Drone Based Survey, GPS & Open-Source GIS

Workshop: Drone (UAV) Techniques for Water Resources mapping and Modeling

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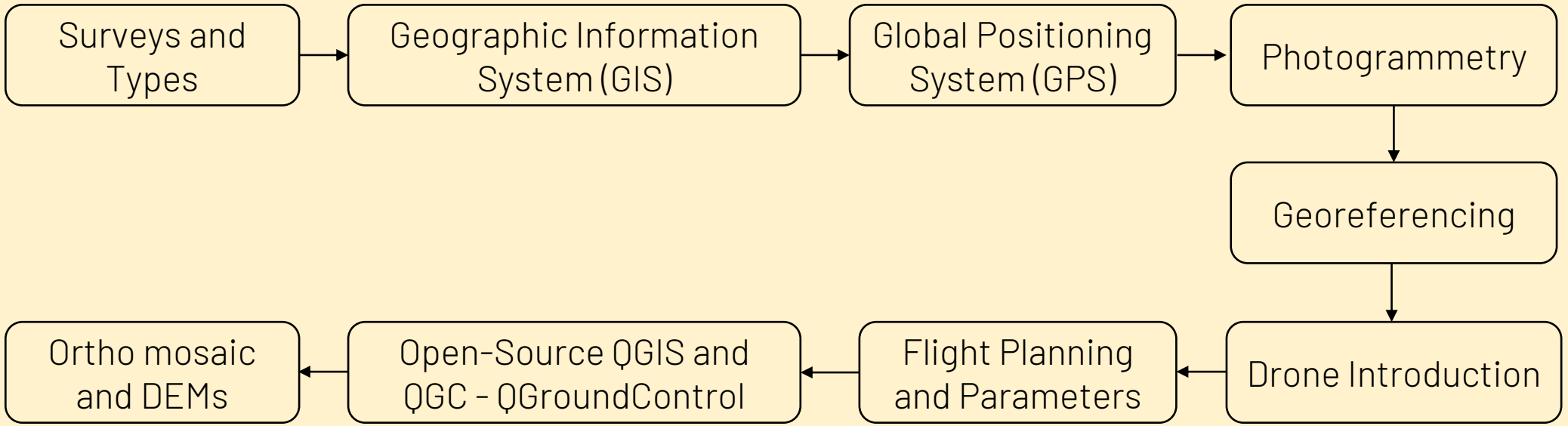
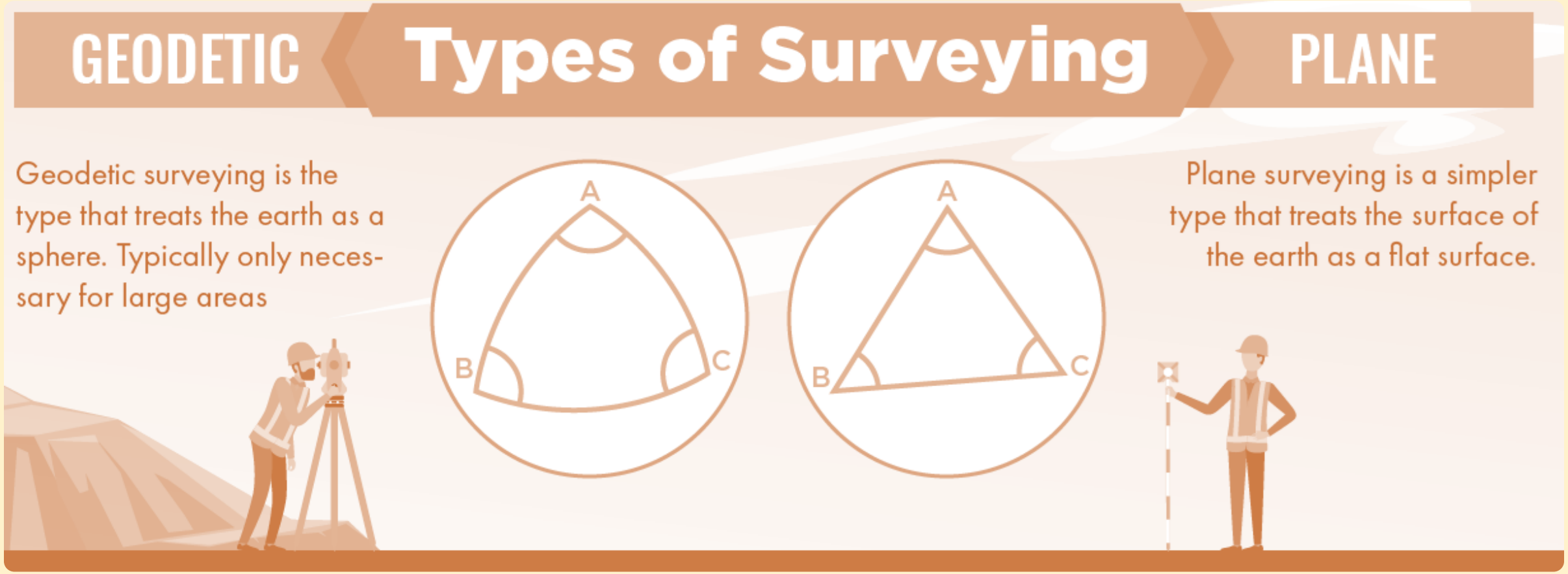
Outline of this session



Introduction of Surveying



Images Source: engineersupply.com

Methods of Surveying

ASTRONOMICAL
Involves mapping sections of the sky

BOUNDARY
Boundaries of sections of land

CLASSIFICATION BASED ON METHOD/ NATURE OF THE SURVEY

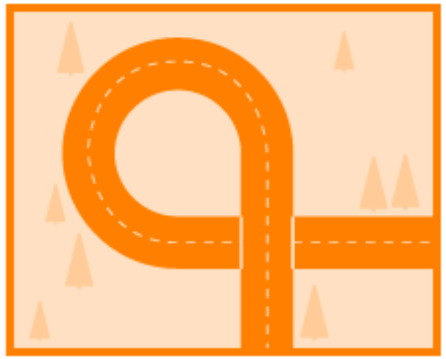
CONSTRUCTION
Used for construction or engineering projects

CONTROL
Used to find the correct positioning of an arbitrary point

HYDROGRAPHIC
Surveying used for bodies of water to aid navigation etc.

MINING
Surface and underground surveying used for mining operations

PHOTOGRAMMETRIC
Utilizes aerial photography



ROUTE
Used for constructing transportation routes

TOPOGRAPHIC
Measures the position and configuration of terrains

Images Source: engineersupply.com

Geographic Information System (GIS)

A geographic information system (GIS) is a computer system for capturing, storing, checking, and displaying data related to **positions on Earth's surface**.

- GIS helps us to **explore spatial patterns** and **relationships in data**.
- GIS can use any information that includes location.
- GIS can show how different factors, such as pollution, population, and land use, affect the environment.

The invention of a GIS is Eratosthenes of Cyrene.

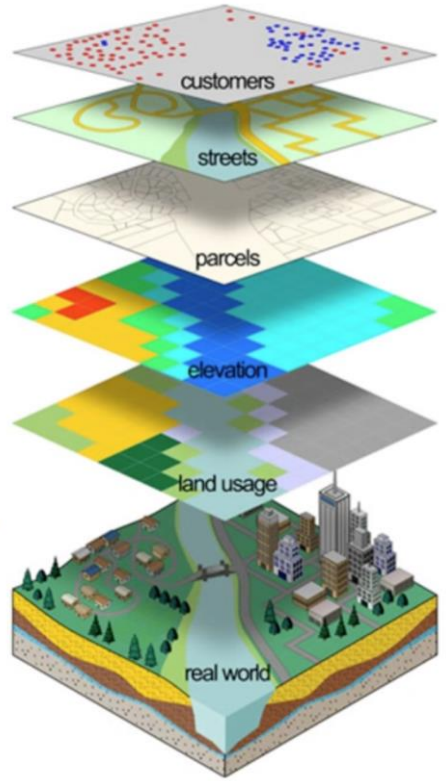


Image Source: https://www.geo.university/

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Examples of GIS applications are:

- Mapping and monitoring natural resources, such as forests, water, and wildlife.
- Managing and optimizing infrastructure, such as roads, bridges, power lines, and water pipes.
- Analyzing and visualizing spatial data, such as demographics, crime, health, and climate.
- Creating and sharing interactive maps and dashboards, such as web maps, story maps, and dashboards.

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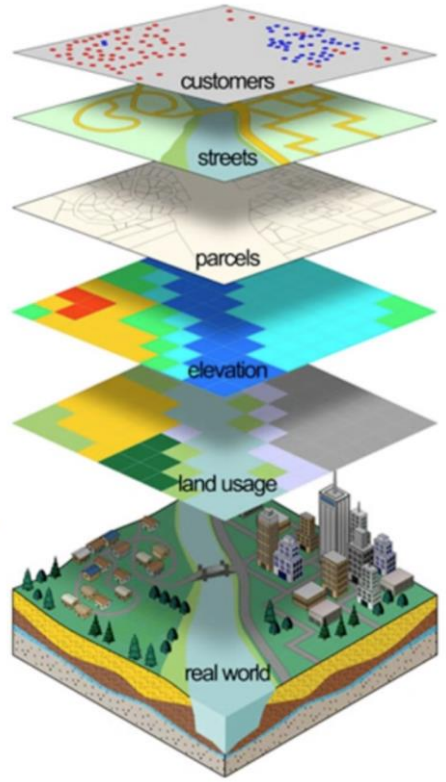

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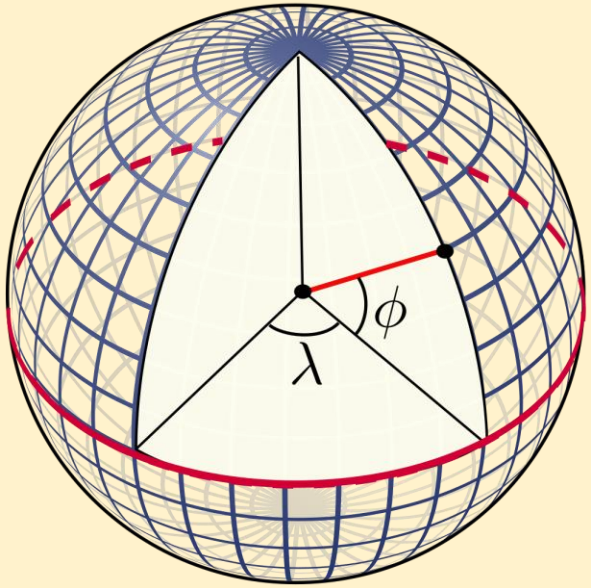
How to show anything on the surface of earth

The latitude ϕ and longitude λ are angle measurements for a spherical model of the Earth.



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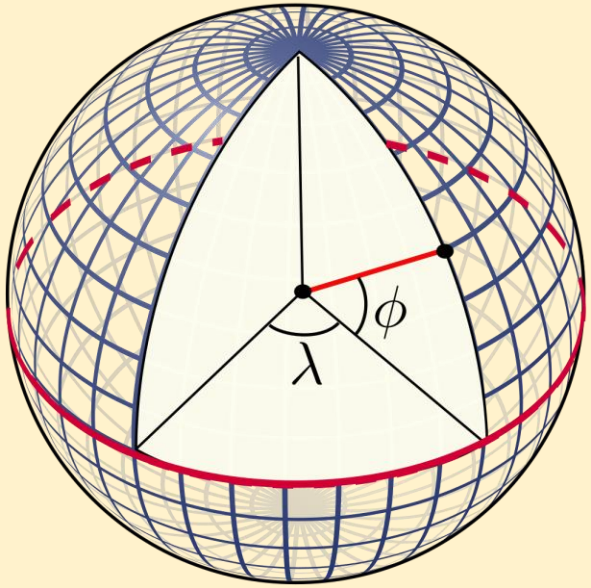
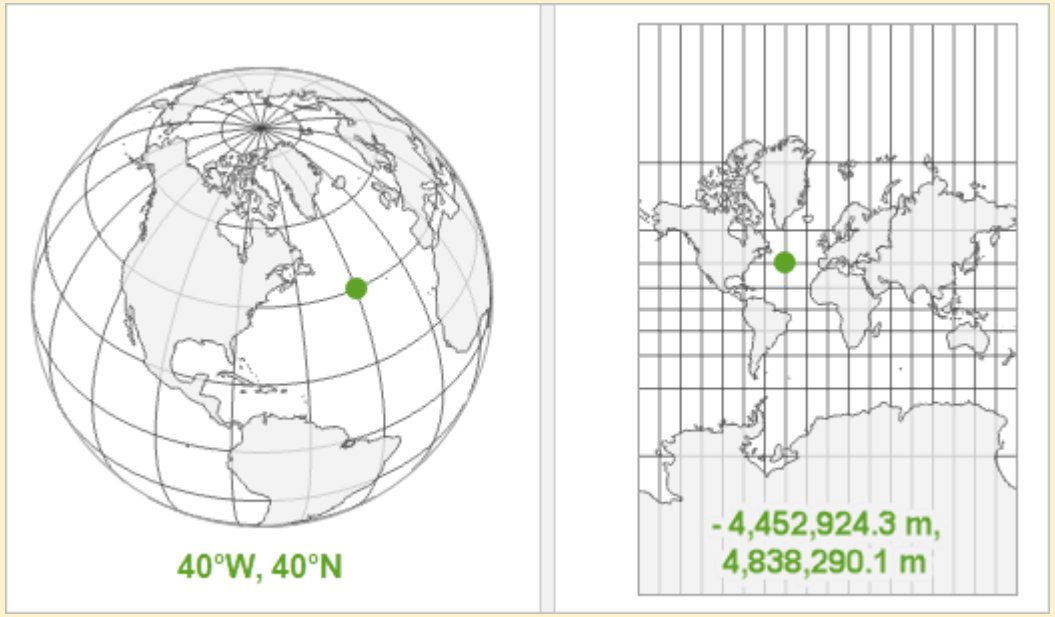


A geographic coordinate system (left) measured in angular units is compared to a projected coordinate system (right) measured in linear units (meters) for the same location in the Atlantic Ocean.



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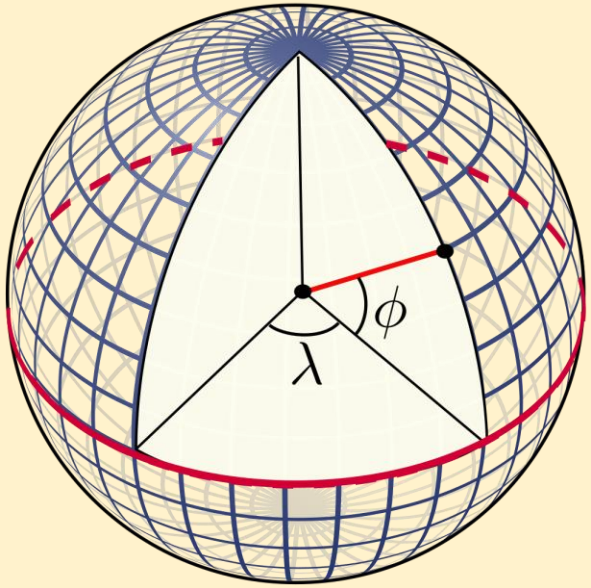
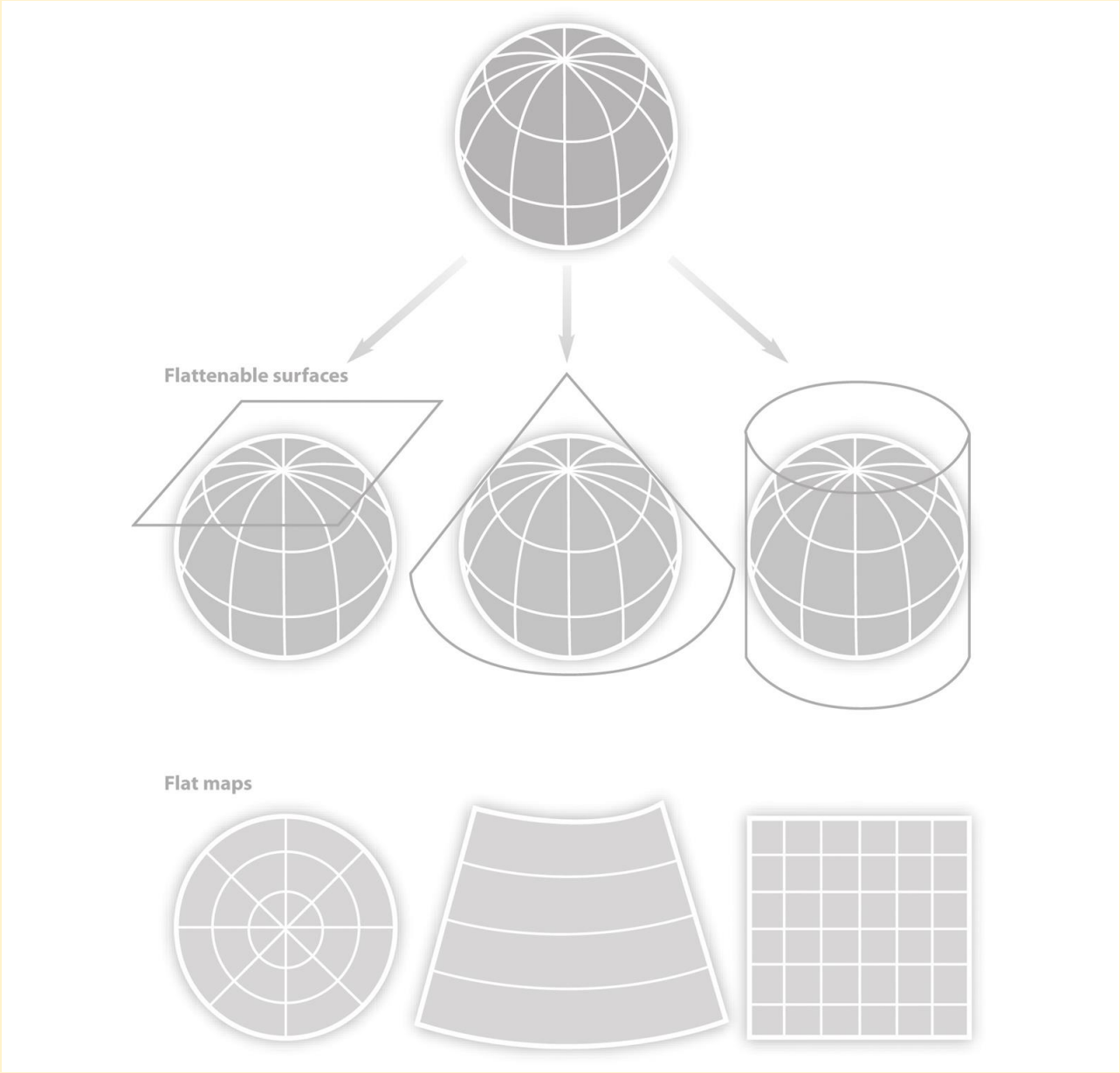




