



senseFly

Extended User Manual

eBee RTK

Revision 1 / September 2014

Copyright © 2010-2014 senseFly Ltd

GENERAL INFORMATION

READ THIS USER MANUAL CAREFULLY BEFORE USING A SENSEFLY LTD PRODUCT.

senseFly Ltd products are intended for professional use only.

Applicable Regulations

senseFly Ltd products are subject to Civil Aviation regulations. Regulations may vary depending on the country where you intend to operate your product.

ANY USE OF SENSEFLY LTD PRODUCTS IN BREACH OF THE LAW OF THE COUNTRY WHERE YOU OPERATE THE PRODUCT IS UNDER YOUR SOLE RESPONSIBILITY.

INFORM YOURSELF BEFORE USING THE PRODUCT. SOME COUNTRIES MAY HAVE LAWS THAT LIMIT THE USE OF UNMANNED AIRCRAFT TO 'LINE-OF-SIGHT' OPERATIONS AND/OR PROHIBIT THE USE OF UNMANNED AIRCRAFT AT ALL OR IN SPECIFIC AREAS.

Privacy

Recording and circulating an image of an individual may constitute an infringement of their image and privacy for which you can be liable. Ask for authorization before taking pictures of an individual, particularly if you want to keep your recordings and/or circulate images on the Web or any other medium. Do not circulate degrading images or ones that could undermine the reputation or dignity of an individual. Check that your use of the cameras on board senseFly Ltd products comply with the legal provision on privacy in the country where you operate your product.

Limited Warranty

SenseFly Ltd warrants that the product will be free from defects in material and workmanship for a period of twelve (12) months from the date of delivery. SenseFly Ltd further warrants that the product will perform substantially in accordance with its specification. During the warranty period senseFly Ltd's sole liability shall be at senseFly Ltd's sole option, either to repair or to replace the defective product with another product or a product with similar specifications, at no charge, or to reimburse the purchase price of the product, or if repair or replacement is not possible, issue a credit note; provided however, that the defect has been confirmed by senseFly Ltd and that the defective product is returned to senseFly Ltd in accordance with the support and repair form together with all required flight logfiles.

Warranty does not apply, without limitation, in case: a) the products are not stored and used according to their specifications, b) the products are damaged due to carelessness, negligence, or wrong use by the user, and c) for defects due to normal wear and tear including, but not limited to, deterioration to the airframe after first flight, normal degradation, misuse, moisture or liquids, proximity or exposure to heat, accidents, excessive strain, abuse, neglect, misapplication, repairs or modifications made by third party other than senseFly Ltd, damage due to manual operation, damage due to take-off or landing location with obstacles, damage due to low altitude flight, damage due to loss of data radio connection, damage due to strong wind, rain or humidity, or other causes for which senseFly Ltd has no control.

THE FOREGOING WARRANTIES ARE IN LIEU OF ALL WARRANTIES, EITHER EXPRESSED OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, AND OF ANY OTHER OBLIGATION ON THE PART OF SENSEFLY LTD.

Limitation of liability

TO THE EXTENT PERMITTED BY APPLICABLE LAW, IN NO EVENT WILL SENSEFLY LTD BE LIABLE FOR ANY LOSS OF REVENUE, LOSS OF PROFIT, LOSS OF DATA, OR INDIRECT, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES, EVEN IF SENSEFLY LTD HAS BEEN NOTIFIED OF THE POSSIBILITY OF SUCH DAMAGES, AND WHETHER THIS LIABILITY ARISES FROM A CLAIM BASED ON CONTRACT, WARRANTY, TORT OR OTHERWISE, WITH THE EXCEPTION OF GROSS NEGLIGENCE AND DEATH.

YOU SHALL AT ALL TIMES OPERATE THE PRODUCT IN AREAS OR UNDER CIRCUMSTANCES SO AS TO GUARANTY SECURITY AND SAFETY OF PEOPLE, PROPERTY AND ANIMALS.

Copyrights

senseFly Ltd reserves the right to make changes to specifications and product descriptions contained in this document at any time without notice. Please consult www.sensefly.com for the latest release.

