TASK - 2

AERIAL PHOTOGRAMMETRY

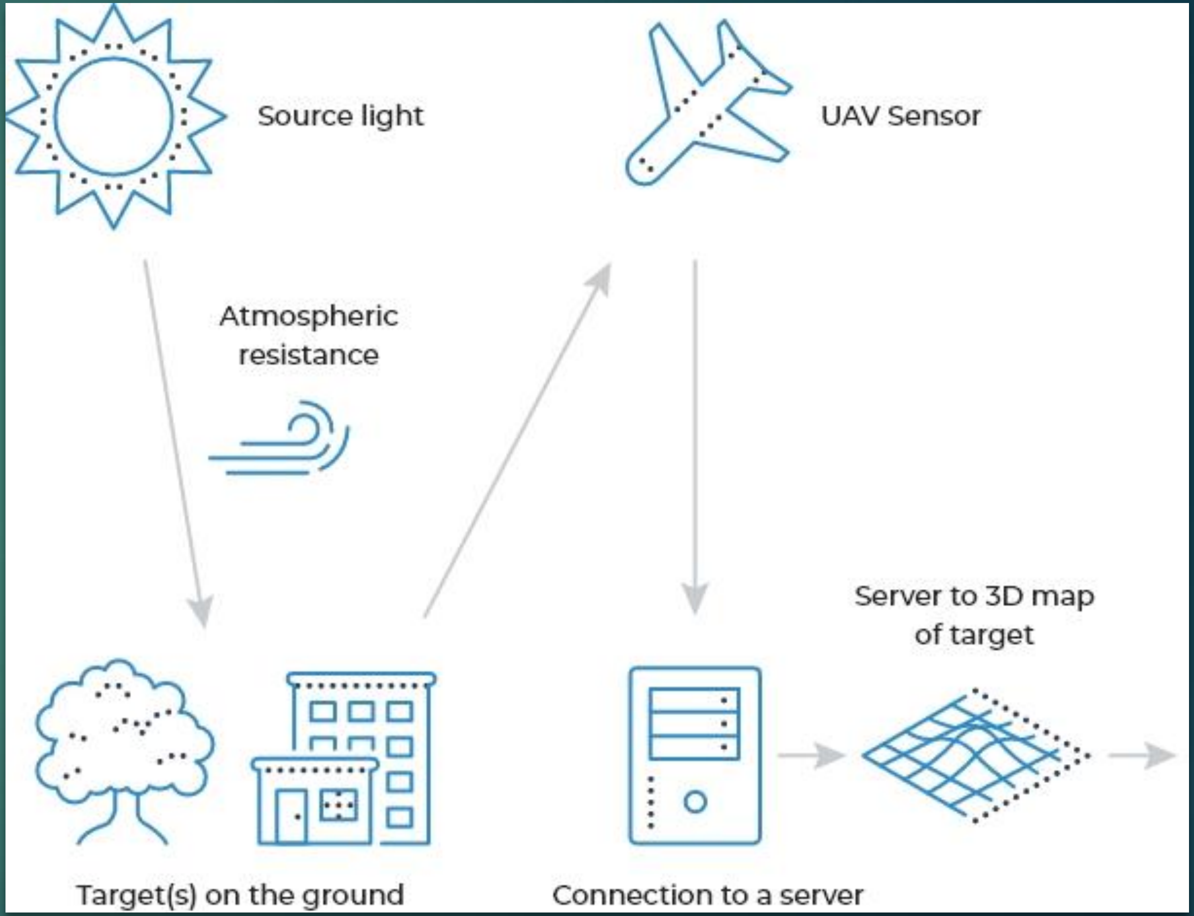
Introduction

- As per the **A**merican **S**ociety for **P**hotogrammetry and **R**emote Sensing (1987), photogrammetry is the art, science, and technology of obtaining reliable information about physical objects and the environment by recording, measuring and interpreting photographic images.

- The word photogrammetry is derived from three Greek words:
- **photos** - meaning "light",
- **gramma**- meaning "drawing" and
- **metrein** meaning "measurement".
- In a simple way, we can define it as the science of making measurements from photographs.

Photogrammetry basics: How does photogrammetry work?