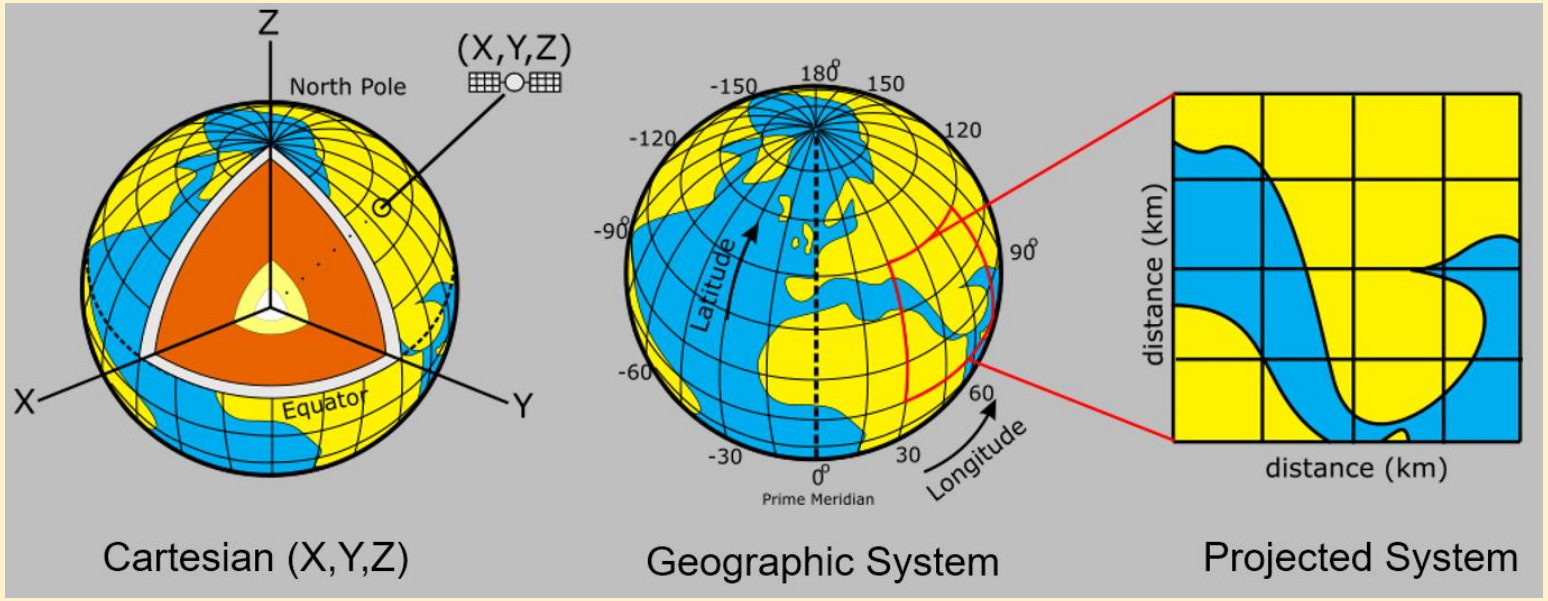
What is Global Positioning System (GPS)

A global positioning system (GPS) is a network of satellites and receiving devices used to determine the location of something on Earth.

GPS can pinpoint a three-dimensional position to meter-level accuracy and time to the 10-nanosecond level, worldwide and 24/7.

GPS is a three-part system: Satellites, Ground stations, and Receivers.

The ground stations monitor and control the satellites, and they help determine their locations.

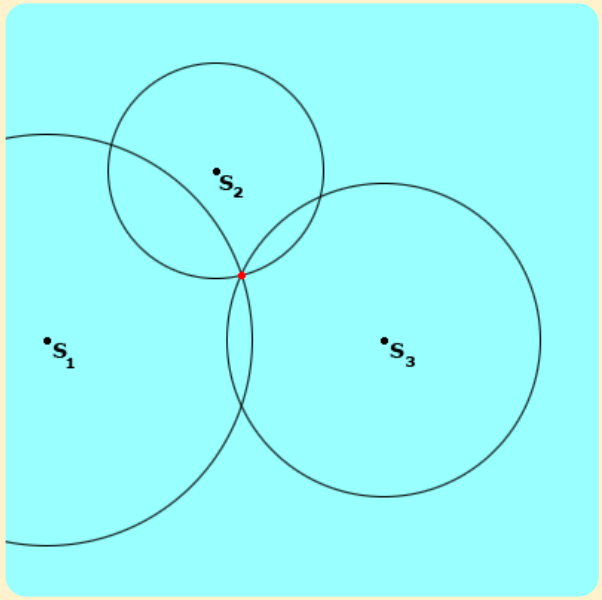


How actual location is determined

The process of using three (or more) spheres to locate a point is called Trilateration.

The picture above shows three circles of varying distances, centered around satellites (S1, S2, and S3).

The point where the three circles (or spheres, as is the case with GPS) meet is the location of the GPS receiver.



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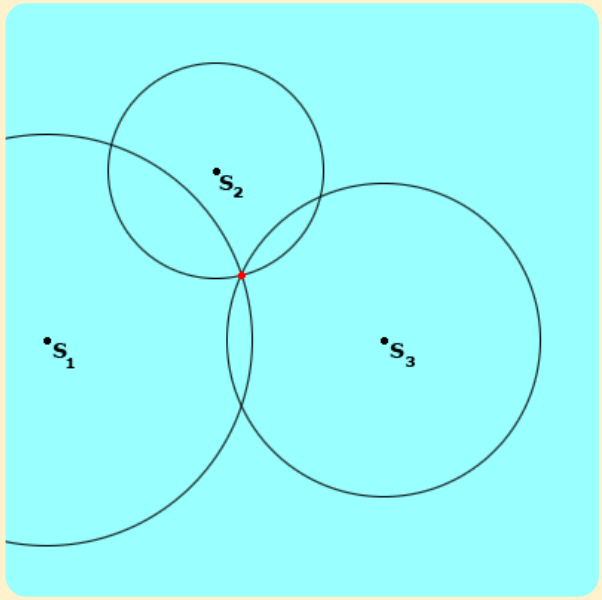

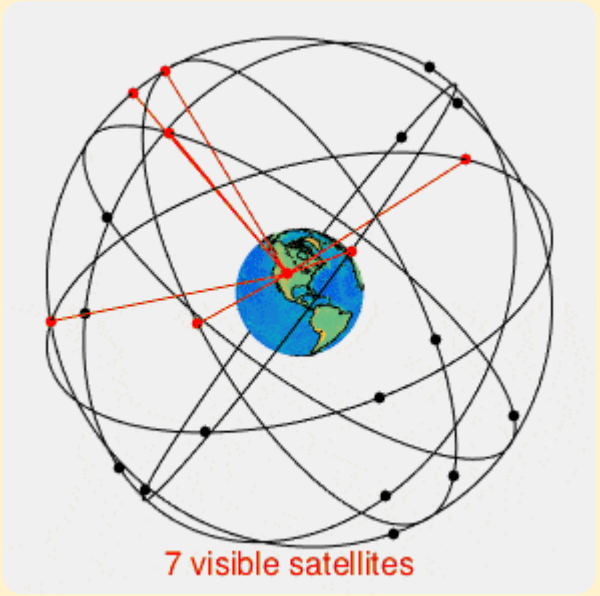

- GPS: the US System
- ~32 satellites
- 20,200 km altitude
- 12-hour orbital period
- Need 4 satellites to be accurate

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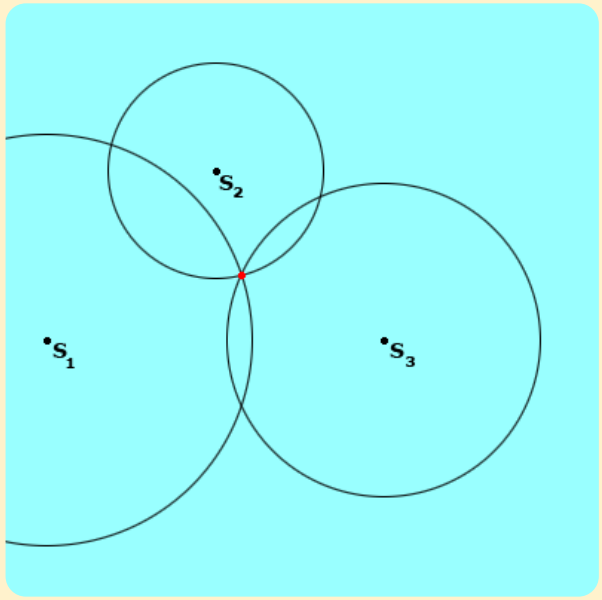

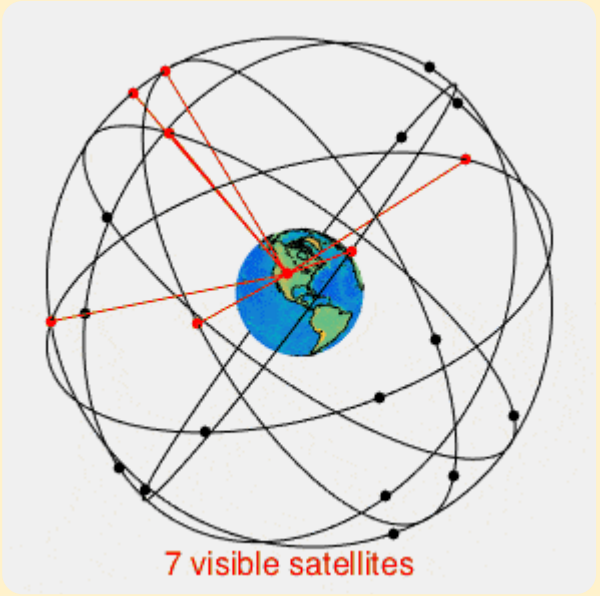

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Most GPS data is recorded and reported using: Geographic Coordinates (World Geodetic System 1984)

India's homegrown navigation system, NAVIC (Navigation with Indian Constellation), is now in the same league as the US, Russia and China after being approved by the International Maritime Organization (IMO).

Image Source: https://talks.navixy.com

Image Source: Paulsava /Wikipedia.org

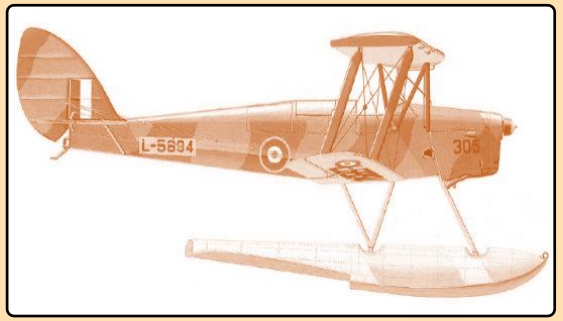
Drone - an Introduction

How the term 'Drone' came?

The term 'Drone' coined from this similarity of flying drone with flying bees sound.

In 1935, British produced a number of radio-controlled aircraft and It's thought that the term 'drone' started to be used at this time, inspired by the name of one of these models, the **DH.82B Queen Bee**.

DH.82 Queen Bee
(mother of drones)



Sourse: Myin Uddin (Shenyang Aerospace University)

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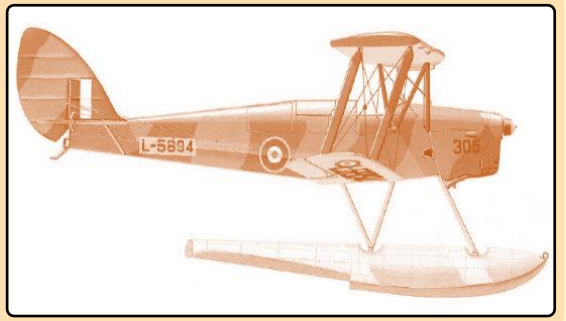


What is considered as Drone?

1. According to most of the dictionaries *"A Drone is an unmanned aircraft or ship guided by remote control or onboard computers."*

2. "Unmanned aerial vehicles (UAVs) or Drones are aircraft with no on-board crew or passengers. They can be automated 'drones' or remotely piloted vehicles (RPVs)."

Sourse: Myin Uddin (Shenyang Aerospace University)

Basic characteristics of Drone:

- A drone is an unmanned Aircraft, **a flying Robot** and known as UAV or RPV (Remotely Piloted Vehicles).
- Drone can be completely **Autonomous** with the help of onboard software.
- Drones can be **remotely controlled (RC)** by Bi-directional radio wave.
- Most Drones works in conjunction with **onboard sensors and GPS**.
- Drone can have fixed wing, rotary wing or hybrid designs.
- Drones can have fuel engines (Gas, turbine, wankle) and Battery as power supply.
- Drones can be **as big as 61m wing span** and can be **as small as less than 1mm**.
- Military drones can carry up to **3000kg** payloads and fly as high as **18000 m**.

The Beginning History

1839: Austrian soldiers attacked the city of Venice with **unmanned balloons filled with explosives**.

1896: First use of UAV using camera for surveillance.

1907: The world's first quadcopter was created by inventor brothers Jacques and Louis Bréguet.

1917: The Ruston Proctor Aerial Target became the first pilotless winged aircraft in history. It was a radio- controlled pilotless airplane, based on RC technology from the inventor Nikola Tesla.

1943: Created for use by the German military during World War II, "Fritz X" was the nickname given to the FX-1400, the first remote-controlled weapon that was put into operational use.

1960: Boom in RC planes popularity in the U.S. Mostly coming in kit form, these RC planes offered everything from indoor-flyable models to much larger outdoor models.

1982: Modern drone warfare began in 1982, when **Israel coordinated the use of battlefield UAVs** alongside manned aircraft to wipe out the Syrian fleet with very minimal losses.

1993: Monitoring of climate and environment using drone begins.

2001: In the aftermath of 9/11, the CIA began flying armed drones over Afghanistan as part of the war against the Taliban. The first CIA drone-based kill operation took place in February 2002.

2006: Recognizing the potential of non-military, non-consumer drone applications, the FAA issued the first commercial drone permits.

2010: The French company Parrot released their Parrot AR Drone, the first ready-to-fly drone which can be controlled entirely via Wi-Fi, using a smartphone.

2013: In December 2013, Amazon released a concept video showcasing founder Jeff Bezos' dream for a drone-based delivery system.

2016: DJI's Phantom 4 introduced smart computer vision and machine learning technology in drone.

2016: The first passenger drone was introduced at the Consumer Electronics Show (CES) 2016

Classification Of Drone

Drones can be categorized by their size, weight, range, speed, endurance, production cost, propulsion etc.

The conventional classification of drone doesn't show all those diversities available in UAV industry.

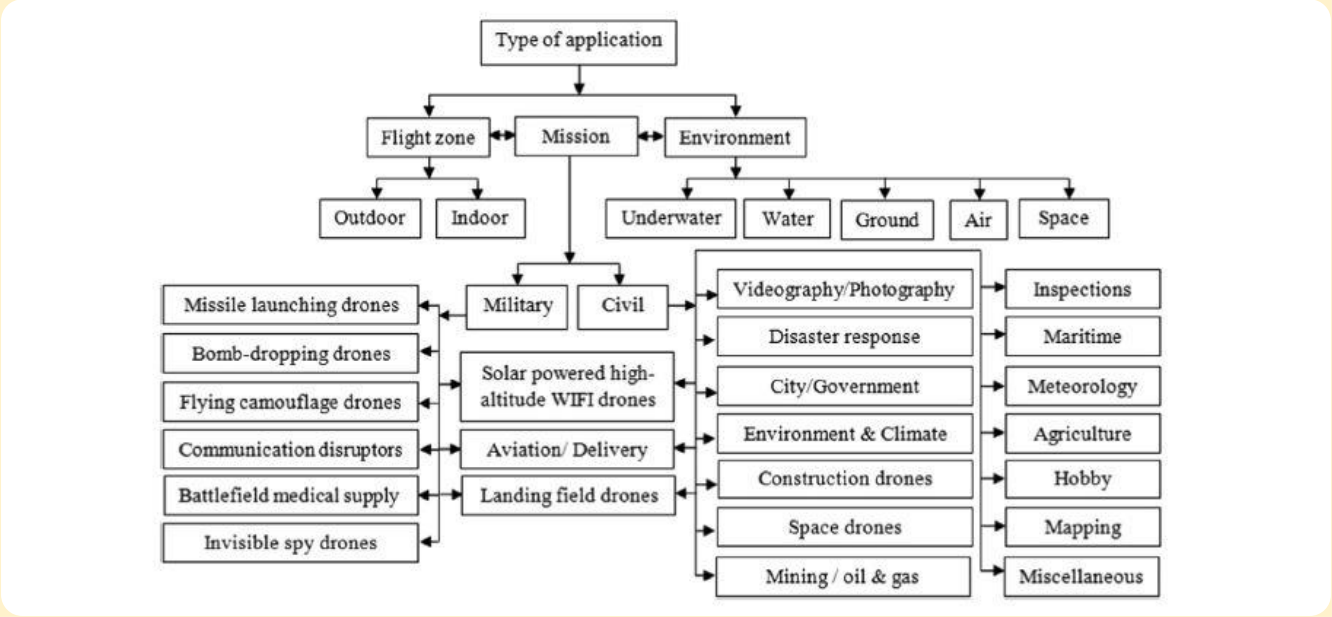
Here drones can be of four types depending on their rotor or wing:

1. Multi-rotor drones
2. Fixed wing drones
3. Single wing Helicopters
4. Fixed wing Hybrid VTOL

Applications Of Drone

Ever imagined *a military weapon will become a toy for kids*, a tool for photographers or an extreme vehicle for racers?

