Geomatics Tools for Surveying and Mapping

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Abstract

Geomatics technology is used to gather, store, process, and deliver geographic information, or spatially referenced information. Geomatics tools are valuable for planning and monitoring social, economic and technical processes. The tools and techniques are used in land surveying, remote sensing (LiDAR, UAV), cartography, geographic information systems (GIS), global navigation satellite systems (GPS, GLONASS, Galileo, and Compass), photogrammetry, geography and related forms of Earth mapping. These tools provide accurate, timely and cost-effective measurement, analysis and visualization of phenomena on Earth surface. World-wide, geomatics tools are being used in a large number of mega projects for better planning and management of resources. With the availability of modern equipment and technology, there is a tremendous saving of manpower and funds for field data collection and their analysis.

Keywords: *Geomatics technology, GLONASS, Galileo, Compass, global navigation satellite systems, (LiDAR, UAV)*

INTRODUCTION

Surveying may be defined as the science of determining the position, in three dimensions, of natural and man-made features on or beneath the surface of the Earth. These features may be represented in analogue form as a contoured map, plan or chart, or in digital form such as a Digital Terrain Model (DTM). It involves largely the field work involving the capture and storage of field data using instruments and techniques appropriate for the survey work in hand. As the surveying technology grew, advanced materials, electronics, sensors and software are introduced encompassing a wide spectrum of professionals, and subsequently new term is coined.

The term Geomatics was created at Laval University in Canada in the early 1980s, based on the concept that the increasing potential of electronic computing was revolutionizing surveys and representation sciences and that the use of computerized design (video diagram) was compatible with the analysis of huge amounts of data (Gomarasca, 2010). Geomatics is a relatively new scientific term, originally used in Canada and progressed to Australia and then to the United Kingdom. When the term Geomatics was introduced to Great Britain, the senior members of the surveying profession emphasized that it could be adopted.

The reasons given for the need to change were firstly to improve the image of surveying by sounding more modern, up-market and embracing of new and developing technologies, and secondly (and possibly, in reality, more importantly) to improve the attractiveness of the profession to prospective candidates of university surveying programmes (Coutts, 2017).

Geomatics which means geo (for Earth) or studying the Earth, phenomena concerning it, relationships and processes and matics is taken from mathematics i.e., to use mathematical relationships about Earth's processes and phenomena. Geomatics (also known as geospatial technology or geomatics engineering) is the discipline of gathering, storing, processing, and delivering geographic information, or spatially referenced information. Geomatics is a valuable tool for planning and monitoring social, economic and technical processes.

The skill-set of the modern surveyor now enables him or her to apply their tools, expertise and their understanding of the precision and relative accuracies of measurements from diverse sources, to the much expanded areas of application, well beyond the traditional surveying and mapping areas (Coutts, 2017).

Geomatics is defined as a systematic, multidisciplinary, integrated approach to selecting the instruments and the appropriate techniques for collection, storing, integrating, modeling, analysis, retrieving at will, transforming, displaying and distributing spatially geo referenced data from different sources with well-defined accuracy characteristics, continuity and in a digital form. It includes the tools and techniques used in land surveying, remote sensing (LiDAR, UAV), cartography, geographic information systems (GIS), global navigation satellite systems (GPS, GLONASS, Galileo, and Compass), photogrammetry, geography and related forms of Earth mapping. It is an accurate, timely and cost-effective tool used for measurement analysis and visualization of phenomena on Earth surface.

For analyzing information related to Earth, geomatics combines geospatial analysis, geospatial models, geospatial databases, human-computer interaction, both wired and wireless networking technologies which are referenced to geographic location. The applications of geomatics tools are multidisciplinary in nature involving various branches of cartography, geodesy, photogrammetry, remote sensing, laser, GPS, field, web-mapping, socio-economic, computer science, computer vision, mobile and game technology, intelligent system, and internet of things, to generate results in the form of maps or reports which allow better interpretation, management and decision making about various human activities on Earth's surface (Oledzki, 2004).

From classical surveying, scientific activities in Earth's observations, data collection and analysis have undergone a rapid expansion which includes ground survey, global satellite positioning systems, traditional and digital photogrammetry, and multispectral remote sensing from airplane and satellite at different geometric, spectral, radiometric, and temporal resolutions, yet there is still only limited awareness of how to use the potential of all the available tools correctly (Gomarasca, 2010). With the availability of modern equipment and technology, there is a tremendous saving of manpower and funds for field data collection and their analysis.

This paper presents brief summary and salient features of some of the geomatics techniques. Other approaches, like Photogrammetry, Remote Sensing, GIS etc., have not been discussed here and readers may refer to Garg (2018).

ELECTRIC TOTAL STATION (ETS)

An electrical total station is an electronic/optical instrument used in modern surveying that uses electronic transit theodolite in conjunction with electronic distance meter (EDM).It is also integrated with microprocessor, electronic data collector and storage system. With the prism method, the total station sends out invisible infrared waves that are reflected by the prism, which is typically attached to a pole. By measuring the prism's position and knowing the precise angle and distance to that prism, the total station calculates the prism's location or coordinates.