Copyright © 2014 senseFly Ltd. All rights reserved. REPRODUCTION, USE OR DISCLOSURE OF ALL OR IN PART OF THIS MANUAL TO THIRD PARTIES WITHOUT THE PRIOR WRITTEN PERMISSION OF SENSEFLY LTD IS STRICTLY PROHIBITED.

Address

senseFly Ltd

Route de Genève 38
1033 Cheseaux-Lausanne
Switzerland

Website: <http://www.sensefly.com>

Technical support

If you have questions on your *eBee RTK* or accompanying software please consult senseFly Ltd's Technical support website at the following address:

<http://www.sensefly.com/support/>

Welcome to your *eBee RTK*

Congratulations on your purchase of the *eBee RTK*, a complex and powerful yet intuitive autonomous mapping system. We take great care to develop and design the best possible hardware and software tools for quick, high-quality and easy-to-use 2D and 3D aerial mapping.

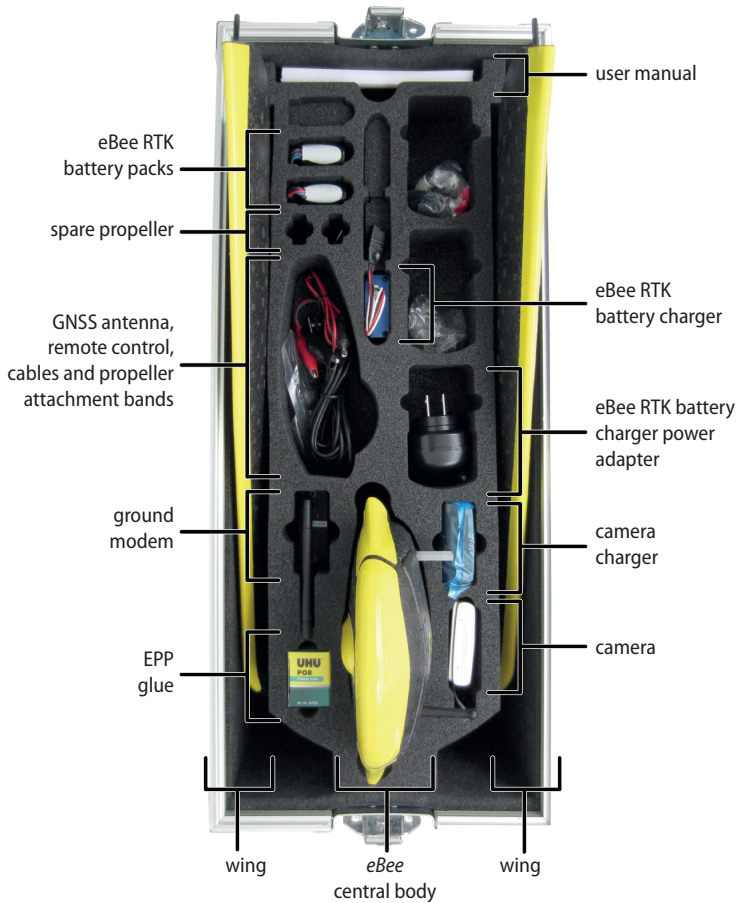


The *eBee RTK* is a fully autonomous survey-grade mapping drone (UAV, RPAS or UAS). It is capable of in-flight processing of RTK corrections from most leading brands of GNSS/RTK base stations via its supplied *eMotion* flight control software and ground modem. The built-in high-performance GNSS receiver in the *eBee RTK* can process GPS and GLONASS L1 and L2 signals. The RTK coordinate correction data it receives via its ground modem enables precise navigation and the storage of image metadata with RTK-level positional accuracy, without the need for Ground Control Points (GCPs).



Note: This manual refers to version 2.4 of *eMotion* and version 3.2 of *Postflight Terra 3D* software. The *eBee RTK* requires *eMotion* 2.4. If you installed *eMotion* before purchasing your drone, check the version and upgrade if necessary. You can consult the Release Notes for changes included in more recent versions of the software.

