

**VISVESVARAYA TECHNOLOGICAL UNIVERSITY
BELGAUM**



ENGINEERING SURVEY

(Subject Code: BCV302)

LECTURE NOTES

(MODULE-5)

III-SEMESTER

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Module 5

SYLLABUS:

GPS Surveying – Introduction. Overview of GPS system- space, control and user segments. Reference co- ordinate systems. Absolute and Differential positioning with GPS. Gagan system in India. Types of GPS Receivers. Engineering survey using Differential GPS.

Surveying with Drone – Introduction, applications and advantages. Features of photogrammetric mapping method. Drone surveying requirements- Drone platform, Flight planning software, Sensor DGPS equipment and Image processing software. Types of drones and sensors. Process of drone surveying – flight planning, DGPS markers, capturing images, post processing of images using photogrammetry software and output maps. Application and uses of Remote sensing and GIS in engineering surveying.

(L1, L2, L3, L4)

GPS SURVEYING

Introduction:

The Global Positioning System (GPS) is a satellite-based navigation and surveying system for determination of precise position and time, using radio signals from the satellites, in real-time or in post-processing mode. GPS is being used all over the world for numerous navigational and positioning applications, including navigation on land, in air and on sea, determining the precise coordinates of important geographical features as an essential input to mapping and Geographical Information System (GIS), along with its use for precise cadastral surveys, vehicle guidance in cities and on highways using GPS-GIS integrated systems, earthquake and landslide monitoring, etc. In India also, GPS is being used for numerous applications in diverse fields like aircraft and ship navigation, surveying, geodetic control networks, crustal deformation studies, cadastral surveys, creation of GIS databases, time service, etc., by various organizations.



The Navigation Satellite Timing and Ranging Global Positioning System (NAVSTAR GPS) developed by the U.S. Department of Defense (DoD) to replace the TRANSIT Navy Navigation Satellite System (NNSS) by mid-90's, is an all-weather high accuracy radio navigation and positioning system which has revolutionised the fields of modern surveying, navigation and mapping. For every day surveying, GPS has become a highly competitive technique to the terrestrial surveying methods using theodolites and EDMs; whereas in geodetic fields, GPS is likely to replace most techniques currently in use for determining precise horizontal positions of points more than few tens of km apart. The GPS, which consists of 24 satellites in near circular orbits at about 20,200 Km altitude, now provides full coverage with signals from minimum 4 satellites available to the user, at any place on the Earth. By receiving signals transmitted by minimum 4 satellites simultaneously, the observer can determine his geometric position (latitude, longitude and height), Coordinated Universal Time (UTC) and velocity vectors with higher accuracy, economy and in less time compared to any other technique available today.

GPS is primarily a navigation system for real-time positioning. However, with the transformation from the ground-to-ground survey measurements to ground-to-space measurements made possibly by GPS, this technique overcomes the numerous limitations of terrestrial surveying methods, like the requirement of inter visibility of survey stations, dependability on weather, difficulties in night observations, etc.. These advantages over the conventional techniques, and the economy of operations make GPS the most promising surveying technique of the future. With the well-established high accuracy achievable with GPS in positioning of points separated by few hundreds of meters to hundreds of km, this unique surveying technique has found important applications in diverse fields.

Overview of GPS system:

GPS consists of three segments:

- Space,
- Control
- User



- **The Space Segment** consists of a minimum of 24 operational satellites in six circular orbits 20,200 km (10,900 NM) above the earth at an inclination angle of 55 degrees with an 11 hour 58 minute period. Although it is not a stated requirement, typically the satellites are spaced in primary orbital slots so that at any time a minimum of 6 satellites will be in view to users anywhere in the world.
- **The Control Segment** consists of a master control station in Colorado Springs, with five monitor stations and three ground antennas located throughout the world. The monitor stations track all GPS satellites in view and collect ranging information from the satellite broadcasts. The monitor stations send the information they collect from each of the satellites back to the master control station, which computes extremely precise satellite orbits. The information is then formatted into updated navigation messages for each satellite. The updated information is transmitted to each satellite via the ground antennas, which also transmit and receive satellite control and monitoring signals.
- **The User Segment** consists of the receivers, processors, and antennas that allow land, sea, or airborne operators to receive the GPS satellite broadcasts and compute their precise position, velocity, and time.

The GPS concept of operation is based upon satellite ranging. Users figure their position on the earth by measuring their distance from the group of satellites in space. The satellites act as precise reference points.

Each GPS satellite transmits an accurate position and time signal. The user's receiver measures the time delay for the signal to reach the receiver, which is the direct measure of the apparent range to the satellite. Measurements collected simultaneously from four satellites are processed to solve for the three dimensions of position, velocity and time.