The instrument is used to measure sloping distance of object to the instrument, horizontal angles and vertical angles. The microprocessor unit enables for computation of data collected to further calculate the horizontal distance, coordinates of a point and reduced level of points. Data collected from ETS can be downloaded into computer/laptops for further processing of information. Total stations are mainly used for topographic surveying, to set out bridges, dams, canal, houses or boundaries. They are also used by archaeologists, police, crime scene investigators, and insurance companies.

Some of the major advantages of using ETS over the conventional surveying instruments are; saving in time, ease in working, increase in accuracy, and facility to use computer for storing, processing the data and to get the final result in a desired format. Modern ETS now include reflector less EDM measurements, have a broad range of on-board application programs, automatically conduct fine pointing to prisms, automatically find prisms and allow one-man robotic operation to conduct stakeout and detail surveys in a highly efficient manner (Hill, 2008).

High-end total-stations which are automatically able to detect, recognize, aim and lock onto a prism, are called Robotic Total Stations (RTS). A total station may be called robotic if it is able automatically to follow a prism (360°) moving through 3D space. The RTS is equipped with servomotors for automatically rotating the instrument horizontally and vertically, and an Advanced Tracking Sensor for tracking the prism (Henk and Lemmens, 2008).

A communication link between the RTS and prism makes it possible for just one surveyor to carry out the survey, controlling the electronic total station from the prism pole side with a remote controller, thus saving time and money. Accuracy is high, even under conditions of low visibility (night).

The RTS enabled surveyors to increase the productivity. The automated guidance of dozers, graders, excavators, harvesters, tractors and scrapers, in short, machine guidance, became major new applications. RTS is also often used for deformation studies, such as dams, towers and plant chimneys. Advanced total stations also use laser beam to take the measurements, called reflector less total stations.

The laser beam based total station can be used in night or underground survey or those locations where it is not possible to keep the prism, such as bottom of the bridge deck. Such total stations have up to 2000m range of measurements in reflector less mode, thus give increased productivity. In addition, it also requires one surveyor to take the measurements. For example, if length of a beam in multi-stories building is required, simply aim and shoot points at each end of the beam with laser. Reflector less measurement helps keep human away from dangerous sites as there is no need to keep the prism at such sites.

Topographic surveys in remote areas often have vegetation that limits the exclusive use of GPS to complete the survey. In many cases, GPS is used to establish control before the survey is continued using total stations. Integrated survey rovers who combine the Global Navigation Satellite System (GNSS) and total station target on a single pole, are already available. The integrated total stations and GPS technology ensures that it is no longer necessary for surveyors to conduct extensive traversing, the equipment can be set-up at a convenient location and the survey can begin immediately. In these applications, the antenna is located collinear with the vertical axis of the total station equipment. Once the antenna is connected to the total station, all operations are conducted through the keyboard of the total station.

Integrated GPS and total station systems (Figure 1) significantly improve the efficiency of surveyors, are easy-to-use and provide a cost effective entry point to RTK GPS technology (Hill, 2008). Total stations with integrated video technology enable surveyors to see exactly what the instrument sees and to capture georeferenced images for use in photogrammetry. The latest developments in ETS have the capability to provide data for building information modeling (BIM) and virtual design and construction.

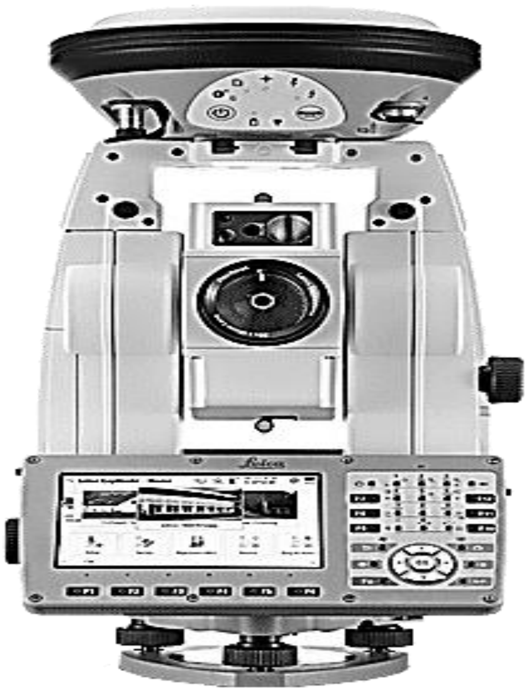

Figure 1 Integrated Total Station and GPS

LASER SCANNING

Among other survey instruments, the laser scanning technique is particularly significant, as it produces complete information of the ground with high precision and by a considerable level of automation and productivity. Many construction professionals are finding they need laser tools just to stay competitive in the industry.

Laser distance meter is a replacement of traditional tape used for distance measurement. It is a small-sized, compact and lightweight electronic gadget which can measure distance up to 60m with one hand only. It has a digital screen to display the measured distance, but also has functions, like addition or subtraction of measurements, calculating the area or volume of a measured room. The distance meter is to be pointed out towards the distant object (e.g., wall) and clicked to get the distance. A laser distance meter sends a pulse of laser light to the target and measures the time it takes for the reflection to return It can measure with greater accuracy (up to ±1 mm), and saves time and money. A laser distance meter is a perfect toolkit of constructor workers, surveyors, architects, engineers, carpenters, event organizers, and many other professionals. The biggest advantage is that it can easily measure hard-to-access areas, such as high ceilings, without climbing a ladder, and reduces estimating errors. With a backlit display and the laser dot, it can be used in relatively poor lighting conditions.

