

MapEO Flight Procedures - RGB



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About this document

This document lists the drone data acquisition standards for MapEO phenotyping missions. It contains the details of the equipment to use and the operations to perform before, during and after the drone flights.

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 MSP
RD2	MapEO Academy - GCP measurement procedures
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

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LIST OF ABBREVIATIONS

FOV	Field Of View
GCP	Ground Control Point
GSD	Ground Sampling Distance
KML	Keyhole Markup Language
ROI	Region Of Interest
UAS	Unmanned Aerial System

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.

Project Coordinator: Project responsible at the customer side. Orders new drone products at the MAPEO platform

Drone Coordinator: Day-to-day management of drone (UAS) operations and legal registration of drone (UAS) operations and insurance. Provides the drone mission details to the pilot and manage the day-to-day planning with communication from both the drone operator/surveyor and site managers.

Pilot: Performs the drone missions and communicates with Drone coordinator & local site manager on exact timing of the operation.

Surveyor: Places and measures Ground Control Points In the field and sends these measurements to VITO

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

2.2 Pilot specific

2.2.1 Specific role of the pilot

- The Pilot collects (from the drone coordinator) all info needed to perform the flights in accordance with the required mission specifications.
- The Pilot selects the proper equipment for the flight and makes sure that it is ready to use as described in section 3.1 "General equipment requirements".
- The Pilot prepares the flight in accordance with the instructions as listed in section 4 "Flight preparation".
- The Pilot conducts the flight in accordance with the flight Instructions as listed in section 5 "Flight".
- The Pilot performs a quality check on the acquired data, as described in section 6.1 "At the field".
- The Pilot uploads the acquired data to MapEO, as described in section 6.2 "At the office".

2.2.2 Specific deliverables of the pilot

The aerial data collected on site will be provided to VITO at the end of each single operation and uploaded by the pilot to the MapEO platform, **provided that the acquired dataset meets the quality requirements (cfr section 6.1.1)!**

Minimal quality level of the **Aerial Data**:

QC (tick)	Data to be checked
	Weather during the flight was according to the instructions
	Drone and camera used for the flight are listed in section 3.2 and 3.3 of this manual
	The Region Of Interest (ROI) is fully covered with no data gaps
	The flight path has been aligned to fly along the longest axis of the field (Figure 1)
	2 additional flight lines have been acquired outside the boundary area, to ensure enough sideward overlap within the ROI (Figure 2)
	All flight lines have been extended beyond the boundary area with 2 additional image acquisition points to ensure enough forward overlap within the ROI (Figure 2)
	The overlap is in line with the expectations
	The image resolution or Ground Sampling Distance (GSD) is according to specifications
	All images are geotagged
	Image quality (in-focus, no blur, not corrupted, taken with highest resolution)

Table 3: Minimal quality checks of the aerial data



Flight lines - Always along the longest axis of the field



Figure 1: Flight lines - alignment



Flight lines

- margin of 2 additional flight lines (sideward)
 - margin of 2 additional image acquisition points (forward)
- outside the region boundary



Figure 2: Flight lines - margins

2.2.3 Specific timings for the pilot

Timing	Action
X-minimum 48h	The Pilot checks the weather conditions and informs the Drone Coordinator and site manager about the provisional flight date.
X-minimum 24h	The Pilot prepares the flights and makes practical arrangements with the site manager on site access.
X	The Pilot performs the flight. Upon successful data acquisition, the Pilot performs a data quality check using the MapEO Field Software tool, as explained in section 6.1 "At the field". If the flight cannot be performed during the planned time range, it may be rescheduled.
X + maximum 8h	When data acquisition was successful and data quality is adequate, the Pilot notifies the Drone Coordinator that the flight has been executed.
X + maximum 24h	The Pilot uploads the acquired drone data to the MapEO platform.

Table 4: Specific timings for the pilot

3. EQUIPMENT DETAILS

3.1 General equipment requirements

When selecting the platform/sensor combination, the pilot should carefully check the received **mission specifications**, which are a combination of required sensor and required data resolution.