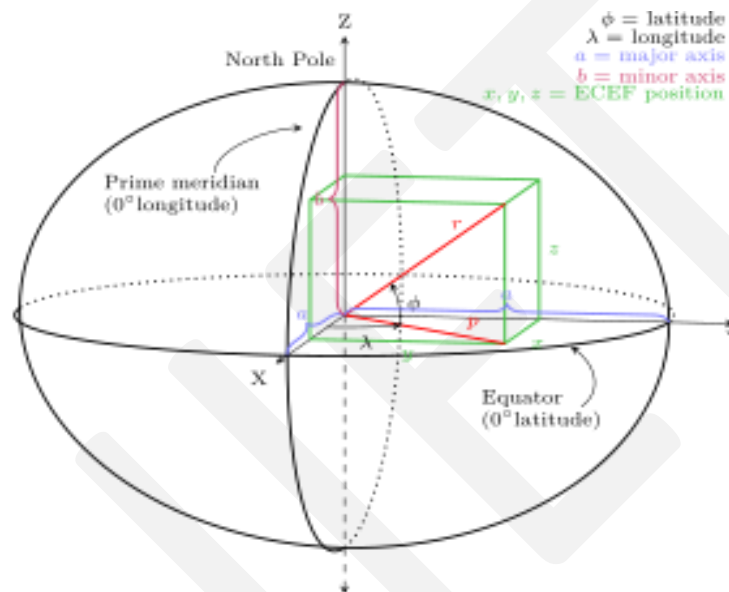
REFERENCE COORDINATE SYSTEM:

In GPS (Global Positioning System), reference coordinate systems are crucial for determining precise locations on Earth's surface. The primary coordinate system used by GPS is the World Geodetic System (WGS84).

WGS84 is a global standard for measuring and representing locations on Earth. It uses latitude, longitude, and altitude to pinpoint a specific point on the Earth's surface in three-dimensional space.

Latitude measures north-south position, longitude measures east-west position, and altitude measures the height above or below a reference, usually the mean sea level.

GPS receivers use WGS84 as the default coordinate system to provide accurate positioning information to users worldwide. This standardized system ensures compatibility and consistency across different devices and mapping applications, allowing for precise location determination and navigation.



ABSOLUTE AND DIFFERENTIAL POSITIONING WITH GPS:

Absolute and differential positioning are two methods used in GPS to determine precise locations, but they differ in their approach and the level of accuracy they offer:

Absolute Positioning:

Stand-Alone GPS: In absolute positioning, a GPS receiver determines its position independent of any external references. This method relies solely on signals received from satellites to calculate its position using trilateration (measuring distances from multiple satellites). The accuracy of stand-alone GPS can vary but typically ranges from several meters to tens of meters, depending on factors like satellite geometry, atmospheric conditions, and receiver quality.



Differential Positioning:

Real-Time Kinematic (RTK) and Differential GPS (DGPS): Differential positioning improves accuracy significantly by using a reference station with a known position. This station measures its position precisely using GPS and compares it to the known location, then broadcasts correction signals to nearby receivers. There are two main types:

DGPS: This method corrects GPS signals for factors like atmospheric interference and clock errors. It uses a fixed reference station at a known location to transmit corrections to mobile GPS receivers.

RTK: Real-Time Kinematic provides even higher accuracy in real-time applications by transmitting corrections from a fixed base station to a mobile receiver. RTK can achieve centimeter-level accuracy.

Difference between absolute and differential positioning:

Accuracy: Absolute positioning can have accuracies ranging from meters to tens of meters, while differential positioning methods like DGPS and RTK can achieve centimeter-level accuracy.

Dependency on External References: Absolute positioning works independently, while differential positioning relies on an external reference source (such as a base station) to provide correction information.

Applications: Absolute positioning is suitable for general navigation and location-based services where moderate accuracy is acceptable. Differential methods, especially RTK, are critical for applications requiring high precision, such as surveying, agriculture (precision farming), construction, and some scientific research.

In essence, while absolute positioning provides a general location, differential methods significantly enhance accuracy by incorporating correction data from known reference points, enabling highly precise positioning for specialized applications.



GAGAN SYSTEM IN INDIA:

GPS Aided GEO Augmented Navigation (GAGAN) is a step by the Indian Government towards initial Satellite-based Navigation Services in India. It is a system to improve the accuracy of a global navigation satellite system (GNSS) receiver by providing reference signals.

