision.

Sanitation problems are endemic to India's urban poor and the numbers are only getting worse. Census data shows that in year 2015, 65 million people were living in India's slums. That may grow to 100 million by 2020 as more of the population moves to urban areas. Improper sanitation causes health problems, including contaminated water and an increase in communicable diseases. It also poses personal safety concerns, particularly for women.

On carrying out survey of Ambedkar Nagar slum in the city of Pune, Shelter Associates realized that just 74 households out of more than 2,200 had their own toilets. The rest shared community toilets, which were unhygienic and overused. The ratio of toilet seat to persons being as high as 1:99. Some of the community toilets were located at the base of hills, a good distance from families who lived on the upper edges of the slope.

During monsoons, the paths to the toilets would become slippery. As a result of all this, many people defecated in the open spaces near the slum. Similar problems were found in other settlements, including Sanjay Park.

Figure 1: A map showing the proximity of households (blue) to communal toilets (red) and areas of open defecation (orange) in Sanjay Park in Pune



In addition, lack of/poor solid waste management in slums is one of the major sanitation issues that contributes to a low quality of life for residents in a major way. Most slums do not have door-to-door waste collection for instance, and communal containers are rare. In the case of Ambedkar Nagar, 2,000 households shared just three waste containers located at the edge of the settlement. Many people threw garbage into the open spaces near the slums, even though these areas were also used as a vegetable and fruit market in the mornings. Food waste was frequently discarded in drainage pipes which led to blockage problems and flooding.

The conditions in Ambedkar Nagar were typical of those in many of India's slums. Sanitation problems are compounded by a basic issue; the lack of even the most basic information about the slum's infrastructure, including its sewage and water lines. In India there is a lack of adequate data to guide urban planning and this lack of up-to-date information leads to ineffective planning policies.

Usage

Sanitation

Shelter Associates conducts household surveys to gather information about living conditions in slums, including the number of people living in each household, the names and ages of each family member, and information about each person's education, occupation and income. The surveys also assess the home's

access to essential services such as water, electricity and waste disposal. Shelter Associates then uses satellite base maps from Google Earth to mark every house on a map. The survey information and the map of the slum are combined on a GIS platform. A new map is then created to display the slum's existing infrastructure and access to various services for individual households, down to street- and house-level detail. Shelter Associates presents this information to government agencies, and together they assess the slum's needs and plan for improvements.

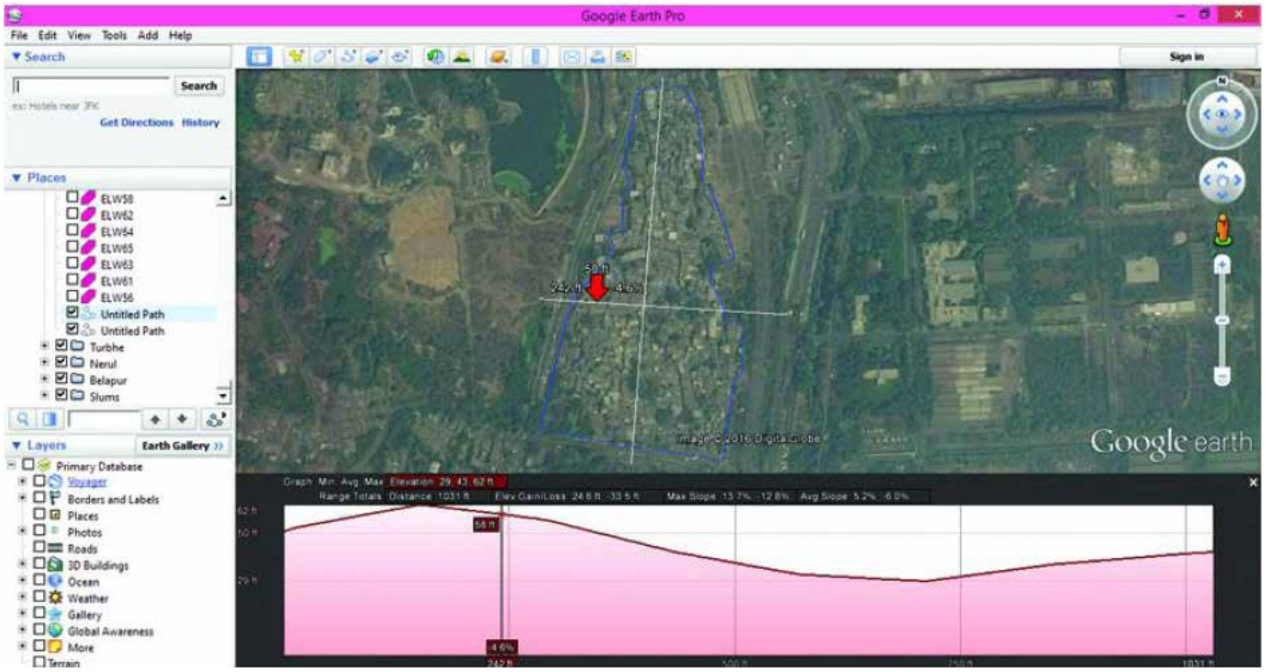
Figure 2: Linking household data (left) to maps (right) results in a comprehensive summary of each household and its occupants

Without this visibility into infrastructure, government agencies have no clear way to identify the most pressing problems being faced by slums, much less solve them. Most government policies and programs are not aligned to the reality on the ground. They specifically lack the spatial data to support urban planning and development. Traditional development maps of cities lack adequate details and are often incorrect.

Due to the initiatives taken by Shelter Associates, it was realised that local governments had very inadequate databases about the poor, especially in big cities, where large sections of the population were living in slums. Without that data, one couldn't fix problems. Hence Shelter Associates felt the need to fill this information gap by gathering vital data about water, sanitation, sewage supply, demographics and electricity in slums. After conducting surveys, Shelter Associates and local government agencies verified information by re-visiting people in their homes. During these follow-ups, staff members gathered more details, such as the diameters and conditions of drainage lines, and the proximity of each home to sewage pipes and water lines.

This information was found powerful, but it was also felt that just the data on its own would not be enough. Shelter Associates needed to meld their data with the power of maps and GIS to create a visual resource that could guide urban planning and government policy changes. The organisation created a strategy, using spatial data as the centrepiece, to join slum dwellers with government officials. Residents and officials would tackle the problem together, using facts about the actual living conditions in the slums.

Figure 3: This map analyses the topography of a settlement, including its gradients, to help plan the expansion of its drainage network



A visual infrastructure directory was an important foundation for everything Shelter Associates wanted to do. Having information and maps on separate layers would not be useful. Hence it would be important to connect data with mapping information to reveal information that otherwise might not be visible.

The accuracy of satellite images has been crucial for communicating the actual condition of a slum. We realised that satellite images in GIS systems were far more accurate and easy to understand than traditional maps. Their use opened up a whole new world of viewing spatial data. One could see where all the slums were within a city. Based on that information, one could plan a very systematic way of dealing with development within the city.

Shelter Associates has refined its approach into a successful and repeatable methodology, which it uses for its One Home One Toilet initiative in slums across Maharashtra. The process begins by mapping the existing infrastructure in urban slums, including drainage lines, water, solid waste management, community block toilets and roads. Field teams often come across drainage networks being choked, broken, or insufficient. They mark these areas on the map and flag the networks to be fixed. This allows families to connect their individual toilets to the drainage networks which are now made problem-free.

Field teams gather information about the cleanliness and maintenance of community toilets. In their surveys, they ask each household 20 questions about their amenities, including water, electricity, toilets and their method to dispose off garbage.

The resulting maps show gaps in the slum infrastructure, making it easy to identify households that do not have toilets, as well as areas which lack sewage and/or drainage lines. Shelter Associates and government officials prioritise repairing and expanding sewage networks based on the information they have collected.

Figure 4: Map displaying connecting potential households to existing drainage network & proposed drainage network in the settlement of Samta Nagar, Navi Mumbai