- Initially known for their military use, drones are now being used by individuals to large companies to accomplish several tasks. Today, the application areas of drones are limitless.
- The technology that was once designed to destroy is now being used for the betterment of mankind. Drones have become an eye in the sky to give us the top-down majority view.
- With drones being allowed for commercial use, an entire industry has emerged. That's why most developed and developing countries are working to integrate drones into their national airspace.

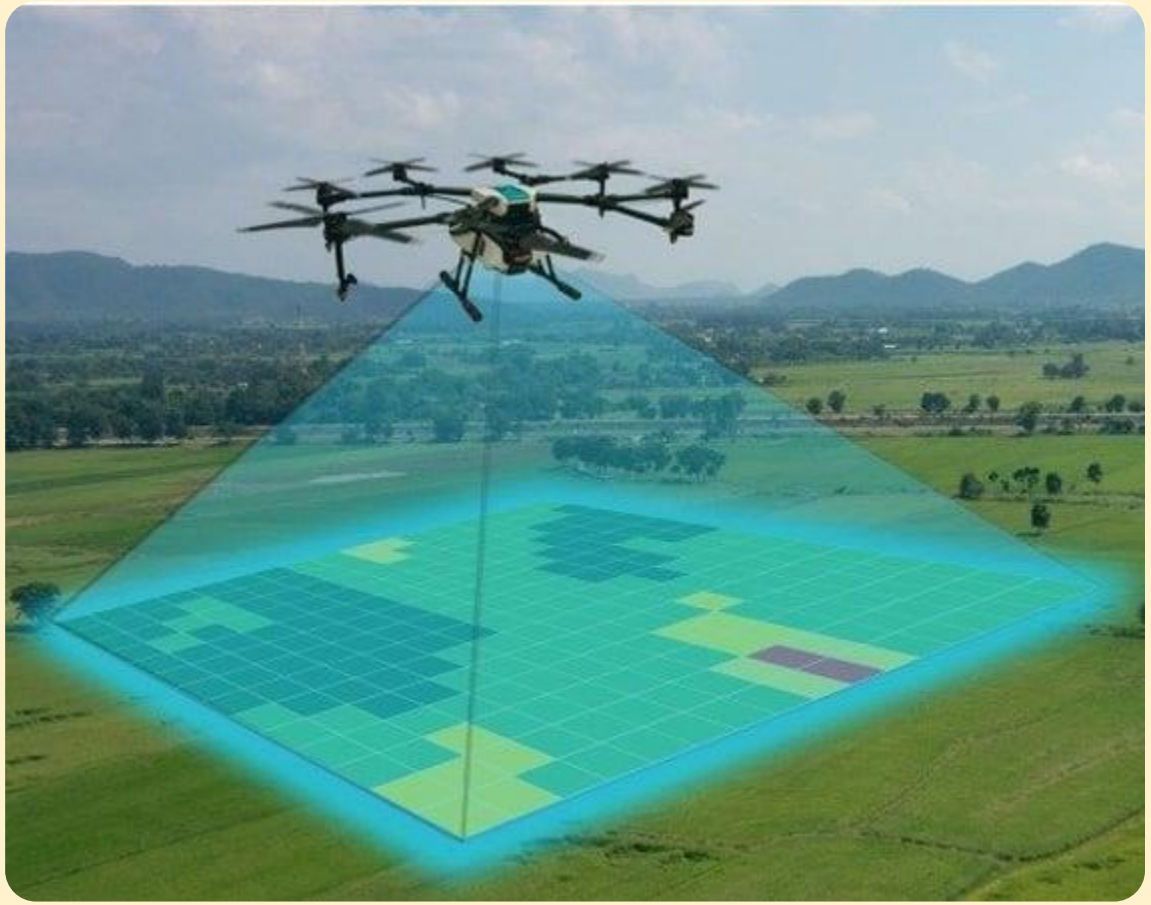


Drone based Survey

Drones can get closer to the subject than satellites and other aerial vehicles.

Images captured with drones are in high resolution and allow for a more accurate survey than satellite surveys.

Drone surveying allows for capturing images from angles that are not possible to take from the ground and can cover large areas quickly



Applications Of Drone/Unmanned aerial vehicle (UAV) Surveying

- Forest resources management and monitoring (removal of litter).
- Agricultural land management (determination of crop growth), crop yield, etc.
- Fish capture- The UAVs enables live stream vision of the catch at sea.
- Drones can monitor roads for potholes.
- Structural monitoring
- GIS – Drones can be used to generate maps for use in geographical information systems (GIS)
- Flood control and flooding mapping
- Hazardous waste considerations, Oil and gas pipeline monitoring, Plant health and crop growth, etc.

UAV for survey

VAJRA - Mapping Drone (AERO360's)

Vajra

Aero360's VAJRA is a quadcopter and is built of carbon fiber, which makes it lightweight, tough, solid, and equipped with powerful landing gears.

- Drone Category: Small Class UAV
- Propulsion: Electric
- Battery: Lithium-Ion
- Max. Flight Distance: 2 kms
- Diagonal Dimension/Wheelbase: 690 mm
- Max Take-off Weight: 3 kg
- Flight Time Upto: 35 minutes

STRUCTURE

70% of the drone body structure is made out of carbon fiber

Battery strap holder
Landing gear bush
Arm caps
Canopy

} 3D Printed Parts

Global Positioning System (GPS)

Operating Temperature: -40℃ to 85℃

Communication Protocol: CAN (Controller Area Network)

Processor: STM32F302

IMU sensor: ICM20948

Positioning accuracy: 3D FIX: 2.5 m

Weight: 48.8g

Photogrammetry payload specifications

Effective Pixels: 24.2 MP

Sensor Type: CMOS

Weight: 512 g

Image Format: JPEG

Image Sensor Size: 23.5 x 15.6 mm

Shutter Speed: 1/4000 - 30 sec

Battery Type: Lithium Battery

T12 Transmitter / Remote Controller

Flight modes

- Loiter
- Alt Hold
- RTL
- Auto

Features:

Frequency: 2.400-2.4833GHz

Working voltage: 3.7V(1s Li-ion)

Working Current: 130mA

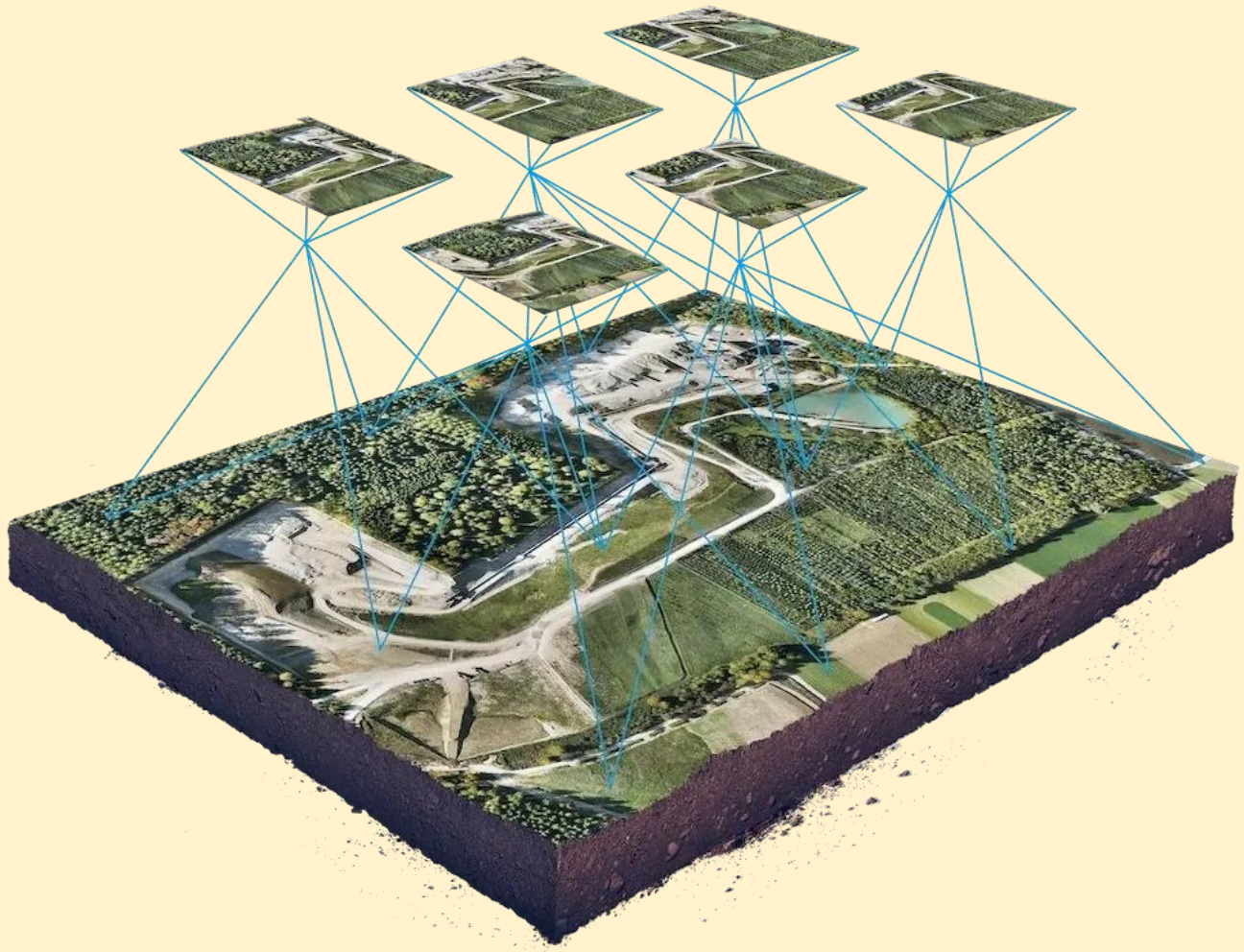
Duration: 25 hours

Range: 2Km

Weight: 560g

What is Photogrammetry

Photogrammetry is the technology of obtaining reliable information from photographs.



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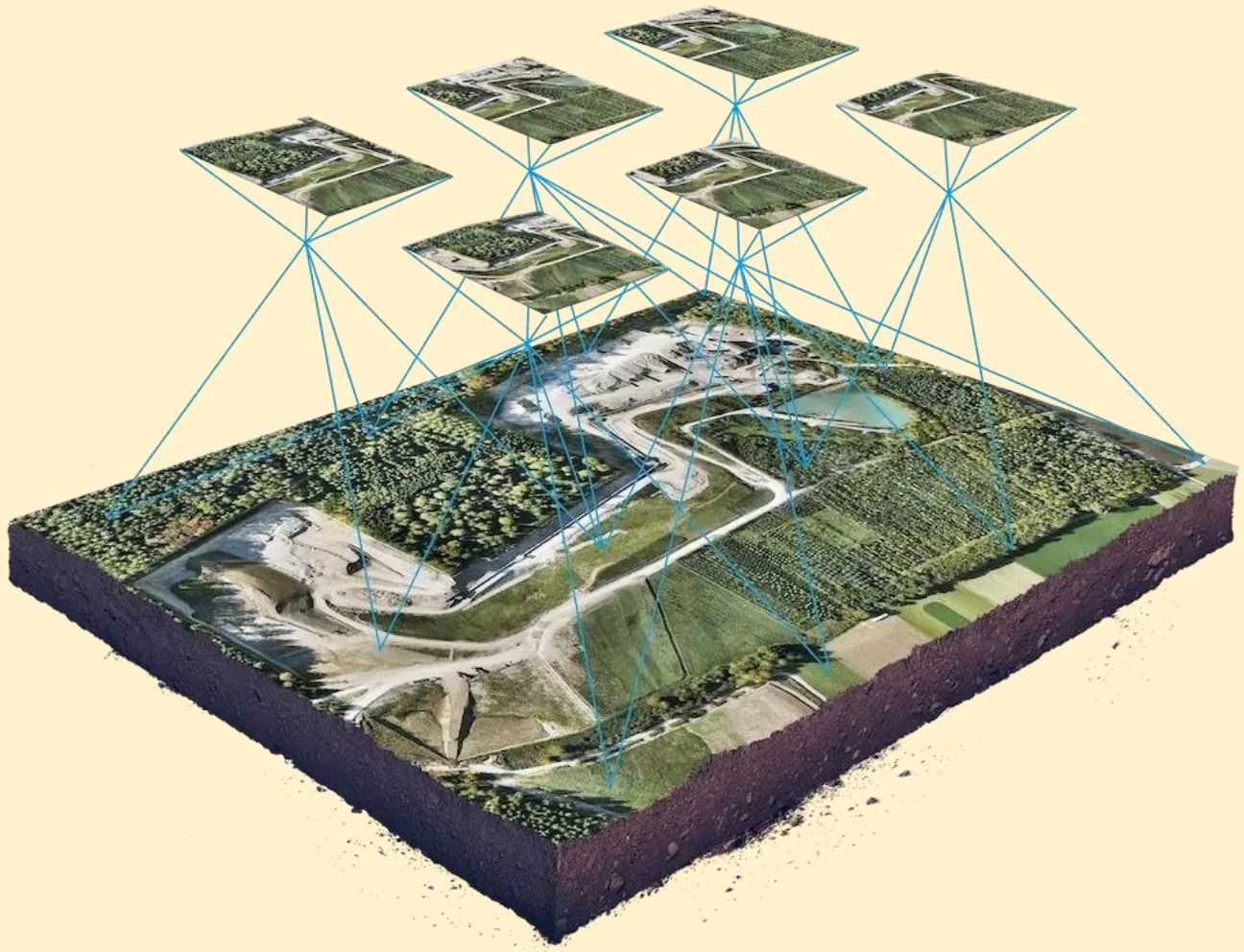
Combine several vertical photographs in the block of photography to create a **photomosaic**.



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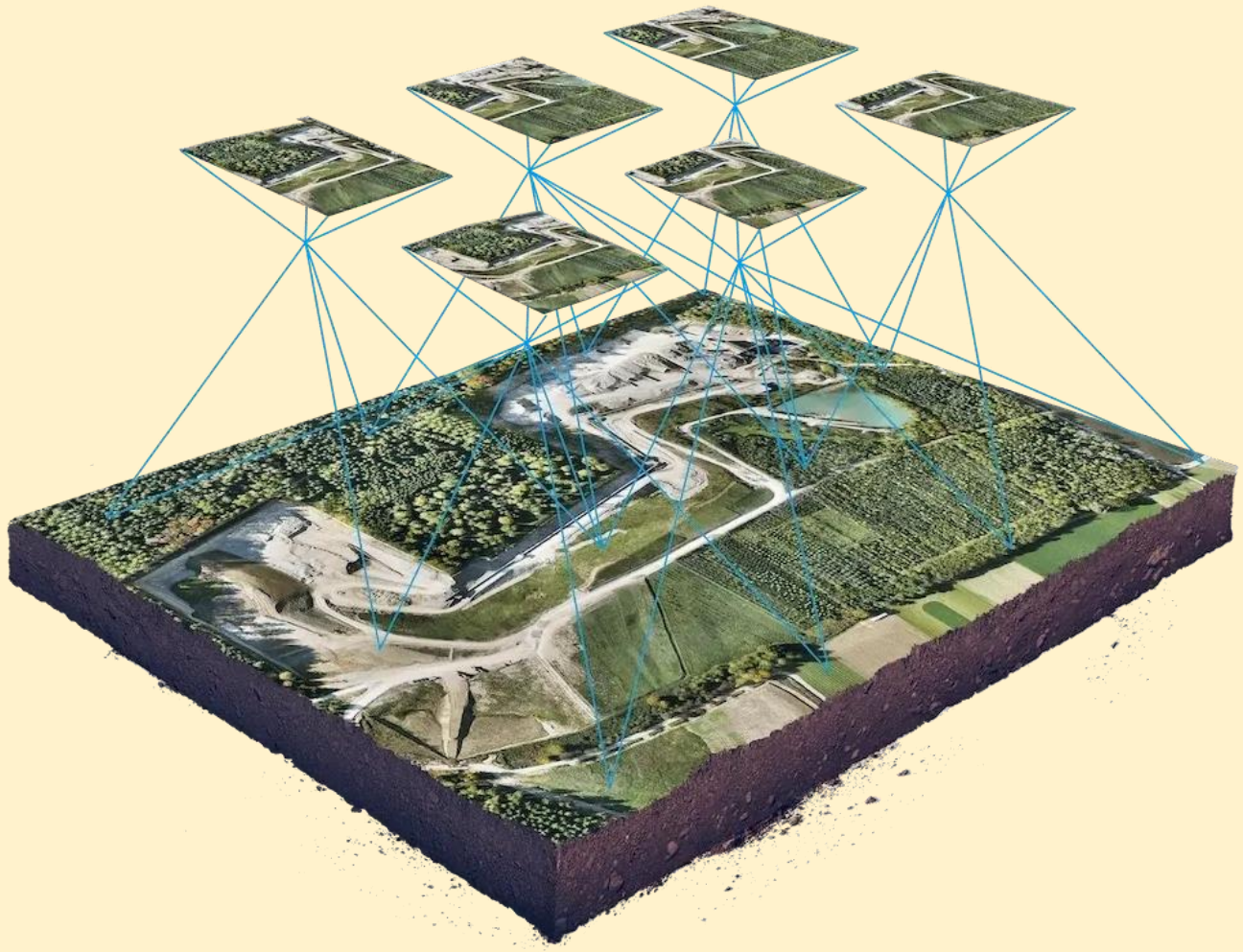