The laser beam concept was introduced in Levels. These, laser Levels give more accurate reduced levels, and are frequently used for leveling, plumbing, machine control, excavation work, landscaping, swimming pool construction, measuring elevation, measuring distance, alignment, site-prep grading, construction stake out, concrete leveling, home building, and many various construction job site tasks. Atomization in laser Levels further enhanced the working and speed of data collection. Rotary laser levels produce a 360° level laser line around a worksite. They have a greater range than line levels, and are more ideal for larger and exterior work sites. Rotary laser levels are used for construction projects indoors for a 360° horizontal or vertical beam around a room, or outdoors to be used with a laser detector and grade rod for excavation work for both digging down or building up.

Land surveying typically uses instruments with direct contact on Earth with everything measured, while LiDAR is a type of measurement that collects 3D data (x,y,z) of ground using laser based equipment. Ground and aerial based laser surveys offer multiple applications. This technology uses laser beams to produce 3D models or other maps. It is also called 3D laser imaging, 3D laser scanning, 3D laser surveying or high-definition surveying (HDS). Laser scanning is also carried out from instrument mounted on a vehicle, called Mobile Mapping method. Modern mobile laser scanners aren't just limited to vehicle mounted systems; mobile LiDAR units can now be mounted to backpacks. Mobile mapping systems utilize the latest in LiDAR technology, with scanners capable of collecting around one million points per second. Figure 2 shows the point cloud data collection of a bridge using Laser scanner. Airborne LiDAR system when combined with GPS, IMU (Inertial Measurement Unit), these geo referenced data points can be used to create more accurate, 3D Digital Elevation Models (DEMs) or Digital Terrain Models (Figure 3). Mobile mapping systems also have many uses across a wide range of industries, from surveying applications, like city modeling and highway surveys to environmental, transportation and utility mapping. Road and corridor surveying has never been safer, faster, and more efficient than with the use of mobile laser scanning. Mobile laser scanning acquires a dense point cloud of data and digital video and imagery from a vehicle moving on roads.

This technology is used in a wide range of applications either alongside traditional survey instruments or as an alternative to total stations, such as historical preservation, surveying hard-to-reach areas, and monitoring construction progress.

Laser scanning technology uses laser wavelengths to determine the distance to objects, detecting structures, surfaces, and any other object. A surveyor can quickly gather a huge amount of accurate 3D laser points from the surface of remote feature as a 'point cloud' image, providing quick surveying solutions for complex geometrical detail and inaccessible elements. A point cloud is much more efficient than a ground survey. The processed data point set would display the measurements of physical features. For most applications, the data collection from LiDAR system is more rapid than the data processing because tremendous amount of data is acquired in the field in a short time. The data from the scanned high definition survey image can then be processed with visualisation and modeling software to represent the surface surveyed.

Figure 2 High Definition Scanning to collect point cloud data of a bridge

It is then used for a wide variety of applications including exporting to Micro Station, Revit, Navisworks, Infraworks, 3D Studio Max, and AutoCAD in 2D or 3D models. The benefits of working with laser scanning data are numerous and provide the advantage to multi-disciplinary teams; Architects, Civil engineers, CAD designers, Planners, Universities, Insurance companies, Utility sectors, Communication engineers. Their weakness is represented by the complex filtering operations necessary to deduce the desired data from the big data, and also to select the enormous amount of data necessary to recreate the DTMs.