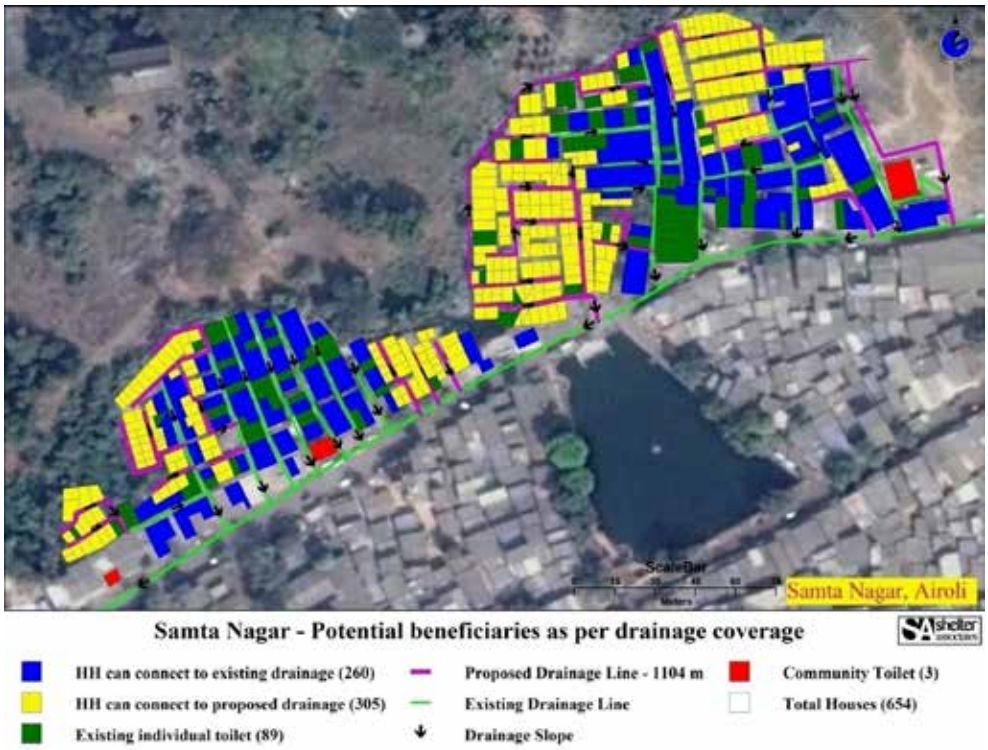
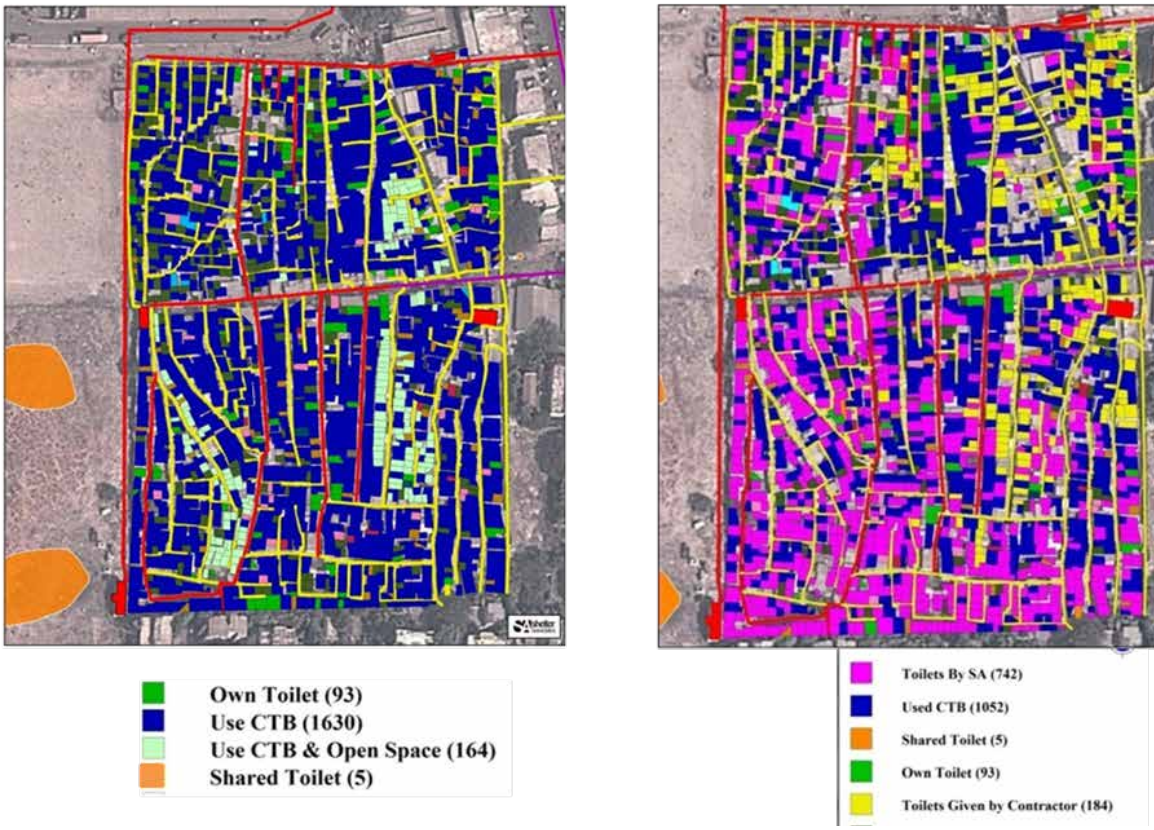


Figure 5: This map shows households in which individual toilets have been installed (yellow pins) in the settlement of Ambedkar Nagar, Pune

Figure 6: Maps showing the location and status of household toilets before (left) and after (right) Shelter's Associates' One Home One Toilet project



Housing

Shelter Associates' new approach to planning, supporting by data, GIS and Google Earth, came to life in 2009, when the organisation started a citywide initiative. Their goal was to rehabilitate 4,000 families living in 29 slums across the cities of Sangli and Miraj by relocating some of the residents to new and improved housing. They realised that visual data would be key not only for logistical planning purposes, but also for getting residents on board with the move.

Shelter Associates mapped the existing slums and conducted surveys, asking residents which public services they used and where they were located. Staff mapped these services, along with the locations of the new housing units. They used GIS software to integrate mapping data with spreadsheets, and to perform spatial querying of the data.

Shelter Associates held meetings in the slums to discuss the new housing with residents and invited government officials to participate. Maps were effectively used to show slum dwellers where they were living, and where they would be moving. It showed them they still had access to their current way of making a living, and how it's not such a bad idea to move.

A mother who had lived with her husband and children in the old slum explains how the meeting affected her perception of moving to a new home, "When we looked at the map, we were surprised" she says. "It showed we would be moving into the heart of the city, which would open up even more employment opportunities for us. We saw all of our amenities would be close by, which would help us save money because we wouldn't have to travel as much as we do now. We could use the money we saved for other

things for our family. So we would be able to send our children to better schools, and they would have a better future and greater opportunities."

Key to the success of the project was not just GIS and mapping data, but also the involvement of key stakeholders — namely, the residents directly affected by the project and government officials who managed the city's infrastructure and public services. Over the last 15 years, Shelter Associates has developed a method of inclusive planning, which is both top-down and bottom-up ensuring a dialogue between the most powerful and most vulnerable members of society.

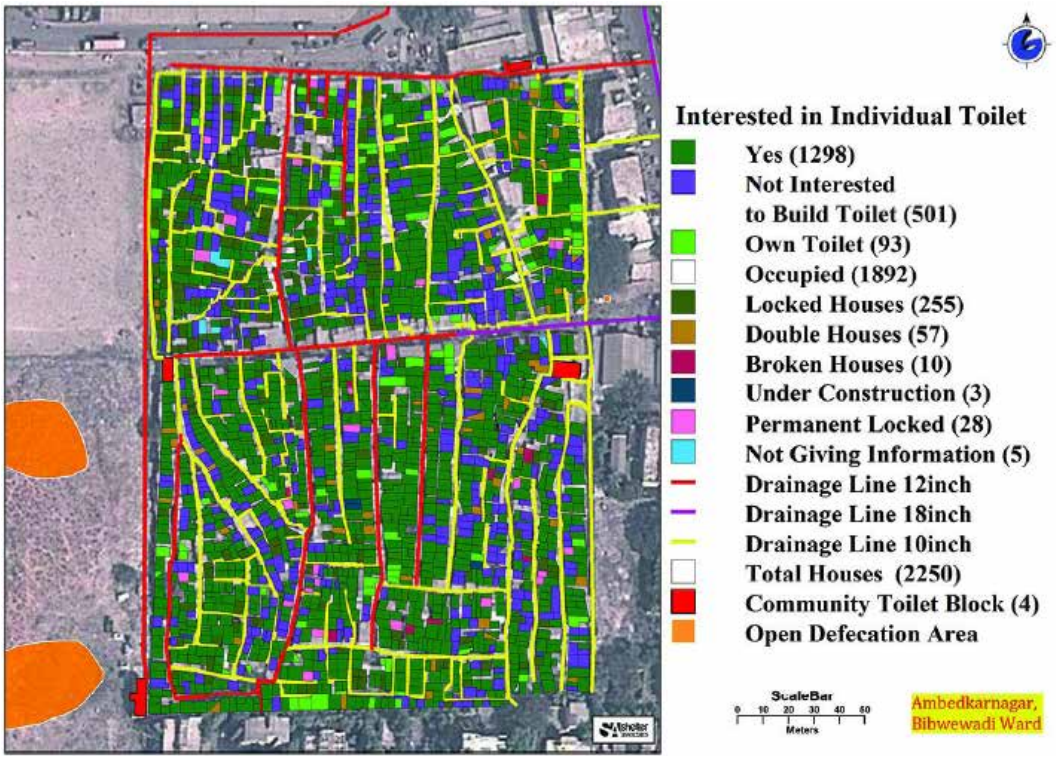
Shelter Associates organises community meetings, workshops and group discussions to educate families on the need for healthy sanitation practices. Families can request to have toilets installed in their homes. When families decide they want toilets in their homes, Shelter Associates delivers the necessary materials. The organisation uses maps to help with planning and logistics and to report on which homes ultimately have toilets installed.

In the past, policy makers, project managers, NGOs and beneficiaries often worked in silos, however, thanks to the power of GIS and mapping, they are all working within the same framework, in touch with the same reality, because of the information displayed on maps.

Results and Benefits

Using GIS, data and Google Earth, Shelter Associates has made life better for thousands of slum dwellers. Overall, Shelter Associates has mapped more than 200,000 households. It has helped 9,000 people improve their housing, and more than 192,500 people get improved sanitation.

Figure 7: An example of a map generated after household surveys, showing households with individual toilets and those that lack them; this helps to identify potential beneficiaries of the One



Data led approach: key to inclusive partnership

Better sanitation improves residents' overall health, cutting down on serious communicable diseases. Using information mapped by The One Home One Toilet project, sewage and drainage networks have been cleaned, and new pipes installed. Women and adolescent girls are not prey to harassment at night when visiting communal toilets, because they now have toilets at home.

