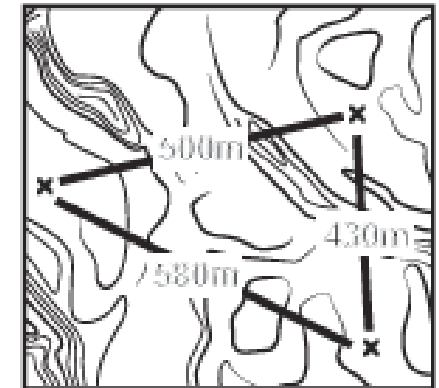


Photogrammetric Ground Control

Ground control point



Georeferenced map



Accurately surveyed ground control points are used to georeference orthomosaic maps produced from UAV imagery.

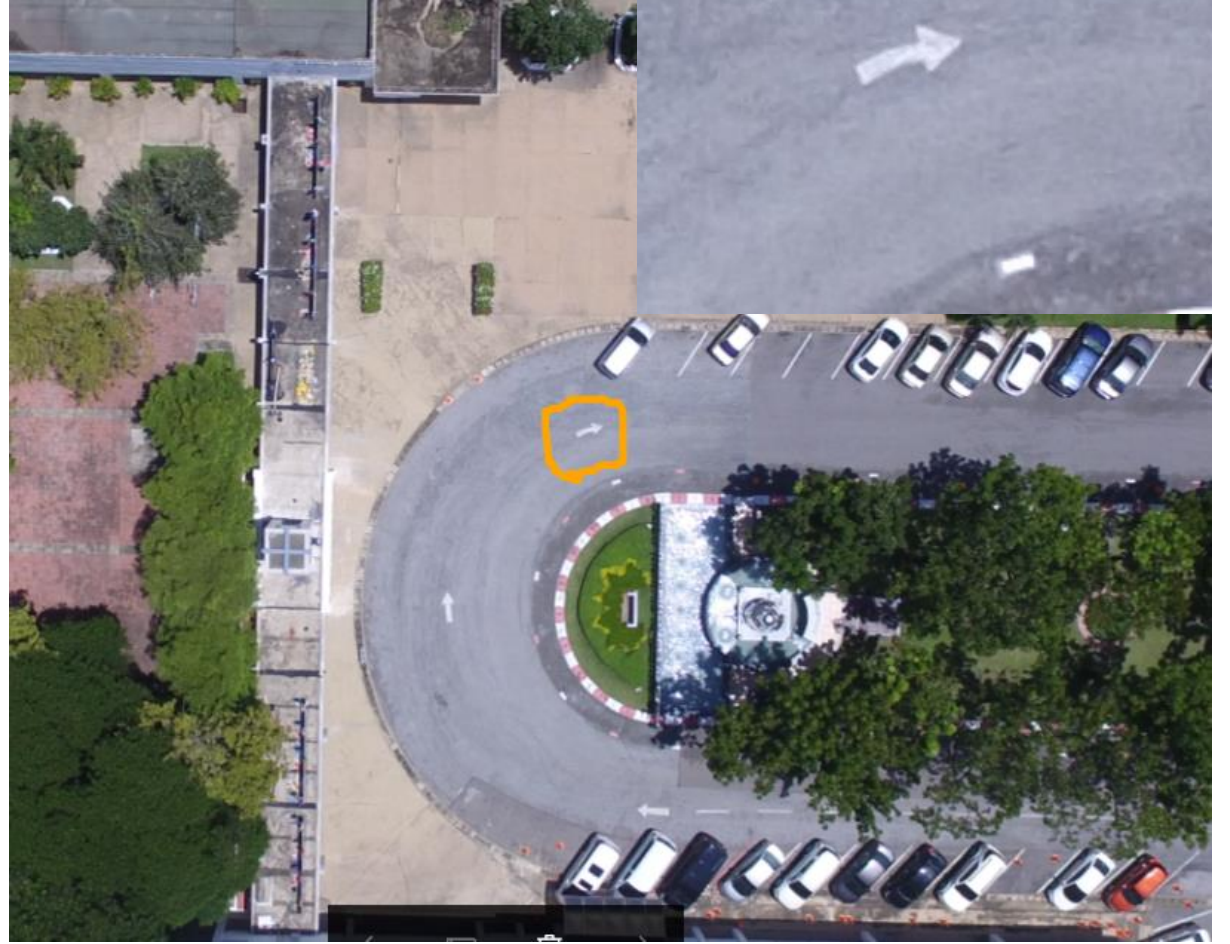
Ground Control Points (GCPs)

- GCP is any point whose positions are known in an object-space reference coordinate system and whose images can be positively identified in the photographs.
- Used for
 - Geo-referencing products
 - Accurate determination of processing parameters (intrinsic & extrinsic)
- The accuracy of finished photogrammetric products can be no better than the ground control
- 3 Types – w.r.t measurement
 - Horizontal Control Points
 - Vertical Control Points
 - **Full Control Points**