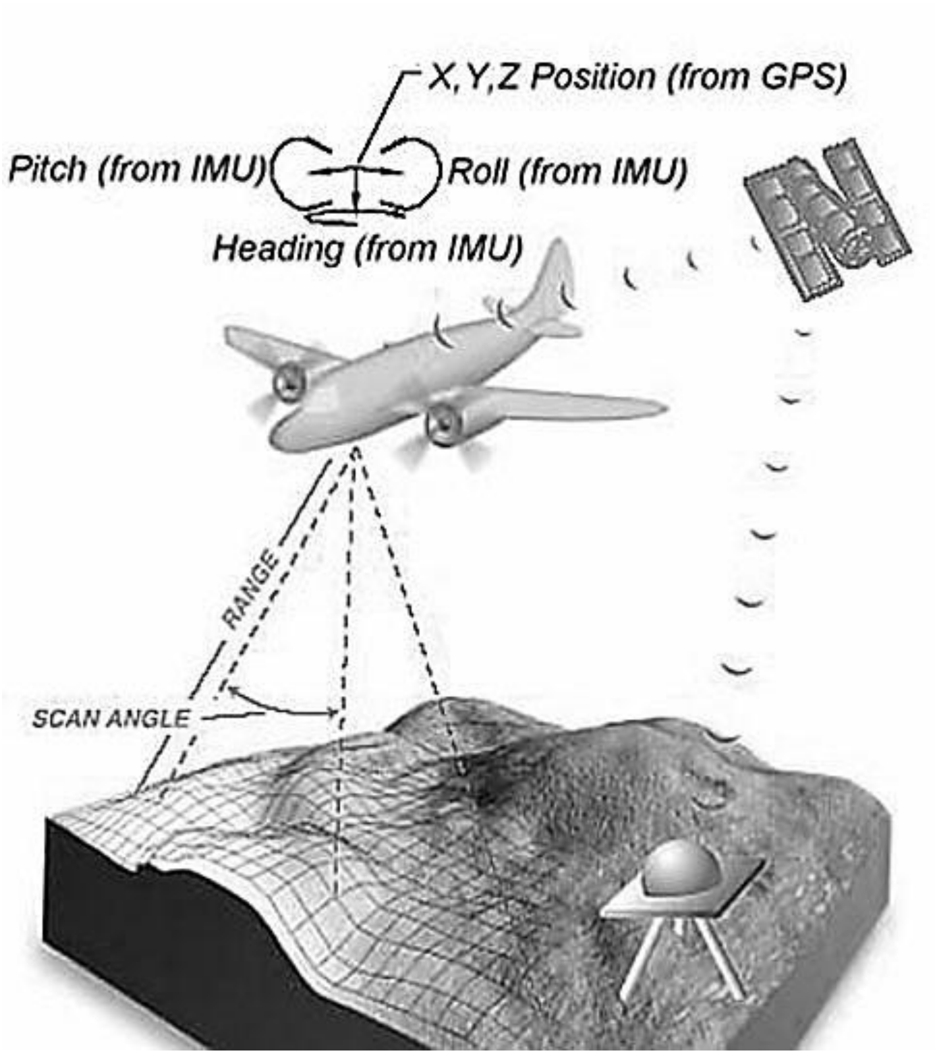

Figure 3 Airborne LiDAR Survey

LiDAR from air can survey very large areas in a short period of time, whereas the HDS equipment mounted on survey tripods is operated similarly to a robotic total station which is moved. A major potential advantage of a laser scan survey is that it can present more confidence in the survey results than those obtained from traditional survey equipment.

The Surveyor moves the HDS from control point to control point, gathering scanner data with overlaying digital photos. Photogrammetry ties in with LiDAR gives high resolution photos taken from an aircraft. Overlapping images with the survey control points on the ground results in ortho-rectifying the dataset as well as creation of DTM.

The laser scanning techniques therefore represent a meaningful evolution of some aspects of photogrammetry, directly obtaining a 3D DTM which traditionally was obtained from the stereoscopic measurements in Photogrammetry, thereby reducing the involvement of expert interpreters and approaching the total automation in the process.HDS has found applications in everything from architectural modeling, historical preservation, and civil engineering design, to food processing and manufacturing, industrial renovation, and mechanical engineering designs.

3D laser scanner stretches the boundaries of survey technology in BIM, facilities, large structures, tunnel, historical architecture, cultural heritage, road surface, slope, profile and volumetric measurement.3D laser scanning is effectively used for building interiors and exteriors, industrial sites, site surveys, bridge surveys and road surveys.

GLOBAL POSITIONING SYSTEM (GPS)

Global Positioning System (GPS) was initially developed by the Department of Defense (DoD) of USA primarily for their military use to provide precise estimates of position, velocity and time.

The GPS was designed to give exact position of objects on the Earth anytime, anywhere, and in any weather condition. Nevertheless, the civil applications of GPS have also grown at an alarming rate. The GPS has revolutionized surveying, providing latitude, longitude, and height information more quickly, economically, and accurately than by traditional surveying methods.

It is the most advanced and popular system of navigation which was launched into space in 1978 with the first GPS satellite (Herring, 1996). In the early 20th century, ground-based radio-navigation systems were developed. GPS is a space-based all weather radio navigation system which receives signals from the GPS satellites.

GPS broadcasts precise, synchronized timing signals to provide precise estimates of position, velocity and time. There is a great technological revolution with the development of GPS as it can be used for multiple applications where the exact position of any object or phenomena is involved, such as locating a petrol pump, restaurant, cinema hall etc.

GPS is based on the principle that position of any object (x,y,z), can be determined given the distances to objects whose positions are known. The GPS satellites act as reference points (i.e., of known locations) from which receivers on the ground resects their position. Ground stations precisely monitor the orbit of every satellite and by measuring the travel time of the signals transmitted from at least four satellites, four distances between the receiver and satellite will yield accurate position, velocity and time.

Increasingly land, sea and air vehicles are making increasing use of the capability of GPS to determine point positions with an accuracy of 100 m. Differential GPS (DGPS) which uses radio links between mobile and fixed GPS receivers, provides relative position in real time with an accuracy of 10 cm to 1 m for civil aviation and coastal navigation.

High accuracy of GPS positioning at millimeter level, makes it useful for tectonic, earthquake, volcano, Earth rotation, sea-level, satellite altimetry, glaciology, meteorology, global climate, ionosphere, and hydrology and ecology studies.

Real Time Kinematic (RTK) GPS provides surveyors with an efficient tool to conduct their survey activities in real-time. Although RTK GPS is now widely used, there are still many surveyors who do not benefit from GPS technology because of a perception of complexity.