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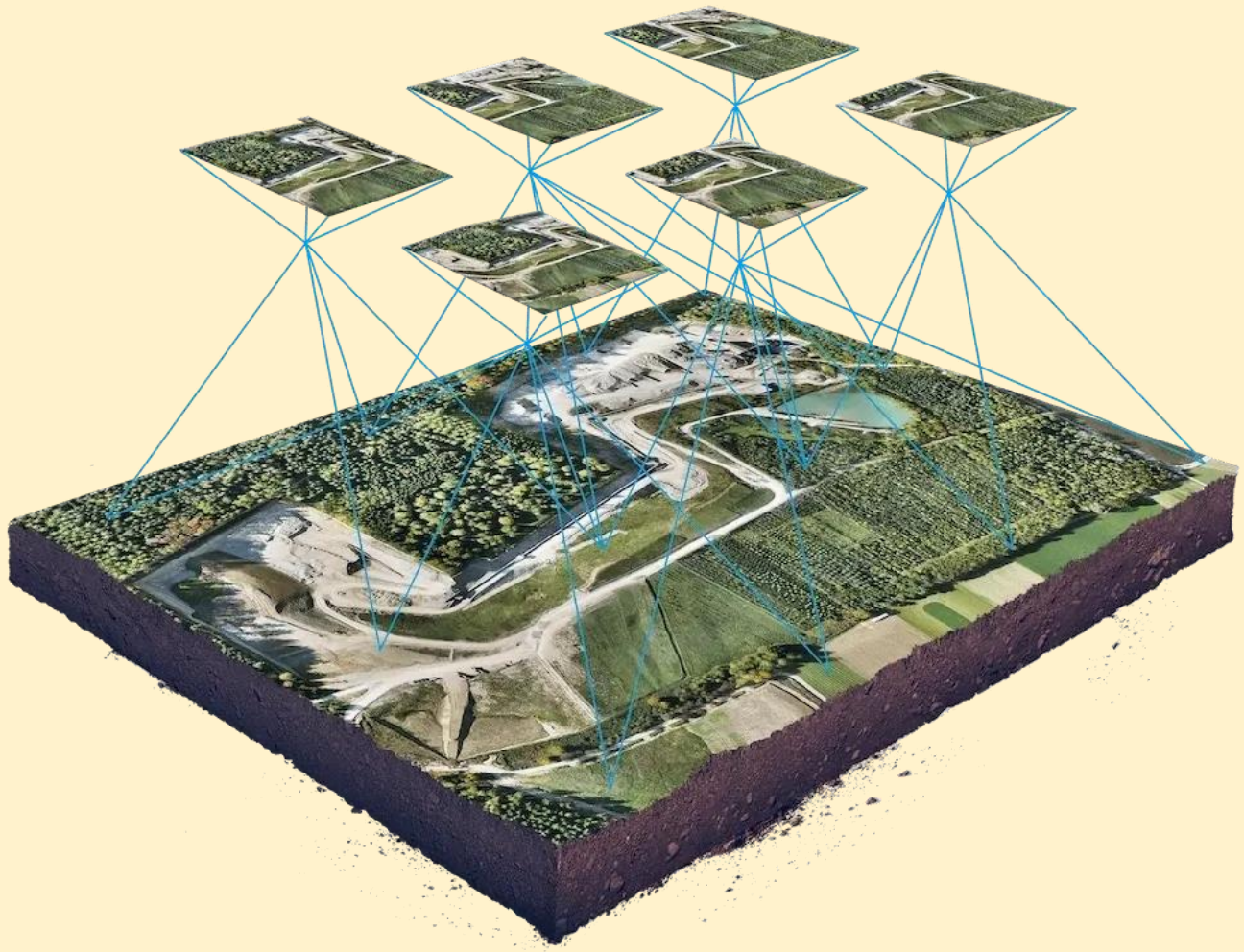

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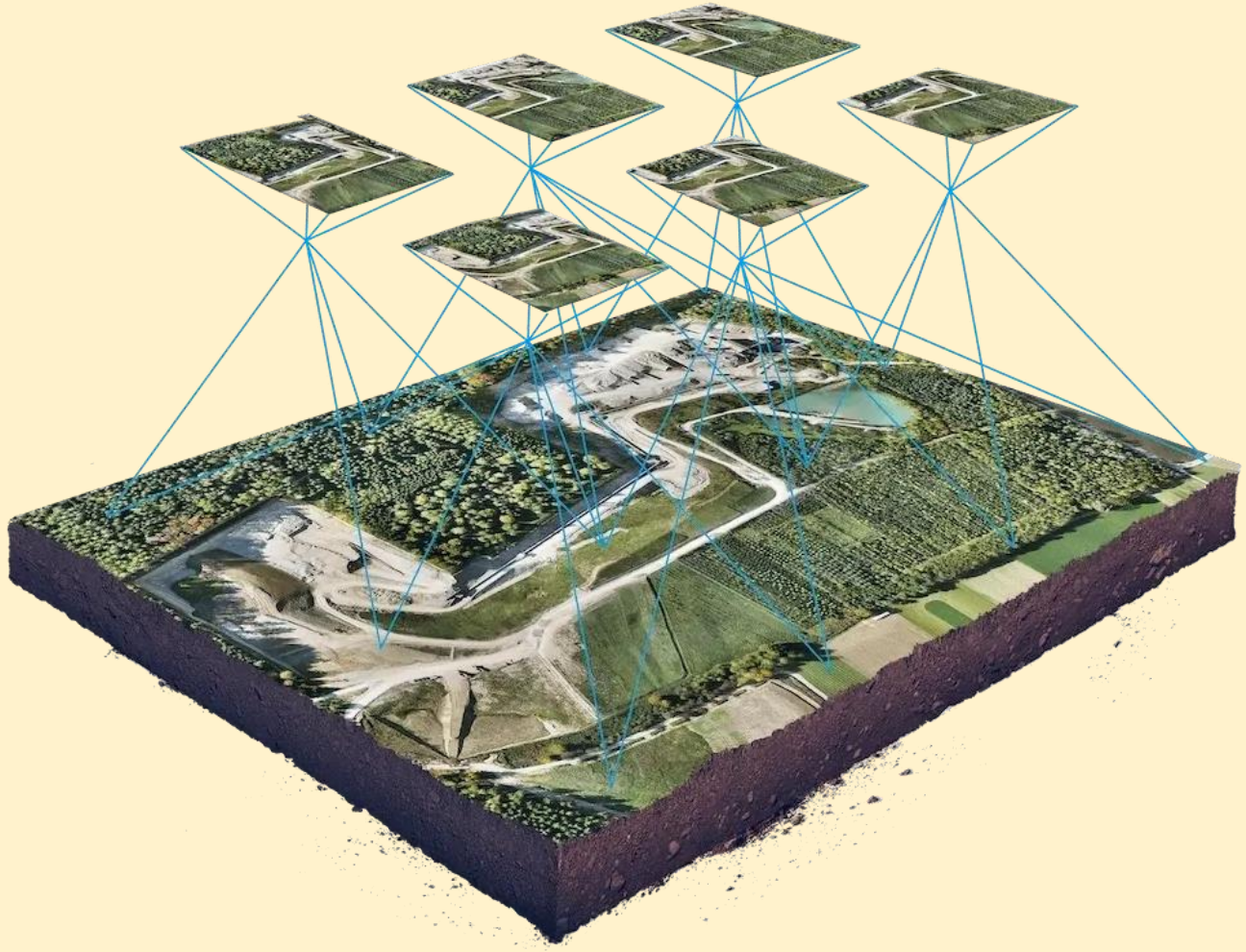
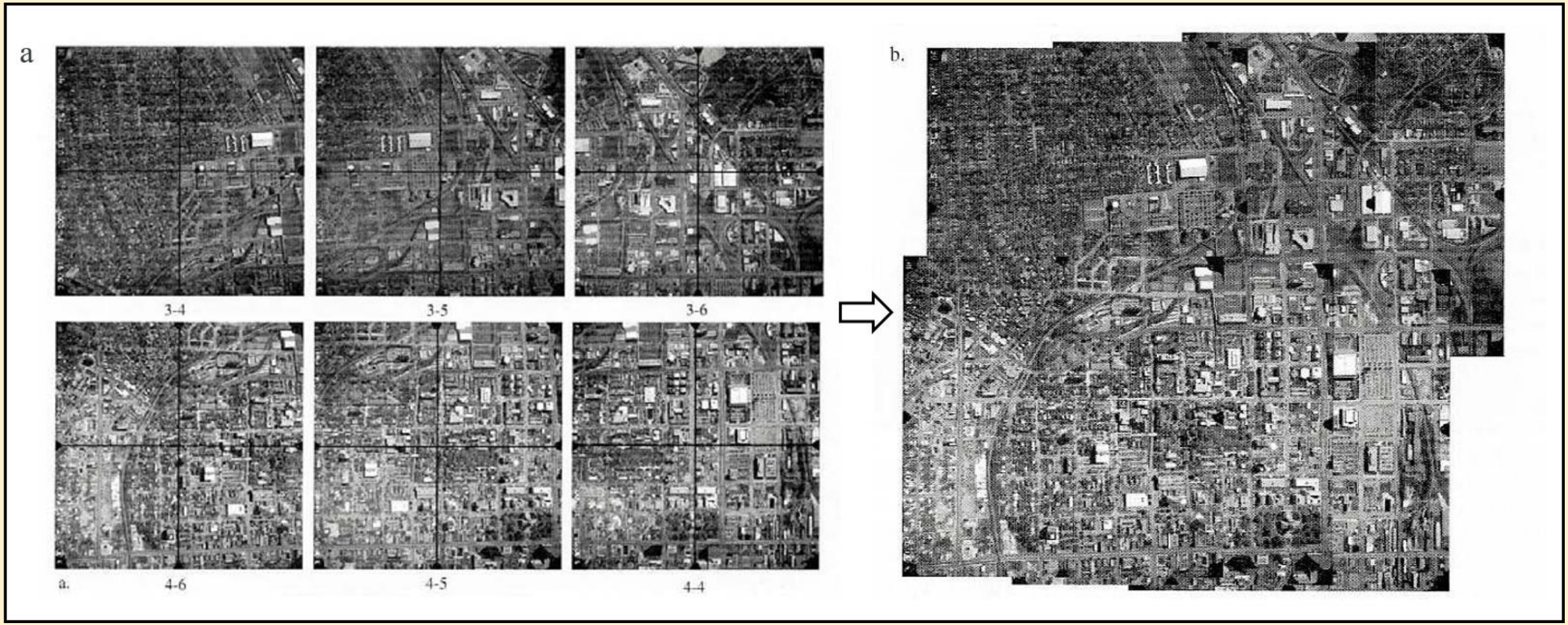
Photogrammetry is used to create 3D models from photos.



Photogrammetry → Orthomosaic



Geotagging vs georeferencing

georeferencing is a completely different process than **geotagging**.

- Georeferencing takes an aerial photograph and assigns coordinates to each pixel in the raster.
- Geotagging simply means a photo (often ground-based photographs) has a **single coordinate point** associated with it.

Georeferencing involves fitting an image to the Earth based on matching up visual features of the image with their known location.

Input: Imagery, Image control points, Matching geospatial control points

Output: Image with data attached showing how it fits onto the globe.

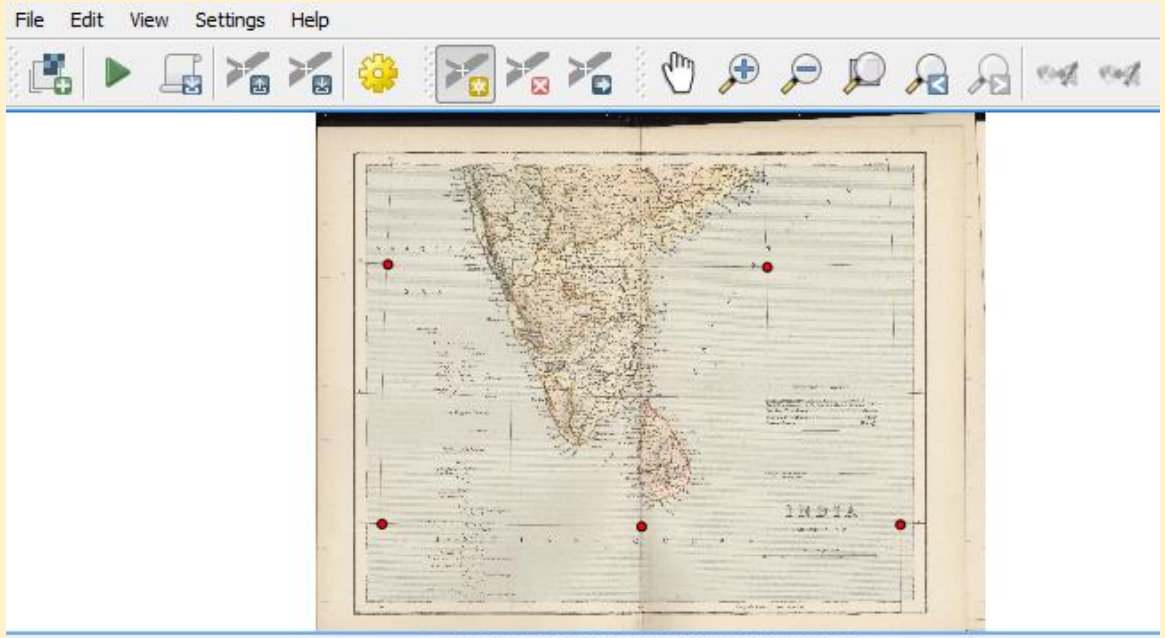
Geocoding involves converting some human placename or label into coordinates. Often this is done thousands of items at a time.

Input: "642 Arbitrary Lane, Cityville, MA" or "Miami" or "FIPS county #64623", large database of spatial reference info

Output: "53.645 N, 73.6453 W"