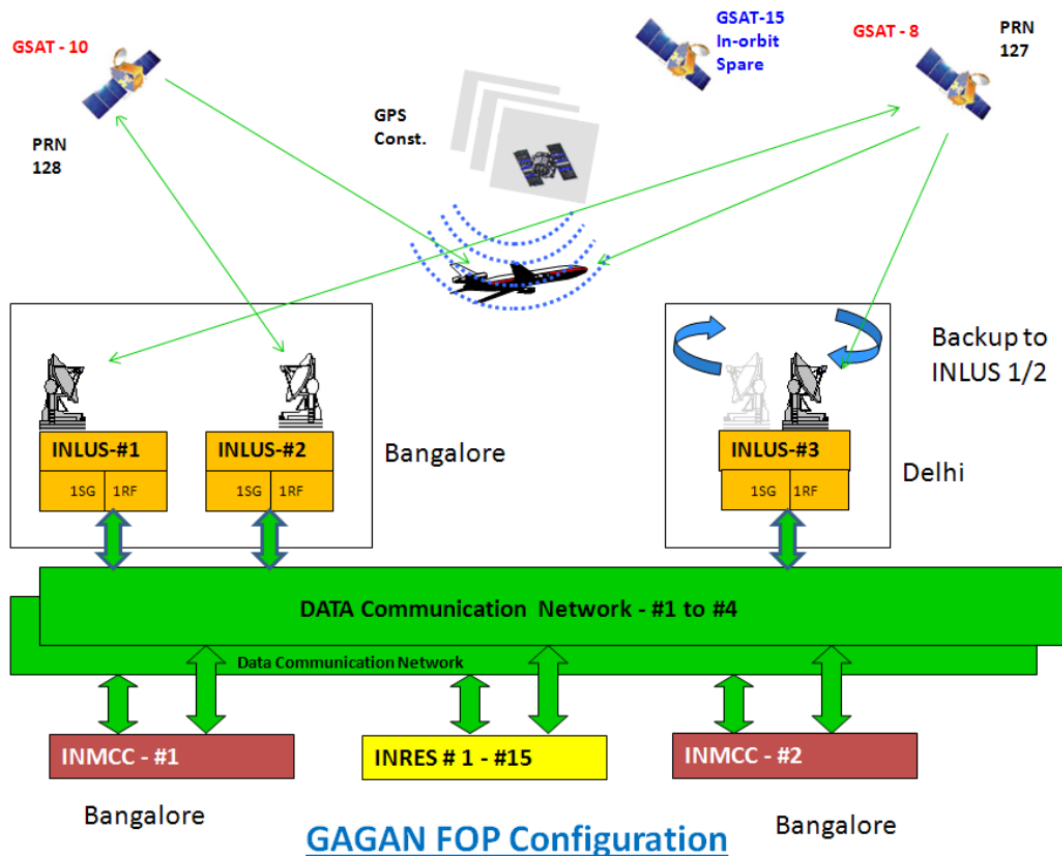
The Indian Space Research Organization (ISRO) and the Airports Authority of India (AAI) have implemented the GAGAN project as a Satellite Based Augmentation System for the Indian Airspace. The primary objective of GAGAN is to establish a certifiable satellite based augmentation system for safety-of-life applications. The functional performance and operational requirements of GAGAN shall be governed by the specifications as mentioned in the international standards. The system shall have inter-operability with other international SBAS systems like US-WAAS, European EGNOS, and Japanese MSAS etc.

GAGAN Final System Acceptance Test (FSAT) was completed on 16th-17th July 2012. Further the GSAT-8 satellite-GAGAN Payload has been integrated with Indian Land Uplink station-1(INLUS), Bangalore and GAGAN SIS (Signal in Space) is available since Dec 15, 2011. GSAT-10 satellite has been integrated with Indian Land Uplink station-2, Bangalore and second GAGAN SIS is available from April 2013. The backup Delhi INLUS has also been Operational since March 2013 and is integrated to GSAT-8.

The Key elements of GAGAN are:

- 15 Indian Reference Stations (INRESs)
- 2 Indian Master Control Centers (INMCCs)
- 3 Indian Land Uplink Stations (INLUSs)
- 4 chains of networks (OFC and VSAT)
- 3 GEO satellites with GAGAN payloads

GAGAN FOP configuration consisting of space segment, ground segment and user segment is shown below.



The successful completion of system stability test during June-July 2013 paved the way for certification of GAGAN System to meet the civil aviation requirements. The objective of Stability Test was to evaluate the system performance and its critical parameters in the integrated live environment using the satellite signals and ground based systems on integrity, accuracy, continuity and availability for aviation use.

India is the fourth country in the world, after USA, Europe and JAPAN, to take up the challenge of establishing the regional SBAS that will redefine the navigation over India and adjacent regions. The footprint of GAGAN will cover huge area beyond Indian Territory, from Africa to Australia and can support seamless navigation across the Globe.



Further, GAGAN is the first system in the world that would be certified to serve the equatorial anomaly region with its unique IONO algorithm (IGM-MLDF: ISRO GIVE Model – Multi-Layer Data Fusion) designed and developed by URSC in collaboration with vendor.

The GAGAN is designed to provide the additional accuracy, availability, and integrity necessary to enable users to rely on GPS for all phases of flight, from en route through approach for all qualified airports within the GAGAN service volume.

GAGAN will also provide the capability for increased accuracy in position reporting, allowing for more uniform and high-quality Air Traffic Management (ATM). In addition, GAGAN will provide benefits beyond aviation to all modes of transportation, including maritime, highways, railroads and public services such as defense services, security agencies, telecom industry and personal users of position location applications.

The GAGAN, a safety of life system, has been certified by DGCA to provide NPA (Non Precision Approach) services of RNP-0.1 over Indian FIR (Flight Information Region) and certified for PA service of APV-1.0/1.5 over Indian landmass.

Types of GPS Receivers:

GPS Receivers A wide variety of GPS receivers are commercially available today. Depending upon the type of application, accuracy requirements and cost factor, the user can select the type of GPS receiver which best suits his demands. The receivers available cover a wide range from the high-precision Rouge receivers developed by the Jet Propulsion Laboratories, (JPL), of the National Aeronautics and Space Administration (NASA), with built-in atomic clock, to the hand-held navigation receivers used by Army personnel, mountaineers, etc., which can give the position to few-metres accuracy. Even wrist-watches with built-in GPS receivers are now commercially available (e.g.: the Casio GPS watch).