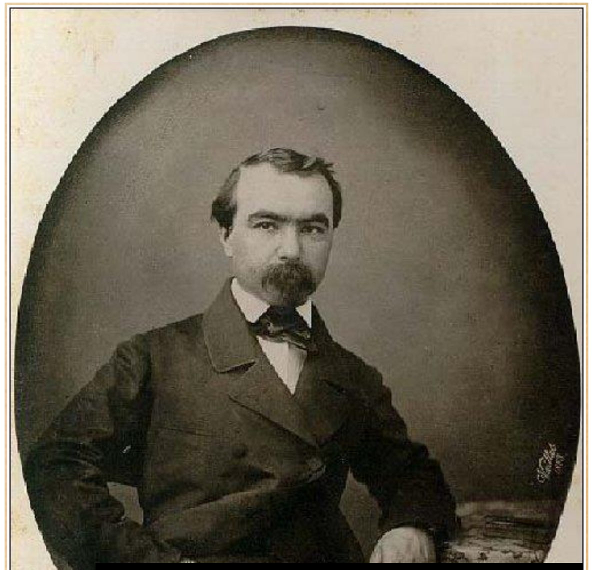
- A popular tool in remote sensing, photogrammetry processes images collected using sensors mounted from UAVs, manned aircraft, or satellites to create large-scale images.
- These images, called orthophotos or orthoimages, are pinned to a location using GPS positioning and normalized using metadata on environmental conditions like humidity, time, date, and more. This information is sent to servers for collection and storage.
- Once collected, orthoimages can be fed into advanced mapping and surveying software to create measurable 3D maps and renderings. Comparing differences in data over time can tease out variations in chemical composition, hydration and humidity, temperature, and other environmental factors — all without putting boots on the ground.
- This eye-in-the-sky view is incredibly valuable for assessing large properties and examining remote infrastructure without substantial investment in manned teams.



History

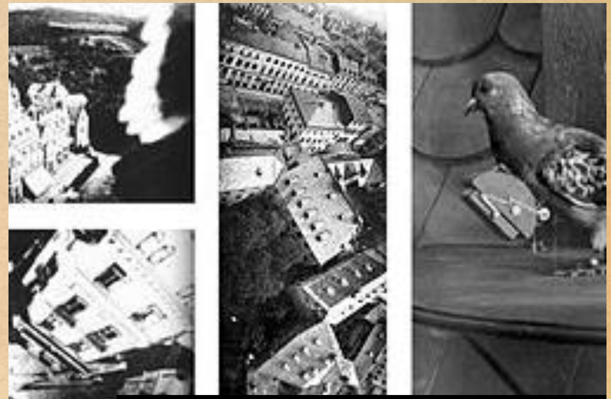
- In 1849, Aimé Laussedat (April 19, 1819 - March 18, 1907) was the first person to use terrestrial photographs for topographic map compilation. He is referred to as the "Father of Photogrammetry".

- In 1862, Laussedat's use of photography for mapping was officially accepted by the Science Academy in Madrid. He also tried balloon photography and is the first person to have captured an image from balloons, but deserted it because of the difficulty of obtaining a sufficient number of photographs to cover all of the areas from one air station.



- The English meteorologist E. D. Archibald was among the first to take successful photographs from kites in 1882.

- Pigeon photography is an aerial photography technique invented in 1907 by the German apothecary Julius Neubronner. A homing pigeon was fitted with an aluminum breast harness to which a lightweight time-delayed miniature camera could be attached.



Fundamentals of Photogrammetry

- The fundamental principle used by photogrammetry is triangulation. By taking photographs from at least two different locations, so-called “lines of sight” can be developed from each camera to points on the object. These lines of sight are mathematically intersected to produce the 3-dimensional coordinates of the points of interest.

Parallax

- You might observe that objects seem in different places if you close one of your eyes. The displacement of an object caused by a change in the point of observation is called Parallax. Stereoscopic parallax is caused by taking photographs of the same object but from the different point of observation. Change in position of an image from one photo to the next is caused by aircraft's motion.