Package contents



The standard *eBee RTK* package contains the following items:

- 1x carrying case with foam protection
- 1x *eBee RTK* central body with built-in autopilot
- 1x pair of detachable wings
- 1x detachable GNSS antenna
- 1x spare propeller
- 10x spare propeller attachment rubber bands
- 2x Lithium-Polymer battery packs
- 1x Lithium-Polymer battery charger (including cables)
- 1x 2.4 GHz USB ground modem for radio data link (including USB cable)
- 1x 2.4 GHz remote control (including including 3 AA batteries)
- 1x modified IXUS/ELPH still camera (including memory card, battery and charger)
- 1x USB cable for interfacing with camera and on-board autopilot
- 1x EPP glue
- 1x *eBee RTK* User Manual
- 1x camera User Manual

Depending on your order, your package may also include other items, such as additional payloads. Please verify upon delivery that your package is complete. In case of a missing item, please contact your *eBee RTK* reseller immediately.



Caution: The built-in GNSS receiver in the *eBee RTK* makes it heavier than the standard *eBee*. You must therefore only fly your *eBee RTK* with the IXUS/ELPH camera provided. senseFly Ltd cannot be held responsible for any loss or damage caused by flying an *eBee RTK* with a different camera installed.

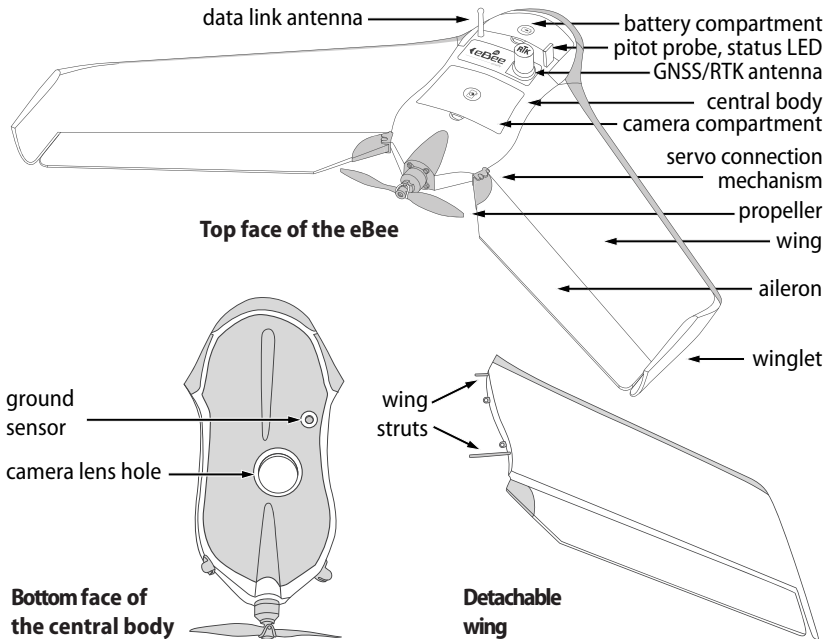


Note: Some of the operating modes of the *eBee RTK* require a GNSS/RTK base station or access to a subscription-based Ntrip stream. These are not provided in the *eBee RTK* package.



Note: Camera user manuals are also available to download from sensefly.com/support/download.

Hardware features



The *eBee RTK* is an autonomous flying drone comprised of the following components:

- **Central body:** This is the core of the *eBee RTK* and includes all the electronics, actuators and communications hardware on-board the drone.
- **Wing:** The two wings of the *eBee RTK* are detachable for storage and replacement. Each wing has two wing struts and two clips to hold it in place within the central body.

- **Winglets:** These structures add aerodynamic stability to the drone while it is in flight.
- **Ailerons:** Used to control the *eBee RTK* while in flight.
- **Servo connection mechanism:** The ailerons are connected to the servomotors within the central body of the drone through this connection mechanism.
- **Propeller:** Used to generate thrust while it is in flight.



Caution: When attached to the motor the propeller spins at high speeds and can be potentially dangerous if it comes into contact with exposed skin. Be sure to always keep your hands clear of the propeller when the battery is attached to the *eBee RTK*.

- **Battery compartment:** The *eBee RTK* is powered by a LiPo (Lithium Polymer) battery stored within the battery compartment.