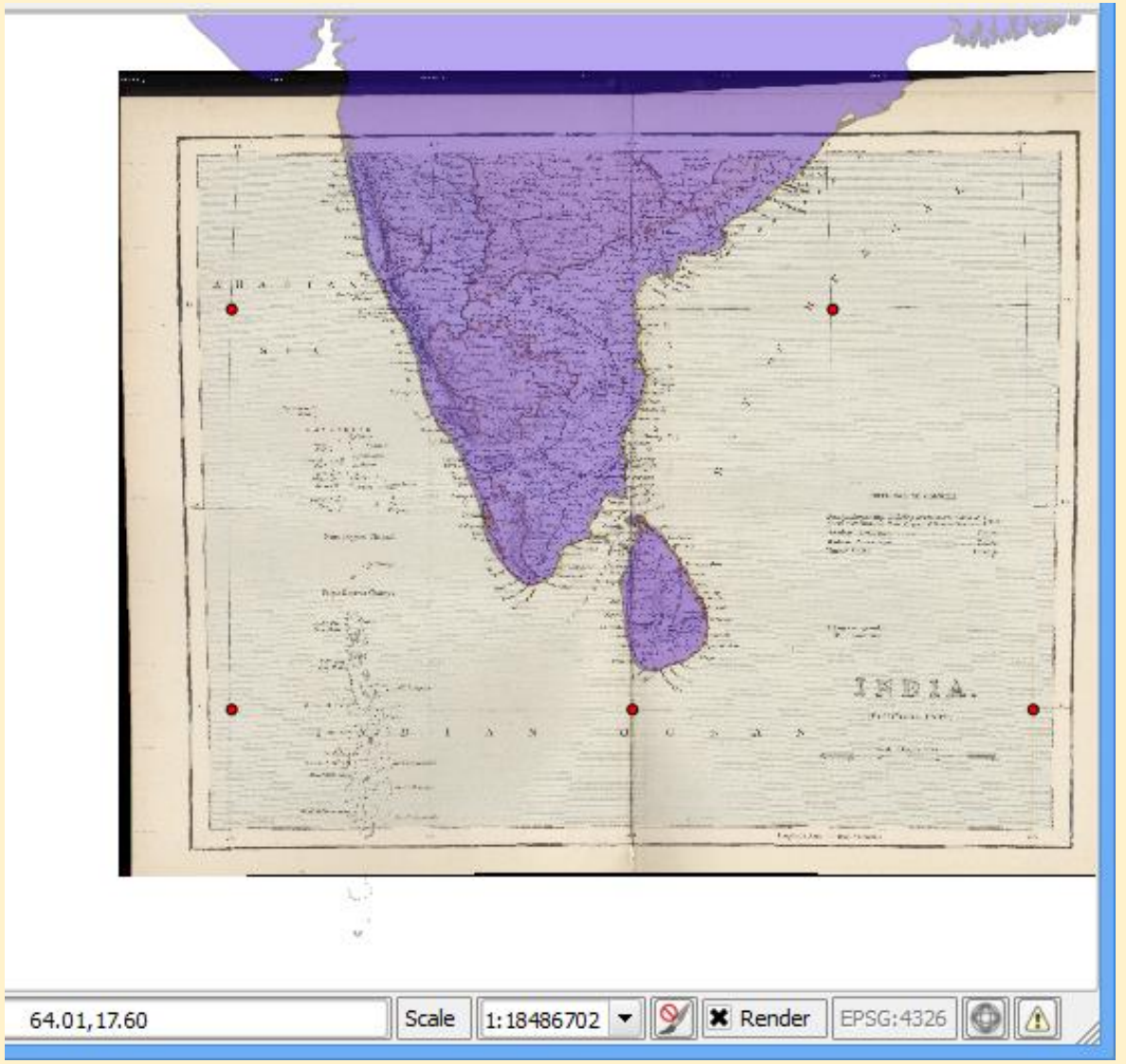
Example form: MappingTomorrow

Georeferencing raster in QGIS



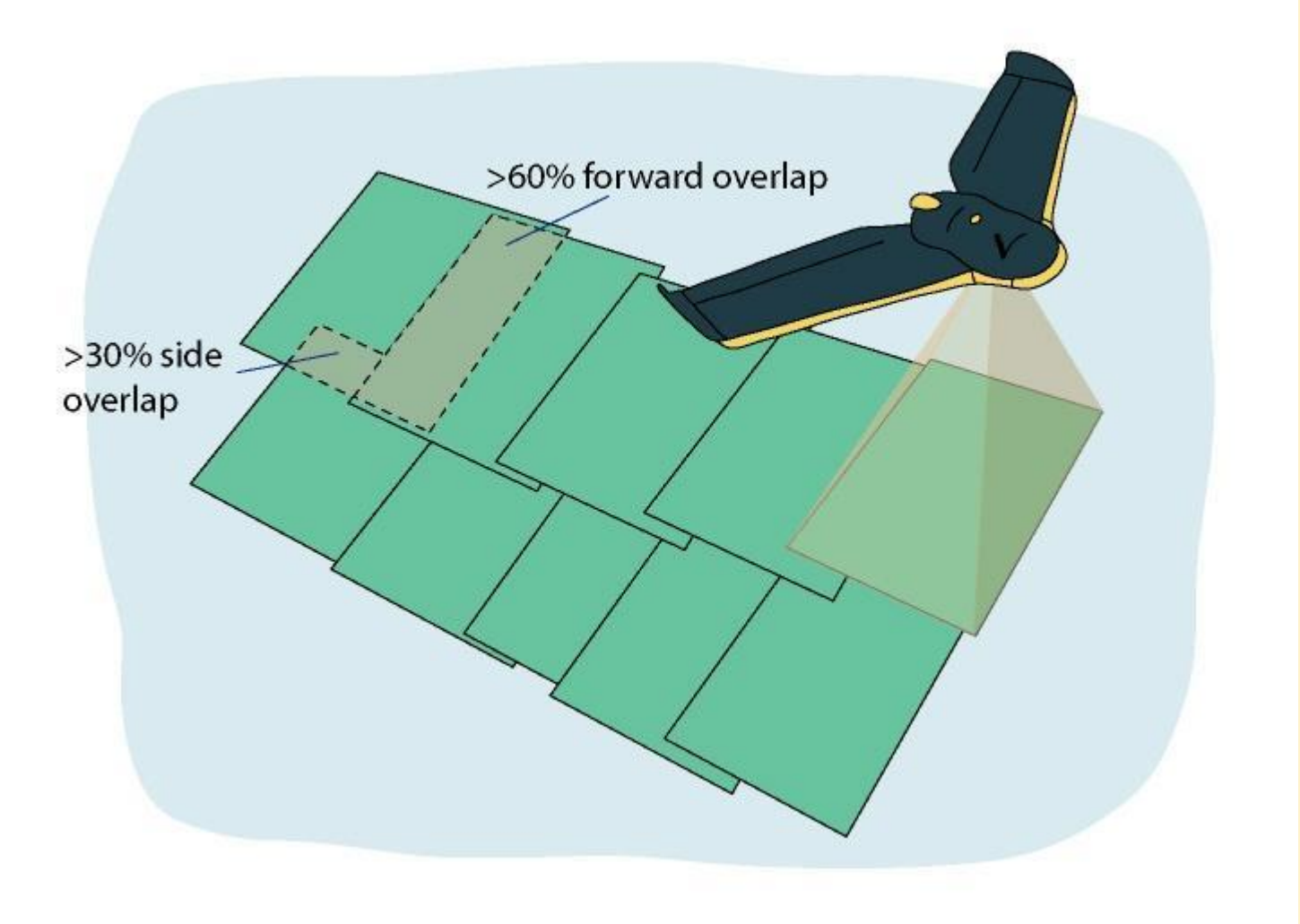
GCP table

on/off	id	srcX	srcY	dstX	dstY	dX[pixels]	dY[pixels]	residual[pixels]
✖	0	416.76	-895.21	70.00	15.00	0.00	0.00	0.00
✖	1	2664.84	-910.74	85.00	15.00	0.00	0.00	0.00
✖	2	381.64	-2431.93	70.00	5.00	0.00	0.00	0.00
✖	3	3454.12	-2435.80	90.00	5.00	0.00	0.00	0.00
✖	4	1919.70	-2446.69	80.00	5.00	0.00	0.00	0.00



Flight planning

To produce accurate terrain models, a minimum forward overlap of 60 percent and a minimum side overlap of 30 percent are recommended



QGIS: A Free and Open-Source Geographic Information System

QGIS is a free and open-source cross-platform desktop geographic information system (GIS) application that supports viewing, editing, printing, and analysis of geospatial data.

- Hydrological Modeling
- Spatial Analysis of Water Features
- Water Quality Monitoring
- Drought Analysis

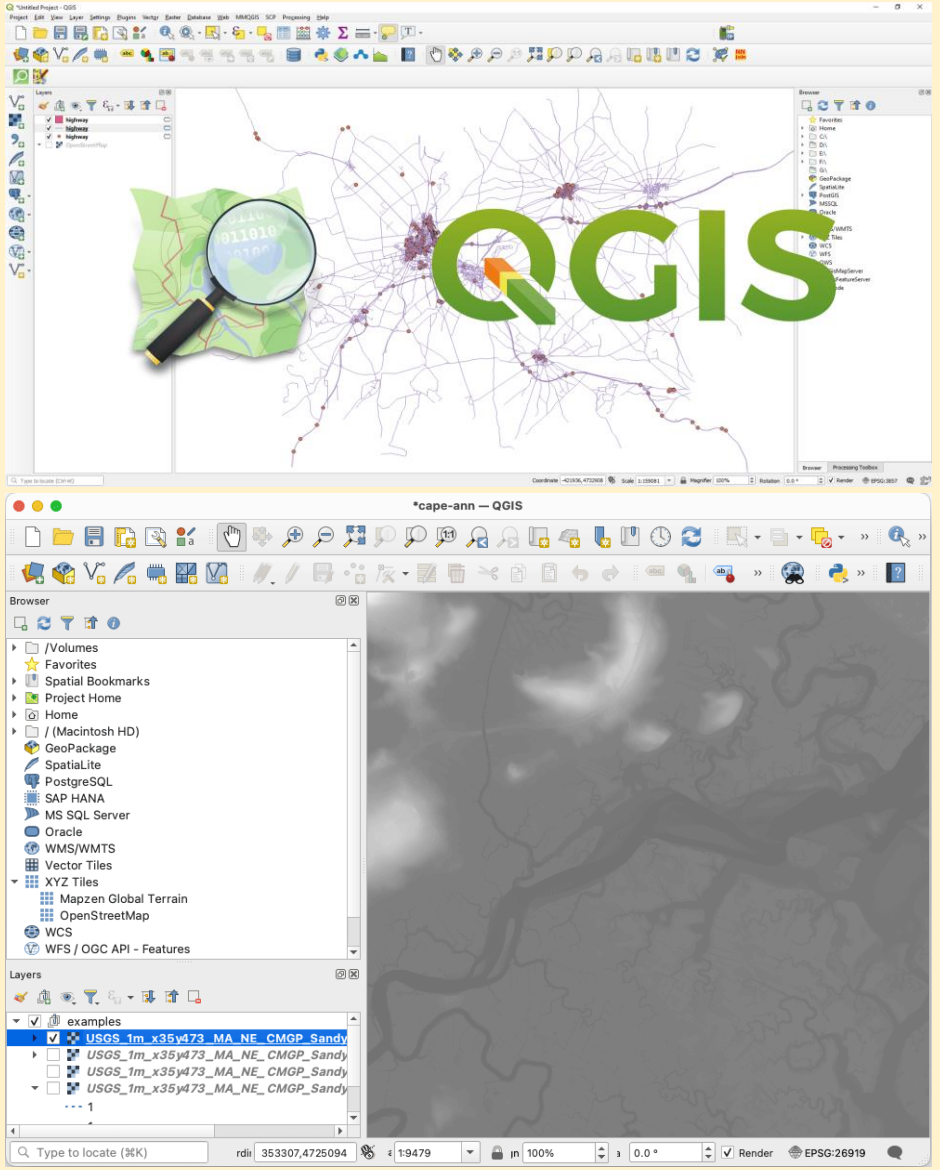
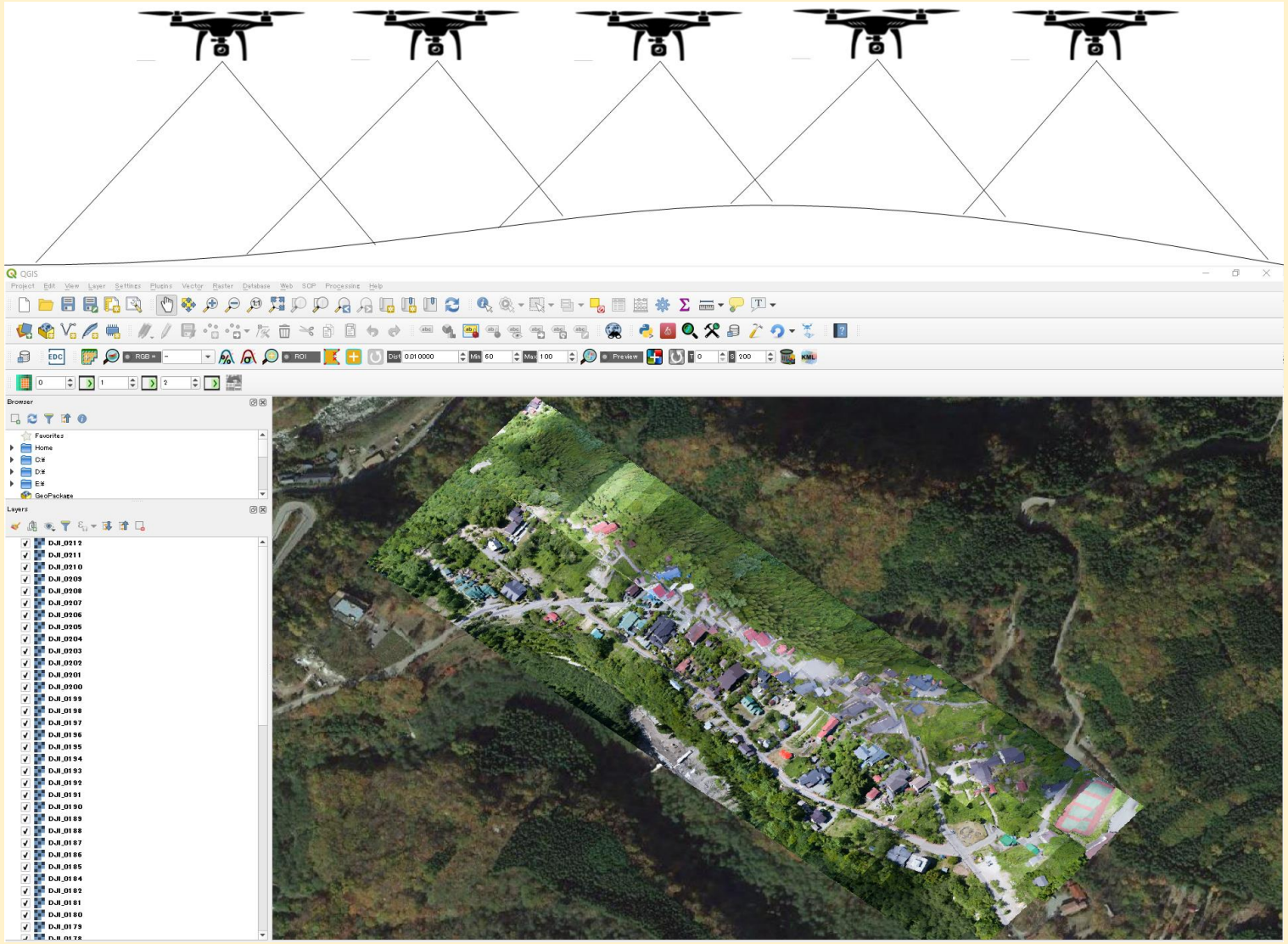


Image Source: https://www.osgeo.org/

QGIS and Drone Processing and

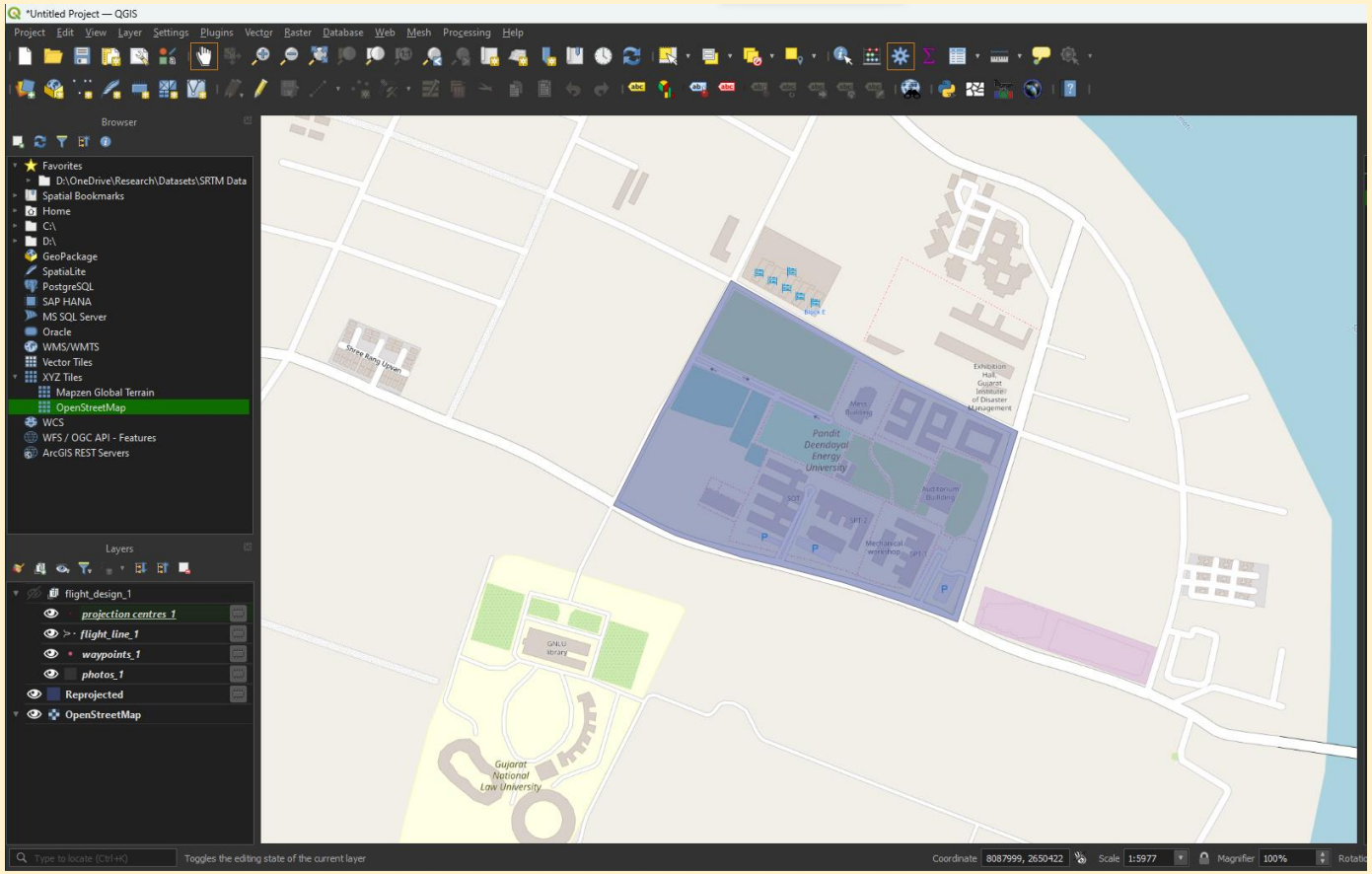
https://github.com/verticalphotoplacer/VerticalPhotoPlacer

