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Mapping of the Assets and Utilities: A vision for the development of Smart Cities in India

Arshad Ahamad Sujauddin Momin
Postgraduate scholar, Department of Civil Engineering,
Symbiosis Institute of Technology, Symbiosis International University,
Gram: Lavale, Pune, Maharashtra, India.
Orcid Id: 0000-0001-7507-8345

Sagar Kolekar
Assistant Professor, Department of Civil Engineering,
Symbiosis Institute of Technology, Symbiosis International University,
Gram: Lavale, Pune, Maharashtra, India.
Orcid Id: 0000-0002-5006-9722

Abstract

Union cabinet has announced to develop 100 smart cities in India. Also, the government of India has introduced new schemes such as "Amrut" for improving the overall efficiency of existing cities. As any city or townships grow over a time it becomes essential to have frontlines of data management with an effective reporting system. Looking for the vision to develop smart cities it is important that our nation should look for a modern approach and implement the same for efficient management and maintain their assets and utility infrastructure. This paper provides a detailed literature review and a framework that can be used for the mapping of the existing utilities. It is proposed to develop comprehensive Asset and Utility management system with a set of exhaustive tools meeting the accurate digital asset mapping, monitoring, and evaluation and planning requirements of the Municipal Corporations. In order to develop such system, it is necessary to carry out an extensive field survey of all the assets and utilities present in the area of interest using different surveying techniques and equipment. The survey shall also require the use of geophysical tools such as cable and pipe locators and Ground Penetrating Radars for mapping the underground infrastructure facilities.

Keywords: Utility Mapping, Geophysical Survey, Smart City, Utility Detection

INTRODUCTION

The Government of India has announced to develop 100 smart cities all over the country. The population in urban cities is increasing day by day and it is been predicted by the experts that urban population would be doubled by 2050. Development of the smart cities that will use advanced technology for improving the overall performance and reduce costs and resource consumption is the need of the hour. Cities in all across the world are already working towards the smartening their infrastructure. Apart from developing new smart cities government of India has also initiated new scheme in the name of "Amrut" for the improvement of the existing cities.

Every municipal corporation or any organization that deals with the Utilities have the responsibility to provide rear line engineering support to the civilian while maintaining their assets in a cost-effective manner. On the other side, these organizations face a significant challenge in tracking the location, quantity, condition, maintenance, and status of their fixed Assets and Utilities.[1]

To do this effectively, it is important to understand where assets such as offices, warehouses, pipelines, electrical cables are located. In the past, multiple software tools were required for viewing parcels, streets, addresses, sewers, streetlights and other elements of a work site. Nowadays, with the development of computers, network software, hardware and GIS allows users to efficiently capture, store, view, manipulate and retrieve any geographically referenced information and it is possible to develop a system that can efficiently manage all the assets and utility-related data at one central location.[2]

GIS-Based asset and utility management system which will enable the user to know precisely where assets and Utilities (including Underground Utilities) are located in the need of the hour. Using GIS-based Asset and Utility Management System for this will give the user a more accurate reflection of real-world circumstances and will allow such organizations to make better business decisions. This will also equip the user with an effective tool for physical planning (e.g. Infrastructure planning, Excavation planning, Maintenance plans and Breakdowns).[3]

Through this paper, an effort has been made to collect different surveying techniques and decide a suitable methodology for GIS-based mapping of all the assets and utilities including underground utilities that will provide the organizations such as Municipal corporations, town planning authorities an effective tool for the management and decision making.

CHARACTERISTICS OF THE EXISTING SYSTEM

a) All information pertaining infrastructure or assets that normally consist of buildings, roads, bridges, culverts, stormwater drainages, Electrical Utilities, Sewage Utilities, Pump Houses and connected water supply equipment, Powerhouses connected Electric supply equipment, DG sets, Air conditioning plants, storerooms, and also underground and above ground pipelines, cables (including HT distribution cables), streetlights, transformers etc. are maintained by analogue methods. [4]

b) All information is stored in a completely different section and accessing the information for planning and management is very difficult for the engineers.

c) Even many times all these maps are stored in different cupboards and finding an appropriate map for the purpose is also a very difficult task.

d) Department usually has no clear idea about the route or location of underground utilities and many times departmental engineers have to rely on the field persons like valve men, operators, and contractor labor those executed the work.