For RGB missions this can be:

- RGB-2-1: RGB sensor with **2mm** resolution
- RGB-5-1 RGB sensor with **5mm** resolution
- RGB-10-1: RGB sensor with **10mm** resolution

More details on supported platform/sensor combinations for each of these drone mission specs are provided in section 3.3 “Cameras”.

The equipment used for the drone flights must be in accordance with the information the pilot has communicated at the time of the flight planning.

Before performing the drone flights, the pilot will ensure that:

- the drone and associated equipment have the latest firmware available
- all the equipment (IMU, compass, etc.) has been properly calibrated before each flight

3.2 Drones

Following table lists all drones which can be used for the **RGB** flight. In case you would need to fly another drone please contact your drone coordinator and VITO contact person.








Drone	Specs	Picture
DJI Phantom4 Pro (v2)	Weight:1375g Max flight time: 30min RTK: No Camera: 20MP RGB	
DJI Phantom4 RTK	Weight: 1391g Flight time: 30min RTK:Yes Camera: 20MP RGB	
Mavic 2 pro	Weight:0.9kg Flight time:31 min RTK:No Camera: 20MP RGB	
Inspire 1	Max Weight: 3060g Flight time: 15min RTK: No Camera: X4S, X5s, XT, XT2, Micasense	
M200/M210	Max Weight: 6kg Flight time: 20min RTK: No Camera: X4S, X5s, XT, XT2, Micasense Software: DJI GS PRO	
M300	Max Weight:9kg Flight time: 55min RTK: Yes Camera: P1,XT2, Micasense	
M600	Max Weight:15kg Flight time: 15min RTK: No Camera: X4S, X5s, XT, XT2, Micasense	

Table 5: supported drones

3.3 Cameras

Following table lists all cameras which can be used for the **RGB** missions. In case you would need to use another camera please contact your drone coordinator and VITO contact person.

Note that the Horizontal Field of View (HFOV) mentioned is the across-track viewing angle, which is depending on the lens focal length.

Camera	Specs	Flight height and acceptable drone mission specs	Picture
Phantom4 pro camera	Resolution: 20 MP HFOV: 73°	36m - RGB-10-1 18m - RGB-5-1	
Mavic 2 pro camera	Resolution: 20MP HFOV: 65°	44m - RGB-10-1 22m - RGB-5-1	
Zenmuse X4S	Resolution: 20MP HFOV: 73°	34m - RGB-10-1 17m - RGB-5-1	
Zenmuse X5S	Resolution: 20.8MP HFOV: 101°/88°	<u>15mm lens</u> 44m - RGB-10-1 22m - RGB-5-1 <u>12mm lens</u> 34m - RGB-10-1 17m - RGB-5-1	
Zenmuse X7	Resolution: 24MP HFOV: 73°/52°/37°	<u>16mm lens</u> 40m - RGB-10-1 20m - RGB-5-1 8m - RGB-2-1 <u>24mm lens</u> 64m - RGB-10-1 32m - RGB-5-1 13m - RGB-2-1 <u>35mm lens</u> 90m - RGB-10-1 45m - RGB-5-1 18m - RGB-2-1	



Camera	Specs	Flight height and acceptable drone mission specs	Picture
Zenmuse P1	Resolution: 45MP HFOV: 52°	<u>35mm lens</u> 84m - RGB-10-1 42m - RGB-5-1 18m - RGB-2-1	
PhaseOne P3	Resolution: 100MP HFOV: 31°	<u>80mm lens</u> 107m - RGB-5-1 43m - RGB-2-1	

Table 6: supported RGB cameras

3.4 Software applications

3.4.1 Flight Software

Following table lists all flight software applications which can be used for the **RGB** missions. In case you would need to use another application please contact your VITO contact person.