Navigation Receivers: These receivers are normally **single-frequency, C/A code, hand-held light weight receivers**, which can yield the position with a few-metres to few tens of metres accuracy. Single channel receivers, which can track 4 or more satellites by either sequential or multiplexing technique, which were more common in this category, are now being replaced by two or five channel receivers. These receivers are very much portable, weighing only few hundred grams, and are fairly inexpensive, being in the few hundred U.S. dollars price range. Examples of such receivers are the Magellan 5000 GPS receiver marketed in India by ROLTA (India), the NAVSTAR GPS PC card that can be fitted in personnel computer, marketed in India By Micronics Ltd., the Casio portable GPS receiver in a watch, etc. The accuracies in positioning obtained by these type of receivers are in the range of few tens of metres in absolute positioning (in the absence of SA), and few tens of cm in relative positioning, over short baselines of few km

Surveying Receivers: The surveying type of receivers are single frequency, **multi-channel receivers**, which are useful for most surveying applications, including cadastral mapping applications, providing tertiary survey control, engineering surveys, etc. These are more expensive than the navigation type of receivers, and more versatile. The data from many of these receivers can be directly imported in to most commonly used GIS software packages / formats. Most of these receivers can also be used in DGPS mode. Examples of surveying receivers are the PRO-XR model of Trimble Navigation Ltd., the SR 100 model of Leica Ag., etc.

Geodetic Receivers: The Geodetic receivers are **multi-channel, dual-frequency receivers**, generally with the capability of receiving and decoding the P-code. They are heavier and more expensive than the navigation and surveying receivers, ranging from the Rouge receivers installed at the GPS tracking stations, to the portable geodetic survey control receivers. They are capable of giving accuracies of the order of few cm-level in absolute positioning with precise post-processed satellite orbit information and of few mm-level in relative positioning. Examples of such receivers are the 4000 SSE of Trimble Navigation Ltd., the WILD 200 of Leica, and ASHTECH Z-12 geodetic receivers, etc.



Engineering survey using Differential GPS:

Differential GPS (DGPS) is commonly used in engineering surveys where high precision and accuracy are crucial. Here's how DGPS is utilized in engineering surveys:

Base Station Setup: A known, fixed GPS receiver, acting as the base station, is set up at a precisely known location (usually established through traditional surveying methods). This base station continuously receives signals from GPS satellites and calculates its own position.

Rover Station Deployment: Another GPS receiver, the rover station, is used by the surveyor or engineer to collect data at various points of interest across the survey area.

Data Collection: The rover station continuously receives signals from satellites, but it also receives correction data from the base station. This correction data helps refine the rover's position, significantly improving accuracy compared to stand-alone GPS.

Real-Time Corrections: Real-time DGPS systems provide immediate correction signals from the base station to the rover station, allowing for on-the-fly adjustments and ensuring high accuracy during data collection.

Data Processing: Once data collection is complete, the collected data from the rover station can be post-processed using software that incorporates the correction data received from the base station. This further refines the accuracy of the surveyed points.

Applications: DGPS in engineering surveys is critical for applications such as construction site layout, road or infrastructure design, land development, precise mapping, and any project where precise positioning and measurement are essential.

The use of DGPS significantly improves the accuracy of survey measurements, often achieving centimeter-level precision. This accuracy is crucial in engineering projects where precise positioning and alignment are necessary for construction and design purposes.



SURVEYING WITH DRONE

Introduction:

- Surveying drones, also known as unmanned aerial vehicles (UAVs), are rapidly becoming a popular tool for surveying and mapping land.
- These drones are equipped with high-resolution cameras, laser scanners, and other sensors that can accurately measure and map large areas in a short amount of time.
- They provide a quick and cost-effective alternative to traditional surveying methods, making them an attractive option for a wide range of industries, including construction, agriculture, forestry, and mining.

Advantages of surveying with drone:

Reduce field time and survey costs

Capturing topographic data with a drone is up to five times faster than with land-based methods and requires less manpower. With PPK geo-tagging, you also save time, as placing numerous GCPs is no longer necessary. You ultimately deliver your survey results faster and at a lower cost.

Provide accurate and exhaustive data

Total stations only measure individual points. One drone flight produces thousands of measurements, which can be represented in different formats (orthomosaic, point cloud, DTM, DSM, contour lines, etc). Each pixel of the produced map or point of the 3D model contains 3D geo-data.

Map otherwise inaccessible areas

An aerial surveying drone can take off and fly almost anywhere. You are no longer limited by unreachable areas, unsafe steep slopes or harsh terrain unsuitable for traditional measuring tools. You do not need to close down highways or train tracks. In fact, you can capture data during operation without an organizational overhead.



Applications of Drone Surveying

The main applications of drone surveying are in:

1. Land surveying
2. Precise measurements
3. Land management and development
4. Volumetric measurements
5. Slope monitoring
6. Urban planning

Land surveying

Drone surveying generates high-resolution orthomosaic maps and 3D models of areas to create accurate cadastral maps. It provides information on a site with low-quality/outdated/no data available.

Precise measurements

The surveyors can perform highly-accurate distance and surface measurements using the high-resolution orthomosaic photos from drone surveying.