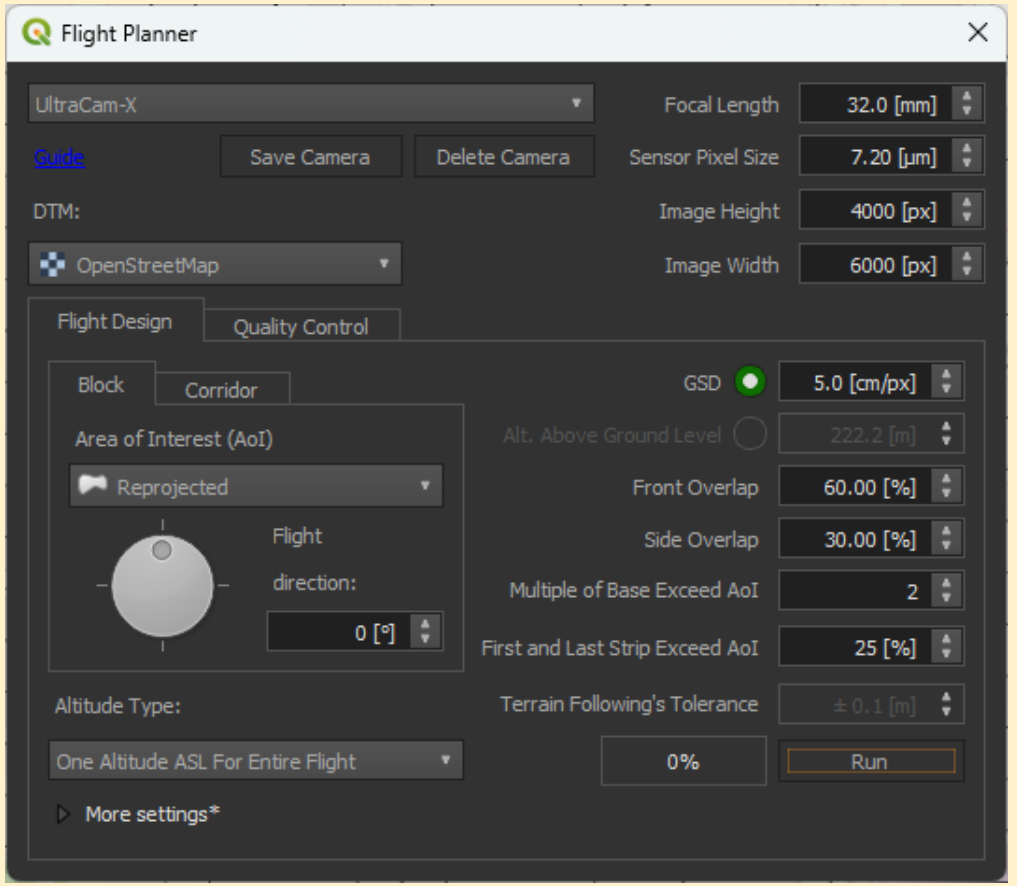


QGIS for flight planning

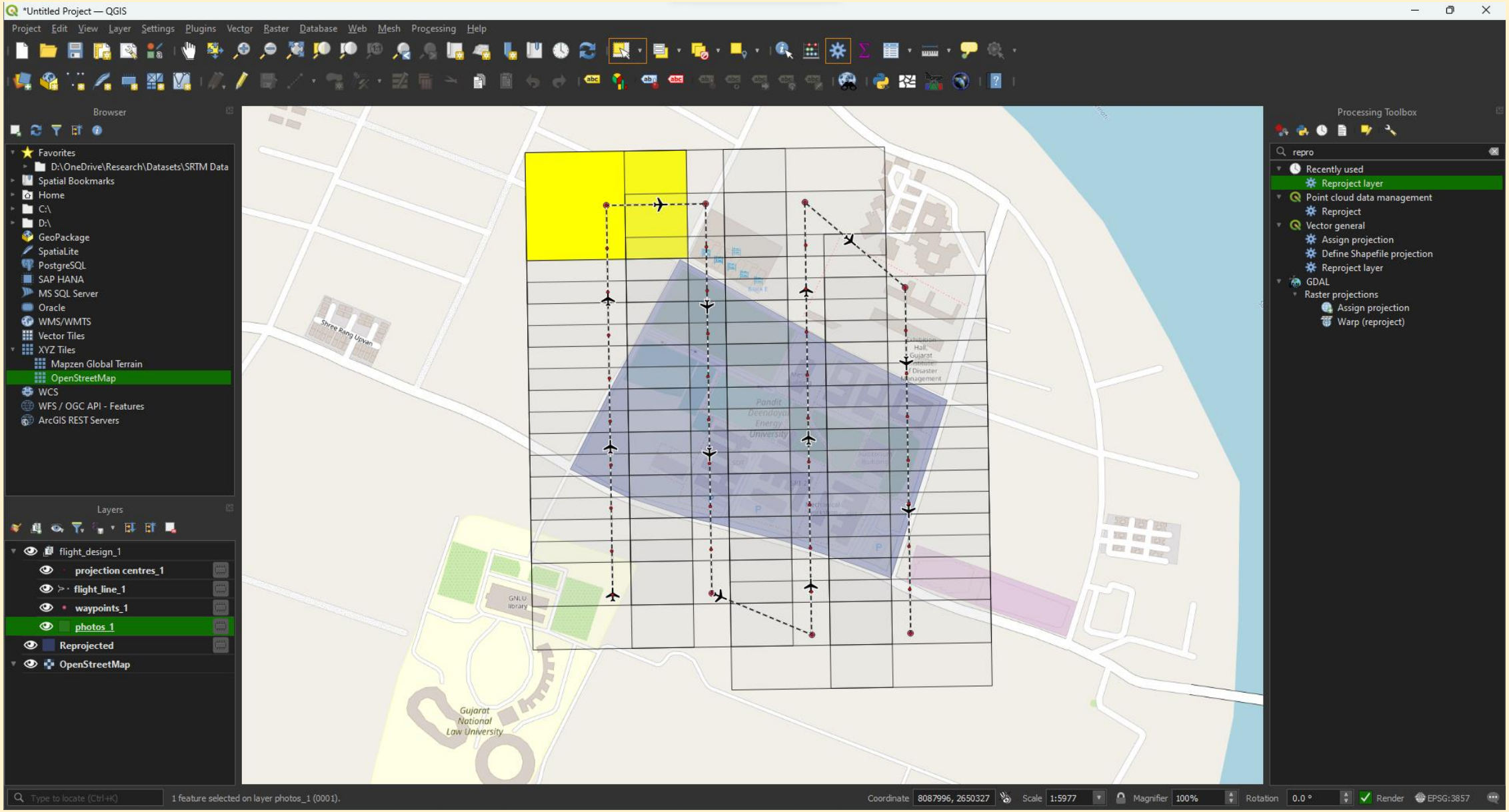
[v3.3 (Detailed) · QGroundControl User Guide]

[Guide · JMG30/flight_planner Wiki · GitHub]





Flight Planning in QGIS



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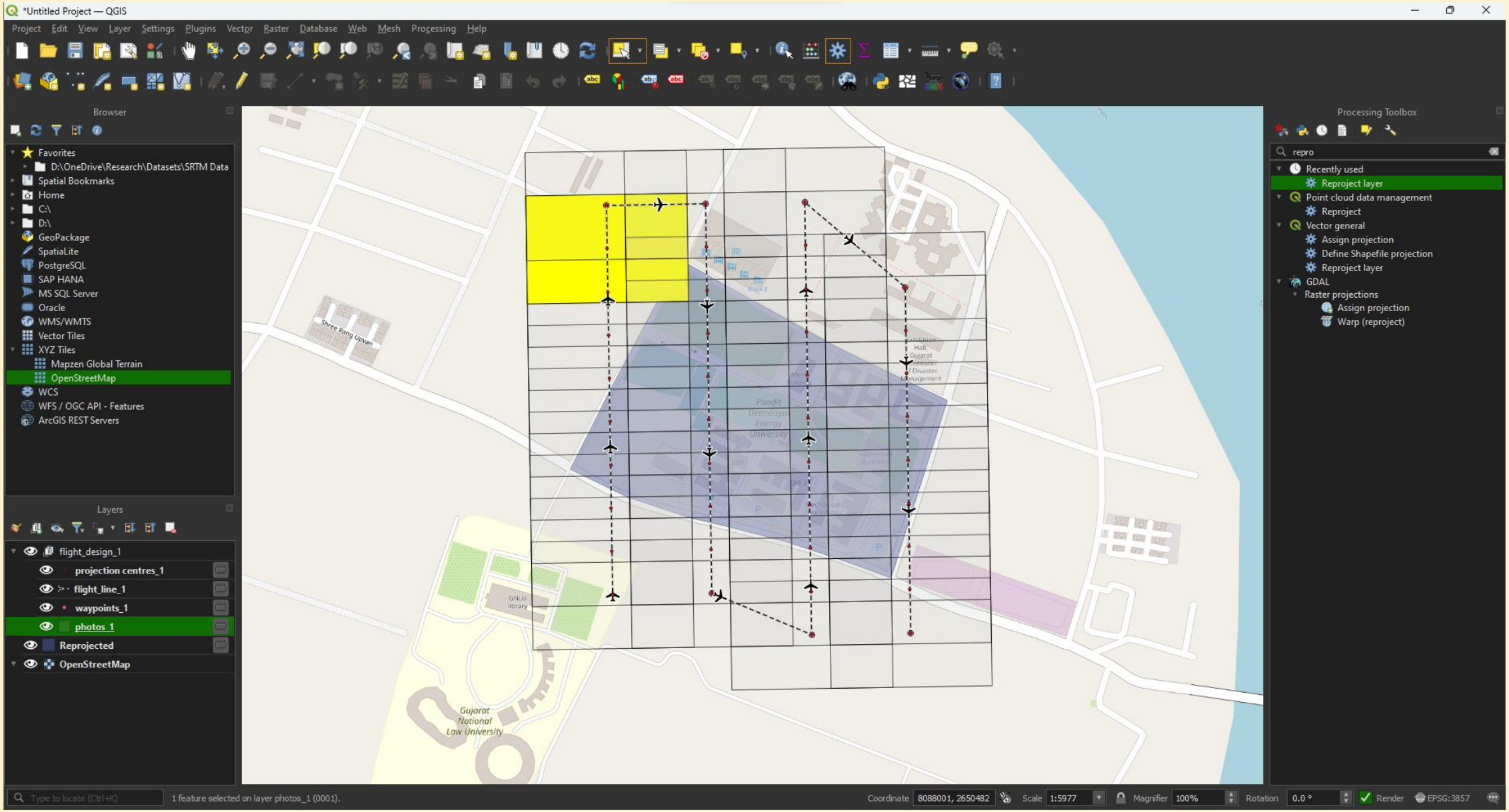
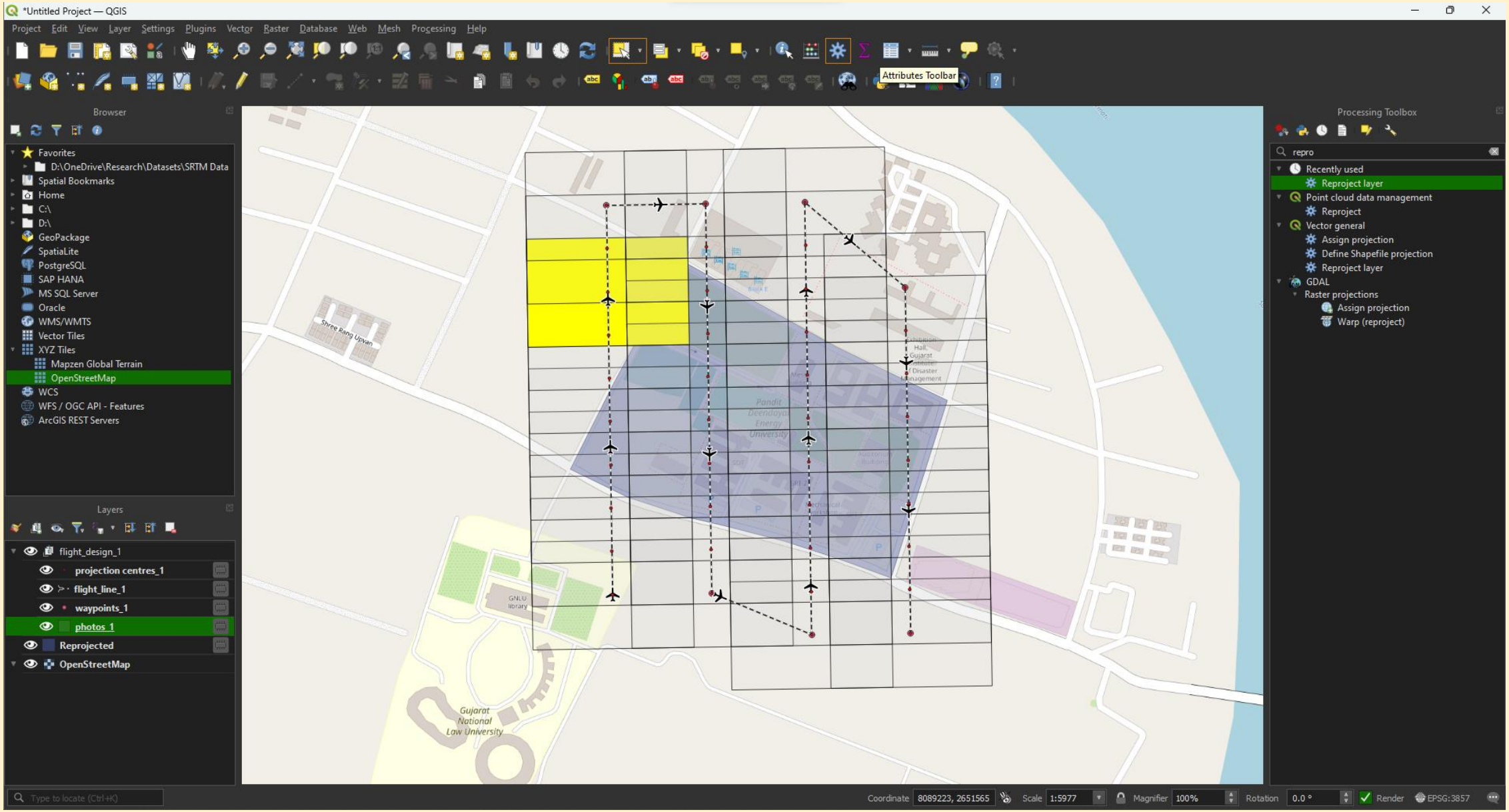
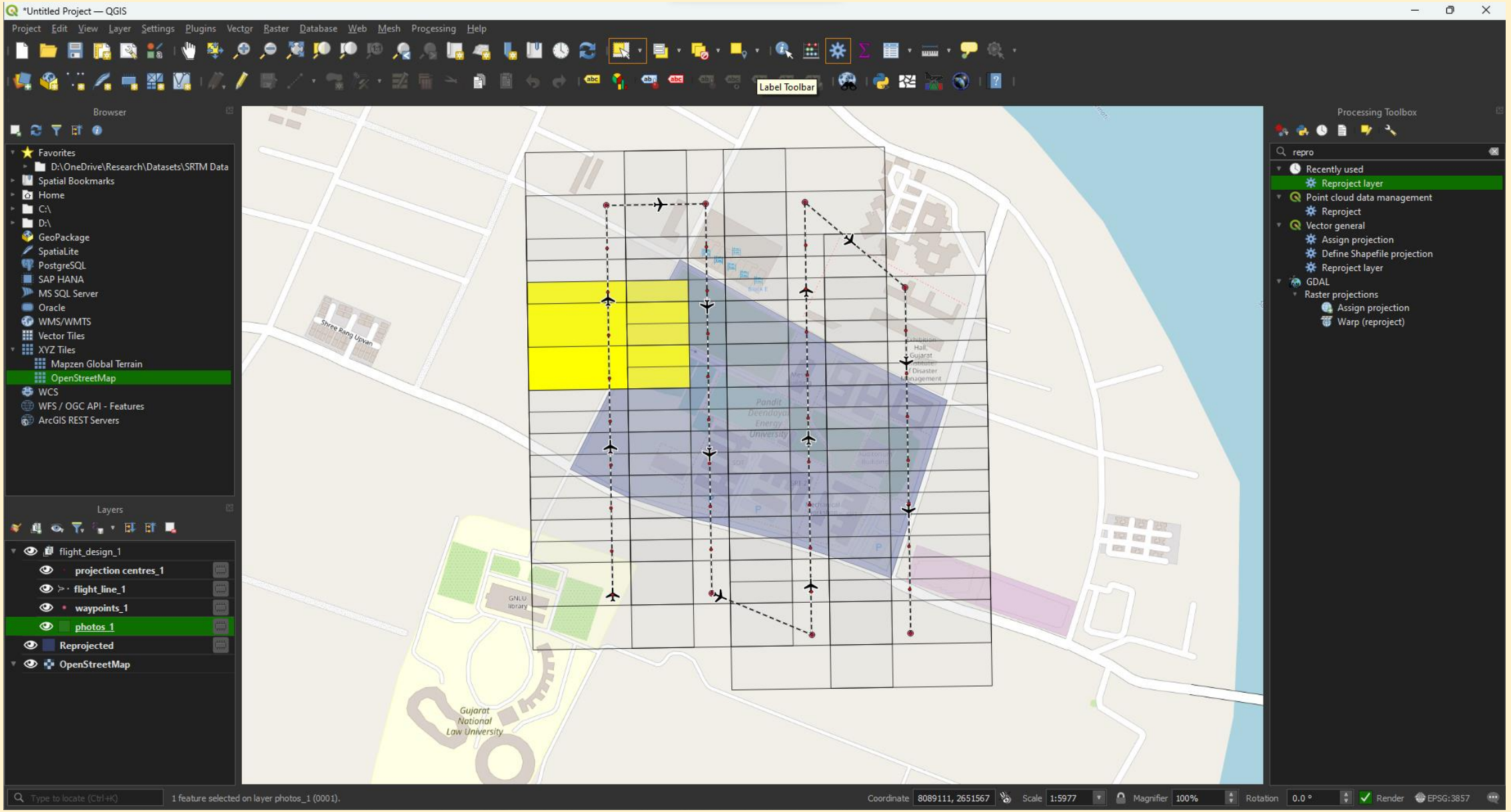


Flight Planning in QGIS

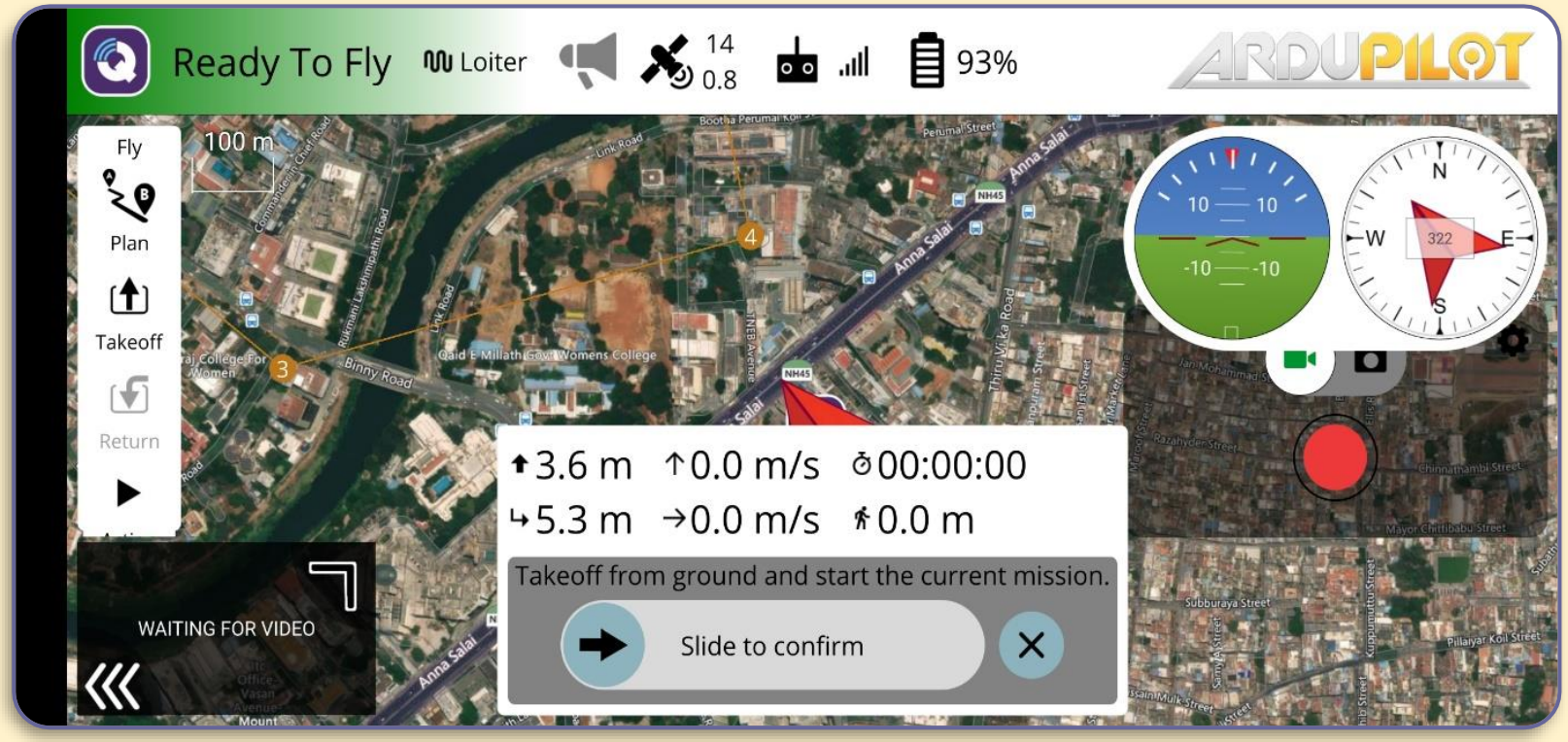


Flight Planning in QGIS



QGroundControl

- QGroundControl (QGC) is an intuitive and powerful ground control station (GCS) for UAVs.
- Provides full flight control and mission planning for any MAVLink enabled drone.
- Its primary goal is ease of use for professional users and developers.