Application name	website	OS
DJI GS Pro	https://www.dji.com/be/ground-station-pro	IOS
DJI GS RTK (*)	Built-in on the controller with integrated screen for the Phantom 4 RTK only	
Pix4D capture	https://www.pix4d.com/product/pix4dcapture	IOS & android
UGCS (*)	https://www.ugcs.com/	IOS & android + desktops
DJI pilot (2) (*) (**)	https://www.dji.com/be/downloads/djiapp/dji-pilot	IOS & android

Table 7: supported flight software applications

(*) These apps allow flight lines with a constant height above a digital terrain model layer that can be imported, which is recommended when working in hilly areas.

(**) Terrain following is only possible in DJI Pilot (2) for the DJI M300. It is not supported for the Phantom 4 RTK on the “SDK controller” running DJI Pilot. For terrain following with the Phantom 4 RTK, use the integrated controller running GS RTK.

3.4.2 MapEO Field Software



The MapEO Field Software comes with a detailed User Manual and a concise Quick Start guide. Please have a thorough review of the manual before going to the field to ensure proper use.

The MapEO field software tool is used to check if drone data acquired meets the quality requirement for further uploading and processing in the MapEO processing platform. The verification step is conducted in the field just after the drone mission and analyses data quality and coverage/completeness. More details on this assessment using the field software are provided in section 6.1.1 “Data quality checking”.

Data upload can be carried out back in the office once internet connection is available, as described in section 6.2 “At the office”.

The jar-file to install the MAPEO Field Software can be downloaded here:
<https://remotesensing.vito.be/software/uav-pc/fieldsoftware/MAPEO-Field-Software.jar>

The quick start guide to get you up and running can be downloaded here:

https://remotesensing.vito.be/software/uav-pc/documentation/generic/MapEO_field_software_Quick_Start_Guide.pdf

The detailed software user manual can be downloaded here:

https://remotesensing.vito.be/software/uav-pc/documentation/generic/MAPEO_field_software_manual.pdf



The account to access the MapEO field software tool can be obtained from your coordinator. First time login requires **Internet connection**, check this before going into the field!

In case you are performing drone flights for different MapEO customers, note that there will be a separate account for each of these customers!

4. FLIGHT PREPARATION

4.1 Flight preparation steps

During flight preparation the pilot prepares the equipment and communicates towards the site manager to ensure a smooth flight operation.

Following steps need to be followed when a drone flight is confirmed:

- Check the weather conditions and communicate to the Coordinator the provisional flight date, which is the date when the Pilot can perform the drone flight (if the conditions don't change).
- Verify whether any permissions are required for performing the drone flight, and in case of temporarily active military geo-zones, verify when flights can be performed.
- Verify whether all permissions for the drone mission have been obtained.
- Verify whether the drones and associated equipment needed for the drone mission is ready for the flight.

Following steps need to be followed at least 24 hours before each drone mission:

- Check the mission KML file which defines the area to be flown. In case it was not provided by the drone coordinator, you can download it using the MapEO field software (see note below).
- Check the elevation profile of the site. If the area is hilly perform the flight preparation with a suitable application which has a follow-terrain mode. Elevation differences can be spotted by overlaying the mission KML file on google earth.

Following table can be used as a guideline to decide whether or not to use the follow-terrain mode:

Pixel resolution	Max. terrain elevation difference
2mm	5m
5mm	7.5m
1cm	10m

Table 8: pixel resolution vs max terrain elevation difference

- Prepare the inspection in DJI Pilot, GSPro and/or any other recommended application specified in Section 3.4.1 "Flight Software". Specific details on settings for DJI GSPro and DJI Pilot are specified in section 4.2 "Flight software settings."
- Check if the flight plan can be uploaded to your drone and the drone can be armed for take-off : depending on the drone type and flight planning/control app, there may be significant limits on the number of waypoints that can be uploaded at once. If you receive a warning that the waypoint limit will be exceeded, the region of interest needs to be split in multiple zones
- Ensure that enough batteries are ready for use based on the planned flight time.
- Ensure all necessary safety equipment is available for the drone flights
- Account for any known obstacles onsite and plan the flights accordingly to ensure the full coverage of the zone ordered.
- Call the site manager to arrange the meet-up on-site. In case planning is changed (weather/no-go from site manager), notify the Coordinator and wait for confirmation for postponing the flight.