Two important aspects of stereoscopic parallax:

Parallax of any point is directly related to the elevation of the point

Parallax is greater for high points than for low points

Stereopair

- The three-dimensional view which results when two overlapping photos (called a stereo pair), are viewed using a stereoscope. Each photograph of the stereo pair provides a slightly different view of the same area, which the brain combines and interprets as a 3-D view.
- the photographs are usually taken by a series of a parallel passes called flight strip. Photographs are normally exposed in such a way that the area covered by each successive photograph along a flight strip duplicates or overlaps part of the coverage of the previous photograph.

- This lapping along the flight strip is called **end lap** and the area of coverage common between two adjacent pairs of photographs called in a flight strip is called stereoscopic overlap (end lap).

Types of Photogrammetry

- **Aerial Photogrammetry** : The camera is mounted in an aircraft and is usually pointed vertically towards the ground with the camera axis vertical or nearly so. Many photographs are taken with the overlapping concept. Later the processing of these photographs is done using stereo-plotter. These photos are also used in automated processing for Digital Elevation Model (DEM) creation.

- ***<u>Terrestrial Photogrammetry</u>*** : Photographs are taken from a fixed, and usually known, position on or near the ground and with the camera axis horizontal or nearly so. The position and orientation of the camera are often measured directly at the time of exposure. The instrument used for exposing such photograph is called photo theodolite.

- ***Space Photogrammetry*** *:In* this branch of photogrammetry, the satellites are used to take photographs. With the development of modern-day satellite, a global coverage of satellite imageries is possible in lesser time with a high-resolution data.

- **Interpretative Photogrammetry** : Under this process, the images are studied and identification is done for judging their significance with systematic and careful analysis.

- **Metric Photogrammetry** : know the relative location of a point the precise measurement is done on the photographs. Planimetric mapping and topographical mapping are the best examples of this.

Aerial Triangulation

- Aerial Triangulation(AT) represents the mathematical process of establishing precise and accurate relationships between the individual image coordinate systems and a defined datum and projection (ground).
- The main objective of aerial triangulation is to produce from ground control, sufficient points in the photogrammetric models to ensure that each model can be oriented accurately as required for stereo compilation in either orthophoto or line mapping.

There are mainly three stages of aerial triangulation:

- Preparation

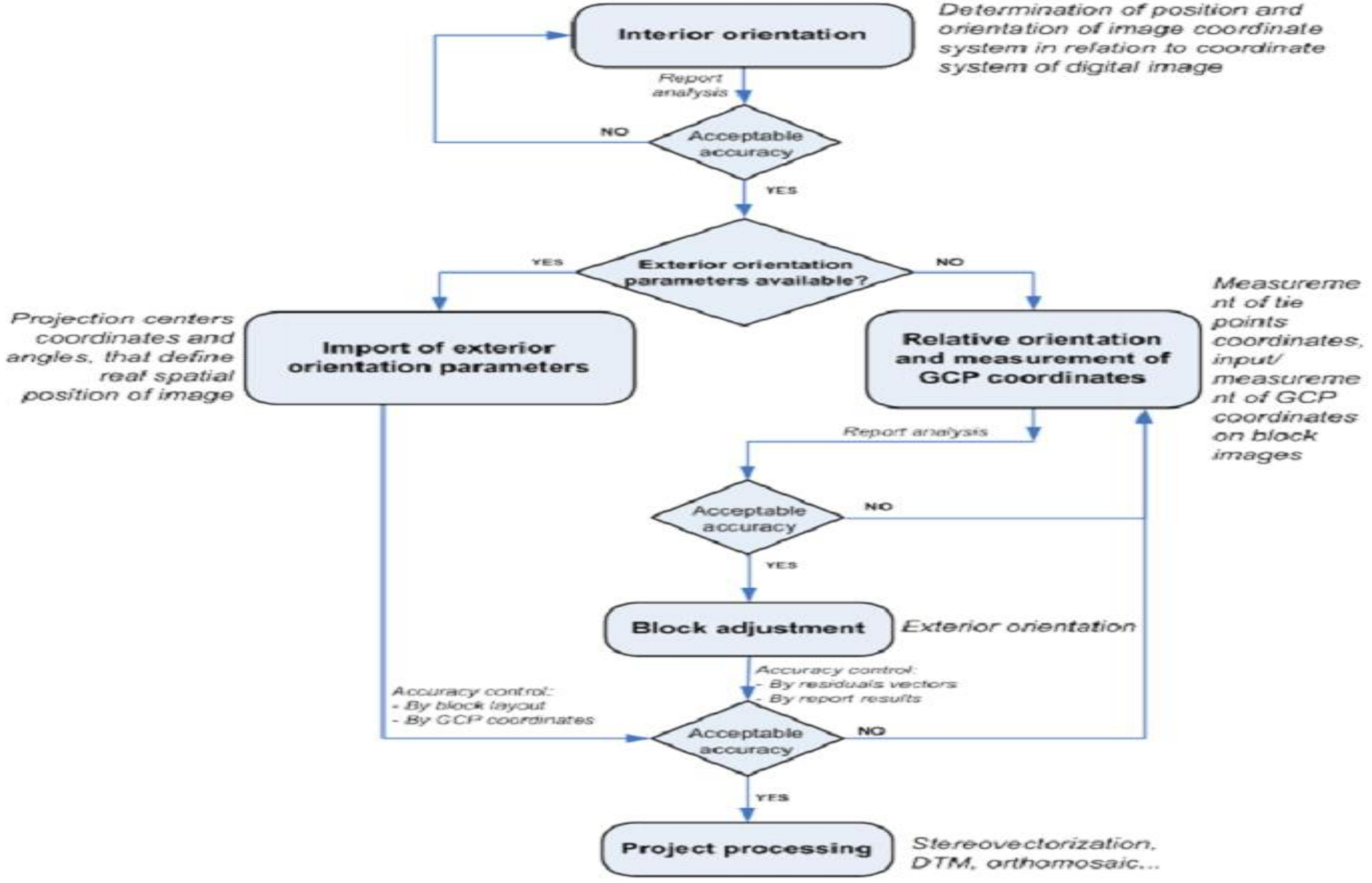
- Point identification of ground control
- Numbering settings for points, images and strips
- Input data: flight details (photo coordinates plus omega, phi and kappa rotation), camera calibration and scanned or digital images