Ground Control Points (GCPs)



Ground Control Points (GCPs)



Direct Geo-referencing

- The images taken from drones are geotagged. (or separate log file is provided)
- Photogrammetry software packages, such as PIE-UAV, can function without GCPs. Instead they use GPS data collected by a GPS logger or by a GPS-enabled camera to create a reasonably geographically accurate image.
- However aiding the model with accurate GCPs can increase the accuracy up to sub meter level

Task: Examine exif metadata in a image

Why GCPs are Important

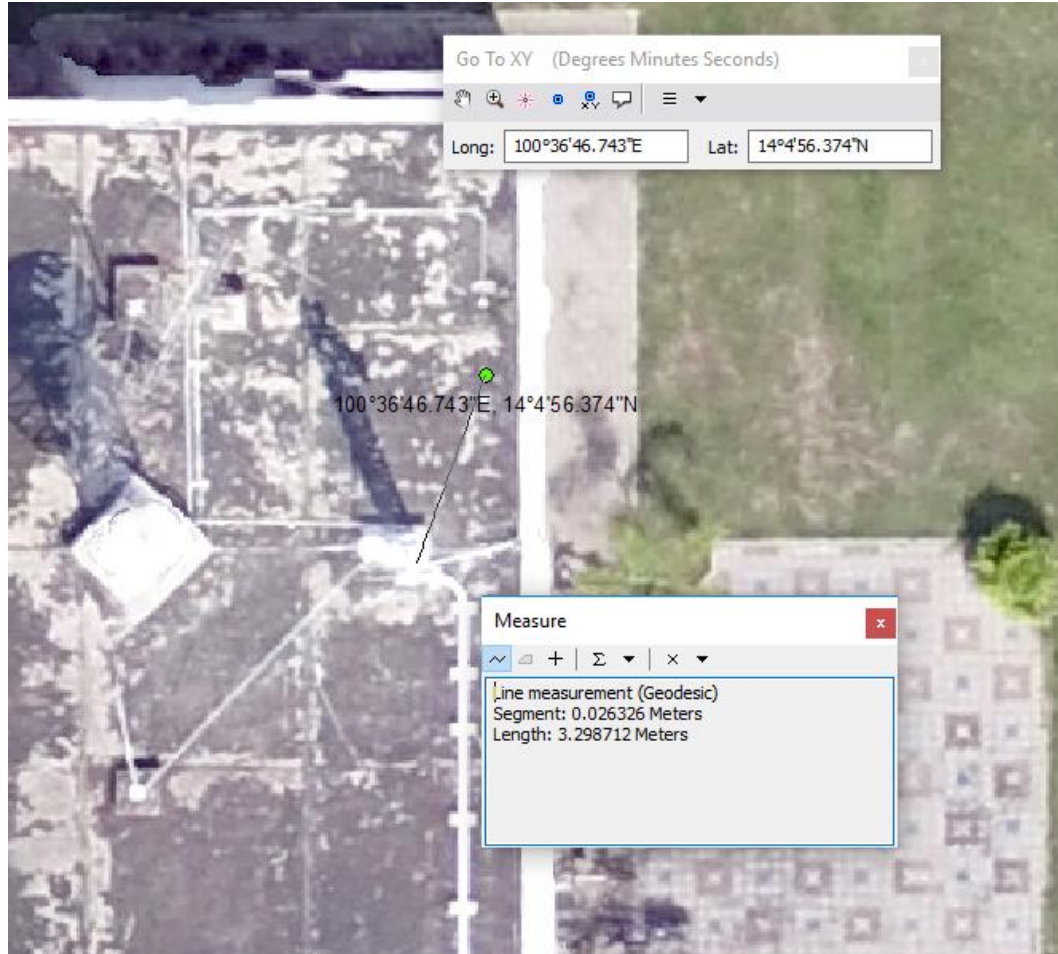
Direct
Georeferenced