GIS and mapping technology provide the tools needed to clearly show where the issues are for India's urban poor, so we can work with government agencies and the people affected to improve their lives. Data-led approach is a key component of inclusive planning, and is central to Shelter Associates' philosophy of acknowledging informal communities as integral parts of any city.

The One Home One Toilet project has also improved overall housing quality for residents, who often decide to upgrade their homes at the same time they install toilets. Many homes in slums are built of tin sheets, which are not weather-resistant and can be easily damaged.

In Pune's Sanjay Park slum, 80 percent of families who have toilets installed also upgrade their impermanent tin shacks to conventionally constructed homes built with brick walls and concrete ceilings.

Visualisation: key to inclusive partnership

The ability to visualise all parts of the process helps Shelter Associates garner support from the population it serves. It becomes a collaborative process. Shelter Associates don't present themselves to residents as benefactors. They work with them as partners to tell them that they are coming to them with a set of skills, which are being shared with them and they are out front in the process of getting toilets installed.

The resulting maps are also used by government agencies to upgrade other infrastructure and plan urban development. Quality mapping is central to the entire process. Government agencies can see the problems with infrastructure. They can see where the water and sewage lines run, what's there and what's missing. Residents can see exactly how far they are from communal toilets, and see how much more difficult that makes their lives.

Pune success story: a road map

In Pune, Shelter Associates has already mapped more than 300 slums, amounting to 70 percent of the total in the city. The maps show water and sewage networks, sanitation problems and solid waste management practices. Shelter Associates' model has been partially adopted and further scaled by the Pune Municipal Corporation to construct more than 35,000 individual toilets in the city under the Swachh Bharat Mission. Pune currently ranks number one nationally in the delivery of individual household toilets, under the Clean India Mission. Shelter Associates has replicated this success in other cities in Maharashtra, including Sangli, Pimpri Chinchwad, Navi Mumbai and Kolhapur. More than 7,500 families have newly installed toilets.

With Swachh Bharat Mission, Pune is looking forward to attaining open-defecation-free status by Jan 2017. Few of the challenges Shelter Associates' innovation has been facing are as follows:

1. Cities look at Community Toilet Blocks as 'One Glove Fits All' solution. Though these are not the most effective solutions as-
    - They are high on maintenance.
    - They have inadequate toilet seat to person ratio.
    - They incur high capital costs & recurring expenditures.
    - They utilise free/open/community spaces which could be put to better use by community.

2. Awareness of Health and Hygiene.
3. Freeing the City of Open Defecation.
4. Data available with ULBs is secondary, which brings in limitations. Cities are in dire need of household level data. To carry out micro-level interventions of bridging the gaps in providing housing & sanitation facilities, granular data is the need of the hour.
5. Intangible and Long Term Social Benefits.

Slums to Swatch Bharat: state of Maharashtra

Shelter Associates aims to institutionalise the process of data collection and mapping within urban local bodies on a state level. It plans to partner with other urban local bodies to scale its One Home One Toilet model across the state of Maharashtra.

Scalability

Shelter Associates believes that in order to scale the project, there is need for convergence and establishment of strategic partnerships between the three stakeholders namely, the State, the Private Sector and the NGO sector. For Shelter Associates, scaling the project translates into greater outreach and more toilets being implemented. Multi-stakeholder collaboration is critical for this to be achieved. As part of the multi-stakeholder collaboration, Shelter Associates has recognised that partnering with the Government is necessary to be able to scale the project in the biggest and the most sustainable way. Hence, Shelter Associates will continue advocacy of its work with the Government to continue to work in collaboration with them and be instrumental in shaping the policy and guidelines around urban sanitation.

Shelter Associates believes that engaging more NGOs to execute the processes will make the work more sustainable and faster. These partnerships with other NGOs working in the sector will enable knowledge transfer and different NGOs can leverage on the core competency of each other. There is also the need to have support of the private sector, including CSR funding that can support the project financially and cover costs which the Government is unable to fund. This will include institutional costs and working capital that is needed when there is a time lag in receiving government funding.

Replicability

Shelter Associates' innovation uses strong Standard Operating Procedures (SOPs) and technology, which make the process consistent and replicable under any circumstances, and thus scalable.

The innovation is based on multi-stakeholder relationships that can be forged across various cities, regions and countries hence, this makes the innovation replicable. By establishing and demonstrating the impact of a sustainable, efficient and scalable model, the same can be replicated across the country through partnerships between NGOs, ULBs and private funders.

The Way Forward

What has already been done using GIS, data and mapping is only the beginning of what Shelter Associates hopes to accomplish. India's urban poor face myriad problems, and are often marginalised by the rest of society. Shelter Associates believe maps & the methodology it has developed, will change that.

Shelter Associates feels visualising data using maps is an extremely powerful tool for infrastructure and much more. One can get a clear picture of the distribution of wealth in communities, people's aspirations, their level of education, their occupations and their incomes. That gives one a fair idea of who they are and what they need. It helps break the silence about the issues faced by slum dwellers, and helps Shelter

Associates design and implement projects that treat them as integral rather than marginalised members of Indian society. Shelter Associates' ultimate dream is to give the most vulnerable in our cities a much better quality of life.

A map can change the world if you are a slum dweller in India without access to water, electricity and proper sanitation. A map can change the world if you are a government agency or an urban planner with intentions to fix problems such as these, but not enough information to do so. And, as Shelter Associates has shown, a map can change the world if you are a civil society organisation devoted to tackling some of society's most intractable issues and are looking for the most effective solutions.

Pratima Joshi

Modernization of Utility Mapping using High-end GNSS Systems in the Municipal Corporation of Greater Mumbai (MCGM)

Introduction

Mumbai

Figure 1: Mumbai City Map

Mumbai is one of its 10 mega cities of the world and the business capital of India. It's the capital city for the state of Maharashtra. Mumbai proper occupies a low-lying area that once consisted of seven islands namely Colaba and Little Colaba which was located in the present day Colaba and Nariman Point, Bombay Island which was the backbone of the City of Mumbai, Mozagaon and Parel which were located on the eastern strip, Worli on its western strip and Mahim on the northwestern strip separated from each other only during high tide. Mumbai is also the most populous city in India with the population rising from 3 million in 1951 to 16 million as on 2015, out of which 50% live in slums. It also supports a daily commuting population of 2 million people. It covers an area of 480.24 sq.km.

Mumbai is located on the western seacoast of India on the Arabian Sea at 18°53` N to 19°16` N latitude and 72°E to 72°59` E longitude. Mumbai city is divided into two revenue districts, Mumbai City District, i.e. the island city in the South and Mumbai Suburban District comprising the Western and Eastern suburbs.

Geographically Mumbai is referred to as three different geographic entities : Mumbai City, Greater Mumbai, and Mumbai Metropolitan Region. Mumbai City is the core of the old port city of Mumbai during the colonial period. Since then, its territory has expanded northward to cover the suburbs and extended suburbs. The Mumbai Island City plus the Mumbai Suburban District comprise what is now called as Greater Mumbai.

It is under the political administration of the Municipal Corporation of Greater Mumbai (MCGM, formerly Bombay Municipal Corporation or BMC). The Mumbai Metropolitan Region was formed to create the urban agglomeration consisting of 7 Municipal Corporations and 13 Municipal Councils. In addition to MCGM, it includes the Municipal Corporations of Navi Mumbai, Mira-Bhayandar, Thane, Kalyan-Dombivali, Bhiwandi-Nizampur and Ulhasnagar.

Municipal Corporation of Greater Mumbai (MCGM)

Municipal Corporation of Greater Mumbai (MCGM) is the primary agency responsible for urban governance in Greater Mumbai. From the time of its establishment in 1882 as India's first municipal corporation, numerous non-political groups, NGO's and organizations of citizens have worked closely with the civic body in the fields of education, public health, creation of urban amenities, art and culture, heritage conservation, etc. MCGM is one of the largest local governments in the Asian continent.

The city is divided into different administrative zones known as 'wards' to ease the day-to-day functioning of the civic authority. In all MCGM is divided into 24 municipal wards of which the Mumbai city district is divided into nine municipal wards and the Mumbai suburban district has 16 municipal wards.

Figure 2: Mumbai Ward Map

Mumbai Ward Map

Figure 3: Organisational Structure of MCGM

Table 1: Zones and Wards in Greater Mumbai

Zone	Name of Zone	Wards
I	Inner island city	A,B,C,D,E
II	Outer island city	FS,FN,GS,GN
III	Inner WesternSuburns	HE,HW,KE,KW
IV	Outer Western Suburbs	PN,PS,RS,RC,RN
V	Inner Eastern Suburbs	L,ME,MW

Table 2: Landuse of Greater Mumbai

Landuse of Greater Mumbai as per Sanctioned Revised DP	437.81 Sq.Km.
MCGM Maintatined Road Length	1950 Km
Water Supply Distribution Network	6000 Km
Sewer network Length	1830 Km
Manholes	65412

Sl.	Land Use Category	Area (Sq.km.)	%
1	Residential	118.8	27%
2	Commercial	4.75	1%
3	Industrial	25.07	6%
4	Public/Institutional	15.97	4%
5	Port	6.82	2%
6	Rail	6.02	1%
7	Recreation	27.02	6%
8	Forest	74.15	17%
9	Coastal Wetlands	75.74	17%
10	Salt Pans	5.69	1%
11	Water Body	6.97	2%
12	Truck Terminal	1.28	0%
13	Roads	63.61	15%
14	Airport	5.92	1%
	Total	**437.81**	**100%**