Caution: Proper care of your battery is essential. Please read section 'Proper battery care' on page 151 before using your drone for the first time.

- **GNSS/RTK Antenna:** The advanced GNSS antenna, capable of capturing several GNSS signals, is used for navigation and to increase geo-tagging precision.



Caution: Proper care of your GNSS antenna is essential. Please read section 'Proper antenna care' on page 152 before using your *eBee RTK* for the first time.

- **Camera compartment:** The *eBee RTK* features a built-in camera for taking aerial images stored within the camera compartment.

- **Data Link Antenna:** Used by the drone to communicate with the *eMotion* software through the USB ground modem.
- **Pitot probe:** This is the sensor used by the *eBee RTK* to detect airspeed, wind and altitude. It must be kept clean and clear of obstructions to function properly.
- **Status LED:** This coloured LED displays the current state of the *eBee RTK*. It is housed underneath the pitot probe and thus illuminates the entire transparent probe in various colours depending on the drone's state.
- **Ground sensor:** The ground sensor, composed of a high-speed optical sensor and lens assembly, is used to detect the proximity of the ground.

Software features

The *eBee RTK* package allows for the download and use of *eMotion* * and *Postflight Terra 3D* * at no extra cost.



eMotion is the integrated software package that allows you to interact with your *eBee RTK*. Its easy-to-use interface allows you to plan a mapping flight intuitively from the comfort of your office or directly in the field. Once the drone is launched, you can use *eMotion's* wireless connection with your *eBee RTK* to track its position, monitor the progress of your mapping flight and send commands if desired.



Once your *eBee RTK* returns after an aerial mapping flight it is the turn of *Postflight Terra 3D* to process the captured images fully automatically. *Postflight Terra 3D* is a full-featured mapping solution: with just a few mouse clicks it can create high-quality geo-referenced 2D and 3D orthomosaics and digital elevation/surface models (DEM/DSM). While you are still in the field *Postflight Terra 3D* analyses the quality of the captured images and generates an easy to understand report, letting you know immediately if the data you captured meets your mapping requirements.

* Software access terms and conditions apply. Postflight Terra 3D is limited to eBee images only.

Contents

I	Quick start guide	19
1	Planning and simulating a flight	20
1.1	Installing <i>eMotion</i> , <i>Postflight Terra 3D</i> , and the ground modem drivers	20
1.2	The <i>eMotion</i> interface	21
1.3	Creating a new flight plan	25
1.4	The mission phase of a flight	26
1.5	Simulating your flight	28
1.6	Getting ready for a mission	29
2	Setting up RTK	31
2.1	Base station compatibility	31
2.2	Setting up your GNSS/RTK base station	31
2.3	Setting up reference points for your GNSS/RTK base station	32
2.4	Setting up virtual reference broadcasters	33
3	Using RTK	36
3.1	Using a local base station	36
3.2	Using your <i>eBee RTK</i> with a virtual reference broadcaster	39
3.3	Using your <i>eBee RTK</i> in standalone mode	39
4	Executing a flight	40
4.1	Weather check	40

4.2	Preparing the <i>eBee RTK</i> for flight	41
4.3	The setup phase of a flight	51
4.4	Take-off	55
4.5	In-flight monitoring and control	58
4.6	Landing	60
4.7	Potential in-flight errors	60
5	Processing image data	62
5.1	High precision geotagging with the <i>eBee RTK</i>	62
5.2	Importing images and flight data	62
5.3	In-field image quality check	67
5.4	Creating advanced mapping products	69
5.5	Transforming coordinates	69
II	Advanced functionalities	71
6	Understanding aerial mapping with the <i>eBee RTK</i>	72
6.1	Waypoints and their properties	72
6.2	Advanced polygonal mission area	77
6.3	3D mission planning using elevation data	78
6.4	Flight visualization in <i>Google Earth™</i>	80
6.5	Autonomous controller and modes of flight	82
6.6	Linear landing	86
6.7	Flying multiple drones at the same time	91
6.8	Individual photo targets and oblique imagery	97
7	<i>eMotion</i> in-depth guide	99