Land management and development

The aerial images obtained from drones simplify topographic surveys for land management and planning. It facilitates site scouting, allotment planning, design, and the final construction of roads, buildings, and utilities. In addition, the data is used for pre-construction engineering studies transferred to CAD or BIM software to work with 3D models.

Volumetric measurements

The images obtained from drone surveying can be used in 3D mapping software, from which volumetric measurements are obtained. The method is used primarily for calculating stocks in mines and quarries for inventory or monitoring purposes.



Slope Monitoring

The DTMs (Digital Surface Model) and DSMs (Digital Terrain Model) generated by drone imagery and GIS analysis enable the extraction of slope measurements. Moreover, in some site conditions, the orthomosaic maps are generated at different times to detect changes in the earth's movement and measurement of velocity. This method, hence, helps in slope monitoring for landslide mitigation and prevention, for example, predicting landslides, preventing potential damage to roads, railways, bridges, etc.

Urban Planning

Drone surveys help urban planners collect up-to-date data of a complex urban area quickly using less staff to study the existing social and environmental conditions of the sites. This makes the planning stage of the development of an urban area easier.

Features of photogrammetric mapping method:

Photogrammetric mapping is a technique used to create accurate maps, models, or measurements using aerial or terrestrial images. Here are some key features of photogrammetric mapping:

- **Aerial or Terrestrial Imagery:** Photogrammetry uses images captured from aerial platforms like airplanes, drones, or satellites, or from ground-based cameras. These images serve as the primary data source for creating maps or 3D models.
- **Image Acquisition:** High-resolution and overlapping images are captured systematically, ensuring coverage of the entire area of interest. Overlapping images from different angles are crucial for accurate reconstruction.
- **Triangulation:** By analyzing overlapping features in multiple images, photogrammetry uses principles of triangulation to determine the precise position of points on the Earth's surface. This process helps in accurately measuring distances, elevations, and angles.
- **Point Cloud Generation:** Photogrammetric mapping generates dense point clouds by identifying and matching common points in multiple images. These points represent the 3D coordinates of objects or terrain features.



- **Digital Elevation Models (DEMs) and Digital Surface Models (DSMs):** Through photogrammetry, elevation data is extracted to create DEMs, which represent the bare Earth's surface, and DSMs, which include all surface features like buildings and vegetation.
- **Orthophoto Generation:** Orthophotos are geometrically corrected aerial images that have been rectified to remove distortions caused by terrain relief, camera tilt, and perspective. They provide accurate measurements and are used as base maps for various applications.
- **Applications:** Photogrammetric mapping finds applications in cartography, urban planning, environmental monitoring, infrastructure development, forestry, archaeology, and disaster management. It aids in creating precise maps, analyzing land use, monitoring changes over time, and supporting decision-making processes.
- **Automation and Software Tools:** Advanced software and algorithms automate the process of feature extraction, point cloud generation, and model creation, making photogrammetry more efficient and accessible.
- **Accuracy and Resolution:** The accuracy and resolution of photogrammetric mapping depend on factors like the quality of imagery, camera specifications, ground control points, and the processing techniques used. High-quality imagery and precise ground control contribute to better accuracy.

Drone surveying requirements:

- **Drone Platform:** The Drones Platform is an architectural solution designed to manage drone fleets, providing services for the control and autonomous navigation of these devices.
- **Flight planning software:** Flight planning software keeps a pilot abreast of all relevant weather conditions as they change and develop with the hours. Knowing in advance what weather an aircraft is heading into, can help a pilot to make calculated decisions with regards to the aircraft's position and thus to conserve fuel.
- **Sensor DGPS Equipment :** The Differential Global Positioning System (DGPS) service transmits correction signals to GPS navigation equipment on board vessels. The DGPS service improves the accuracy of your GPS position and the quality of the signal.



- **Image processing software:** Image processing software is software that's designed to manipulate digital images. In particular, it captures the image if that hasn't already been done, it converts it to a digital form, and it performs a manipulation or manipulations on it.

Types of drones:

1. Multi-Rotor Drones
2. Fixed-Wing Drones
3. Single-Rotor Drones
4. Fixed-Wing Hybrid VTOL

Multi-Rotor Drones

Multi-rotor drones are the easiest and cheapest option for getting an 'eye in the sky.' They also offer greater control over position and framing, and hence they are perfect for aerial photography and surveillance. They are called multi-rotor because they have more than one motor, more commonly tricopters (3 rotors), quad copters (4 rotors), hexacopters (6 rotors) and octocopters (8 rotors), among others. By far, quad copters are the most popular multi-rotor drones.

Advantages:

- It provides better control of the aircraft during the flight.
- Due to its increased manoeuvrability, it can move up and down on the same vertical line, back to front, side to side and rotate in its own axis.
- It has the ability to fly much more closely to structures and buildings.
- The ability to take multiple payloads per flight increases its operational efficiency and reduces the time taken for inspections.



Disadvantages:

Multi-rotor drones have limited endurance and speed, making them unsuitable for large scale aerial mapping, long-endurance monitoring and long-distance inspection such as pipelines, roads and power lines.

They are fundamentally very inefficient and require a lot of energy just to fight gravity and keep them in the air.