Image Measurement

- Interior orientation (fiducial marks measurement for analogue cameras)
- Automatic tie points determination using images pyramid levels
- Ground control points measurement
- Manual tie points measurement if necessary (in cases where automatic measurement could not determine an acceptable number of tie points per image or in failure situations.

Block Adjustment

- The input of observations (x, y, z coordinates or GPS/IMU, ground control) and initial parameter values.
- Preliminary data processing, including generation of initial values for bundle adjustment parameters.
- Interactive solution (including specials algorithms for determination of blunders and error propagation)
- Acceptance of results (after accuracy and reliability assessment)
- The final output of results (EO data)



Interior orientation
Determination of position and orientation of image coordinate system in relation to coordinate system of digital image
Report analysis
Acceptable accuracy
NO
YES
Exterior orientation parameters available?
YES
NO
Import of exterior orientation parameters
Projection centers coordinates and angles, that define real spatial position of image
Relative orientation and measurement of GCP coordinates
Measurement of tie points coordinates, input/ measurement of GCP coordinates on block images
Report analysis
Acceptable accuracy
NO
YES
Block adjustment
Exterior orientation
Accuracy control:
- By residuals vectors
- By report results
Accuracy control:
- By block layout
- By GCP coordinates
Acceptable accuracy
NO
YES
Project processing
Stereovectorization, DTM, orthomosaic...

How Aerial photographs are differ from Orthophoto maps?

- **Perspective :**
- One main difference between an aerial photo and an orthophoto map is that an aerial photo shows perspective. The photographer can tilt the camera up and down to give the photo's viewer a sense of scale and height. An orthophoto map corrects for any camera tilt and removes any sense of perspective. For example, in an aerial photo a photographer can make skyscrapers look tall, but in an orthophoto map, they all look the same size -- you just see the building's roof from directly above.

- Scale :
- While creating an orthophoto the effect of camera tilt and terrain relief is removed. Both these items distort the map's scale. By removing these effects, a map has a uniform scale.

- Base Map :
- Unlike an aerial photo a cartographer can overlay additional information on an orthophoto map. Orthophoto can be used as a background image in GIS and useful in creating base maps

- Use :
- An orthophoto gets used as either a map or in combination with GIS, an aerial photo gets used more when the photographer wants to show a different perspective of the Earth.

