MapEO GCP measurement procedures

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About this document

This document lists Ground Control Point measuring standards for MapEO phenotyping missions. It contains the details of the equipment to use and the procedures to place, measure and maintain the GCPs in the field.
This document is part of the 'MapEO Academy procedures', a series of operational procedures to enable our clients and partners to take full control of their drone-based phenotyping work and to ensure a smooth transition into their operations.

Symbols

The warning symbol appears in this document, urging the user to pay more attention to any actions or checks.

References

MapEO reference documents are listed in Table 1

RD1	MapEO Academy - phenotyping - flight procedures RGB
RD2	MapEO Academy - phenotyping - flight procedures MSP
RD3	MapEO Academy - phenotyping - product overview
RD4	MapEO Academy - phenotyping - product ordering procedures
RD5	MapEO Academy - phenotyping - data analysis procedures

Table 1: MapEO reference documents

Document change record

Version 2.2
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Added disclaimer

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Version 1.0
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Initial version

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LIST OF ABBREVIATIONS

EPSG	European Petroleum Survey Group
GCP	Ground Control Point
GNSS	Global Navigation Satellite System
NTRIP	Networked Transport of RTCM via Internet Protocol
PPK	Post Processed Kinematic
RTK	Real Time Kinematic

1. INTRODUCTION

1.1 What is MapEO?

MapEO is a drone-based high-throughput phenotyping solution for research and breeding. Our online platform gives **plant breeders, researchers and agricultural site managers** a more complete and objective view on experimental field trials of any size:
https://mapeo.vito.be/en

1.2 What is phenotyping?

Plant phenotyping is the study of plants in outdoor field experiments. Small patches (plots) of plants are sowed in regular gridded patterns and studied for many traits like emergence, height, flowering, disease, senescence and yield. With drones we fly over these fields and assist in measuring these traits with Imaging techniques. Although such an experimental field may look like an ordinary agricultural field, every Inch Is closely managed and monitored. That Is why at NO circumstances a drone Pilot Is allowed on field without proper Instruction of the local site manager. This site manager will Indicate where to and where not to walk as we want to avoid stepping on experimental plant material on any time. More: https://emphasis.plant-phenotyping.eu/Plant_Phenotyping

1.3 What is the MapEO Academy?

The MapEO Academy aims at providing a series of operational procedures to enable companies to take full control of their drone-based phenotyping work and to ensure a smooth transition into their operations.
Procedures are classified into different ‘modules’, dedicated to specific activities and roles, as shown in Table 2.

Module	Document	Who
Phenotyping products	MapEO Academy - Phenotyping - product overview	Coordinator
Ordering procedure	In preparation	Coordinator
GCP measurement	MapEO Academy - GCP measurement procedures	Surveyor & Site Manager
Flight procedures and quality check	MapEO Academy - Phenotyping - flight procedures RGB MapEO Academy - Phenotyping - flight procedures MSP	Pilot
Data analytics	In preparation	Data analyst

Table 2: MapEO Academy documents

2. ROLES AND ACTIVITIES

2.1 In general

The following roles/activities have been identified for the partners in general:

VITO: Main contractor responsible to deliver end products and image analytics to the customer. Provides drone mission details and procedures towards the drone pilot and/or drone coordinator.

Drone coordinator @customer: Day-to-day management of drone (UAS) operations and legal registration of drone (UAS) operations and insurance. Orders new drone products at the MapEO platform, provides the drone mission details to the local drone provider and manages the day-to-day planning with communication from both the drone operator/surveyor and site managers.

Pilot @customer: Performs the drone missions and communicates with the drone coordinator & local site manager on the exact timing of the operations.

Surveyor @customer: Places the Ground Control Points (GCP) in the field, measures their exact location and sends these measurements to VITO in the proper format.

Site manager @customer: A site manager is the responsible of the experimental field. He/She can define the exact location of the field, the position of the GCPs and the access points to the field. This site manager can be employed by the customer itself or by a third-party organization and should be contacted prior to any field visit (surveying or drone flight).

2.2 More specific

2.2.1 Specific role of site manager

- The site manager is responsible to securely place the GCPs according to the instructions in section 4 GCP placement.
- The site manager is responsible to accompany the surveyor in the field to show the exact location of the GCPs.
- The site manager is responsible to maintain the GCPs throughout the growing season, until they are removed again from the field. Especially before every drone flight the GCPs should be checked according to the instructions in section 4 GCP placement.

2.2.2 Specific role of surveyor

- The surveyor should contact the site manager to arrange for the measurement of the GCP positions.
- The surveyor measures the GCP positions according to the instructions in section 5 GCP measurement.
- The surveyor sends the GCP position info to VITO according to the instructions in section 5 GCP measurement.