GPS is being used for surveying, monitoring darn, dikes, landslides, and subsidence, positioning infrastructure for use in GIS, time transfer for telecommunication systems, automated construction and facilities management, precision farming, forest and resource management, natural resource exploitation. GPS networks provide valuable data for numerical weather prediction models. Now a days, GPS are used extensively mainly by navy, air force, army, coast guard, rescue & relief personals, civilian carriers, surveyors, commercial transport, hikers, and trekkers (El-Rabbany, 2006). World-wide, there are a large number users of GPS enabled gadgets, like mobile phones, wrist watches etc., for a variety of utility (Xu, 2010).

It offers the advantages of accuracy, speed, versatility and economy to provide location-based data. The benefits of using GPS for mapping and modeling include improved productivity, fewer limitations (such as open to sky requirements), and faster delivery of 3D coordinates. In fact, GPS today has become an essential element of our daily life.

DRONES/UAV

Now, drones or Unmanned Aerial Vehicles (UAVs) are steadily being adopted to rapidly collect the huge data accurately. A UAV can acquire data faster from a height in the form of geospatial images with high resolution. Data is often captured in the millions of data points in several short flights over a sizable parcel. The planning software also enables the planner to enter specific routes, speeds, altitudes and hover times over each point. Recent technology even enables the Drone/UAV to land automatically. With GPS equipped drones, digital cameras and powerful computers, surveys may have accuracy up to 1 centimeter (Figure 4).

The UAV will be a perfect platform for aerial photography and remote sensing. UAV is armed with a built-in camera to photograph the land parcel. UAVs as well as photogrammetric and point cloud software have matured to provide workable solution for surveyors.

Many new software packages are available, led by Leica, Iwitness, Drone Mapper, Photo modeler and others. UAV photographs processed using photogrammetry software can produce 3D accuracy that is equal to or better than conventional aerial photography. Standard GIS software and AutoCAD can be used to stitch and georeferenced drone aerial photos.

Figure 4 Drone/UAV Survey

The user downloads the collected images from UAV, and combines the images with either the surveyed ground control points or the UAV's Real Time Kinematics (RTK) data into a photogrammetric software package. This process produces high-resolution orthophotos (aerial photos geometrically corrected) of the site, along with a dense point cloud data. The benefits of using UAVs for surveying are the high resolution and valuable images generated. Images captured and processed from a camera (mounted on a drone) can be used for measurements in 3D.

This enables construction project managers and planners to understand every important detail from the comfort of their office on their computer screen. The other advantage of drone is that it can access areas where human surveyors dare to reach. Every site for surveying may not have easy access or safe to survey, e.g., hazardous waste sites and landfills, snow cover, landslide affected area etc.

This would be an ideal application for UAV surveying. UAVs offer surveyors a new technique for cost-effective and efficient technique to acquire data for medium to large-scale projects that require surface models, such as mine sites, quarries and construction sites with earthworks. Drones/UAVs have emerged as a powerful technology that is being adopted at a very rapid pace for a variety of commercial applications (such as aerial surveying, mapping, surveillance, etc.) in industries like infrastructure, mining, agriculture, oil & gas, power utilities and many more.

The use of quadcopters and multirotors in photogrammetry and lidar mapping is still in the very early stages but growing very fast. UAV lidar involves mounting a laser scanner on a UAV to measure the height of ground points below the UAV. Lidar scanners can capture hundreds of square kilometers in a single day. By measuring 10 to 80 points per square meter, a very detailed digital model of the terrain can be created (Corrigan, 2018).The accuracy of the measurements allow the 3D models created using the lidar drone to be used in planning, design, and decision making processes across many sectors. Lidar sensors can also pierce dense canopy and vegetation, making it possible to study vegetation categorization and change monitoring. Through the use UAV photogrammetry and lidar mapping, there are many products which can be extracted from the aerial imagery, such as DEM/DTM/DSM (surface models), orthophotos (geospatially corrected aerial images), 3D building models, contour maps, plannimetric features (road edges, heights, signs, building footprints, etc)and volumetric surveys.

Although Drones/UAVs have been around for a while, the technology has not yet been widely used in the surveying, but it soon will be, due to the advent of practical, lightweight lithium polymer batteries, low-cost drone technology, lightweight digital cameras and advances in close-range oblique aerial photography–all of which make the future of Drones/UAVs in land surveying exciting (Willis, 2013). While airspace regulations and safety concerns have slowed down the adoption of UAVs for their use in some cases, but there are other advantages such as cost and safety as well as permanent record of ground, particularly to monitor the progress of construction from a distance (Galvin, 2016).

However, Drones/UAVs must first overcome the problems associated with safety, privacy and homeland security. Regulatory restrictions for safety, although necessary, are the biggest threat to the development of Drone/UAV technology. Most low-cost Drones/UAVs are not nearly as reliable as manned aircraft and have a much higher crash rate. This remarkable new technology has the potential to transform the surveying profession (Willis, 2013).

GROUND PENETRATING RADAR (GPR)

Ground Penetrating Radar (GPR) was invented in the 1970's, originally for military purposes, such as locating land-mines and underground military tunnels but soon public utility companies started using it for mapping pipes and utility lines under city streets, and for locating cavities and voids. GPR is a geophysical method that employs radio waves, typically in the 1 to 1000 MHz frequency range, to offer the best compromise between spatial resolution and exploration depth to map structures and features buried in the ground (or in man-made structures).