7.1	Toolbar	100
7.2	Simulator	103
7.3	Control Bar	105
7.4	Flight Monitoring tab	108
7.5	Setup Phase tab	112
7.6	Mission Planning tab	116
7.7	Mission Waypoints tab	125
7.8	Camera tab	127
7.9	Flight Parameters tab	132
8	Manual control of the <i>eBee RTK</i>	136
8.1	Enabling manual control	136
8.2	Pre-flight testing of the remote control	138
8.3	Full Manual mode	139
8.4	Assisted Manual mode	140

III	Maintenance, Repair and Troubleshooting	143
9	Maintenance and repair of the <i>eBee RTK</i>	144
9.1	Updating the <i>eBee RTK</i> software	144
9.2	Cleaning and storage	147
9.3	Full airframe and sensor inspection	147
9.4	Repairing the <i>eBee RTK</i> airframe	151
9.5	Proper battery care	151
9.6	Proper antenna care	152
10	Troubleshooting	154
10.1	Pre-flight errors	155
10.2	Take-off vetoes	158
10.3	In-flight warnings	160
10.4	Critical failures	173
10.5	Resetting default camera settings	176
10.6	Improving radio signal communication	176
10.7	Losing and locating your <i>eBee RTK</i> in the field	177
10.8	Reporting a problem with your <i>eBee RTK</i>	178
IV	Specifications	179
1	Software requirements	180
2	Drone specifications	181
3	Onboard GNSS/RTK receiver	183

Part I

Quick start guide

The first part of this document introduces you to the *eBee RTK* and contains the basic information you will need to plan and execute a simple mapping project. A typical mapping project can be divided into three main phases:

1. **Planning and simulating a flight:** Every project begins with careful planning, whether it is a quick flight over a small area or a multi-stage flight in complex terrain. Section 'Planning and simulating a flight' on the following page describes how to use the Mission Planning feature to quickly generate a flight plan and to test it using the built-in simulator.
2. **Executing a flight:** Once planning is complete, it is time for the drone to perform its flight. In section 'Executing a flight' on page 40 you will learn how to prepare your drone for flight, connect it to *eMotion*, and to monitor it in flight while it gathers images. Though the *eBee RTK* can complete a flight fully autonomously from take-off to landing, you can also modify its flight plan at any point during flight.
3. **Processing image data:** The last step in a project is converting the images taken by your *eBee RTK* into usable products such as precise geo-referenced orthomosaics or 3D terrain models. section 'Processing image data' on page 62 leads you through the process of transferring images from the drone to a computer, checking if the image quality suits your needs while still in the field and producing advanced 2D and 3D maps.

1 Planning and simulating a flight



Goal of this section: This section introduces the *eMotion* software used to interface with the *eBee RTK*. It describes the steps required to plan, simulate, and save a simple mapping flight. A more detailed description of *eMotion* and its advanced functions is presented in section '*eMotion* in-depth guide' on page 99.

1.1 Installing *eMotion*, *Postflight Terra 3D*, and the ground modem drivers

You can download the latest version of *eMotion* and *Postflight Terra 3D* at:

www.sensefly.com/support/download

Use the password provided with your *eBee RTK* to access the download section.

We recommend that you download and install *Google Earth™* to take full advantage of the features of *eMotion*. You can find more information at the following address:

www.google.com/earth/

To install *eMotion* on Windows, simply execute the provided installers for *eMotion* and *Postflight Terra 3D* and follow the on-screen instructions. The *eMotion* and *Postflight Terra 3D* software will be available in the 'Start' menu. Drivers for the USB ground station ground modem will automatically be installed along with *eMotion*.

In case a problem arises after connecting the ground modem to the computer for the first time you can find the drivers in one of the following directories (depending on your version of Windows):

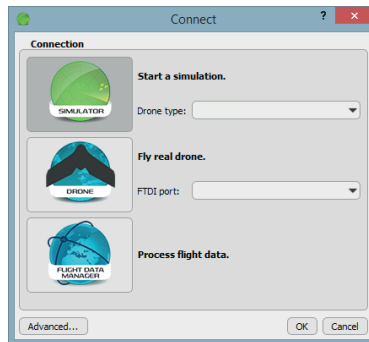
```
C:\Program Files\senseFly\eMotion 2\usb_driver\  
C:\Program Files (x86)\senseFly\eMotion 2\usb_driver\  

```

See section 'Updating the *eBee RTK* software' on page 144 if you have any difficulty with software installation.