**IMPORTANT NOTE (1) on accessing the correct KML file for mission preparation**

The correct mission boundary files are stored on the MapEO servers and synchronized with the Pilot MapEO Field Software as soon as you sign in and are connected to the internet. It can be accessed on PC by typing in your windows explorer:

“%appdata%/Mapeo Field Software”

4.2 Flight software settings

Plant Phenotyping RGB - DJI GSPRO



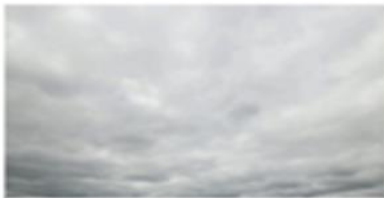
		Data Product	Plant Phenotyping (RGB)
		Flight Type	RGB
GSPro settings	General	Product Type	3D Map Area
	Basic parameters	Shooting angle	Parallel to main path
		Capture mode	Capture at Equal Distance Interval
		Flight course mode	Scan Mode
		Resolution	0.2 cm/px;0.5 cm/px;1 cm/px
	Advanced parameters	Front overlap	80
		Side overlap	80
		Gimbal pitch	-90 (nadir)
		Course Angle	Use the Course Angle to align the flight path to fly along the longest axis of the field
		Margin	Adjust such that the flight path is at least 2 flight lines outside the boundaries in all directions
		Flight lines	Area should be completely covered and extended with at least 2 flight lines at each side. This because we should at least have pictures of all GCPs from all directions! Along the longest axis of the field!
		Timing & cloud cover	From 9am – 5pm No cloud cover restrictions
	Example	<div></div> <div>Overcast: OK Blue sky: OK Changing light- OK</div> <p>Check predicted weather conditions. Following weather and timing limitations should be taken into account depending on the product type.</p>	

Table 9: Typical DJI GSPRO settings for plant phenotyping RGB flights

Plant Phenotyping RGB - DJI Pilot

		Data Product	Plant Phenotyping (RGB)
		Flight Type	RGB
DJI Pilot settings	General	Mission Type	Mapping
	Basic parameters	Smart Oblique	OFF
		Altitude mode	Relative to take-off point (ALT)
		Target Surface to Take-off	Set elevation difference between take-off and elevation at ROI
		GSD	0.2 cm/px;0.5 cm/px;1 cm/px
		Take-off Speed	Default
	Advanced parameters	Front overlap	80
		Side overlap	80
		Course Angle	Use the Course Angle to align the flight path as such to fly along the longest axis of the field
		Margin	Adjust such that the flight path is at least 2 flight lines outside the boundaries in all directions
		Photo Mode	Trigger on Distance
		Focus Mode	First Waypoint Autofocus
		Dewarping	OFF
		Flight lines	Area should be completely covered and extended with at least 2 flight lines at each side. This because we should at least have pictures of all GCPs from all directions! Along the longest axis of the field!
		Timing & cloud cover	From 9am – 5pm No cloud cover restrictions

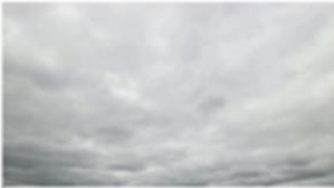


<p>Example</p>	<div>    </div> <div> <p>Overcast: OK</p> <p>Blue sky: OK</p> <p>Changing light- OK</p> </div> <p>Check predicted weather conditions. Following weather and timing limitations should be taken into account depending on the product type.</p>
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Table 10: Typical DJI Pilot settings for plant phenotyping RGB flights

5. FLIGHT

5.1 General

- The drone flight is conducted following the highest quality standards as is expected from a professional pilot.
- The pilot completes the flight of the entire area **without breaks longer than 30 minutes**. In case there is a need for a longer break, the pilot shall repeat the flight of the entire area.

5.2 Weather and light conditions

Before take-off, the pilot ensures there is sufficient daylight for the RGB flight to be performed.