No GCP



Georeferenced
with GCPs



Why GCPs are Important



Direct Georeferenced
No GCP



Georeferenced with GCPs

Why GCPs are important



Distance AB

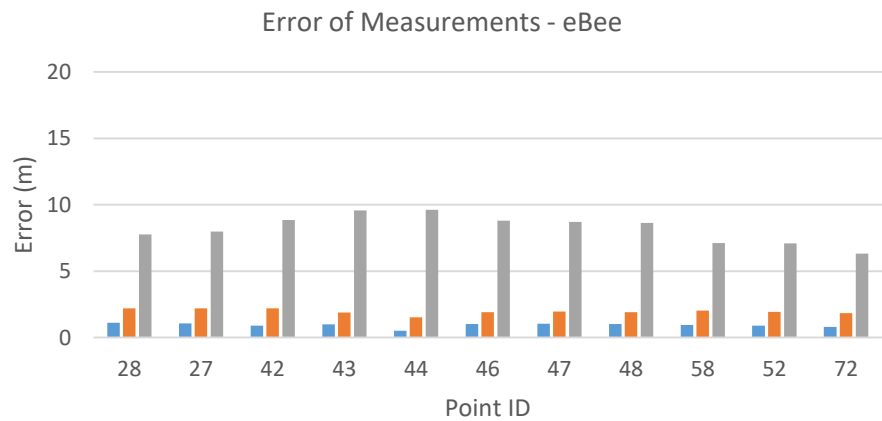
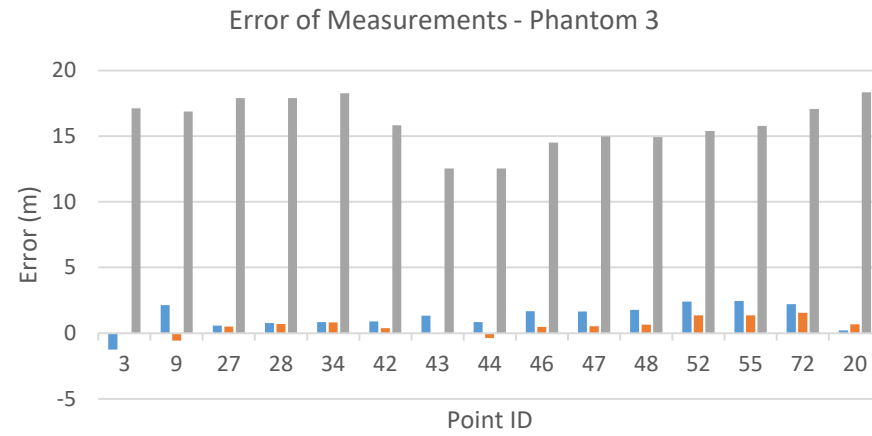
Georeferenced with GCP = 707.4m

Direct Georeferenced = 708.6m

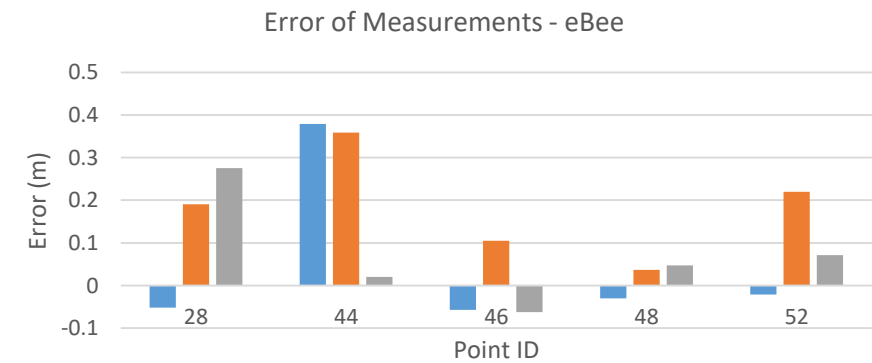
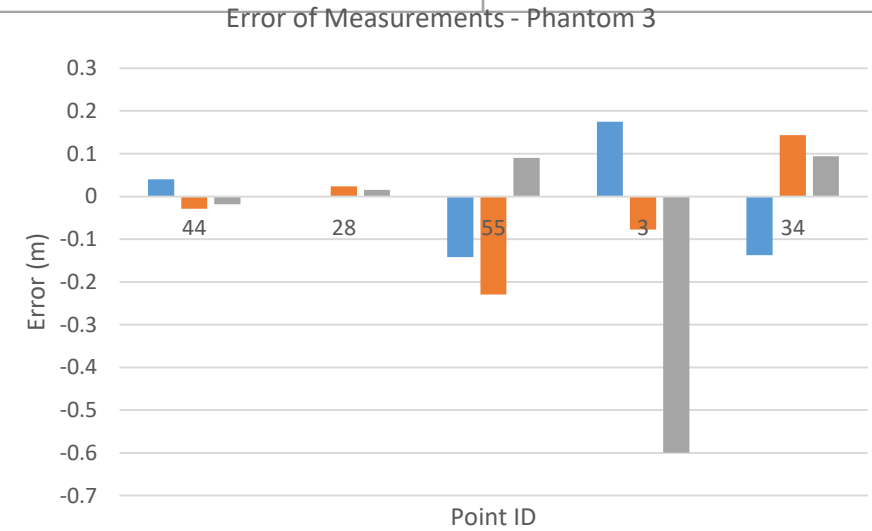
Difference = 1.2 m

Geo-Location accuracy

	Without GCP		With GCP	
	Planimetric Accuracy (m)	Height Accuracy (m)	Planimetric Accuracy (m)	Height Accuracy (m)
Phantom 3	1.750	16.098	0.174	0.275
eBee	2.187	8.283	0.274	0.132