e) Lack of knowledge about underground services results in the additional and unnecessary expenses during the execution of the new project.

f) Separate map sheets are used each for buildings, pump houses, electric cables, street lights, roads, pump houses, wells, trees, and facilities data are maintained by printed data sheets in text form.

g) Normally all the maps available with the department are either outdated or rarely updated.

h) This infrastructure is continuously being augmented as a result of on-going works. Therefore it is logically impossible to maintain and update data like type/model/ manufacturer/vintage/rating of electrical equipment (pumps, motors, compressors, condensers, VCB, OCBs, RMUs etc.), Rating / Manufacturer / Vintage / sizes / MOC of Cables and Pipelines, location and routes of underground and overground cables and pipelines, location of valves, length and breadth of roads, dimensions of buildings etc. manually or in the form of standard Maps.[5]

i) Due to the unavailability of updated maps, measurements and selection of the shortest and most practical way for laying new cable/ pipeline has to be done physically on the ground. Same happens during the breakdown of any line.

j) All the utilities are geographically dispersed.

k) Lack of centralized facility for providing instant information to departmental engineers and thus data sharing within the organization becomes very difficult.[6]

l) Any decision making such as allocation of the quarters to offices, painting, and change of bulbs of electric poles has to be done on the rough basis by referring old data sheets.

THE NEED OF THE SYSTEM

The ability to manage all utility networks as regards monitoring, maintaining and updating remotely as well as the ability to plan all future installations of these networks meticulously and cost-effectively are the pillars that support the need for such a system to be in place. This can be concluded on the basis of the following advantages that such asset management solutions should provide.

They are as follows:

a) Storage of tabular data (attributes) in association with the cartographic features (points, lines, and polygons)
b) Relations can be established using attributes
c) Entry, management, manipulation, editing, analysis, query and display of large collections of spatial data should be easy
d) Availability of complete asset profile remotely
e) Asset condition can be monitored
f) Exact geographic location of assets
g) Data sharing and access possible
h) Dynamic addition of new assets and deletion of discontinued assets
i) Easy updates on existing assets (like increase in capacity, pipe diameter changes, etc.)

Adding to these advantages are the operational benefits of having such a system in place. They are as follows:

a) Measurement of Cable or Pipeline along the route to be taken for planning new works
b) Shortest and most practical route to be chosen
c) Avoiding losses /damages /downtime on account of cable /pipeline breakages due to lack of knowledge of exact routes
d) Hassle-free replacing of elements which have exceeded their lifespan

Management of assets shall be extremely benefited from recording using asset management database since it leads to a systematic process of maintaining, upgrading and operating physical assets. The ability of such solutions to search asset records /information database and performing the user-friendly queries shall be significant to the adoption of a modern system of financial planning for asset management and plan to utilize their full potential.

OBJECTIVE

It is proposed to develop a comprehensive Asset and Utility Management System using GIS and Global Navigation Satellite System (GNSS), Total Station Data, Cable and Pipe

Locator devices, Drawings available with the departments, manual observations and develop digital maps and database for data visualization, query, and analysis. The detailed objectives are:

a) Establishment of DGNSS control points all over the Area of Interest (AOI) for further total station survey and differential corrections.
b) Carry out detailed survey of AOI using DGNSS and Total Station for Assets (e.g. Buildings, Roads, Bridges, Manholes, Culverts)
c) Carry out detailed geophysical survey of AOI using ground penetrating radars, cable and pipe locators, coupled with handheld GNSS device / Total Station for underground utilities (e.g. HT cable, LT Cable, OFC, sewer lines, water pipelines)
d) Design and development of Geographically reference database for the data collected using DGNSS and Total Station
e) Collection of attribute or field data for the assets and utilities surveyed in above steps.
f) Customizations in the user interface of the GIS package so that it would be easy to comprehend and use.
g) Training of the user
h) Support to the user for any changes made in the infrastructure

METHODOLOGY

The execution of the project will be carried out in stages mentioned below

A. Survey
B. Detailed geophysical survey of underground utilities/assets
C. Base map creation
D. Plotting of all utilities/assets
E. Attributes or Field data collection
F. Feature Configuration and database creation
G. Training of the User
H. Support for to update the changes/modifications in the infrastructure