5.3 Re-planning a flight

In case the planning is changed (e.g. due to bad weather or no-go from the site manager), notify your coordinator and site manager and wait for confirmation to postpone the flight.

5.4 Upon arrival at the site

The pilot meets with the site manager and:

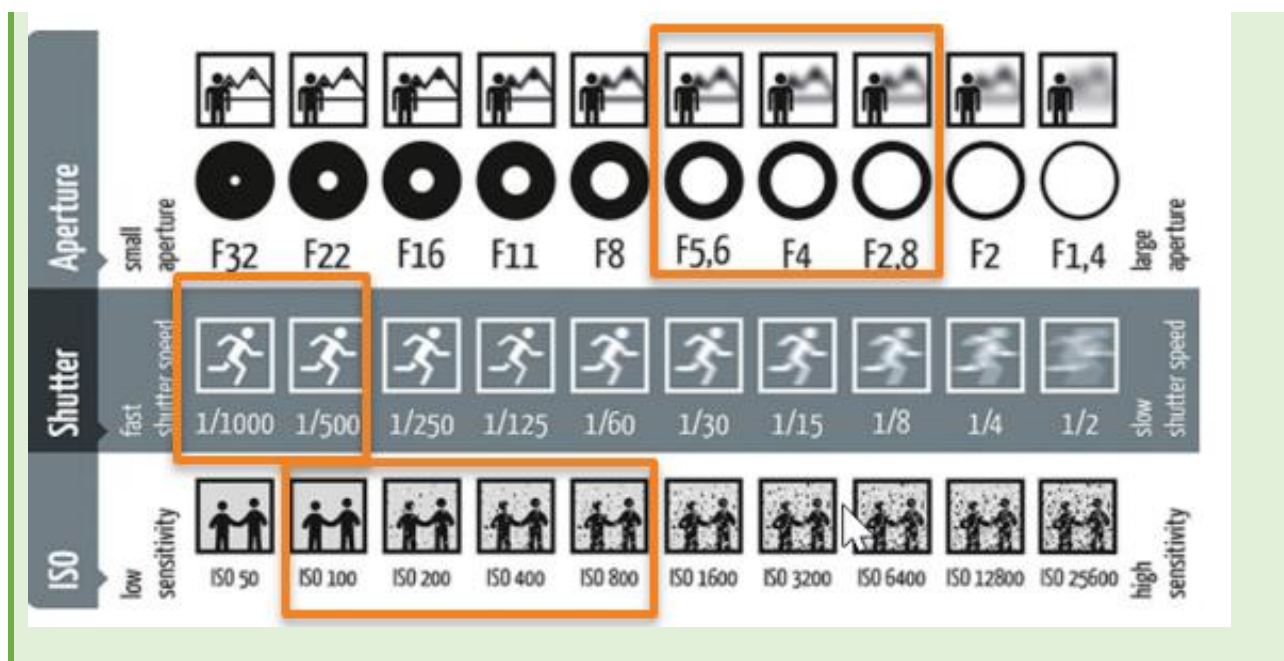
- Prepares the drone for the flight, checks the prepared flight parameters and adapt camera settings to light conditions, flight characteristics and camera specifications to get sharp images.
- Finds a suitable take off area, checks weather conditions and flies the mission.



IMPORTANT NOTE (2) on defining the camera parameters:

Setting the camera parameters is the responsibility of the pilot as this depends on both the camera type, flight parameters (speed and altitude) and light conditions. If this is your first flight with a particular drone/camera setup we recommend to:

- Use the default auto parameters for your first couple of test flights and inspect image quality vs shutter speed and aperture
- Use the M+Auto-ISO for next flight and adapt shutter speed to light conditions
- Following table provide realistic ranges for the Aperture/Shutter Speed and ISO values of the captured images



6. POST-FLIGHT

6.1 At the field

After completing the drone flight, the pilot will:

- Copy all the data on the laptop and ensure all the pictures are well organized on the computer, i.e. per customer, location and date, and that possible duplicate file name issues are solved. Instructions on how to organize/name the acquired drone data files and how to handle duplicate file names are provided in the MapEO field software user manual. The download link for this user manual is provided in section 3.4.2 “MapEO Field Software”.
- Open the MapEO field software, select the correct mission and camera type, and check that all data collected is satisfying the quality and completeness criteria, as described in section 6.1.1 “Data quality checking”.
- Inform the Coordinator about completing the drone mission.