With the current battery technology, they are limited to around 20-30 minutes when carrying a lightweight camera payload. However, heavy-lift multi-rotors are capable of carrying more weight, but in exchange for much shorter flight times.

Due to the need for fast and high-precision throttle changes to keep them stabilised, it isn't practical to use a gas engine to power multi-rotors, so they are restricted to electric motors. So until a new power source comes along, we can only expect very small gains in flight time

Fixed-Wing Drones

A fixed-wing drone has one rigid wing that is designed to look and work like an aeroplane, providing the lift rather than vertical lift rotors. Hence, this drone type only needs the energy to move forward and not to hold itself in the air. This makes them energy-efficient.

Advantages:

- Fixed-wing drones cover longer distances, map much larger areas, and loiter for long times monitoring their point of interest. The average flight time is a couple of hours. But with a greater energy density of fuel (gas engine powered), many fixed-wing UAVs (Unmanned aerial vehicles) can stay aloft for 16 hours or more.
- This drone type can fly at a high altitude, carry more weight and are more forgiving in the air than other drone types.

Disadvantages:

- Fixed-wing drones can be expensive.



- Training is usually required to fly fixed-wing drones. The first time you launch a fixed-wing drone, you need to be confident in your abilities to control through the flight and back to a soft landing.
- A fixed-wing drone is always moving forward, and they move a lot quicker than a multi-rotor, and hence you might not get a chance to put it into a hover. In most cases, a launcher is needed to get a fixed-wing drone into the air.
- With fixed-wing, the flight is just the beginning. The hundreds and thousands of captured images have to be processed and stitched together into one big tiled image.

Single-Rotor Drones:

Single-rotor drone types are strong and durable. They look similar to actual helicopters in structure and design. A single-rotor has just one rotor, which is like one big spinning wing, plus a tail rotor to control direction and stability.

Advantages:

- A single-rotor helicopter has the benefit of much greater efficiency over a multi-rotor, which increases if the drone is gas-powered for even longer endurance.
- A single-rotor helicopter allows for very long blades, which are more like a spinning wing than a propeller, giving great efficiency.
- If you need to hover with a heavy payload (e.g. an aerial LIDAR laser scanner) or have a mixture of hovering with long endurance or fast forward flight, then a single-rotor helicopter is really your best bet.
- They are built to be strong and durable.

Disadvantages:

- Single-rotor drone types are complex and expensive.
- They vibrate and aren't as stable or forgiving in the event of a bad landing.
- They also require a lot of maintenance and care due to their mechanical complexity.
- The long, heavy spinning blades of a single rotor can be dangerous.



Fixed-Wing Hybrid VTOL(Vertical Take off and Landing)

Hybrid VTOL drone types merge the benefits of fixed-wing and rotor-based designs. This drone type has rotors attached to the fixed wings, allowing it to hover and take off and land vertically. This new category of hybrids are only a few on the market, but as technology advances, this option can be much more popular in the coming years. One example of fixed-wing hybrid VTOL is Amazon's Prime Air delivery drone.

Advantages:

- The autopilot can do all the hard work of keeping the drone stable, leaving the human pilot the easier task of guiding it around the sky.
- Hybrid VTOL drones offer you the best of both worlds – fixed-wing & rotor-based designs.
- They are perfect at either hovering or forward flight.

Disadvantages:

- Only a handful of fixed-wing hybrid VTOLs are currently on the market
- The technology used in these drone types is still in the nascent stage.

Types of sensors:

Sensors come in various types, each designed to detect and measure specific physical properties or environmental conditions. Different types of sensors categorized based on their functionalities:

1. Temperature Sensors:

- Thermocouples: Measure temperature by detecting voltage changes between different metals.
- Thermistors: Use resistance changes in materials to determine temperature variations.
- Infrared Sensors: Detect infrared radiation emitted by objects to measure temperature without contact.

2. Pressure Sensors:

- Piezoelectric Sensors: Generate electrical charges in response to applied pressure.
- Strain Gauge Sensors: Measure changes in resistance caused by mechanical strain or pressure.



3. Humidity Sensors:

- Capacitive Sensors: Measure changes in electrical capacitance due to humidity variations.
- Resistive Sensors: Use changes in resistance of a material due to moisture to measure humidity levels.

4. Motion Sensors:

- Accelerometers: Detect acceleration or movement in various directions.
- Gyroscopes: Measure orientation or angular velocity.
- Magnetometers: Detect changes in magnetic fields to determine orientation or direction.

5. Light Sensors:

- Photodiodes and Phototransistors: Convert light into electrical current for detecting brightness.
- Photoresistors (LDR): Measure light intensity by changing resistance in response to light.

6. Proximity Sensors:

- Inductive Proximity Sensors: Detect metallic objects without physical contact.
- Ultrasonic Sensors: Use sound waves to detect the proximity of objects.
- Capacitive Proximity Sensors: Identify non-metallic objects based on changes in capacitance.

7. Gas Sensors:

- Electrochemical Gas Sensors: Measure gases by chemical reactions generating electrical currents.
- Metal Oxide Gas Sensors: Detect gases by changes in resistance when exposed to gases.