Drivers for Change

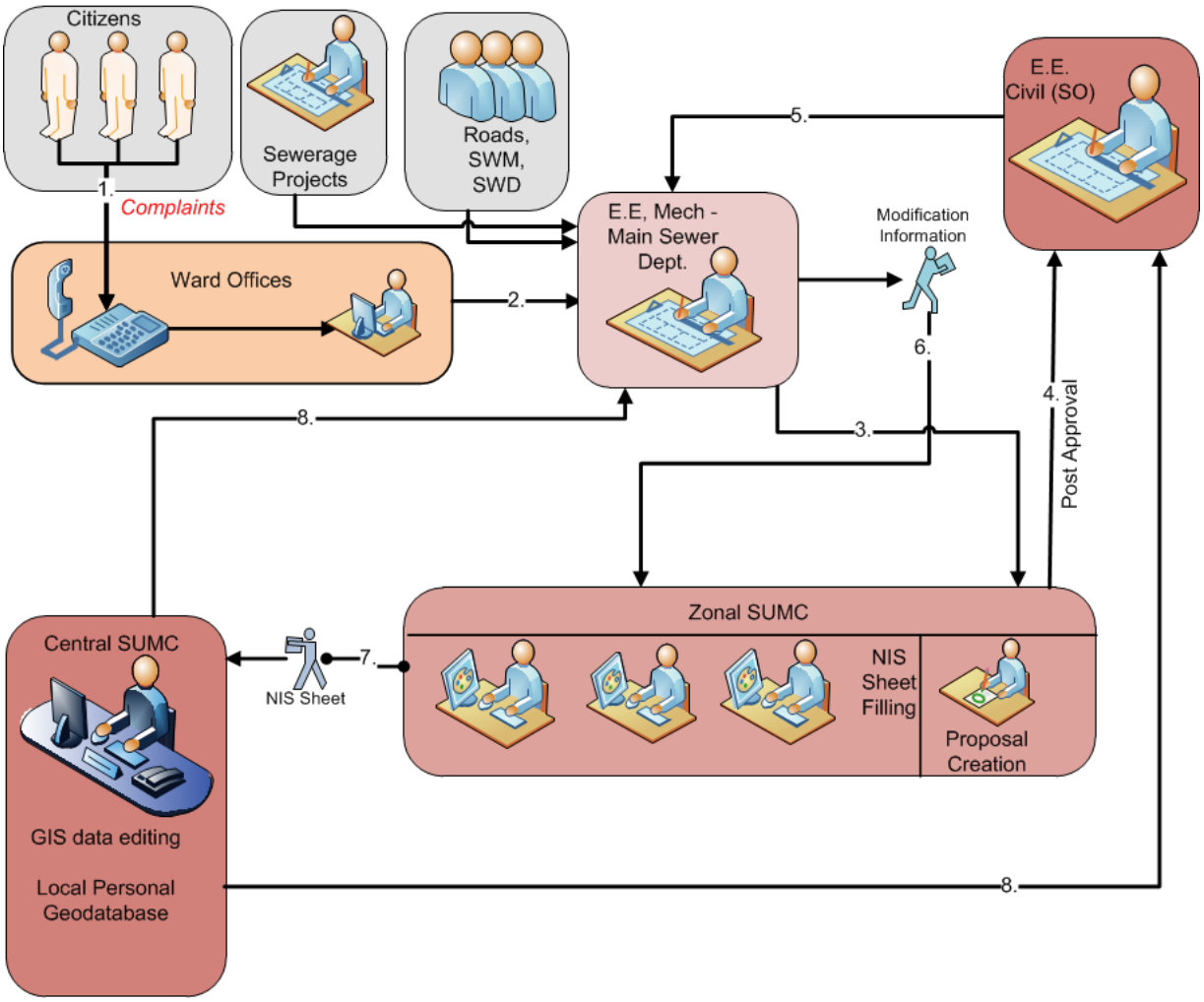
Existing Methodology

Local governments over the years have typically managed their utility systems by hard copy paper maps. These maps are updated manually by the department persons or the contractors. MCGM is using Mumbai Base Map Digitized by National Informatics Center (NIC) with ArcGIS systems to manage their utilities. MCGM departments realized that this Map has to be updated from time to time using the Real Time System like GNSS. MCGM started researching ways to update their data and efficiency within the departments and wanted a centralized system that could be accessed across all departments in the city.

The first department to plan to tackle these problems was the Sewerage Utility Management Centre (SUMC) team at MCGM. The existing methodology employed by the SUMC team at MCGM was out dated and hence there was an urgent need for change to a more scientific process where data availability was faster and more accurate. Hence the need for the following issues that needed rectified:

1. Utility Data Collection Using old Methodology
2. Isolated work flows of O&M Activities
3. History of maintenance - Not available to HoD readily
4. Inadequate monitoring of SO Works
5. Lack of professional Asset Management
6. Duplication of DATA / Info Reporting

Figure 4: Existing Methodology Employed by SUMC at MCGM

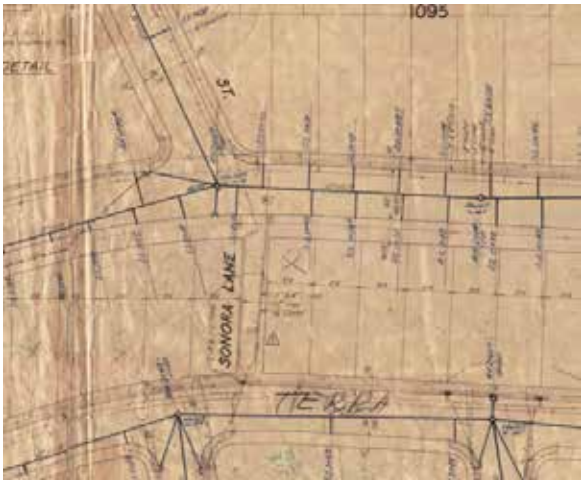


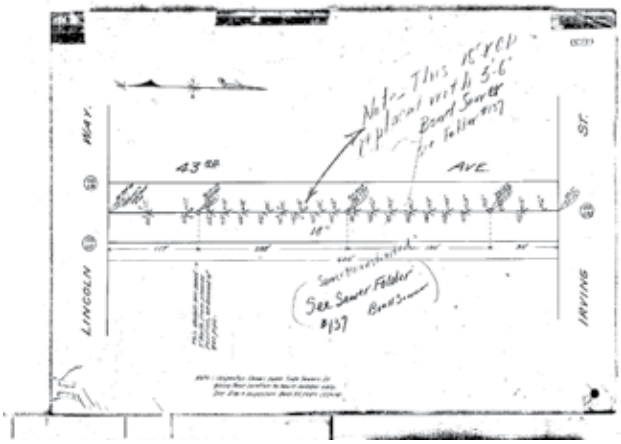
History of Utility Mapping in MCGM

Before going to the solution it is very essential that we understand the old methodology being followed by SUMC at MCGM.

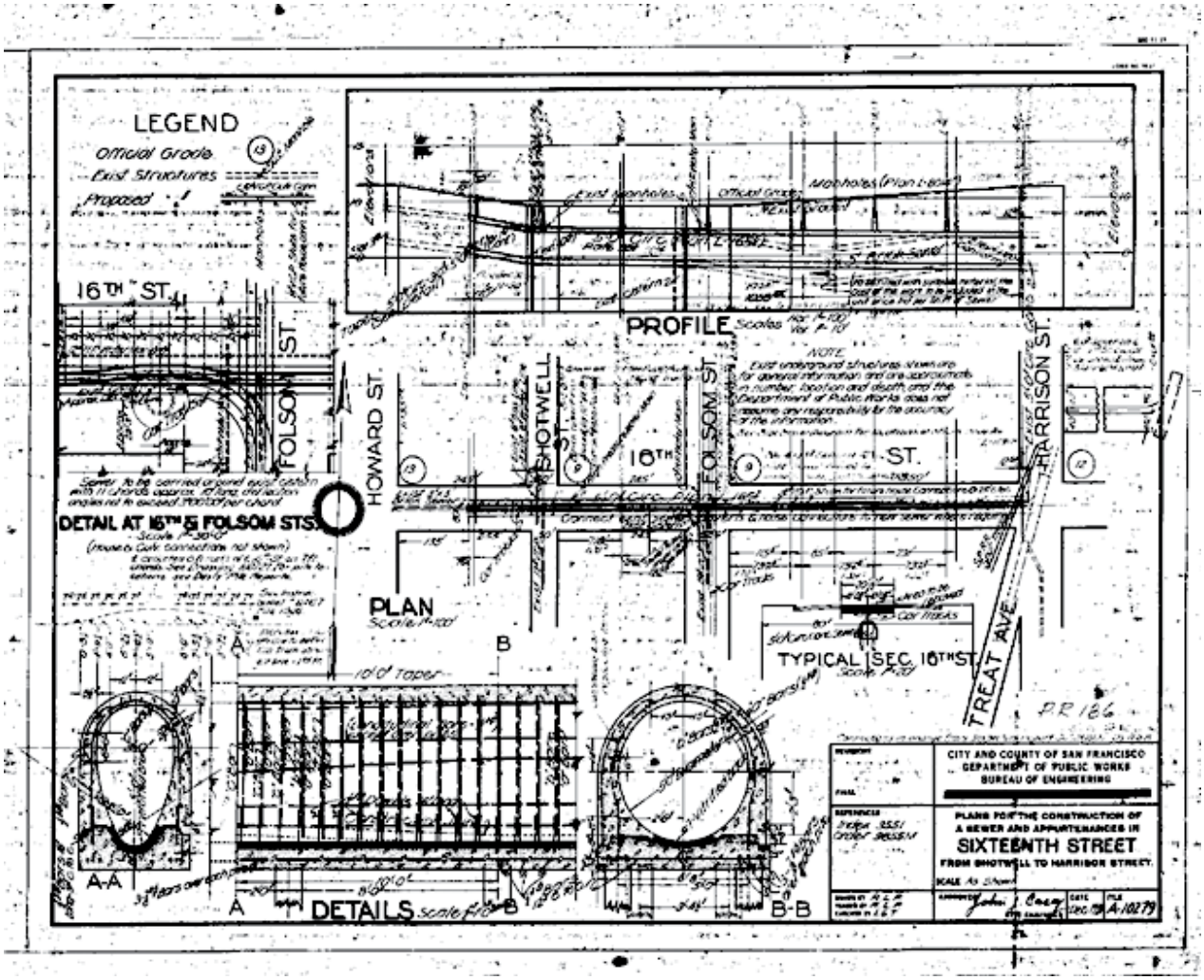
1. Typical Paper Mapping System Using Surveyor's own experience and imagination
2. Very Old Section Maps
3. Different versions with different Utility Attribute Number
4. Marked on aerial photos and Topographical Sheets