This non-destructive method emits electromagnetic waves and detects the reflected signals from subsurface structures. GPR has its own source of energy, locates both metallic and non-metallic objects, and detects disturbed soil conditions and other buried structures (Figure 5).

Figure 5 GPR Survey

The GPR device is an essential tool for exploring the sub-surface to determine & validate the presence of underground utilities subject to soil conditions. GPR not only responds to the buried pipe or cable, it can also sense soil disturbances that may be associated with prior installation excavations. Detection and interpretation of buried utilities, water, sewerage, pipelines, electrical and optical cables can be done. The advantage of GPR lies in its ability to detect any structure with differing properties and materials, like soil, rock, concrete, asphalt, wood and water.

GPR systems are used to locate reinforcing and post tensioning in concrete, monitor airplane runways for structural integrity, conducting groundwater studies, detect unexploded land mines as well as forensic research and surveying land for construction purposes. Engineers can identify and delineate the voids under the surface of concrete and asphalt roads using GPR. The depth and position of pipes and plastic conduits, such as gas and water line can be determined in real-time. For utility scanning, GPS integration with GPR scans has allowed for more effective results. Municipalities can use GPS and GPR to locate and record the underground utilities for producing accurate 2D &/or 3D maps of buried utilities.

FUTURE OF GEOMATICS IN INDIA

India has long been a leader in using modern surveying technologies. These modern technologies are fast expanding their presence in India, across a wide range of disciplines, researchers and academia, national survey & mapping organizations, industries, environmental agencies, and local & national governments (Ramprasad, 2013). For example all major Telecom companies use geomatics technologies to lay their cables and locate mobile towers, and power sectors for locating the electrical assets in towns.

In various programs of the government, such as Digital India, Smart Cities, Skill Development, Start-Up India, Make in India, National Mission for Clean Ganga, Interlinking of Rivers, Delhi Mumbai Industrial Corridor, Smart Power, and Agriculture, Bharat Mala, Sagar Mala, River Rejuvenation, e-governance and Digital Economy Initiatives, remote sensing, GPS and GIS technologies are poised to play a critical role (IGE, 2018). The use of these technologies in national importance projects will have a significant role to play related to project planning, conceptualization, design, implementation and monitoring. The modern surveying technologies along with the ICT are being integrated into planning and management to monitor, evaluate and apply spatial planning of natural resources, utilities, infrastructure and urban development and transport sectors in India (Sonnen, 2010). The adoption of various modern surveying technologies in different sectors is presented in Figure 6.

While Defence is the major user of geospatial technologies, the initial lead for the usage of geospatial technologies in India was taken by the natural resources sector (Sonnen, 2010). There are various other fields, such as, construction and maintenance of roads, railways and waterways, civil aviation, public utility services, education, health, command area development, flood control and management, urban renewal, urban water supply, rural water supply, etc., that essentially use modern surveying tools and technologies for planning, management and decision-making in various departments of Government of India. Figure 7 shows the sectors where geospatial service providers are focusing currently as well as for future. As per Geospatial Economy (IGE)-2018 report, the GIS and spatial analytics market is the second biggest contributor to the geospatial market in India, constituting 23.1% of the total market with estimated market revenue of INR 1,771 crore in FY 2017-18. This figure is estimated to reach INR 2,674 crore in FY 2020-21.

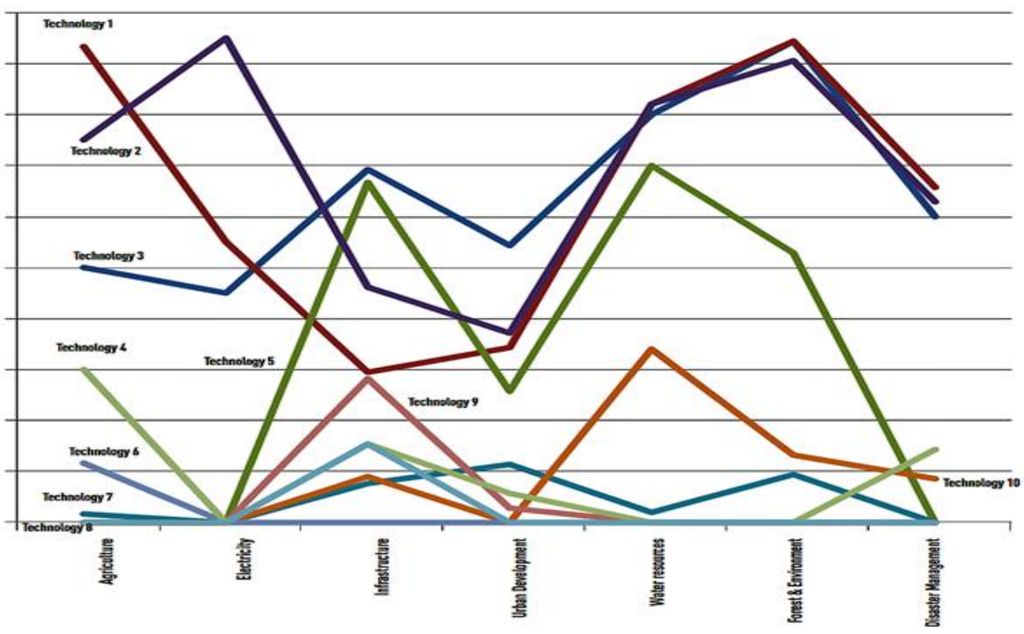

Figure 6 Geospatial technology contributing to major ongoing projects in India (Source: Vardhan, 2015)