8. Biometric Sensors:

- Fingerprint Sensors: Capture and analyze fingerprint patterns.
- Heart Rate Monitors: Measure heart rate using optical sensors or ECG sensors.
- Retina Scanners/Iris Scanners: Identify individuals based on unique eye patterns.

9. Sound Sensors:

- Microphones: Convert sound waves into electrical signals.
- Piezoelectric Sensors: Convert mechanical stress caused by sound waves into electrical signals.

10. Chemical Sensors:

- pH Sensors: Measure acidity or alkalinity of a liquid.
- Ion-Selective Electrodes: Detect specific ions in solutions.



Process of drone surveying:

The key components of drone hardware include:

GPS SYSTEM

The GPS system is an essential component of a drone survey. It allows the drone to determine its location and altitude accurately. This information is essential for creating accurate maps and 3D models. The GPS system also enables the drone to navigate to specific locations, follow a pre-planned flight path, and return to its starting point safely.

CAMERA AND SENSORS

The camera and sensors on the drone capture the data needed for the survey. High-resolution cameras are used to capture images and videos, while sensors such as LiDAR and infrared sensors are used to capture other types of data. The camera and sensors on the drone can be customized according to the specific requirements of the survey.

BATTERIES AND CHARGING SYSTEMS

Drones require batteries to fly, and a drone survey may require multiple flights. Therefore, having spare batteries and a charging system is essential to ensure that the drone can complete the survey. The battery life of the drone is an important consideration when planning the flight path, as it affects the duration of the flight and the area that can be covered.

DRONE SOFTWARE

Drone software is a critical component of drone technology that enables unmanned aerial vehicles (UAVs) to conduct surveys and gather aerial data. The software includes the programs and applications that run on the drone's onboard computer or a ground-based computer. Drone software plays an important role in flight planning, data processing, and reporting and visualisation.

FLIGHT PLANNING

Flight planning software is used to plan the flight path of the drone. The software takes into account the project requirements, site and environmental factors, and regulatory requirements. It also ensures



that the drone flies safely and captures the required data. Flight planning software can also be used to adjust the flight path in real-time, in case of unexpected changes in the environment or other factors.

DATA PROCESSING

Data processing software is used to process the data captured by the drone. This includes creating maps, 3D models, and other survey outputs. The software may also include tools for analysing and interpreting the data. Data processing software can be customised according to the specific requirements of the survey.

REPORTING AND VISUALIZATION

Reporting and visualisation software is used to create reports and visualisations based on the data captured by the drone. The software may include tools for creating maps, charts, and other visualisations. This software can be used to create reports that provide insights into the data captured, allowing stakeholders to make informed decisions

Post-processing of images in photogrammetry software:

Post-processing of images in photogrammetry software involves several steps to convert raw images into accurate maps or 3D models.

- 1. Import and Organize Images:** Upload all captured images into the photogrammetry software and organize them for processing.
- 2. Image Alignment and Matching:** The software identifies common features in overlapping images to align them accurately. This step involves matching points between images to create tie points or control points.
- 3. Bundle Adjustment:** Adjust the camera positions and orientations in 3D space to minimize errors. Bundle adjustment refines the camera parameters and corrects for distortions, improving the accuracy of the model.
- 4. Point Cloud Generation:** Using the aligned images, the software generates a point cloud—a collection of 3D points representing the surface of objects or terrain. These points have X, Y, and Z coordinates in space.



5. Mesh Generation: The point cloud is used to create a mesh—a connected network of triangles that approximates the surfaces of objects or terrain. This mesh forms the basis for creating a detailed 3D model.

6. Texture Mapping: Project the images onto the 3D model to apply textures and colors accurately, creating a realistic representation of the surfaces captured in the images.

7. Orthomosaic and DSM/DEM Generation:

- **Orthomosaic:** Stitch together individual images to create an orthomosaic—a geometrically corrected and accurately scaled aerial image. This mosaic represents a detailed and accurate map of the survey area.
- **Digital Surface Model (DSM) and Digital Elevation Model (DEM):** Extract elevation data from the point cloud to generate DSMs (including buildings and vegetation) and DEMs (representing bare terrain).

8. Quality Check and Editing: Review the generated models, point clouds, meshes, and maps for any errors or inconsistencies. Editing tools within the software allow for adjustments and cleanup if needed.

9. Exporting Outputs: Once satisfied with the results, export the finalized maps, models, or point clouds in various file formats suitable for further analysis or visualization in other software or applications.

The output maps and models obtained from photogrammetry software provide detailed and accurate representations of surveyed areas, supporting a wide range of applications in industries like urban planning, agriculture, environmental monitoring, construction, and archaeology. These outputs serve as valuable tools for analysis, decision-making, and visualization.

Application and uses of Remote sensing in Engineering survey:

1. Structural Health Monitoring

Structural health monitoring involves assessing the condition of buildings, bridges, and other structures to detect any damage or deterioration. Remote sensing can be used to monitor these structures in real-time by using sensors and cameras that capture data on the deformation, vibration, and temperature of the structure.

2. Mapping and Surveying

One of the primary applications of remote sensing in civil engineering is mapping and surveying. Remote sensing technology can be used to create highly accurate maps of the land, which can be



used for a variety of purposes such as land-use planning, resource management, and urban development.