Figure 5: Existing Method of Utility Mapping at MCGM

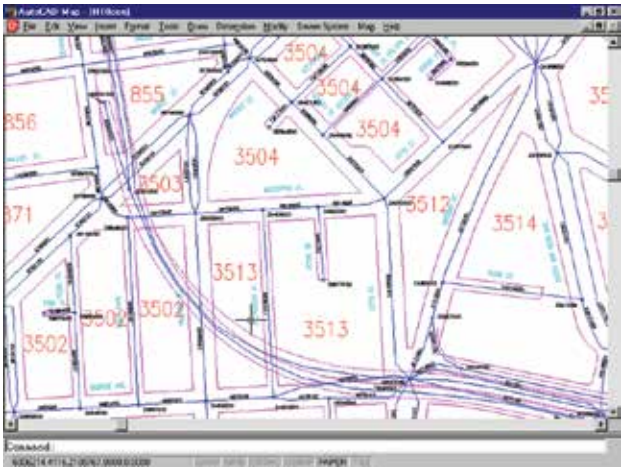


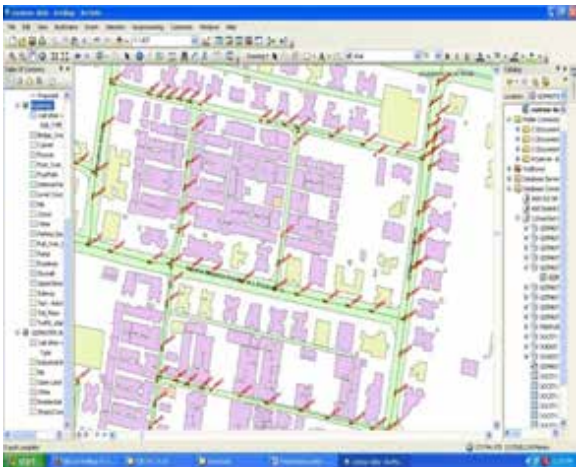


Engineering Drawings

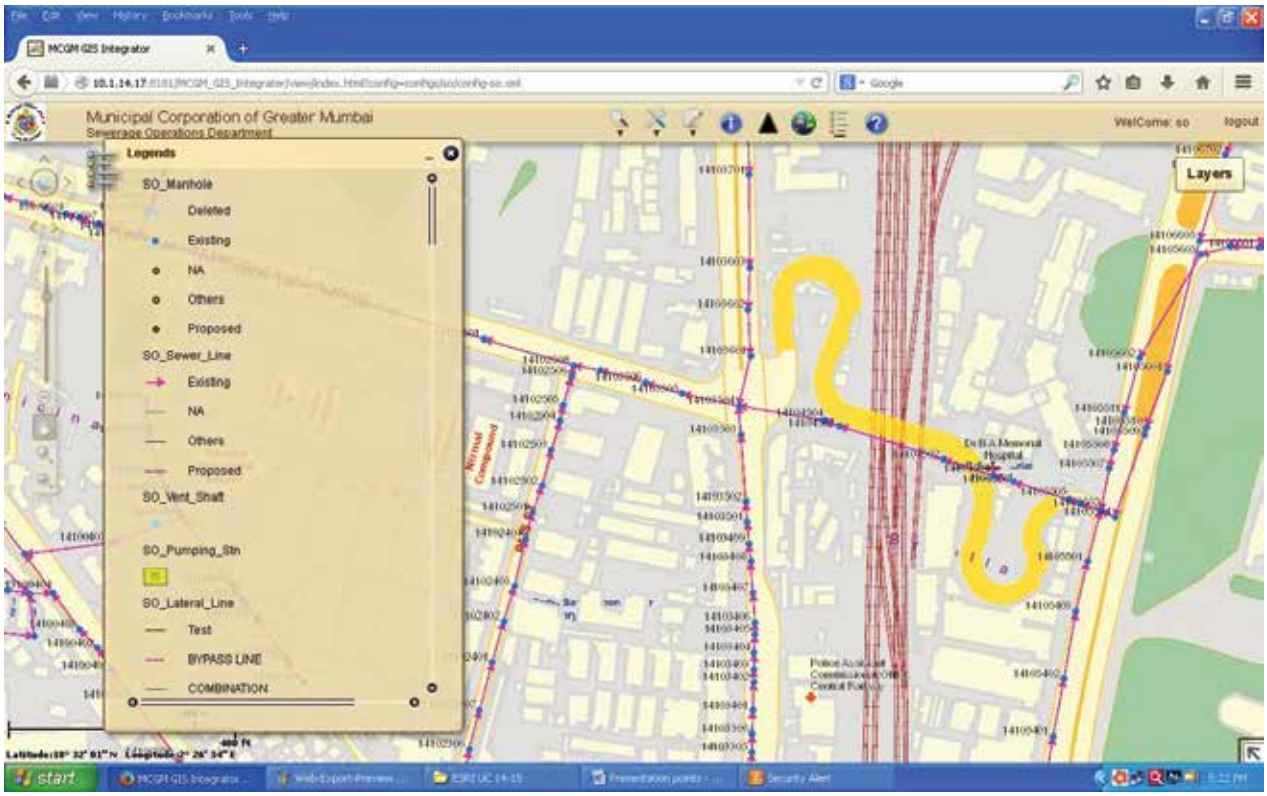


Base Map Creation





Sewer Mapping Using Base Maps



MCGM Approach Planned for Base Map preparation

SUMC took up the first step of creating correct Base Maps, as they rightly felt that this step was essential for laying the foundation for a sound Sewerage management system. The steps outlined by them for the same were as follows :

1. As-Is study of present business process for data flow for MCGM Utilities
2. Business Process Re-Engineering for ongoing GIS data management.
3. Training and capacity building for GIS.
4. Procurement of skilled manpower services for GIS data management, & administration.
5. Adoption of surveying techniques like GNSS survey for GIS Data Updation for Utilities in MCGM.
6. Establishment of a network of Continuously Operating Reference Stations (CORS) within Mumbai at strategic locations
7. Procurement of DGPS Rovers

Establishing CORS in MCGM

A CORS is a Continuously Operating Reference Station. CORS can take the place of a traditional base station used in differential GNSS positing. They can give an instant position to an accuracy of ± 20 mm and are used in many industries including Precision Agriculture, Construction, Mining, Surveying and in Scientific Research. Surveyors in urban areas view CORS network as a service which can save them the cost of a base station and the associated time it takes to set it up for each survey. This method also avoids interference from other base stations. Urban area surveyors will generally use CORS networks in detail surveys and for set out work but will use traditional surveying methods for cadastral work.

Typically, the maximum distance between a base station and rover GNSS set up is around 10 - 15 km. This is due to the effect of the atmosphere on the GNSS signals as they travel from the satellite to a GNSS receiver. With the establishment of a network of CORS, the distance between the base and the rover can be extended. The CORS can be spaced around 70 km apart and using at least 3 of these CORS, the atmospheric effects can be modeled and corrected for, yielding the ± 20 mm position solution required by so many industries.

So in 2013 the 2013 MCGM took the step for setting up a single Reference System for all Utility Mapping within its jurisdiction. Thus establishing of CORS station was taken up. It was felt that an initial network of 4 stations needed to be set up. The steps initiated were :

1. Study done for pinpointing locations for Permanent CORS Station in MCGM Area
2. The first two locations selected for MCGM 24x7 CORS Stations were :
    a. Dadar and
    b. Jogeshwari
3. The 3rd location selected for a Permanent Reference station was at IIT Campus in Powai
4. The fourth station was to be used from Aimil Ltd. office located in Vashi, Navi Mumbai

GIS Mapping Using Rovers

After planning the CORS locations, SUMC started the procedure for zeroing on the High End GNSS Rovers to be used to collect data. The steps they took to finalize on the correct instrument and model was :

1. A study was done by MCGM Engineers for the best Hand-held Rovers in Industry
2. Various manufactures or their local distributors did a Pilot and Demo for the Hand-held rovers for GIS Mapping
3. The same data was superimposed on the GIS base maps prepared by SUMC GIS Department
4. After this extensive exercise the panel decided to procure the best suited CORS and hand-held Rovers for the initial Sewer Mapping Project