Application of Photogrammetry

- To prepare planimetric topographical maps (Surveying/mapping)
- To determine the space position of ground objects
- Creation of Digital Terrain Models (DTM)
- For acquisition of military intelligence (Military/artificial intelligence)
- To classify soil (Forestry/agriculture)
- For the interpretation of geology (Geology/archaeology)
- Assessment of crop damage due to floods or other natural calamities
- To prepare a composite picture of ground
- To relocate existing property boundaries
- In the field of medicines and many more

Problems with Data

Distinct Phenomena can be confused if they look the same to the sensor, leading to classification error.

Example: artificial & natural grass in green light (but can be esily identified with infra red)

Expensive for small areas, particularly for one time analysis

Requires specialised training for analysis of images.

Nadir & Oblique Positions

- Using drones for analyses includes many steps such as
- flight planning,
- a ground control points survey, georeferencing,
- image acquisition,
- calibration of the camera and image processing.

Nadir & Oblique Positions

- UAV surveys usually use **nadir photography**, which means that the images are shot with the camera axis straight below in a vertical position.
- UAV surveys usually use Oblique Photography, which means that images are shot an axis titled at an angle with respect to vertical
- With both methods 3D clouds are calculate different measurements.

View tips for collecting high-quality images

- Altitude and speed : Altitude and speed must be properly balanced to produce high-resolution imagery. Gathering data from a lower altitude allows for more detail, however, aircraft must travel slowly and steadily enough to create low altitude images without distortion and blurriness.

- The ideal speed and altitude will change depending on the drone model, camera hardware, or even the chosen landscape. In order to suss out the best combination for a project, it’s best to conduct test runs and work with a seasoned professional.

- Also, remember that altitude is defined as the distance above an object of interest, and that may vary throughout the drone flight depending on the height of buildings or landscape features. You will want flight control software that can adjust to different heights with a distance-to-subject ratio rather than distance-above-sea-level settings.

View tips for collecting high-quality images

- **Image angles** :In order to get orthoimages that easily normalize for uniform processing, the camera should be pointed straight down from the nadir (in drone-based photogrammetry, the nadir describes a perpendicular field of view to the ground or object).
- Images taken from an oblique angle will show a slightly different angle than other images in the data set. This causes distortion in the final orthomosaic map, which reduces accuracy and limits the potential for measurement and analysis.
- To avoid non-nadir images, it's important to plan your flight with turns in mind. Don't use images taken during takeoff or landing, and stop image collection while reorienting on the flight path.

View tips for collecting high-quality images

- **Camera settings** :When it comes to camera settings, test and test again; default settings aren't always the best configuration for aerial photos. Subtle miscues in contrast, aperture, shutter speed, and ISO can introduce distortion that is difficult to correct (and may impact your data).
- The right camera settings may change depending on the time of year, the time of day, and the weather, all of which can affect color and shadow in images. Overcast days with light cloud cover tend to produce good-quality images.

View tips for collecting high-quality images

- **Image overlap** :Image overlap is necessary for creating highly detailed orthomosaic images with no gaps in visual or data continuity. The more overlap, the more data is collected for the software to include in a composite map — and the more detailed and accurate the map will be.
- When planning your drone flight, aim for at least 70% image overlap. Some projects will require more detail and less distortion to be effective, in which case 80% or 90% overlap may be needed. For less detailed maps and models, 60% may be adequate. Be sure to weigh the cost of extra drone coverage against the detail necessary when setting your flight plan.
- Keep in mind that older or weaker software may get bogged down when processing an excess of images, which can drastically slow down processing time. For highly detailed maps, software choice (which we cover below) is especially important. You don't want to end up manually choosing which photos to upload in order to move the process along.

What is metadata?

- Metadata is a series of data-encoded notes collected alongside orthoimages to provide additional context for mapping and modeling software. Metadata may include:
- GPS coordinates
- Time/date
- Focal length
- Resolution settings
- Atmospheric conditions
- And more
- Metadata will tell users the conditions in which the data set was created and who created it, both of which offer valuable information for building a uniform scale and perspective.