■ Easting ■ Northing ■ Height



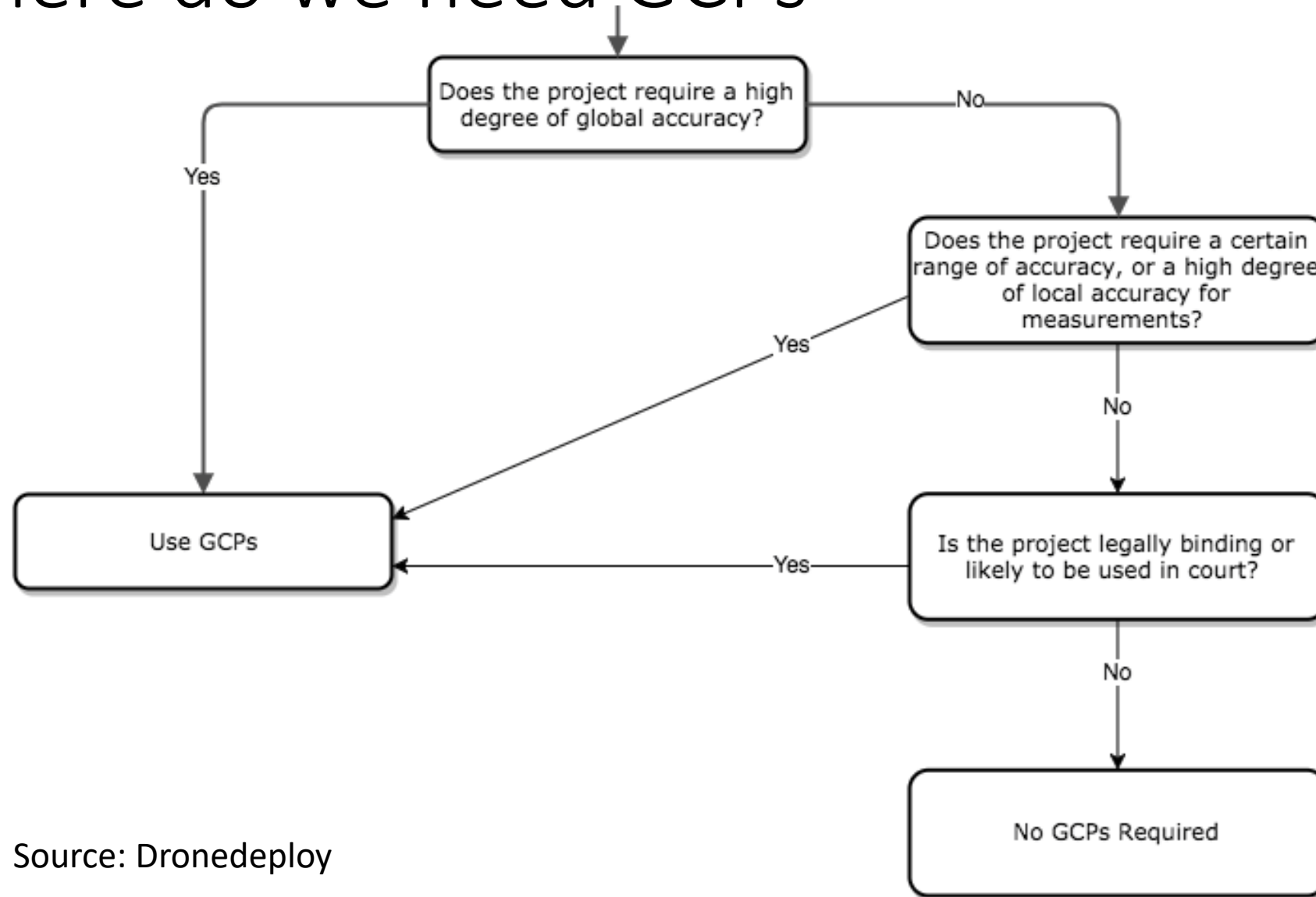
■ Easting ■ Northing ■ Height

Where do we need GCPs

- Ground control is essential when you need **High Global Accuracy** (in other words Absolute Accuracy)
- GCPs are needed when you need products to certain range of accuracy
- They are required to Verify the Accuracy.