Figure 6: MCGM's shortlisted solution

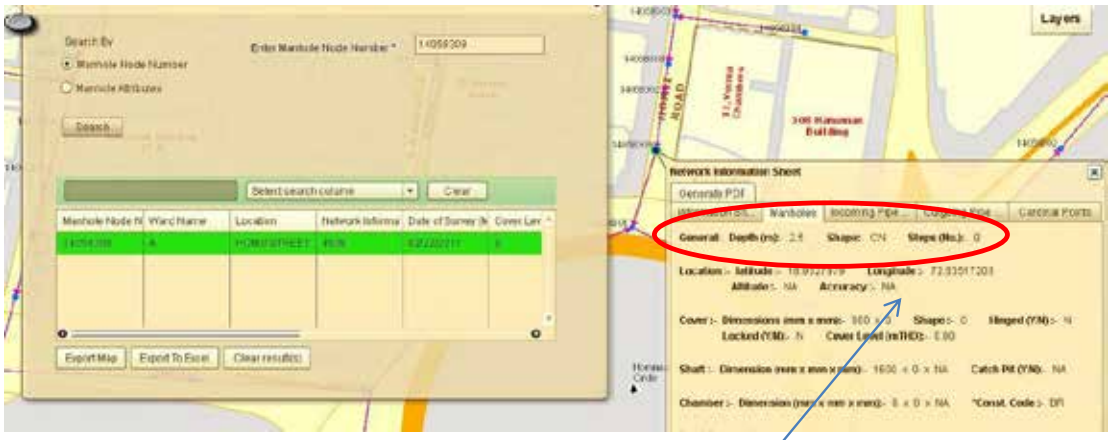
Figure 7: Triangulation of the 3 CORS Stations initialed installed

GIS Mapping Using Rovers

SUMC initially used 3 Rovers to collect data. After their study they decided to go with Trimble GeoXH 6000 handheld high precision GNSS rovers

1. The Data collection was done for the Man Holes and the Roads
2. This Data Collection helped to get the exact Man Holes Location with Road Edges for the perfect Road Width and Length
3. GeoXH 6000 rovers were also used to map the Building locations and sewer network to buildings
4. After this exercise the same data was superimposed to the Base map and Analysis done on results

Figure 8: Some sample Readings



Data Collection started by Using GeoXH 6000 and Data Dictionary Prepared for MCGM Sewer

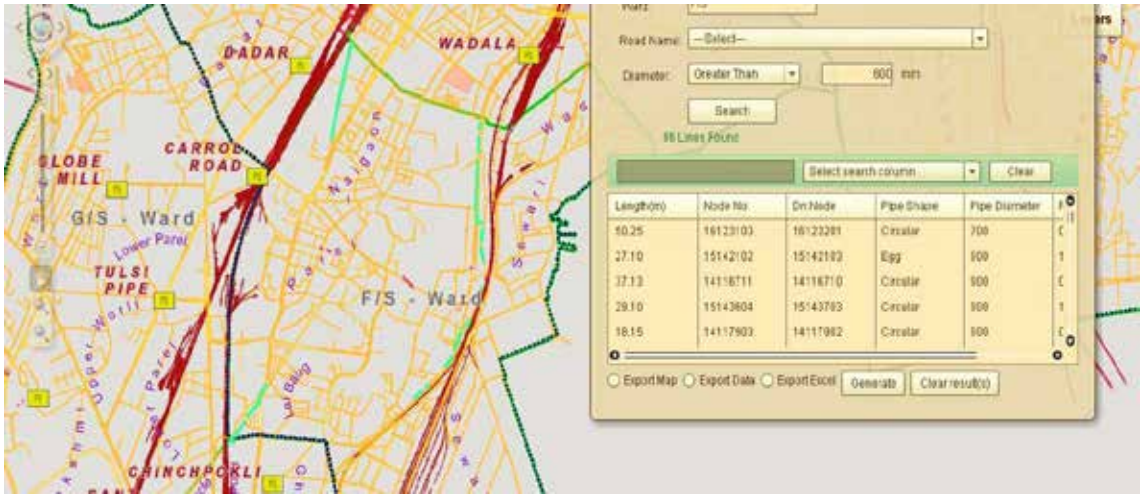


Figure 9: Pipe Choke & Damage Data

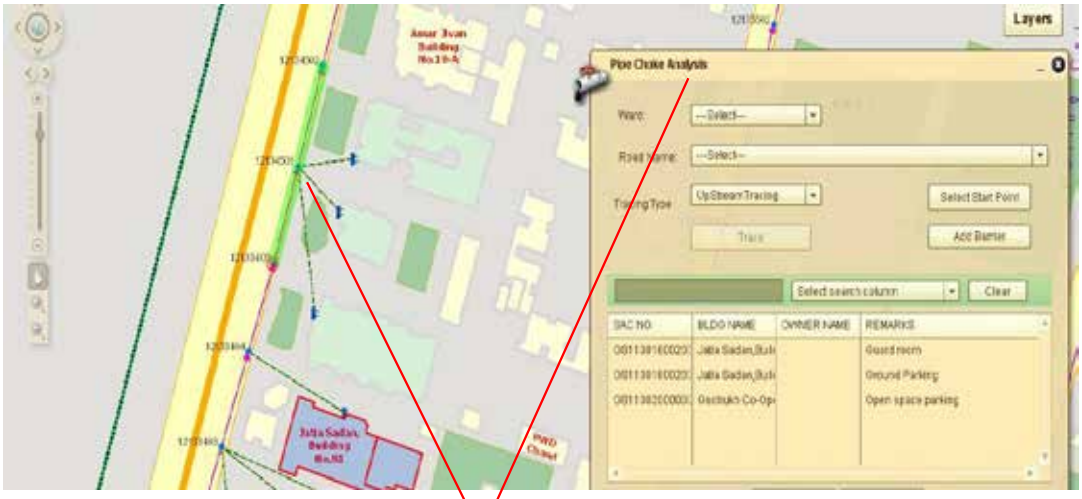


Figure 10: Manhole Management

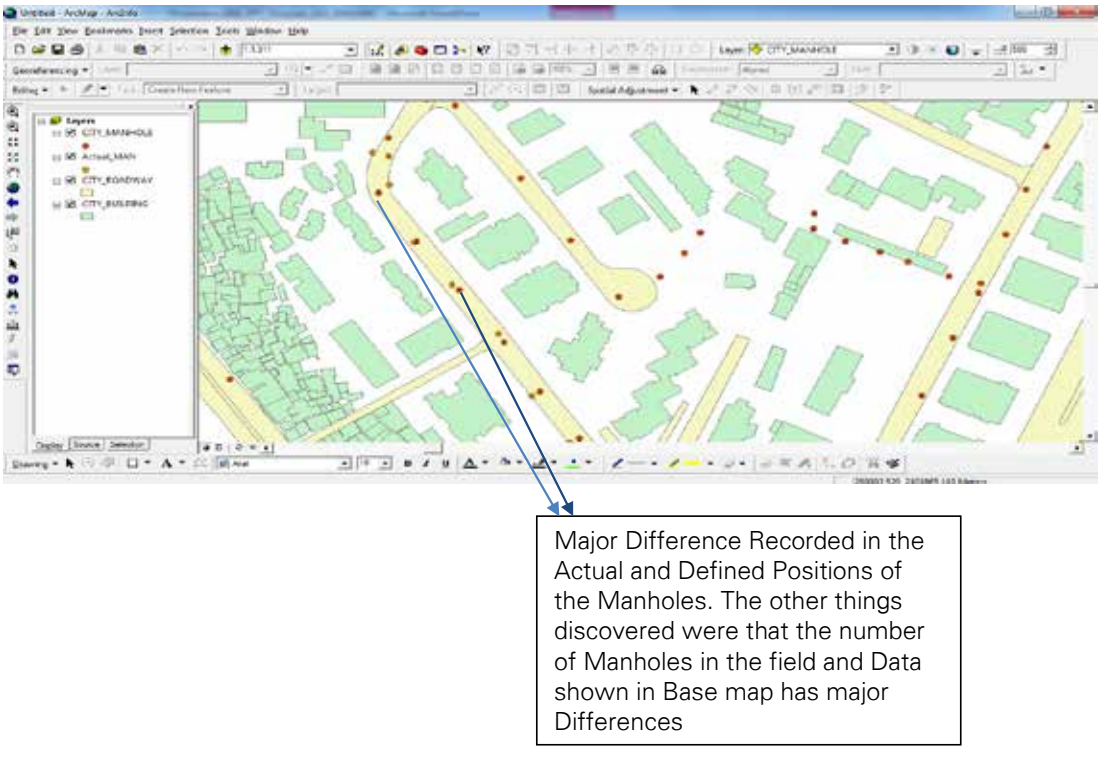
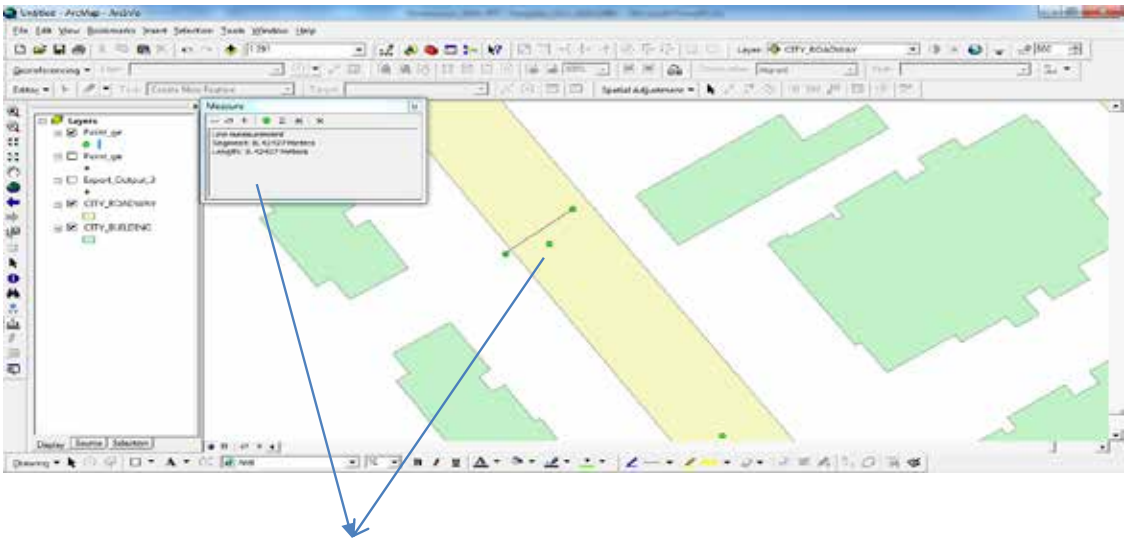