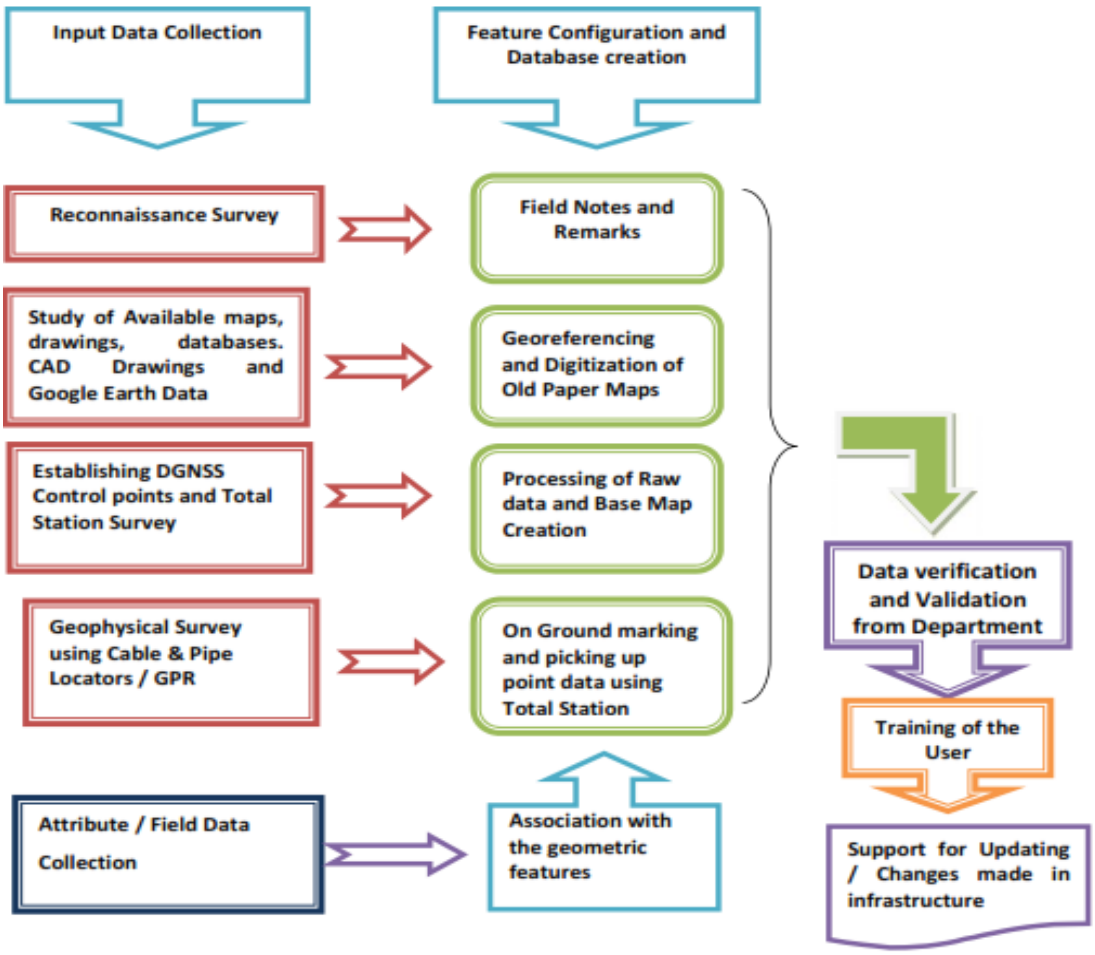

Figure 1: General Flow Chart of activities

A. Survey

The schedule below is a simplified version of options and listing the limitations of each type of survey.