Global Accuracy = Correspondence of map with the real world location w.r.t a fixed coordinate system

Where do we need GCPs



Source: Dronedeploy

Where do we need GCPs

- Applications
 - Mapping the terrain - Contour Map / DTM / DSM
 - Civil Engineering Construction Project design
 - Property boundary survey
 - Land title surveys
 - Insurance assessments
 - Large volume measurements
 - Volume measurements: When Contracted to provide measurements within a certain range of accuracy
 - General liability

Where GCPs can be omitted

- When the area is small and **only relative accuracy is important**; you can omit GCPs

Relative Accuracy: Correspondence of the map locations relative to the other locations of the same map

Where GCPs can be omitted

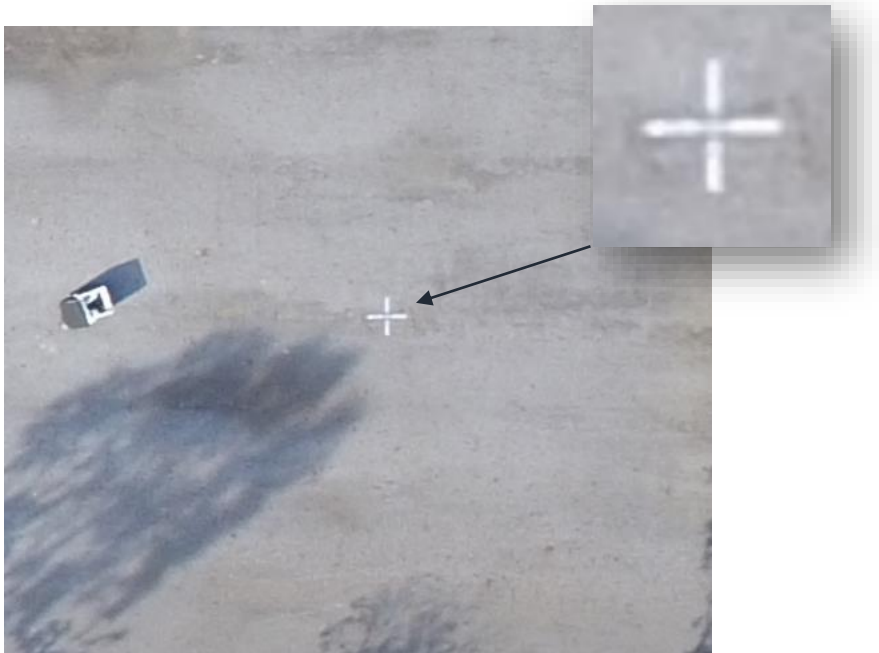
- Application
 - Flood monitoring
 - Forest fire monitoring
 - Small scale area measurements
 - Small scale volume measurements
 - Construction progress monitoring and management
 - Crop monitoring
 - 3D modelling
 - Visual inspection of powerlines/buildings

Establishing GCPs – Factors to be considered

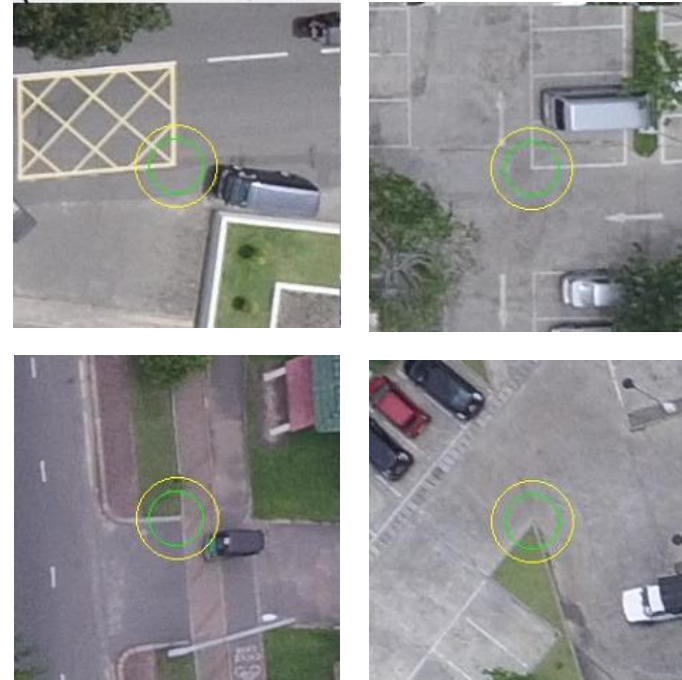
- Accuracy Requirement of the task
 - As a general rule of thumb, photo control should contain error no greater than one-third the horizontal map accuracy
- Type of equipment and field techniques
- Budget
- Terrain Condition and GCP distribution

Ground control design

- GCPs must be
 - sharp, well defined, and positively identified on all photos
 - must lie in favourable locations in the photographs