2.2.3 Specific deliverables of surveyor

- Text file with coordinates and accuracy indication of all GCPs, as described in section 5 GCP measurement.

2.2.4 Specific role of Drone coordinator

- The drone coordinator, which has access to the MAPEO platform, will ingest or updates the GCP information based on the text file with GCP coordinate send by the surveyor. In case the field boundaries are not yet finalized, the drone coordinator will finalize the boundaries. After this, the first missions can be uploaded by the drone pilot

2.2.5 Specific timings for Surveyor, Site manager and VITO

Timing	Action
X - 10d	The surveyor contacts the site manager and communicates the provisional survey date. The site manager places the GCPs.
X - 10d	The surveyor and site manager go to the field and measure the position of the GCPs.
X - 9d	The surveyor sends the GCP coordinates file to the Drone coordinator.
X- 5d	VITO updates the field boundaries and GCP coordinates in the MapEO platform.
X	The Pilot flies the first mission. If the mission cannot be performed during that time range, the mission may be rescheduled

Table 3: Timing of activities

3. EQUIPMENT DETAILS

3.1 Ground Control Points

The ground control points should be flat banners of at least 0.5m*0.5m, with holes at the 4 corners to securely place them in the ground. Tent pegs or root cloth ground pegs can be used to pin them down to the ground. GCPs should be purchased by the customer/site manager.

Figure 1: Proper GCP banners and ground pegs

Figure 2: Improper GCP markers

3.2 GNSS receiver

The GNSS receiver should be able to record GCP coordinates with cm-level accuracy.
To obtain this level of accuracy, you need to use a dual-frequency receiver.
Furthermore, GNSS data should be differentially corrected either in real-time or in post-processing, i.e. the GNSS receiver should be capable of RTK correction using correction data received either from a base station nearby or a virtual reference station, over radio or from a NTRIP provider, or the GNSS receiver should log raw GNSS observables for use in PPK correction (done by the surveyor before sending the GCP coordinates to the drone coordinator).

A measurement pole should always be used to ensure good placement of the central position of the GNSS.

© https://metricaltalks.com/

Figure 3: Positioning the GNSS receiver

3.3 (Robotic) total station

To determine an absolute location of ground control points, a total station requires line of sight observations with a reflector pole held at the GCP locations while the total station itself is set up over a known point, or by making use of 2 line of sight observations with known points before proceeding to measure the GCPs. A typical total station can measure distances up to 1500 m with an accuracy of about 1.5 mm ± 2 ppm, and therefore enables approximately 10x higher relative accuracy (coherence between the GCP measurements) than can be expected from multiple GNSS measurements only. While the absolute georeferencing accuracy of the whole block is the same as that of the reference point measurement made by GNSS, the much higher relative accuracy of total station measurements is ideally suited to process sub-cm GSD imagery to obtain pixel-level alignment between multitemporal layers.

4. GCP PLACEMENT

The ground control points (GCP) are fixed targets placed inside the area to be mapped with a drone. Based on the location of these GCPs:

- The drone flight plan is defined
- The drone image products are georeferenced with cm accuracy such that products of consecutive drone flights are aligned perfectly together.

GCPs should be spread across the whole area as uniformly as possible and should not be placed too close to the border of the area of interest
Position 1 GCP in every corner approximately between 5 to 10 meters from the boundaries and within the area of interest. Note that in case your area of interest Is not rectangular additional GCPs should be added to every corner. For an area up to 2ha: 1 GCP should be positioned in a central position and 1 at a random position within the area of interest as far as possible from any other GCP. 1 additional GCP should be placed for every additional hectare. Examples of positioning the GCPs are given in Figure 4.

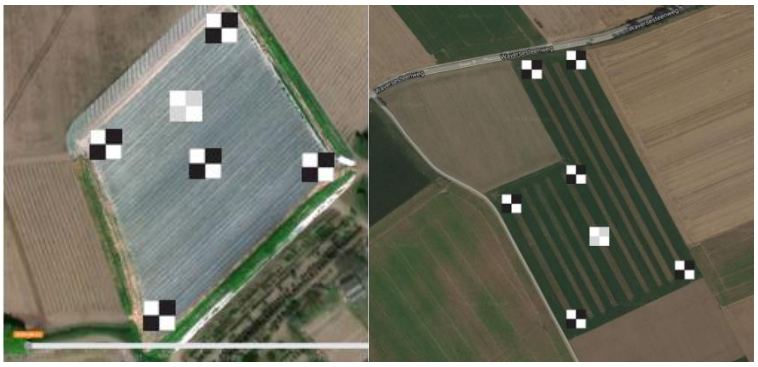

Figure 4: Positioning the GCPs

Before every drone flight, the GCPs should be checked by the site manager to see if they are

- still at the same location
- clean (no dirt!!)
- free from any plant material

Situations as shown in Figure 5 are not acceptable.