- Level 1: A kind of preliminary reconnaissance Survey, this survey is usually executed rapidly and at relatively low cost, prior to actual survey and mapping in detail and with greater precision. The intention is to alert the surveyor to any difficulties that were not anticipated at the survey proposal stage. Almost 80% of the information about the on-ground utilities and Assets can be achieved with this.
- Level 2: Available records and maps are studied extensively with the results consolidated onto base mapping. This also involves consultation with JEs, valve men, substation operators, and analysis of Departmental drawings and databases.
- Level 3: A Level 2 but with a predefined percentage of the survey area covered with Total Station, DGPS. This data to be post-processed and interpreted at a later stage for incorporation into digital mapping along with the Level 4 data.
- Level 4: Using just a cable & pipe locator search in active and passive modes with located utilities being marked out on the ground surface only.
- Level 5: A Level 4 survey but the results plotted onto digital base mapping in CAD
- Level 6: A Level 5 survey but with Test pits, lifting of manhole and inspection pit covers etc. This gives confirmation and confidence to surveying personnel. These results recorded digitally in Handheld GPS. This is the highest level of the survey with 100% coverage of the survey area.

Various options can be added to any of the above to enhance that level of the survey.

B. Geophysical Survey of Underground Utilities and Assets

Detection and mapping of existing underground utilities can be taken up as a new and challenging task by the municipal authorities though underground utilities have already been emplaced for many decades. [7]

Advanced geophysical tools such as Ground Penetrating Radar (GPR) as well as Cable & Pipe Locator can be largely used to detect underground facilities.

i. Ground Penetrating Radar

Ground penetrating radar (GPR) is one of the non-destructive geophysical methods that provides a cross-sectional profile of the underground/subsurface features. GPR can be used to locate the buried utilities and objects without drilling, digging or probing. GPR shows a cross-section of the subsurface and shows ground surface on the top of it. [8]

Ground penetrating radars can be successfully used to locate underground utilities almost of any type independent of the material of construction.[7]

GPR profile can be used to evaluate the depth and shape of subsurface utility.

ii. Cable and Pipe Locators

Cable and Pipe Locators, on the other hand, allows the detection of metal pipes by detecting electromagnetic field created or inherently present in the facility. This has become the universal technology for locating and tracing buried utility lines.

Cables and pipe locators are used by transmitting the signal to the utilities via induction. The receiver picks up the electromagnetic signal induced onto the utility. This method is used for utilities which are made of conductive material.

The utilities will be located using these instruments and then simultaneously location data will be captured using handheld GNSS device. The GNSS data can be post-processed to apply corrections from DGNSS device from the base station.

The fact should not be neglected that Cable & Pipe Locators will simply aid in finding the path of existing UG cable or pipeline for which there must have an opening or any known starting point. A lot of co-operation from the department is required in order to bring perfection.

Additionally, available information of all existing assets can be used as a reference to verify and achieve detail oriented detection of assets.

C. Base map creation

The creation of base map here refers to the creation of vector map that will describe the basic details of Area of interest such as Buildings, roads, landmarks and political boundary. This base map will form a foundation for locating the buried utilities and other thematic information can be placed on this map such as road names, garden names, vegetation details etc.

For the creation of the accurate base map, high-resolution satellite images can be used. Further to improve the accuracy DGPS and total station data can also be accompanied. DGPS can be used for making control points which can be used for georeferencing satellite images and also these points can be used for back sighting during total station survey.

D. Plotting of Utilities and Assets

Once the base map is ready, the underground utilities can be plotted on the base map using cable & pipe locator / GPR accompanied by handheld GPS device or with a total station.

The use of handheld GPS device enables the user to plot utilities simultaneously during the detection and thus results in greater accuracy and less time consumption. The requirement of Total station operator and rodmen can be eliminated through this.

But it should be kept in mind that the accuracy of DGPS will differ due to the errors associated with it such as Multipath, ionosphere and tropospheric errors. Necessary correction needs to be considered while post-processing of the data.

Once the utilities are plotted using handheld GPS device, the data can be exported to PC in ESRI shapefile or any other GIS compatible format.

E. Field/Attribute Data Collection

The distinction from other Information Systems is that for a GIS the data inputs are of two types:

a) Spatial data (latitude/longitude for georeferencing the features on a map, e.g. land type, units, administrative districts), and

b) Attribute data (descriptive data about the features, e.g. Building Name, Type, Area, contractor etc.)