Figure 11: Results in Road data



The Actual Road Width during the Data collection using DGNSS

The Road Width during the Data Digitization Process

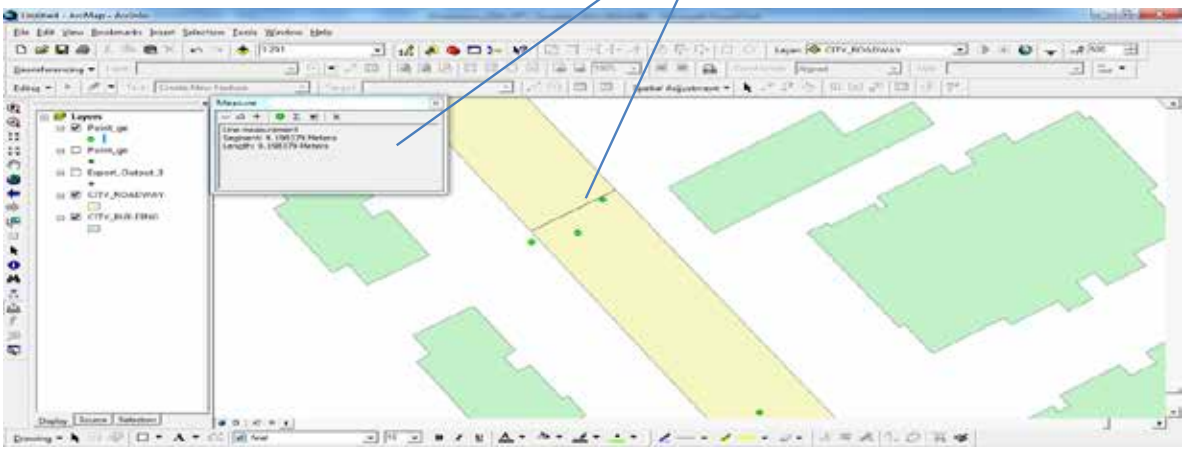
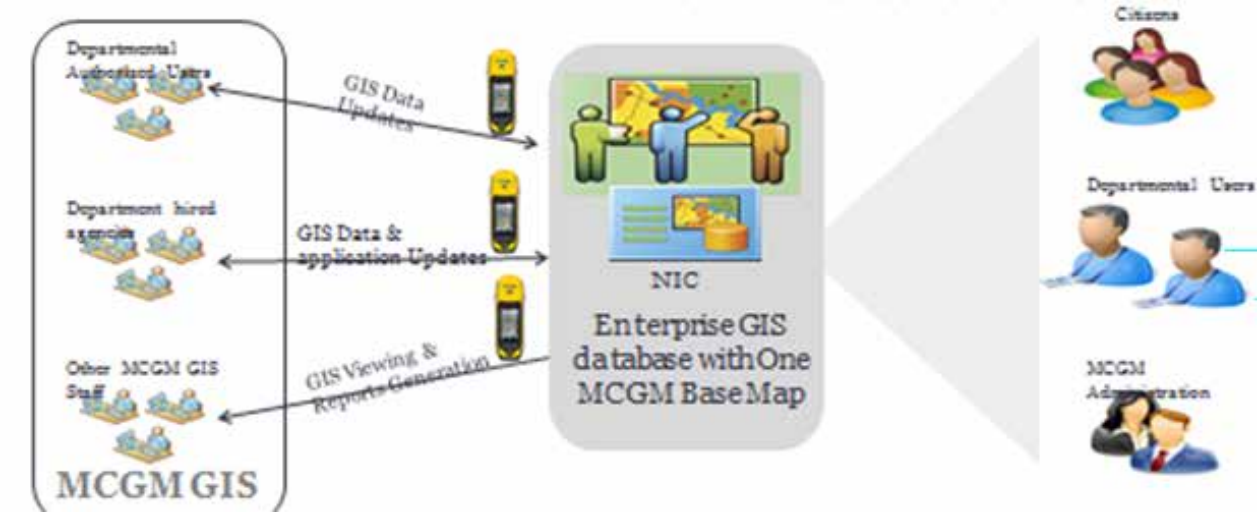
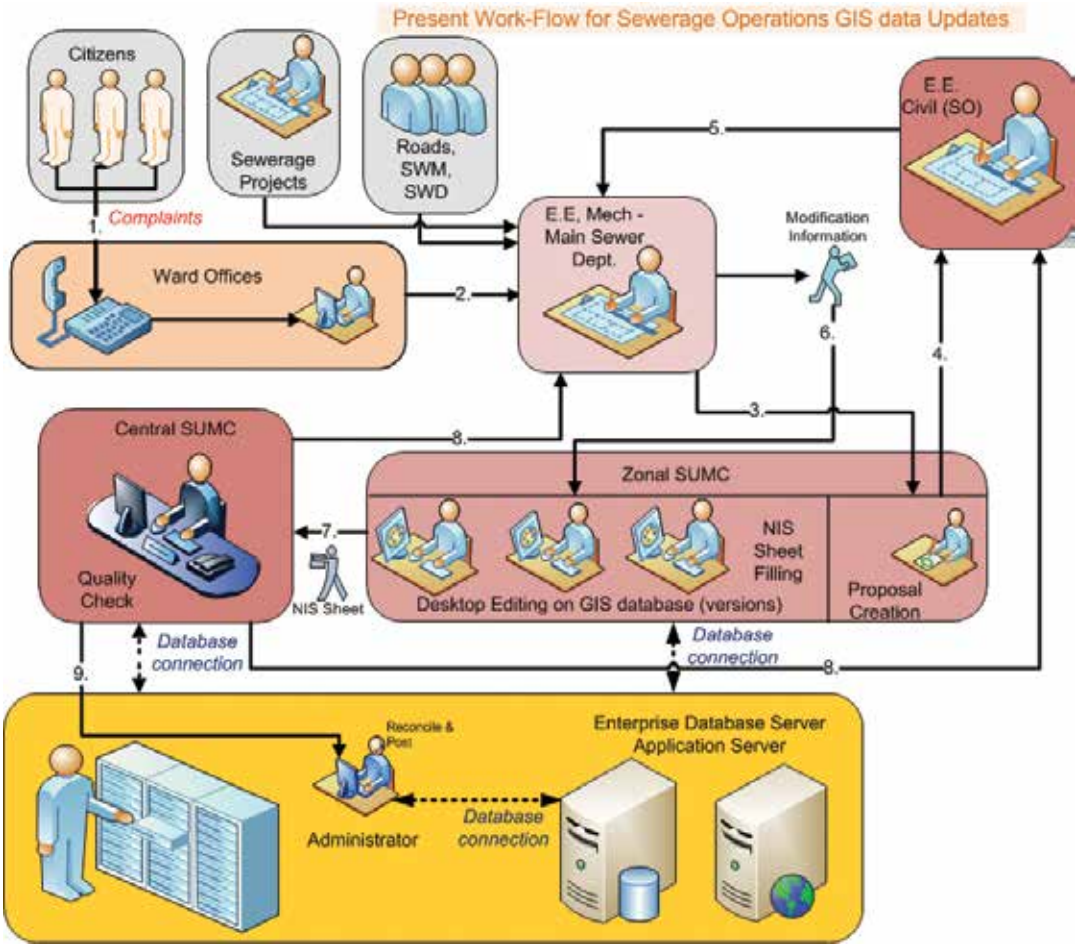


Figure 12: Present Workflow in MCGM After success of Base Rover Data Collection





Initiative After the Positive Result

1. SUMC is procuring 2 additional Trimble NetR9 based CORS stations to increase the reach of the base network
2. Simultaneously MCGM has started planning for a Virtual Reference Station (VRS) network so that the networked stations collectively and precisely can further model Ionospheric errors for the individual GNSS rover in the network coverage area
3. SUMC has recently procured 25 Trimble Geo 7x Rovers meant for each Ward Office and future Data collection will be done for Sewers and Manholes using only these devices

Future Expansion of the solution to other MCGM Departments

1. The MCGM Water Department has also started mapping their Asset collection Using MCGM CORS stations and Geo 7 Rovers
2. The Slum Rehabilitation Agency (SRA) also started using this Base stations for their Survey for the Slums
3. NIC announced their plans to use MCGM CORS stations for all their ongoing surveys in Mumbai Metropolitan Area

Three MAIN Learnings:

1. The focus of this White Paper was to review, explain, and show an example of how MCGM is trying to use the technologies like GNSS and GIS for the City of Mumbai's utility departments.
2. This project would provide individuals with a reference to implement a utility GIS from the start to the end
3. The implementation process would provide other similar cities and municipalities, especially those covered under the Indian government's flagship Smart City Project and AMRUT Project, with the knowledge and foundation to develop their own GIS.