Legend

Technology 1 GIS

Technology 2 GPS

Technology 3 LiDAR/Laser scanning

Technology 4 Satellite images

Technology 5 Aerial photographs

Technology 6 Total station

Technology 7 RADAR

Technology 8 CAD

Technology 9 UAV

Technology 10 BIM

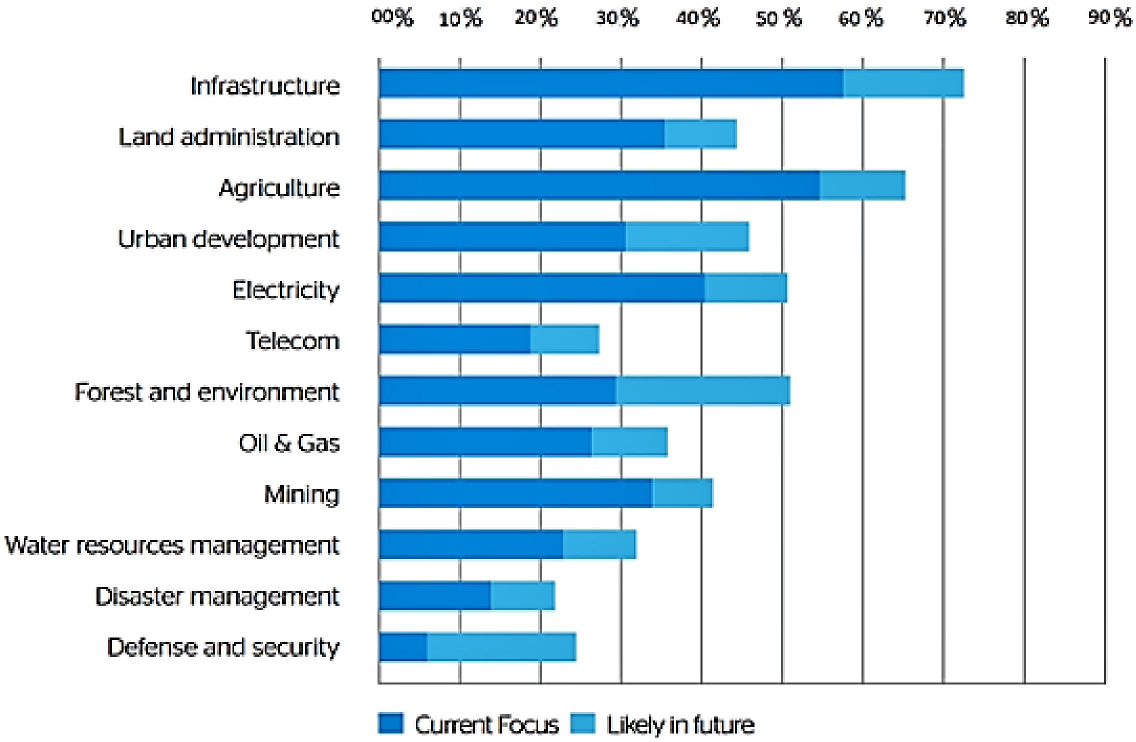

Figure 7 Adoption of various geospatial technologies in different sectors in India (Source: Report on India's Geospatial Market and Prospects, 2016)

India is recognised for its strong IT skills and space programmes. Capacity building is the major key to capitalise on the opportunities presented before the Indian geospatial industry. India has shortage of skilled human resource in the field of modern surveying technologies, so there is an opportunity to take this as hotspot career. Geoinformatics is not only for the people studying surveying, remote sensing, GPS, GIS or geography, but recently more disciplines, like computer science, information technology, electronics and communication, electrical engineering, civil engineering, architecture, geology, earth sciences, environmental science etc., have included geoinformatics as their minor or even as their major subjects (Virrantaus and Haggrén 2000). Ongoing advances in surveying and mapping technologies are expected to further unleash the hitherto untapped potential for applications in development planning.

FUTURE OF GEOMATICS WORLD-WIDE

To forecast the size of geospatial market segments with respect to five main regions, namely, North America, Europe, Asia Pacific (APAC), the Middle East & Africa (MEA), and Latin America, Market and Market Research (2018) carried out a study. According to study, a key restraining factor impacting the growth of the geospatial analytics market is the high cost of geospatial analytics solutions. The development of geospatial analytics solutions for acquiring real-time data also increases the complexity of the GIS software. High complexities involved in the development of GIS software and real-time data collection result in high cost of software.