Attribute data can be simply described as the information attached to each object in the layer. For example, In case of Buildings layer the attribute such as Name of building, type of building, Area (Plinth Area), Number of story's etc. would be used to form the database for Buildings layer. Attributes of all mapped elements for instance infrastructure details like type / model / manufacturer / vintage / rating of electrical equipment (pumps, motors, compressors, condensers, VCB, OCBs, RMUs etc.), rating / manufacturer / vintage of overhead and underground cables' sizes / vintage of pipes, sizes / location of valves, tee junctions, length & breadth of roads etc. shall be used for generating the exhaustive database of the asset management software. In short, this database will carry detailed information about each facility in a tabular format. [9]

It is also proposed to store the maintenance related data in this tables. This information can be retrieved through simple query function available in the asset management system.

A detailed attribute data will be collected to form a database using[10]

a) Field Visits (Visual Inspection)

b) Staff knowledge

c) Operation and Maintenance Manuals

d) Maintenance records

e) Available databases / reports

F. Feature Configuration and Database Creation

Once the survey of AOI is done in all respect it is necessary to collect and compile the entire survey database into a unique and integrated database. This will also facilitate to sharing of information (cartographic and thematic) about the utility network to various persons of the department.

Feature configuration here also describes the conversion of the survey data right from raw GSI file from the total station and then its subsequent conversion from GSI to CSV and then CSV to ASCII and from ASCII to AutoCAD DXF and after that processing the data in AutoCAD map and exporting the data in ESRI Shapefile format.[11]

All these data have to be compatible with GIS platform so that it can be viewed in any GIS package either Proprietary or open sources like QGIS or Google Earth.

Hence once the data is collected the data need to be stored on a central platform (e.g. GIS).

G. Training of the User

A successful implementation is as very essential. Through clearly defined objectives, an understanding of process and knowledge, the transition couldn't be easier.

For the successful implementation of the system, training sessions should be organized so that user will be able to use the system whenever requires. The training should be consisting of min. 7-8 working days and user should be trained for the basics of the GIS technology, about how to view the data, print the data as well as upgrade it.

H. Support for to update the changes/modifications in the infrastructure

Any modifications or up gradation that occurs within the AOI need to be updated into the system database to keep the system up to date and efficient. Although the user can update the database by his own using the handheld GPS device and his knowledge of GIS package it is advisable that trained professionals should do this job in order to maintain the consistency in the data.

Hence this database would be updated on a quarterly basis and also depend upon the requirement of the user.

CONCLUSION

Accurate information about the underground utilities becomes a key requirement for the maintenance and management of the existing utilities as well as for the planning of the new utilities. Lack of knowledge regarding underground utilities results in the catastrophic and fatality damage to the existing utilities. Many government organizations are greatly suffering due to interruption of the utility services such as Power supply/ water supply etc. and financial losses associated with it. Understanding and having accurate information about the utilities will not only save time and money but also it can mitigate the risk of injury and provides the confidence to the user especially when working with the underground power lines.

From this study, it can be concluded that a GIS-based Asset management system can be used for improving the overall planning and management activities of the Municipal corporations or any other civic bodies. Further, we can say that the drawbacks of the conventional system where we are not aware of the exact data of assets at one point and confusion about the location of assets that leads for the

creation of problems in executing new work and related maintenance work can be easily solved.

Various infrastructural facilities, utilities, and assets can be created under the jurisdiction of different subdivisions within the City. Different divisions have their own maintenance, expansion and developmental plans. So, in this scenario, a database that has the ability to interlink various utility networks may facilitate the close communication and coordination among other departments by reducing the redundancy and hence, improving the overall organizational efficiency of the station.

Information retrieval through simple query generation feature in location-based asset recording would be useful for to reach a decision about the location of a new electrical network, water supply, and sewerage projects etc. with maximum benefits. Asset recording and mapping can be presented succinctly and clearly allowing focus on future development issues. This ensures that handing over assets from one engineer in charge to another is highly simplified, objective and accurate.

Once a GIS-based asset and utility management system is in place further the system can be used for the planning of the Automation of the existing system using PLC-based SCADA Automation.

Also, it should be remembered that going underground for utility detection will pose a very big challenge to the authorities and the fact should not be neglected that Cable & Pipe Locators will simply aid in finding the path of existing UG cable or pipeline for which there must have an opening or any known starting point. A lot of co-operation from the department is required in order to bring perfection.

Additionally, available information of all existing assets in the database can be used as a reference to verify and achieve detail oriented detection of assets.

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