In case there is an issue with the data collected, the COMPLETE ARE NEEDS TO BE RE-FLOWN, not only the problematic line or area!

6.1.1 Data quality checking

The pilot will use the MapEO field software tool to check if the acquired drone data meets the quality requirements for further uploading and processing in the MapEO platform.

The field software quick start guide provides a brief description of the different steps in this quality check, full details can be found in the user manual. The download link for both documents is provided in section 3.4.2 “MapEO Field Software”.

This is a summary of the different steps in the quality check:

- Open the tool, login with the provided user account and select "New" to start the quality check of the new mission
- Select the proper drone Mission ID of your flight, choose your camera type and verify the locations ROI and GCP info
- Add image data from the local drive containing the drone Image data and verify image quality
- Select start and stop position of the mission and verify images selected for upload
- Verify image overlap
- Verify mission metadata
- Verify overall drone mission quality

6.2 At the office

Upon arrival at the office the Pilot shall:

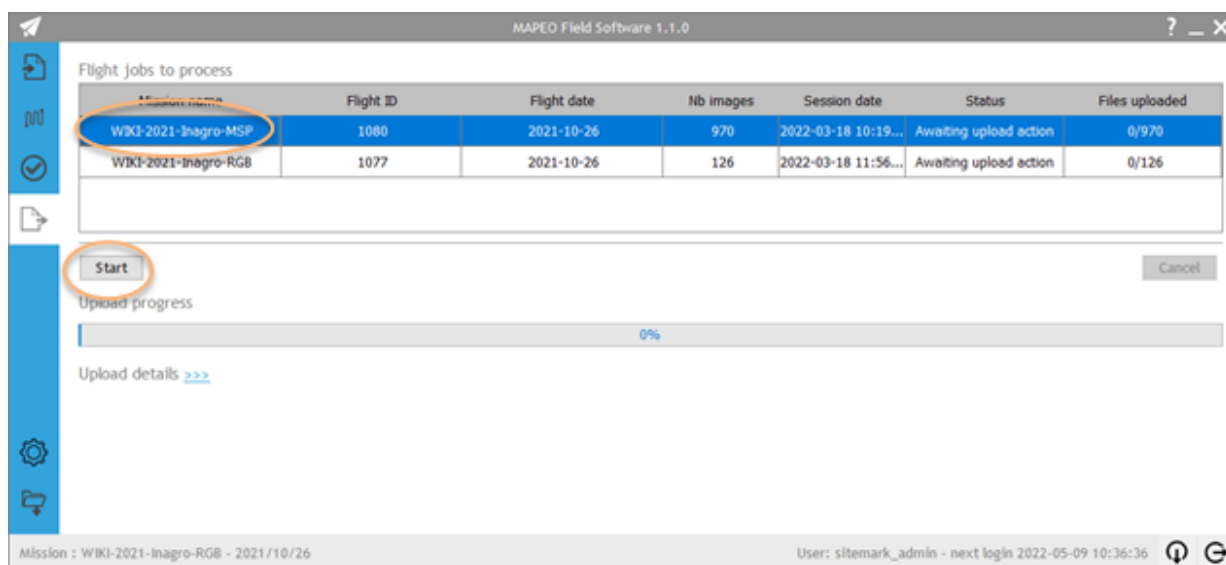
- Open the MapEO field software and **Upload** the data and flight log on the MapEO platform.

Mission upload can be conducted by clicking the last tab “mission upload”
The upload can be started by clicking the “Start” button. It can take some seconds before the actual upload is starting, the progress can be followed in the “upload details” screen.



Leave the application open and do not shut down the PC before the upload is finished!

- Verify that upload is completed



The end