Figure 5: Poor visibility of GCPs

Important note for the site manager:

GCPs need to stay at the exact same location throughout the crop growing cycle. Carefully select this location such that they experience minimal (mechanical) movement. Before every drone flight, inspect the GCPs and remove any surrounding plants.

In case GCPs need to be placed <10m from each other, it can become difficult to distinguish them from each other. For this situation
In case GCPs need to be placed close to each other (<10m) it can confuse an operator during GCP selection step as multiple GCPs appear in one image. For this situation we advice to place a marker next to ONE of the GCPs which are close-by.

5. GCP MEASUREMENT

After placement, the GCPs are measured in the central position with an RTK GNSS receiver or (robotic) total station.
Make sure to take the altitude of the measurement pole into account during the measurement. Geolocation of each point is saved in one of the following supported projection systems:

- UTM coordinate systems with EGM96 height reference - **DEFAULT.** To know in which UTM zone you are located, you can consults following map. https://www.dmap.co.uk/utmworld.htm. In total there are 60zones in the Northern Hemisphere and 60 zones in the Southern Hemisphere. For Belgium this is for instance UTM – 31N. Every UTM zone has a unique "EPSG" code.
    - For Northern hemisphere ESPG = 326XX with XX the UTM zone (For Belgium = 32631)
    - For Southern hemisphere EPSG = 327XX with XX the UTM zone (For Madagascar = 32738)

  Next to the horizontal reference system, it's important to now the height reference system. This can be either:

  - Global Elipsoide (EPSG:4326) -> used by the raw GPS measurements, but not all GPS systems are using this.
  - Global Geoid (EPSG:5773) ->**used in eg Google Earth and DEFAULT for MAPEO**
  - Other systems

- EPSG:31730
- EPSG:4326

Go through the manual of your GPS to know in which coordinate system your device is measuring.

In case coordinates are supplied in other coordinate systems, MAPEO will convert the coordinates to the UTM coordinate systems of your zone with reference to the EGM96 geoid.

The coordinates should be stored in a csv file according to the template shown in Table 4. In the ESPG tag of the header, the EPSG reference code for both the vertical and horizontal projection system is given. Adapt it according to your situation. This file with coordinates should be send towards the drone coordinator for final definition of the area of Interest and processing activities. The surveyor should store the original measurement file so that metadata can be retrieved afterwards if necessary, for debugging (e.g. to verify measurements had a fix solution instead of float, standard deviations, …).

```
name;x;y;z;#EPSG=32631+5773#

1;509362.9233;5639784.181;22.9567

2;509400.6921;5639798.2129;23.1014

3;509372.1706;5639819.5277;23.6486

4;509360.3004;5639838.6218;23.91

5;509377.3504;5639858.8789;23.9102

6;509341.6933;5639845.6813;24.1698
```

Table 4: GCP coordinates – csv file format

5.1 Accuracy assessment of GCPs

GCPs are the single source of reference which is used to accurately geolocate your drone products. But that doesn't mean they are 100% error free. Think about bad quality RTK correction connection, large distance to RTK base-stations, wrong handling of GPS device etc. The quality of the ground control points can now be analysed with MAPEO. In case you upload a GCP file with coordinates which are located within 1m distance from each other, the mean X,Y and Z value will be calculated and standard deviation between those point set as point accuracy. In case the accuracy is lower than 5cm, the involved GCP coordinates will not be uploaded. This feature supports users who take several independent measurements for GCPs as additional check for their positional accuracy. In practice, surveyor needs to measure the GCPs 2 or 3 times. If there

are eg 6 GCP points he will measure GCP1->2>-3->6 and again GCP1->2>-3->6. In this case the GCP coordinates file looks as follows where the differences in coordinates between the first set and second set is within the 5cm threshold.

```
name;x;y;z;#EPSG=32631+5773#

1;509362.9233;5639784.181;22.9567

2;509400.6921;5639798.2129;23.1014

3;509372.1706;5639819.5277;23.6486

4;509360.3004;5639838.6218;23.91

5;509377.3504;5639858.8789;23.9102

6;509341.6933;5639845.6813;24.1698

11;509362.9133;5639784.171;22.9667

12;509400.6721;5639798.2029;23.1114

13;509372.1806;5639819.5177;23.6386

14;509360.3304;5639838.6418;23.93

15;509377.3404;5639858.8889;23.9202

16;509341.6833;5639845.6613;24.1598
```