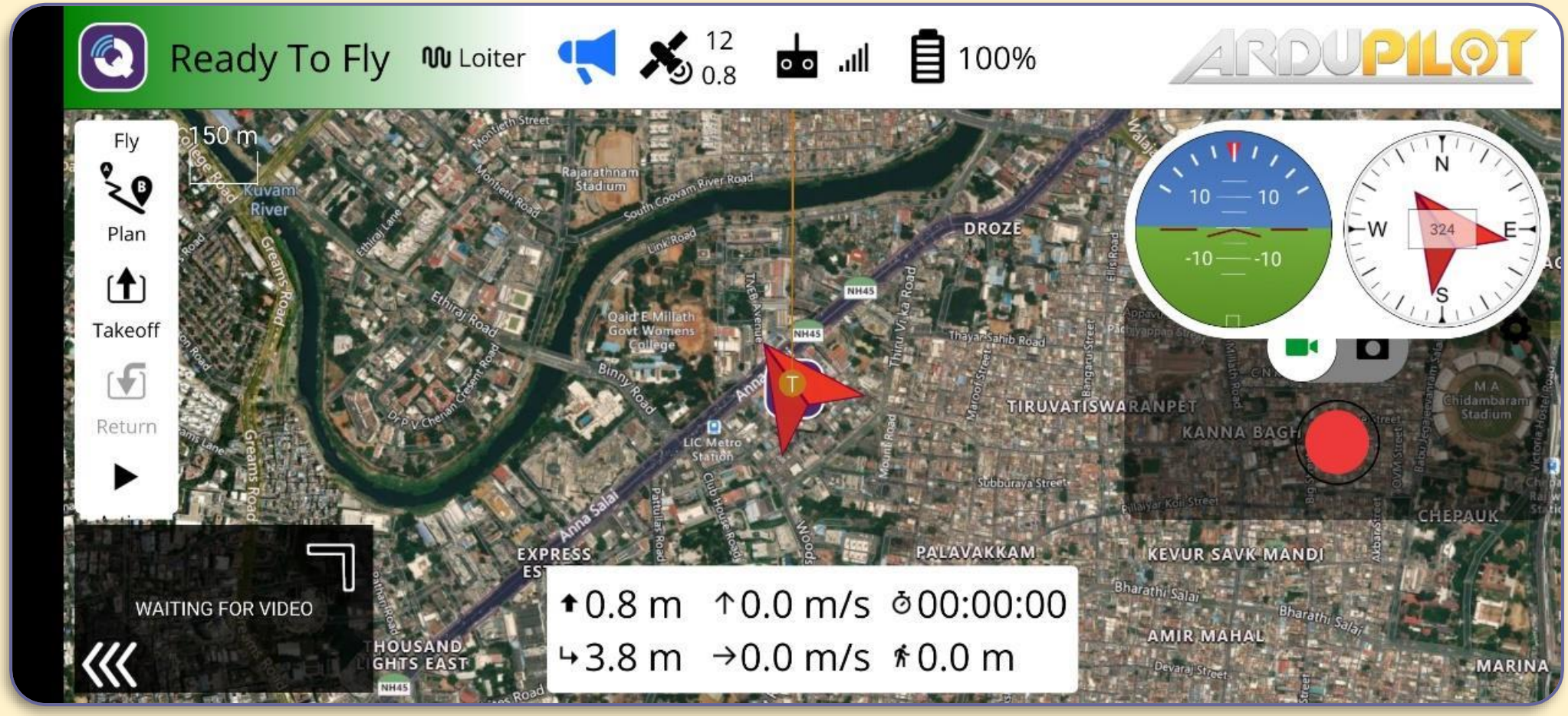
Caution while using QGroundControl (QGC)

While using a QgroundControl following things should be appear on QGC.

1. Ready to Fly should be appear in top left corner
2. Satellite count should be more than 10s
3. Horizontal Dilution of Precision (HDOP) should be less than 1.