3. Detection and Monitoring of Landslides and Earthquakes

Remote sensing can provide detailed information about the terrain, soil conditions, and other factors that can affect the stability of a structure. This data can then be used to create models that predict the likelihood of a landslide or earthquake occurring in a particular area.

4. Monitoring Coastal Erosion and Changes in Shorelines

With remote sensing, engineers can easily monitor changes in shorelines caused by natural processes such as waves, tides, and storms. By analyzing data collected through satellite imagery or aerial surveys, they can identify areas that are most vulnerable to erosion and plan accordingly to protect them.

5. Flood Mapping and Management

Flood mapping is done through the use of satellite images and other remote-sensing techniques. These methods are used to identify areas that are vulnerable to flooding and help plan for evacuation routes, emergency response, and mitigation measures.

6. Land Use and Land Cover Classification

Land use planning is concerned with land-use policies, including land development and planning, conservation, and reclamation of natural land. It involves the collection, evaluation, and utilization of information about land use in a particular area.

7. Monitoring Water Quality and Availability

Remote sensing can be applied to water resources management to estimate rainfall and snowfall amounts, river flows, flood prediction, and management of groundwater resources.



This technology allows civil engineers to assess, understand, and predict water resources to mitigate risks and to prevent future crises.

8. Analysis of Terrain Characteristics and Features

Remote sensing can be used to analyze terrain characteristics and features. This involves using data on elevation, slope, and other factors to understand the terrain and its features, which can help in planning and designing infrastructure projects.

9. Urban Planning and Development

Urban planning is an important aspect of the city infrastructure. Urban design involves the planning and design of roads, bridges, parking lots, and other facilities that are required for the safety and convenience of the residents and visitors.

10. Traffic Management and Analysis

One of the core areas of remote sensing in civil engineering is traffic management and analysis. Remote sensing technologies like LiDAR, radar, and cameras can provide valuable data on traffic patterns, volume, speed, and congestion levels. This information can help transportation planners make informed decisions about road design and optimization.

11. Forest Cover and Deforestation Monitoring

Remote sensing can be used for monitoring forest cover and deforestation. This involves using satellite imagery and other data to monitor changes in forest cover, which can help in developing strategies for forest management and conservation.

12. Monitoring and Mapping of Natural Resources

Monitoring and mapping of natural resources is an essential aspect of remote sensing in civil engineering. With the help of advanced technologies such as satellite imagery, LiDAR, and geospatial tools, it has become possible to monitor and map various natural resources such as water bodies, forests,



agricultural lands, and mineral deposits. Remote sensing allows engineers to collect data on the earth's surface from a distance without disturbing the natural environment.

Application and uses of GIS in Engineering survey:

GIS (Geographic Information System) plays a significant role in engineering surveys, offering numerous applications and benefits:

- 1. Site Selection and Analysis:** GIS helps in selecting optimal sites for engineering projects by analyzing various factors like topography, land use, environmental conditions, and accessibility. It aids in identifying suitable locations for infrastructure development or construction projects.
- 2. Survey Planning and Data Collection:** GIS assists in planning survey activities by determining the most efficient routes, establishing control points, and managing field data collection. It helps in organizing and managing survey data efficiently.
- 3. Spatial Analysis and Visualization:** GIS performs spatial analysis to assess relationships between different features or layers of data. Engineers can analyze terrain, slopes, elevation, and other spatial data to inform design decisions or assess the impact of proposed projects.
- 4. Utility and Infrastructure Management:** GIS is crucial for managing utility networks (like water, gas, electricity) and transportation infrastructure. Engineers use GIS to map, analyze, and maintain these networks, facilitating efficient management and maintenance.
- 5. Environmental Impact Assessment:** In engineering projects, understanding environmental impacts is crucial. GIS aids in assessing potential environmental impacts by overlaying project plans with sensitive environmental areas, helping in mitigation planning and compliance with regulations.
- 6. Geotechnical Engineering:** GIS helps geotechnical engineers by integrating soil data, geological information, and other spatial data to assess ground conditions, analyze risks, and plan foundations for construction projects.



7. Flood Risk Analysis and Management: Engineers use GIS to model floodplains, analyze flood risks, and plan mitigation measures. It helps in understanding potential flood areas, designing drainage systems, and assessing flood impacts on infrastructure.

8. Asset Management and Maintenance: GIS enables engineers to track and manage assets, such as bridges, roads, or pipelines, by providing spatial data on their condition, maintenance history, and future needs.

9. 3D Modeling and Visualization: GIS platforms often support 3D modeling and visualization, allowing engineers to create detailed 3D representations of projects, enhancing communication, and aiding in design and planning phases.

10. Construction Management and Monitoring: During construction, GIS helps in managing resources, monitoring progress, tracking equipment, and ensuring adherence to project specifications.

REVIEW QUESTIONS

1. List and explain GPS systems
2. Differentiate between absolute and differential positioning GPS system
3. Briefly explain about GAGAN system of India
4. List and explain types of GPS Receivers
5. Explain the features of photogrammetric mapping methods.
6. Explain different types of drones and Sensors.
7. Explain step by step process of drone survey
8. List the application and uses of remote sensing used in Engineering survey
9. List the application and uses GIS used in Engineering survey