Acknowledgment

The Sewerage Utility Management Centre (SUMC) team at MCGM for sharing the details of the Project and the learnings and strategies planned to mitigate present problems

The Mumbai Area Manager and Mumbai Survey & Geospatial Team of Aimil Ltd., who were closely involved in assisting the team at MCGM in designing and implementing the solution

The Geospatial Team and the Infrastructure Team at Trimble Inc.'s India office for the advice they provided in selecting the correct products for the final solution

MCGM and various International websites for the general data that has been used in creation of this White Paper

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Agri-business Solutions: Solving Tricky Problems of Over/Under Estimation	**Mr. Pritish Bisoyi** National Manager-India & SAARC Hexagon Geospatial	pritish.bisoyi@intergraph.com
	Dr. Sudhakar Manda Chief Remote Sensing and GIS Skymet Weather Services Pvt. Ltd.	
	Mr. Vasudeva Rao Senior Manager-Technical Services Hexagon	vasudeva.rao@intergraph.com
	Ms. Anjul Garg Marketing Specialist Asia-Pacific & SAARC Hexagon Geospatial	anjul.garg@hexagongeospatial.com
Better Nutrient Management on Standing Crop Using GreenSeeker Sensor with GPS Data Logger	**Mr. Nikhil Kumar** Director - Technical Marketing (SAARC Region) Trimble Navigation India Pvt. Ltd.	nikhil_kumar@trimble.com
Countrywide Fire Hazard and Risk Analysis for Revamping the Fire and Emergency Services in India	**Mr. Sushil Gupta** General Manager - Risk Modelling and insurance RMSI Pvt. Ltd.	sushil.gupta@rmsi.com
Flood Inundation Modelling using UAVs	**Mr. Dhruv Shah** Associate - Business Development ideaForge Technology Pvt. Ltd	lakshmi.narayan@ideaforge.co.in
	Mr. Lakshmi Narayan Associate - UAV Applications ideaForge Technology Pvt. Ltd	dhruv.shah@ideaforge.co.in
	Ms. Ciara Arora Associate – Marketing ideaForge Technology Pvt. Ltd.	ciara.arora@ideaforge.co.in

Success Story	Contact person	Contact details
GIS & GPS based Emergency Response System for Smart Cities	**Dr. C. R. Bannur** Sr. Divisional Director Homeland Security, Global Products and Technology Solutions Division Rolta India Ltd.	crbannur@rolta.com
Integrated Web GIS based Crime Investigation System for Railway Passenger Safety	**Dr. Sandeep Goyal** Sr. Principal Scientist & Head M.P. Resource Atlas Division M.P. Council of Science & Technology **Mr. Maithili Sharan Gupta, *IPS*** DG (Police Reforms) MP Police	sgoyal@mpcost.nic.in sgoyalbsg@gmail.com maithilisharan@gmail.com
Geospatial Data Modelling for Creation of Web-Portal Services for Industrial and Infrastructure Development under GOiPLUS in Odisha	**Dr. Debajit Mishra** Scientist Odisha Space Applications Centre and Department of Industries Govt. of Odisha, and Project Coordinator Govt. of Odisha Industrial portal for Land use and Services (GOiPLUS)	djmishra@yahoo.com
Integrating UAVs in Social Research: Summary of a Successful Pilot Study	**Ms. Samayita Ghosh** Senior Research Associate Outline India	samayita@outlineindia.com
Innovative use of LiDAR Technology for Smart City Surveillance	**Dr. Aniruddha Roy** Chief Technology Officer Genesys International Corp. Ltd.	ani.roy@igenesys.com
eLoc: India's First National Digital Address System	**Mr. Rohan Verma** Director MapmyIndia **Mr. Shishir Verma** Vice President MapmyIndia	rohanv@mapmyindia.com shishir.verma@mapmyindia.com

Success Story	Contact person	Contact details
Mapping Technologies Help Indigenous Communities Preserve Access to Water Resources and Biodiversity	**Mr. T. Balachander** Programme Coordinator Information & Communication Keystone Foundation	bala@keystone-foundation.org
Sujal - NRW Management for Jalgaon Municipal Council	**Mr. Anshul Sethiya** Manager – Branding and Marketing ADCC Infocad Ltd.	anshul.sethiya@adccinfocad.com
Drones, Data and the Indian Railways	**Mr. Shinil Shekhar** Co-founder AIRPIX	shinil@airpix.in
LiDAR Scanning for Railway Infrastructure	**Ms. Amrita Gokhale** FARO Business Technologies India (P) Ltd.	amrita.gokhale@faro.com
Road Asset Management System for National Highways	**Mr. Atul Kumar** Former Chief General Manager National Highways Authority of India Ministry of Road Transport and Highways, Govt. of India	atulkumar55@gmail.com
Integrating Disruptive Solutions with Traditional Survey Tools for Efficient Project and Stakeholder Management	**Mr. K. Gokul** Business Development Executive Skylark Drones Pvt. Ltd **Mr. Mughilan Thiru Ramasamy** CEO Skylark Drones Pvt. Ltd.	gokulk@skylarkdrones.com trmughilan@skylarkdrones.com
Tamil Nadu Highway Department to take the High Road to Success	**Ms. Rashmi Gupta** Group Head – Marketing Esri India	rashmi.gupta@esriindia.com
Gayatri Projects Improves Grading Productivity	**Mr. Nikhil Kumar** Director - Technical Marketing (SAARC Region) Trimble Navigation India Pvt. Ltd.	nikhil_kumar@trimble.com
Ground up Approach for Solving Local Transportation Issues	**Ms. Surabhi Patodia|** Corporate Communications Ola	surabhi.patodia@olacabs.com

Success Story	Contact person	Contact details
GIS Based School Bus Tracking	**Ms. Nirupama Dixit** Founder Safeplanet Innovations LLP **Mr. Amit Sharma** Safeplanet Innovations	spinnovations.india@gmail.com
Transportation: A Successful Geospatial Solution Case Study	**Dr. Manosi Lahiri** MD & CEO ML Infomap	manosi@mlinfomap.com
Mapping Technologies Utilised for Urban Planning to Improve Sanitation for India's Urban Poor	**Ms. Pratima Joshi** Founder & Executive Director Shelter Associates **Ms. Resham Badri** Architect Shelter Associates	info@shelter-associates.org resham@shelter-associates.org
Modernization of Utility Mapping using High End GNSS Systems in the Municipal Corporation of Greater Mumbai	**Mr. Nikhil Kumar** Director - Technical Marketing (SAARC Region) Trimble Navigation India Pvt. Ltd.	nikhil_kumar@trimble.com

FICCI Committee on Geospatial Technologies

MISSION

Making Geospatial Technologies more pervasive in India

VISION

To make a collaborative ecosystem with help of all possible stakeholders to ensure that geospatial is embedded into all systems and processes/ governance related functions.

FICCI started working for the sector under the guidance of Prof. V.S. Ramamurthy, Former Secretary, Department of Science & Technology, Govt. of India. The Committee is working on the larger vision of mainstreaming applications of geospatial technology as an effective decision making tool for governance in India.

Programmes

- Location Based Services (LBS) - 2016: *Transforming Coordinates to Business*
- Location Based Services (LBS) - 2015: *Transforming Coordinates to Business*
- Location Based Services (LBS) - 2014: *Transforming Coordinates to Business*
- Location Based Services (LBS) - 2013: *Transforming Coordinates to Business*
- Launch of FICCI Publication "Empowering India through Geospatial Technologies - *Select Stories"*
- Geo-enabling Uttarakhand: *Opportunities and the Way Forward*
- Geospatial Technologies for Good Governance
- GIS: Opening the World to Everyone – Visionary Talk by Jack Dangermond, President, ESRI Inc.
- NSDI-10: National Geospatial Ecosystem: *The Road Ahead*
- Geospatial Technologies for Utilities & Infrastructure
- NSDI 8: Geospatial Technologies in India – *Challenges & Opportunities*
- International Conference on Spatial Data Infrastructure (SDI) & Its Role in Disaster Management with Department of S&T, Govt. of India

Thought Leadership

I. Reports / Papers

- Location based services: Adding another dimension to smart cities
- Capacity Building – Geospatial Technologies
- Geospatial Technologies for a Smarter Planet
- Empowering India through Geospatial Technologies
- Indian Geospatial Market Report 2009

II. Policy Recommendations

- White Paper on recommendations to the Govt. of India on the draft Geospatial Information Regulation Bill, 2016
- Recommendations to DST, Govt. of India on the Concept note on National Geospatial Policy (NGP) 2016
- Geo-enabling Uttarakhand: *Opportunities and the Way Forward*
- Use of GIS for Development - FICCI inputs to the Planning Commission for 12th Five Year Plan

Chair – Mr. Rajesh Mathur, Advisor, Esri India

Co-Chair – Mr. Nikhil Kumar, Director, Trimble

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About FICCI

Established in 1927, FICCI is the largest and oldest apex business organisation in India. Its history is closely interwoven with India's struggle for independence, its industrialization, and its emergence as one of the most rapidly growing global economies.

A non-government, not-for-profit organisation, FICCI is the voice of India's business and industry. From influencing policy to encouraging debate, engaging with policy makers and civil society, FICCI articulates the views and concerns of industry. It serves its members from the Indian private and public corporate sectors and multinational companies,drawing its strength from diverse regional chambers of commerce and industry across states, reaching out to over 2,50,000 companies.

FICCI provides a platform for networking and consensus building within and across sectors and is the first port of call for Indian industry, policy makers and the international business community.

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