The GeoBuiz-18 report estimates the GIS and Spatial Analytics market to be the second largest after the GNSS and Positioning market. The GIS and Spatial Analytics market is expected to grow from US$ 66.2 Billion in 2017 to US$ 88.3 Billion in 2020 growing at a CAGR of 12.4%. In the recent period, the demand of 3D GIS is on the rise. As more developing countries, like China and India, focus on the development of Smart Cities, the adoption of GIS for 3D urban mapping becomes imperative, thus contributing to the increasing market of GIS/Spatial Analytics technologies. This has resulted in the creation of new breakthroughs in spatial modeling and location analytics.

While the software GIS market is expected to be US$ 17.9 Billion in 2020, the Services and Solutions, and the Content segment is going to hold the largest share of the pie with US$ 46.2 Billion and US$ 24.2 Billion in 2020 respectively. Similarly, the Asia-Pacific region is expected to grow at a much faster pace than all other regions, capturing approximately 26.9% of the total GIS and Spatial Analytics market in 2020.The global market is projected to witness a massive growth, majorly driven by the increasing penetration of Internet of Things (IoT), integration of geospatial technology with mainstream technologies, and advancements in geospatial analytics with the introduction of artificial intelligence and big data (Narayab, 2018).

According to the GeoBuiz-18 report, Cloud Computing, Big Data Analytics, Artificial Intelligence, Virtual Reality and the Internet of Things (IoT) are the key drivers of the GIS and Spatial Analytics market (Figure 8). Today, most of the GIS services such as maps database, imagery, and base maps are all available in the cloud. It enables users to use geospatial data with ease without having to worry about data storage, data security, and other privacy concerns. Similarly, Big Data Analytics is a crucial driver of GIS and Spatial Analytics segment. Big Data Analytics has expanded the scope of applicability for GIS-based solutions to create integrated and actionable contexts. With the introduction of artificial intelligence and big data in the market, geospatial analytics can provide better and less expensive geospatial data to organizations across the globe (Geospatial Analytics Market, 2018).

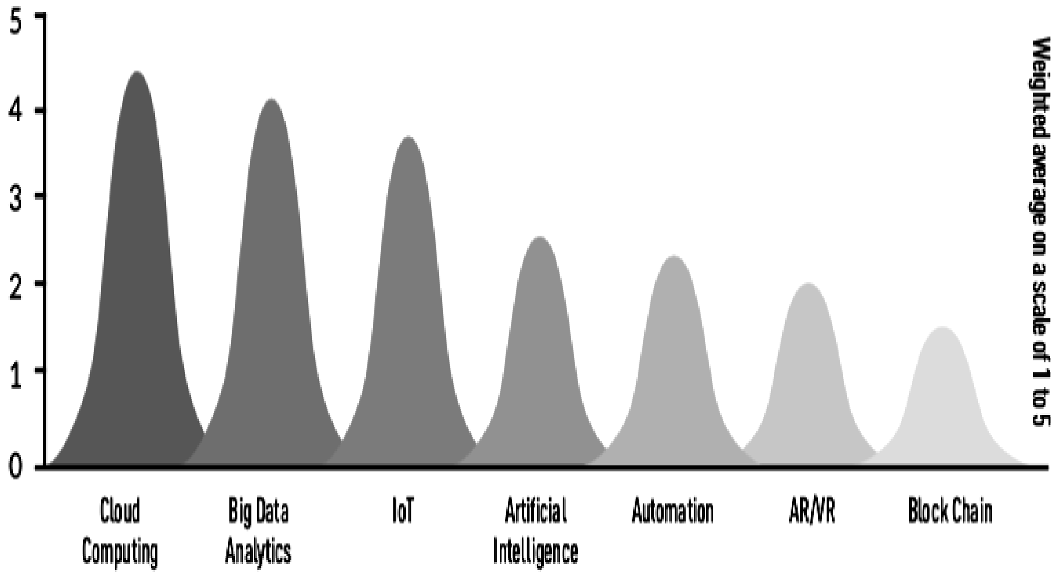

Figure 8 Key drivers of the GIS and spatial analytics market (GeoBuiz-18).

CONCLUSION

Development in surveying and mapping equipment has been presented in brief in this paper. There are numerous advantages in using the modern surveying equipment and technology. Most important one is the saving in time and manpower for collection of accurate and reliable data about the land surface. With the availability of very high spatial resolution images from satellites, LiDAR, UAV/Drones and other associated technologies in the recent years, applications of geomatics have increased. Geomatics has become an important component of planning and decision making in diverse sectors of the Government. Public perception towards geomatics has also changed and its benefits are now easily understood by the common man, especially with the availability of high resolution images on Google.

The uses of geomatics technologies are growing in power and use, and so are the software systems and niche support applications (cloud-computing, online geo-databases, cell phone controlled equipment, multispectral analysis). http://www.imsinfo.com/industry-insights/game-changer-advances-in-surveying-technology/ (22 March 2016).Adaptation to this new technology is challenging in itself as the speed of change is so rapid. Technology updates are arriving in the market at an unprecedented pace. Work methodologies, software and hardware requirements are continuously changing but due to lack of understanding of the changing technology and reduced skill level of surveyors, the risk of gross inaccuracy is actually increasing against the client's expectations of decreasing costs (Hill, 2008). The reality is that modern technology when implemented properly is still expensive but it performs a lot faster and produces much accurate results.

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