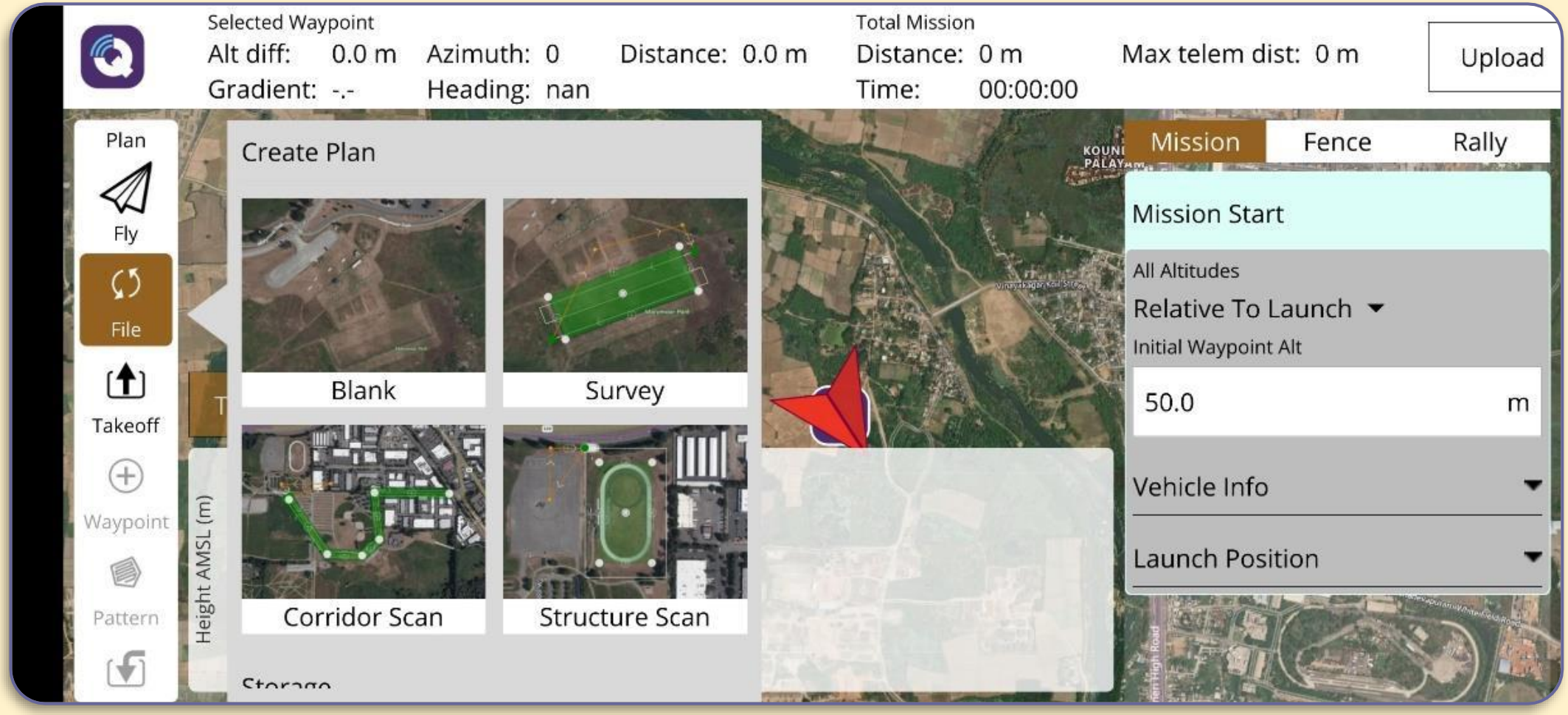
Steps to plan a survey mission

1. Click on plan



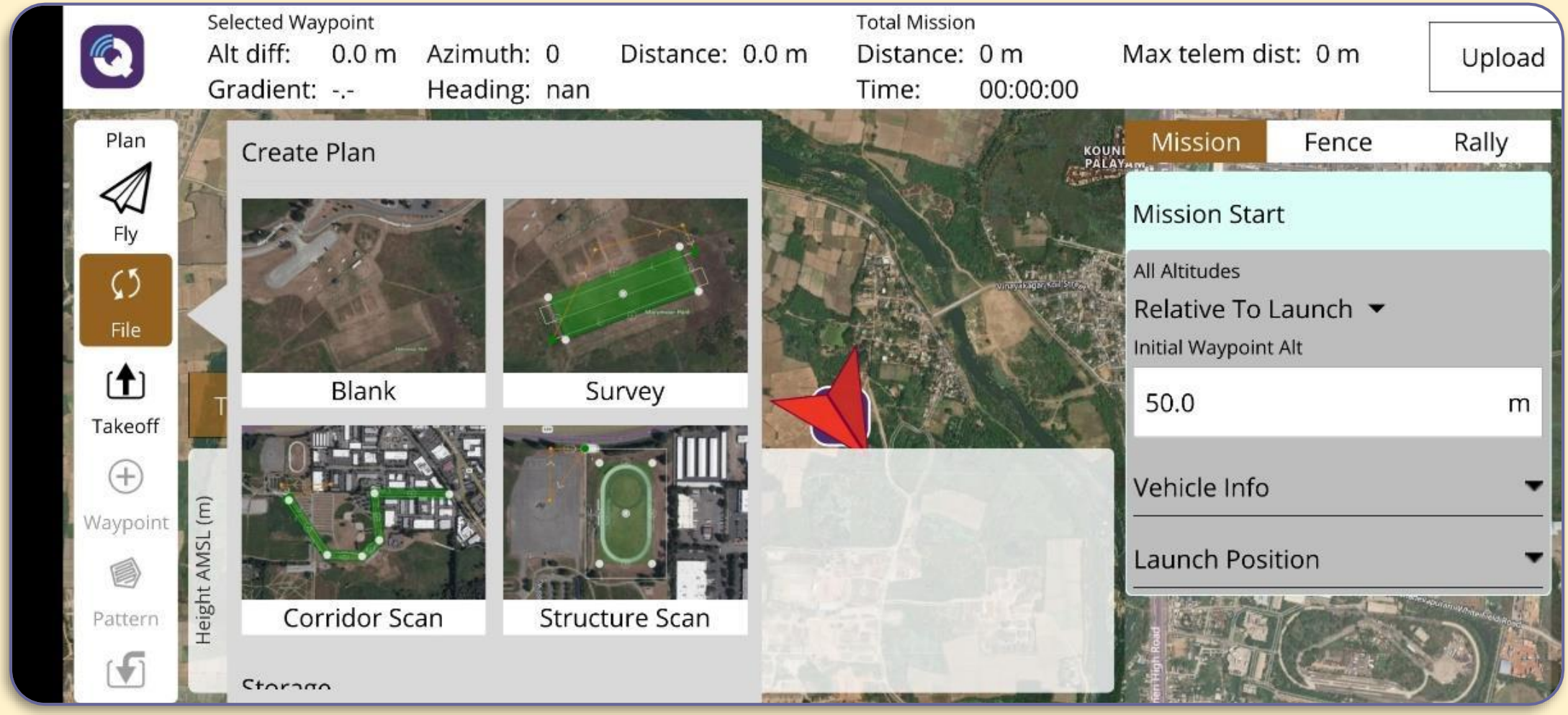
Steps to plan a survey mission

2. Select Survey



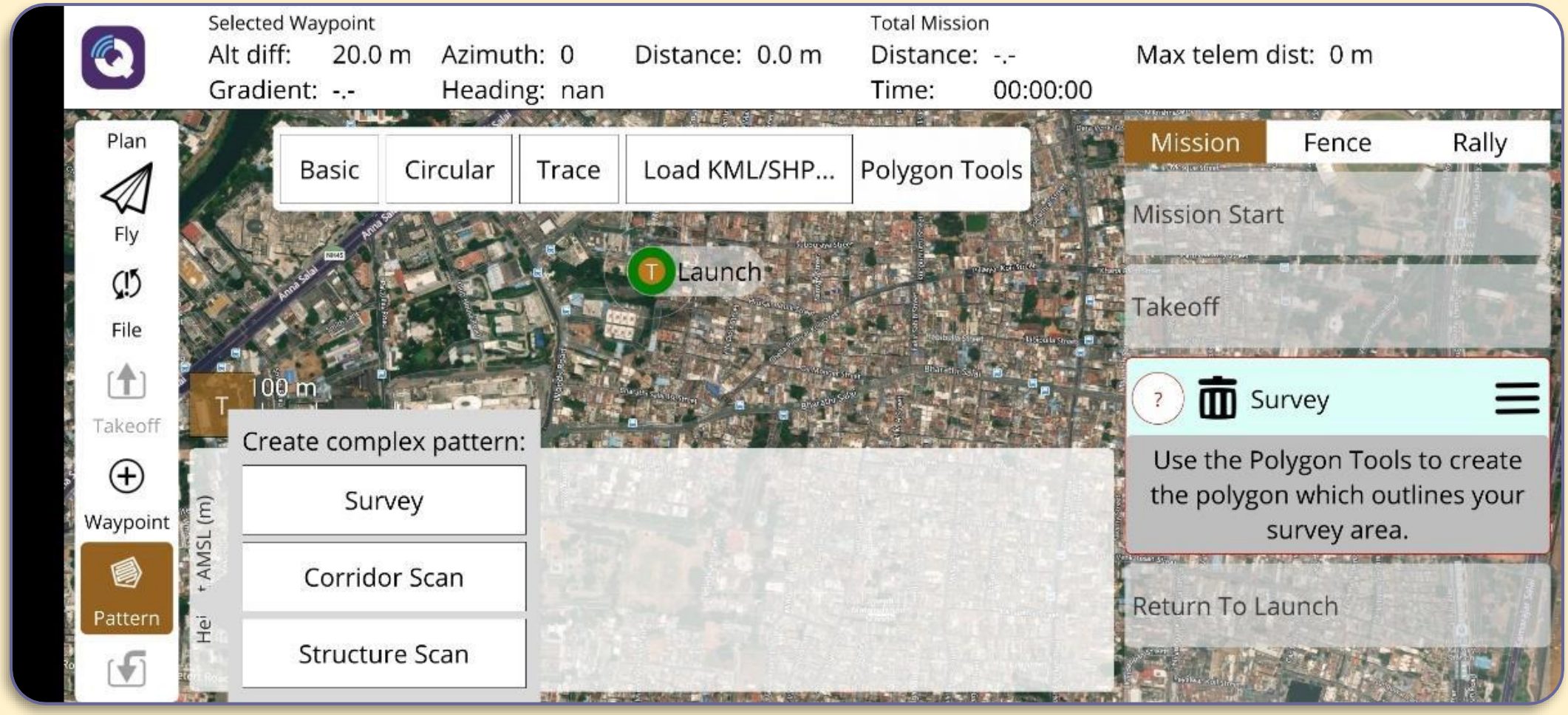
Steps to plan a survey mission

3. Add take off (Altitude) value in m. and Flight Speed



Steps to plan a survey mission

4. From mission tab select survey and then from *"pattern tab"* select survey, Mark the area accordingly.

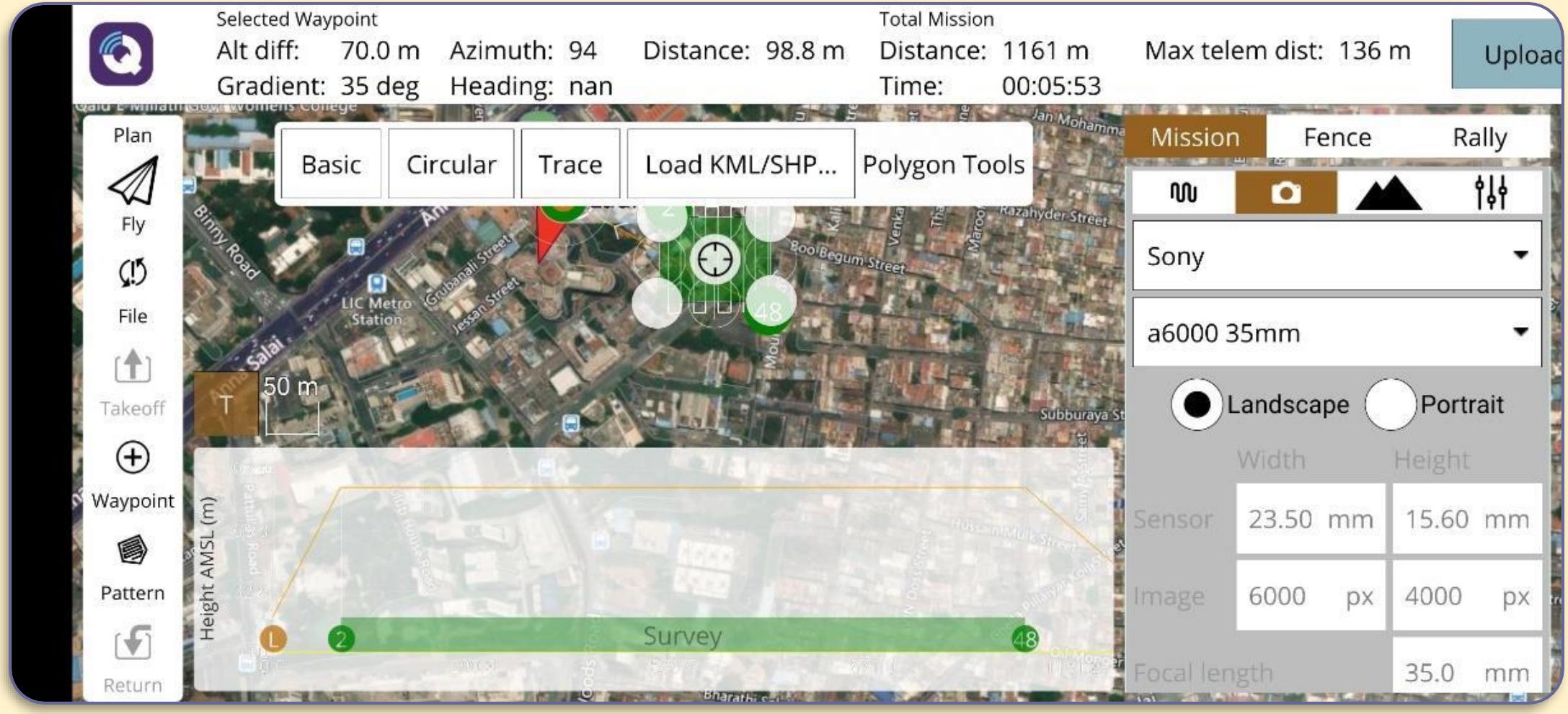


Steps to plan a survey mission

5. Add overlap more than 60% and altitude accordingly

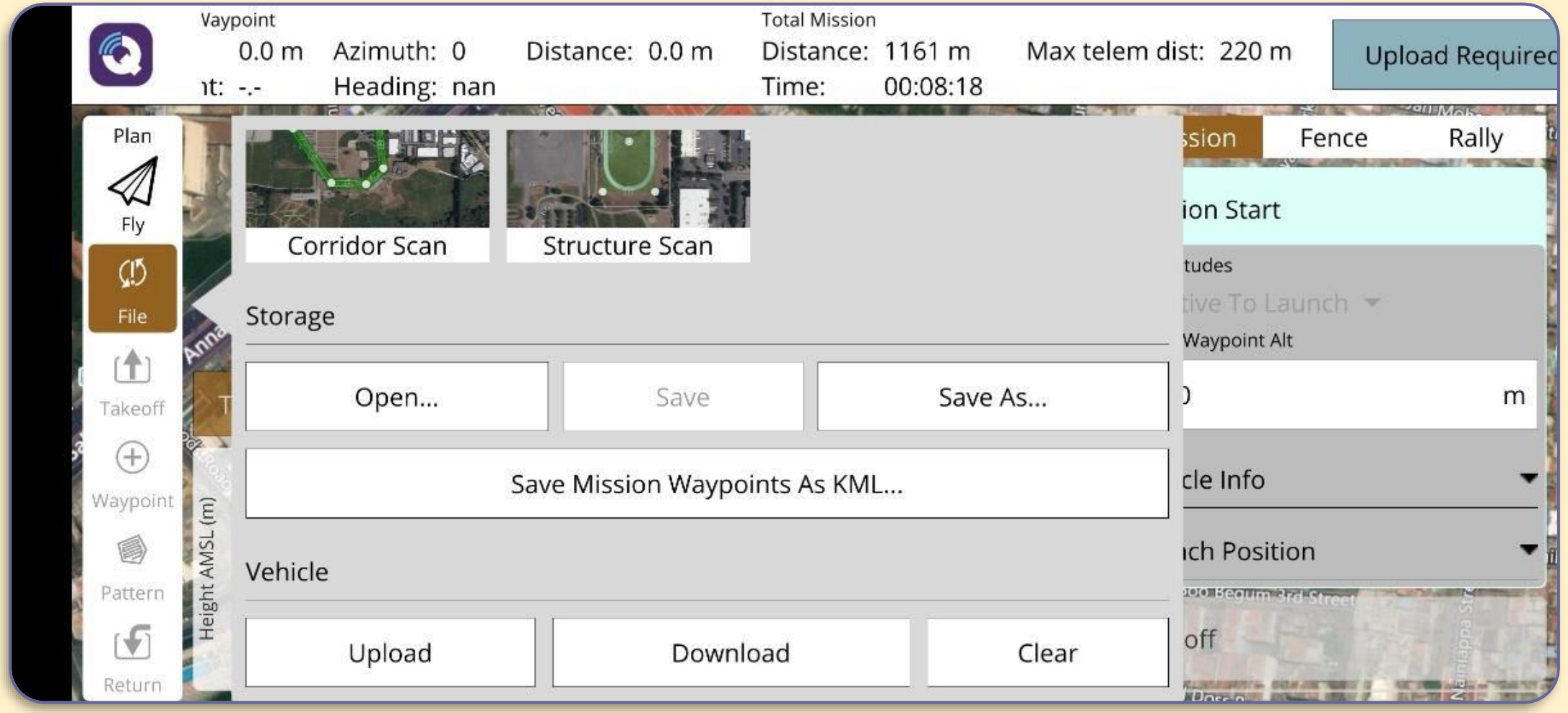
Steps to plan a survey mission

6. Then select camera as Sony and model **as a6000 35mm** and upload the mission



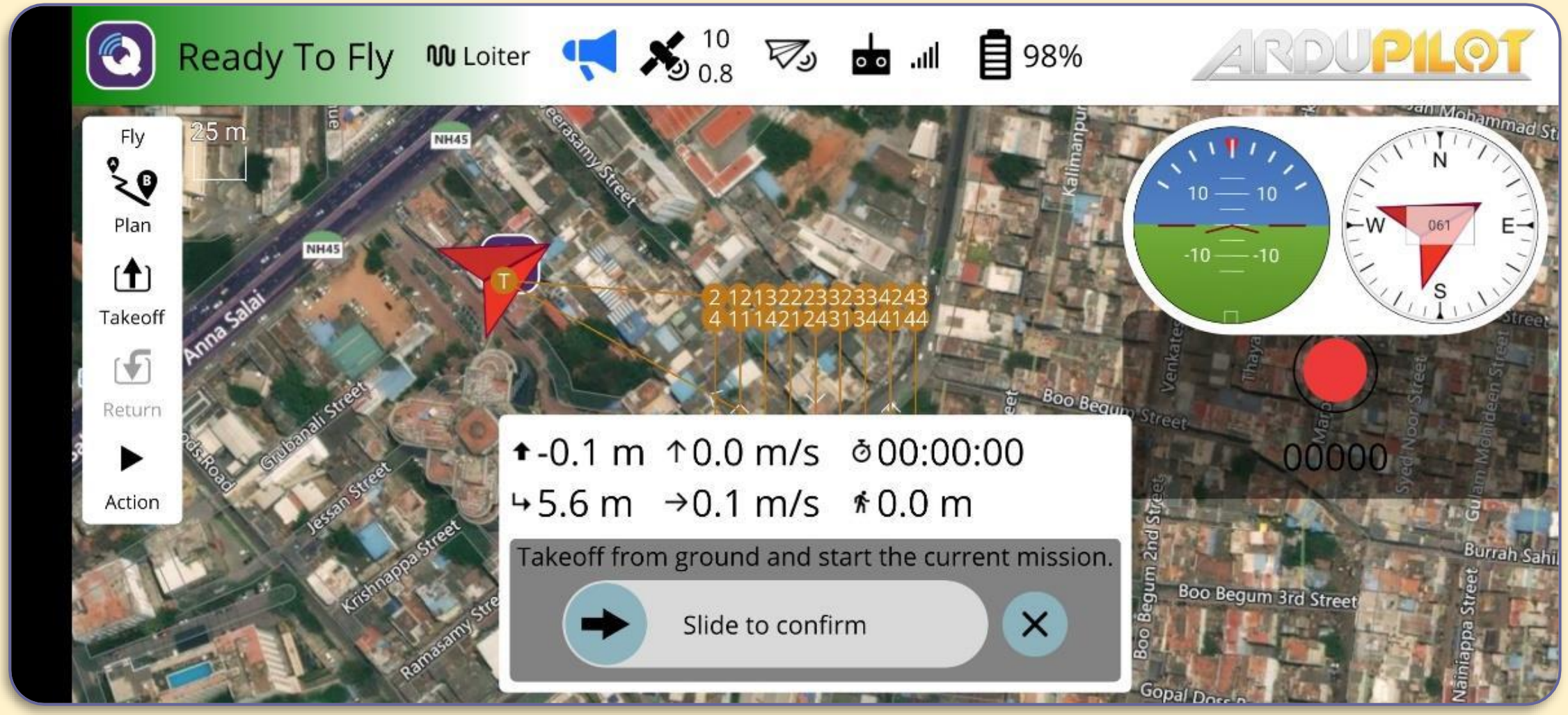
Steps to plan a survey mission

7. Go to file Download the mission



Steps to plan a survey mission

8. Arm the Drone and slide the bar to execute the mission



Post processed data with Emlid Studio, Agisoft Metashape, and Pix4D

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Emlid Studio is a cross-platform desktop application designed specifically for Georeferencing[1] the images (from Main sensor)[2]

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Pix4D to generates 3D spatial data, Ortho-mosaic, and DEM.

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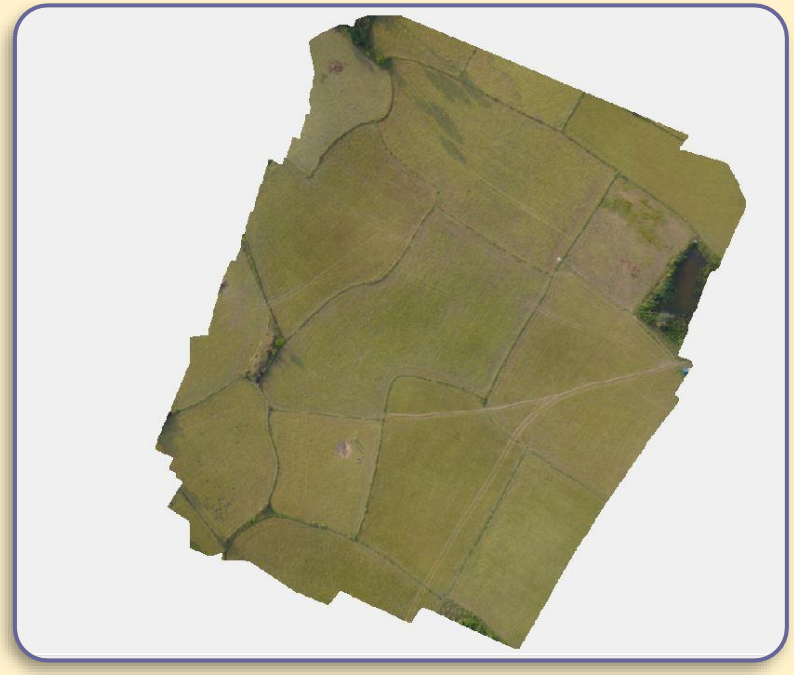
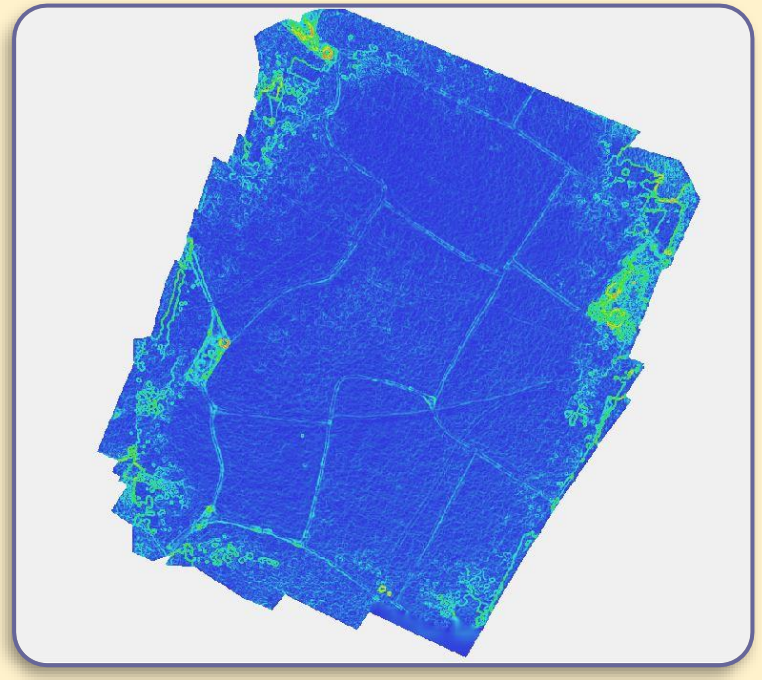
Ortho-mosaic



Digital elevation model



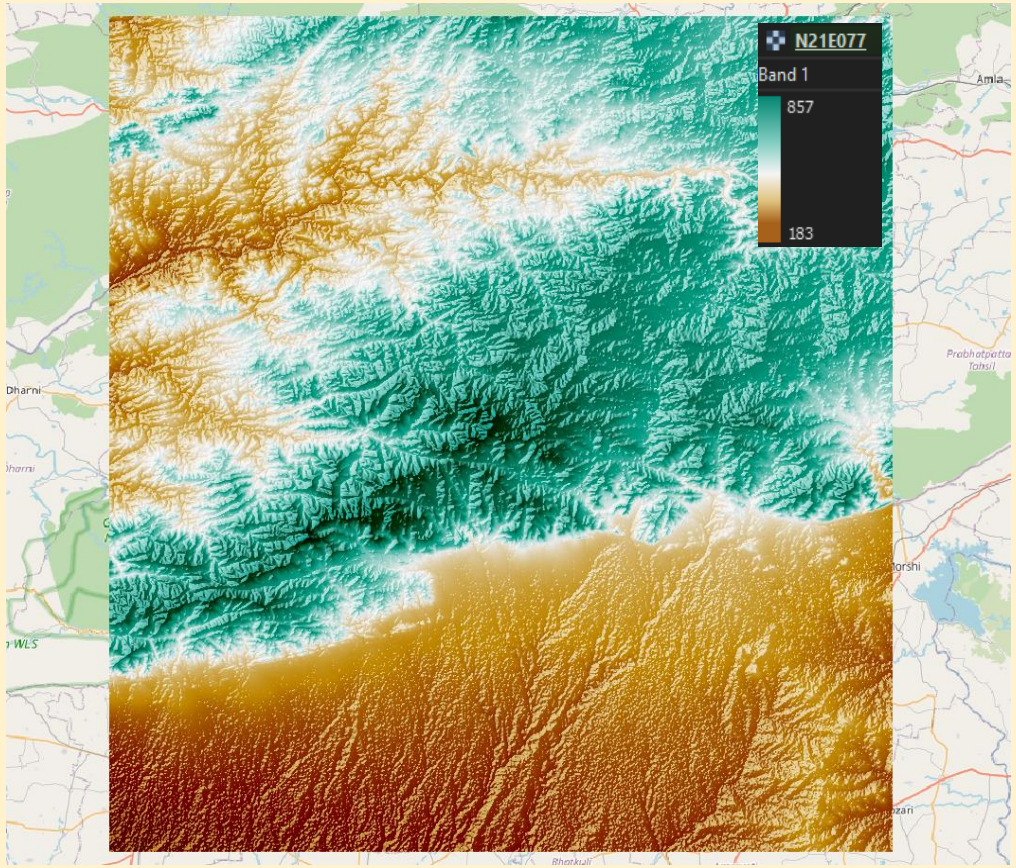
1: Georeferencing or georegistration is a type of coordinate transformation that binds a digital raster image or vector database that represents a geographic space to a spatial reference system
2: https://docs.emlid.com/emlid-studio/

A Digital Elevation Model (DEM)

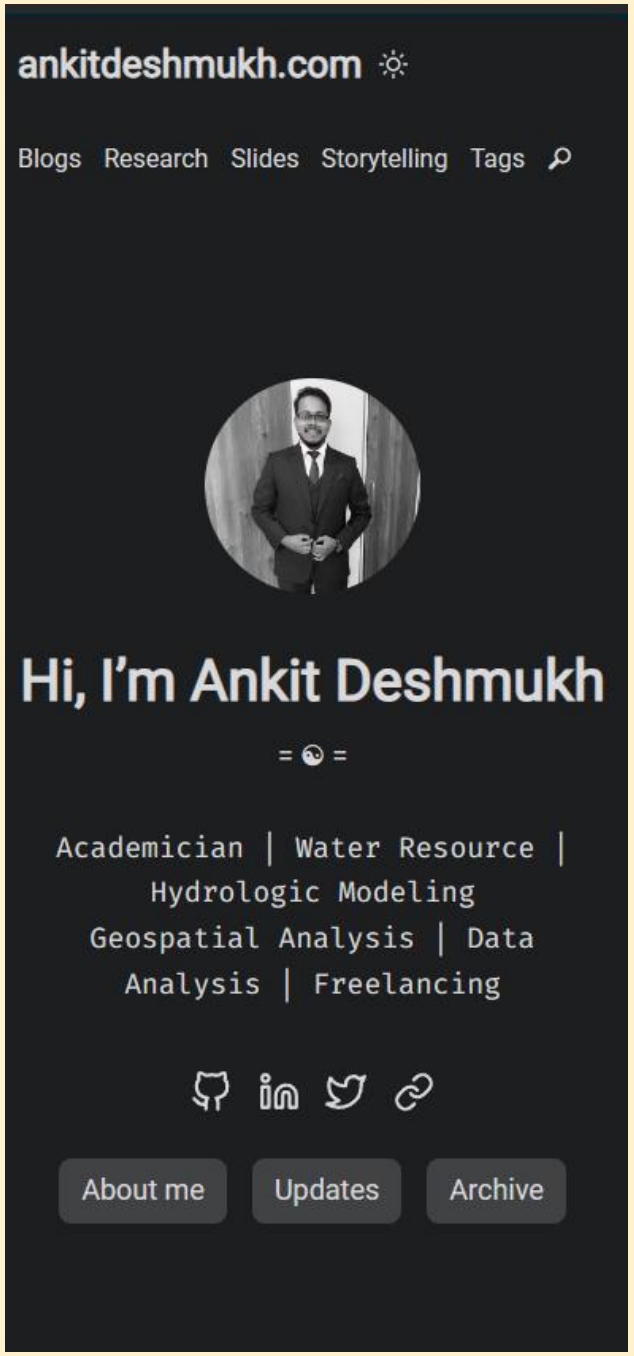
A Digital Elevation Model (DEM) is a representation of **the bare ground (bare earth) topographic surface** of the earth

The built (power lines, buildings, and towers) and natural (trees and other types of vegetation) aren't included in a DEM.

- Hydrologic Modeling
- Terrain Stability
- Soil Mapping
- Land use and Land cover



Source: DEM, DSM & DTM: Elevation Models in GIS



About my research

- My fields of interest are:
- Computational Hydrology,
- Water resource management
- Understating the catchment response under anthropogenic changes.

My specialization is on: "The approaches to identify the catchment vulnerability to environmental changes."

My current research focuses on the development of a Physio-climatic catchment characteristics dataset for the Indian subcontinent that can be utilized for prediction in the ungauged basins. I possess a strong understanding of GIS processing and am efficient in Geo-spatial analysis.
I am highly motivated in the field of data analysis (finding meaningful insights in data and ML), skilled in programming with R, MATLAB, and Python scripting.

Reach out to me:

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