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 2.1
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Affected sections:
Added disclaimer

Version 2.0
Release Date 07/07/2022
Affected sections: All
New template and major update

Version 1.0
Release Date dd/mm/yyyy
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 role of VITO

- Based on the GCP coordinates file, VITO updates the field boundaries and GCPs on the MapEO platform.

2.2.4 Specific deliverables of surveyor

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

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 VITO.
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 and if needed can be provided by VITO.

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 VITO).

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

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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 50 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.

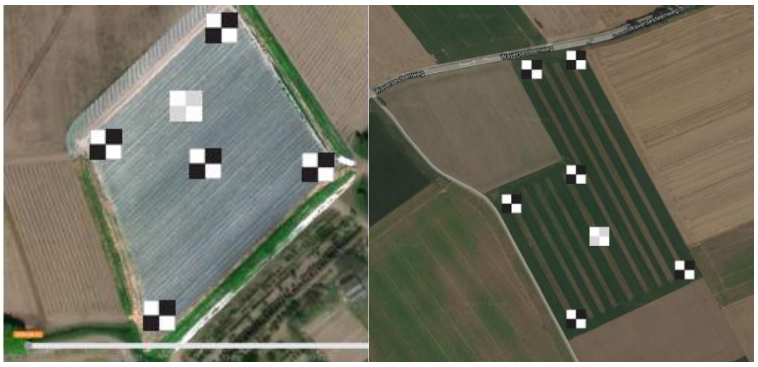

Figure 4: Positioning the GCPs

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

- still at the same location
- clean
- 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.

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 the **EPSG:4326** projection system with **ellipsoidal height** reference and stored in a csv file according to the template shown in Table 4.
This file with coordinates should be send towards VITO 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=4326#

1;3.131954511;50.89633066;26.489

2;3.131683154;50.89635411;26.4143

3;3.131059594;50.89666645;25.5026

4;3.131159196;50.89606588;26.208

5;3.132288951;50.89605195;26.3394

6;3.132202299;50.89664872;26.4506
```

Table 4: GCP position data – csv file format