Artificial GCPs

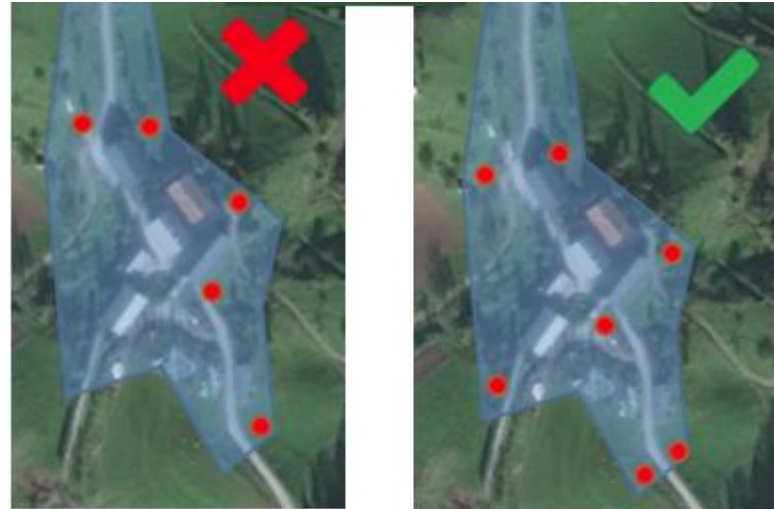
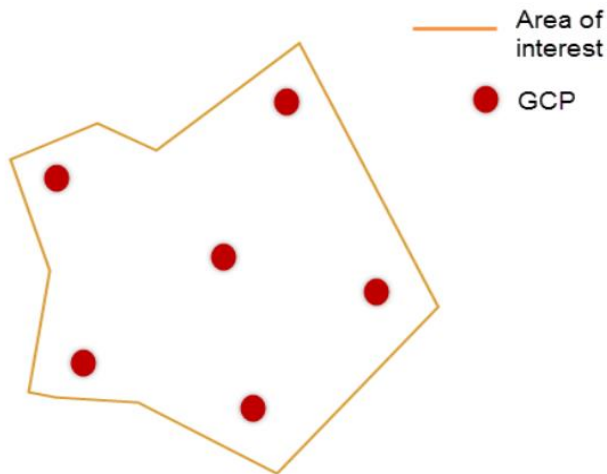


Natural GCPs

Ground control design

Placement of GCPs

- Should be placed homogeneously in the area of interest.
- 5 to 10 GCPs are usually enough, even for large projects. More GCPs do not contribute significantly to increasing the accuracy. It is recommended to place one GCP in the centre of the area in order to further increase the quality of the reconstruction. A minimum number of 5 GCPs is recommended.



Ground control design

Placement of GCPs

- Terrain variations should be considered. If the terrain is undulated, GCPs are needed distributed in the undulated features. (Ex: Ridges and Valleys) to get required height accuracy
- In cases that the topography of the area is complex, then more GCPs will, indeed, lead to better more accurate reconstruction.



Artificial & Natural GCPs

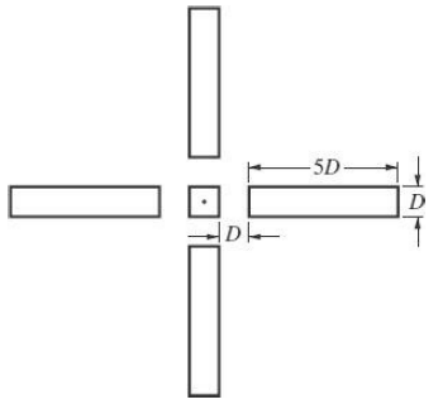
- Natural GCPs Sometimes misidentified



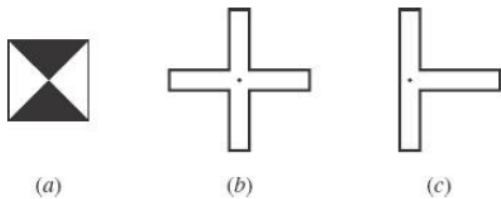
- Artificial markers' unique appearance makes misidentification of artificial targets unlikely
- Disadvantages of artificial targets are that extra work and expense

Design of Artificial Markers for GCPs

- Main elements in target design
 - Good colour contrast – Dark background; light target
 - Symmetricity
 - Target size - yields a satisfactory image on the resulting photographs

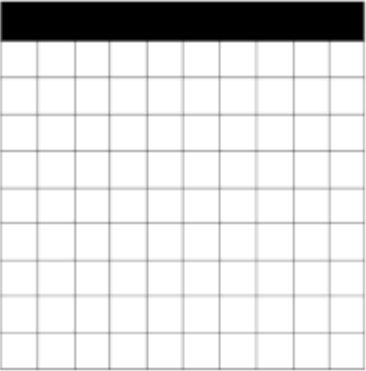


Artificial photogrammetric target.



Other common artificial targets.

This design is termed as optimum design for GCPs in aerial mapping



What makes GCPs bad

- **Obstacles:** Don't put GCPs under a tree
- **Clustered Distribution**
- **Edges:** If the GCPs located in the edge of the surveyed area, there will be no adequate images to mark them
- **Movement:** when GCPs are underweighted or placed in unsecured places
- **Size:** Too large or Too Small
- **Not Flat Surface**

Exercise

- Design artificial target to optimum dimensions for 5 cm/px GSD

Field Survey for Photogrammetric GCPs

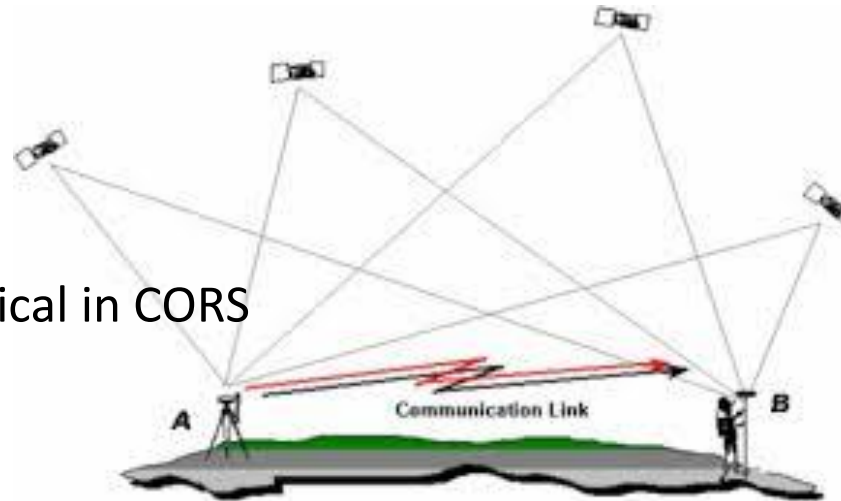
- Traditional Methods

- Theodolite Survey and Levelling
- Total Stations : Accuracy 1.5 mm



- Common Methods

- GNSS Methods
 - 8 mm horizontal 15mm vertical in CORS
 - 1cm accuracy in RTK



GCP Innovations

- Smart GCPs : <https://www.propelleraero.com/aeropoints>

Introducing AeroPoints

The world's first smart ground control points

WIRELESS CONNECTIVITY

One-button activation lets you use a wifi connection or a mobile hotspot to upload position data.

FULLY SOLAR POWERED

With a powerful solar panel, AeroPoints will never run out of batteries while capturing position data.

EXCEPTIONAL DURABILITY

AeroPoints are waterproof, shock and weather resistant. Their LiFePO₄ batteries are high temperature, impact, puncture and aviation safe.



INCREDIBLE ACCURACY

Inbuilt PPK gives you global/absolute accuracy down to 2cm.

VISUAL GROUND CONTROL

Our tested checkerboard pattern is visible from the air and won't blow out on overexposed photos

SPEED & INTEGRATION

Our processing servers will have precision points ready - usually just minutes after uploading.

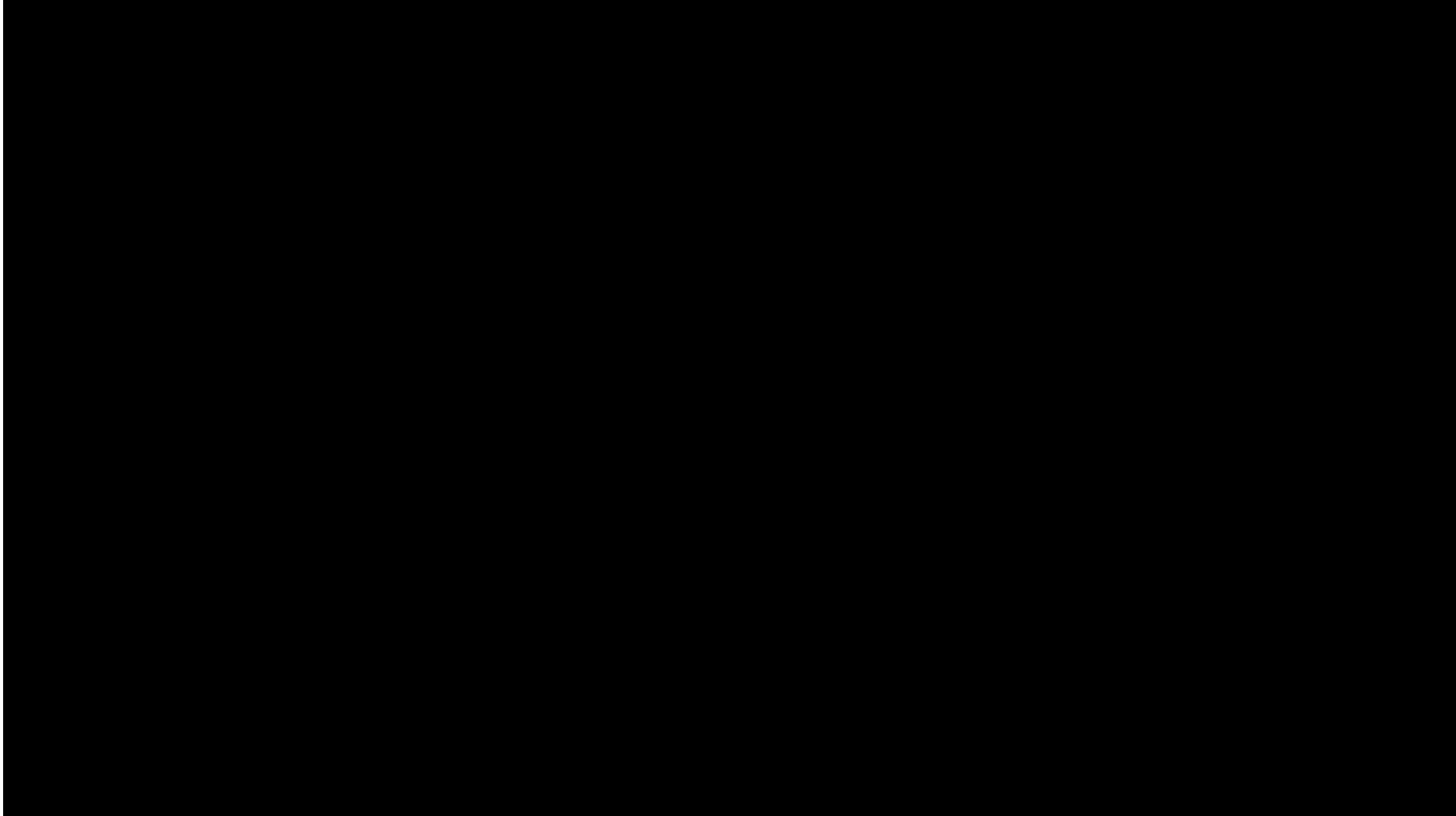
GCP Innovations

- Smart GCPs : <https://www.propelleraero.com/aeropoints>

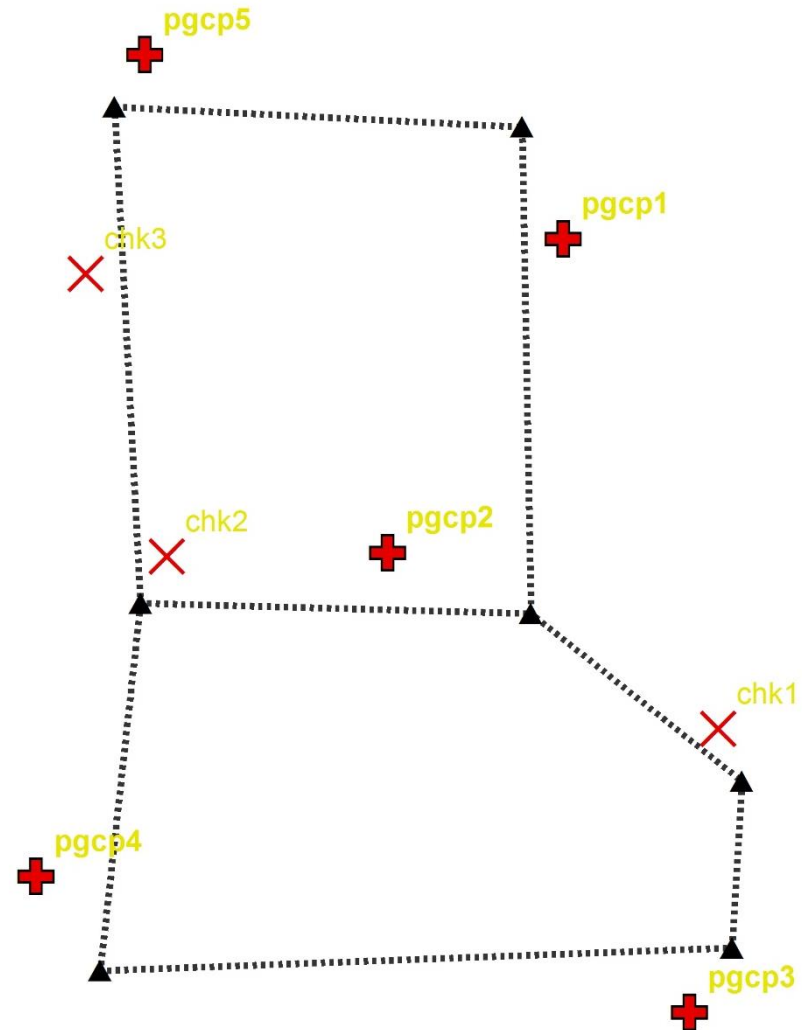


GCP Innovations

- OneButtonSurvey: <https://www.epocdronesurvey.com/>



Total Station survey to establish GCP



Total Station survey to establish GCP

- Very High Accuracy
- Ability to perform remote measurements
- Appropriate for projects which is small in area and require very high accuracy – Ex: Accurate 3D model of building
- Time intensive and high labour cost
- Need at least 3 known points to georeferenced to a world coordinate system

GNSS for GCP establishment

- Most convenient way to establish GCPs
- cm level accuracy with RTK/PPK

- GNSS survey cost??
- What types of GNSS units to be used?

To be contd.....