1.2 The *eMotion* interface

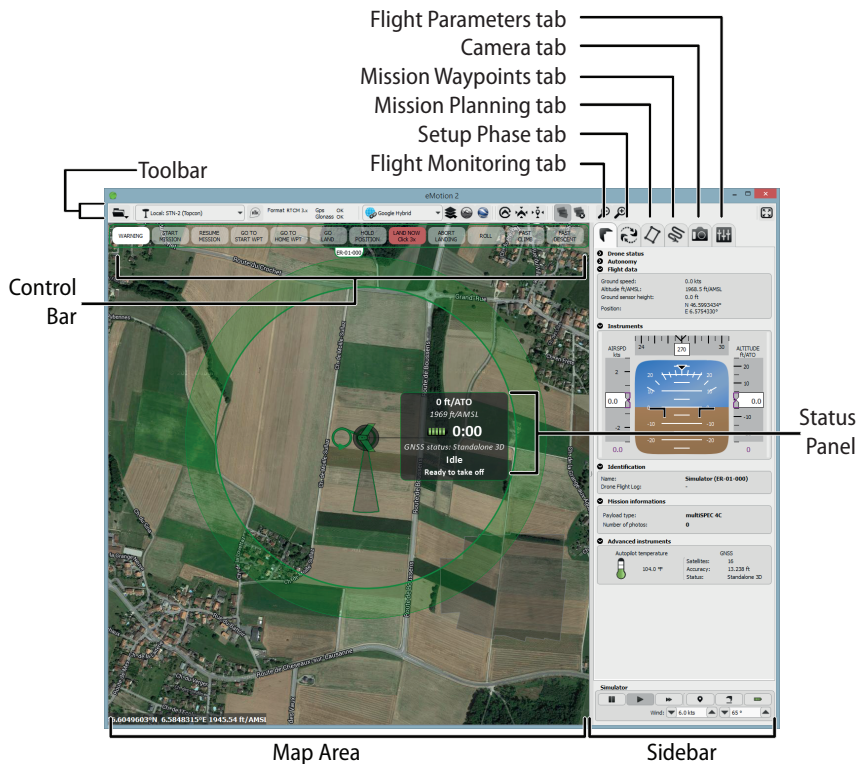
Thanks to the powerful tools available within *eMotion*, designing a mapping flight for your *eBee RTK* is a simple process. To get started, launch *eMotion* and choose what you would like to do...




- To run a simulation, select the simulator, choose the drone you want to simulate and click OK.
- To fly a drone, connect your ground modem to your computer and select Drone. If you have more than one USB device connected to your PC (for example, you have a ground modem and GNSS base station), choose the ground modem you want to connect to from the list and click OK. Otherwise, just click OK.
- To process flight data you already created, select the Flight Data Manager and click OK.

We recommend that you plan flights using a simulated drone. Once connected to a real or simulated drone you will see the main screen of *eMotion*.


Quick start guide



The main screen of *eMotion* is split into four sections:

- Map Area:** The Map Area of *eMotion* displays a map with the drone's current position, indicated by the  symbol. A small Status Panel floats beside the symbol, indicating important status information including the *eBee RTK's* current altitude (both Above the Take-off Altitude, marked as ATO, and Above Mean Sea Level, marked as AMSL), battery level, flight time, and status. The Status Panel can be hidden by clicking on the drone. Moving around the

map is done by clicking and dragging at any place not occupied by a symbol (such as a waypoint or the drone symbol).

- **Control Bar:** The Control Bar is used to issue various commands to the *eBee RTK* while it is in flight, such as starting the mission phase or holding position. It is also used to display and acknowledge warnings that may occur either before or during a flight.
- **Toolbar:** The Toolbar contains buttons to control the layers, sources or map information and other display options related to the Map Area. *eMotion* can use many sources of mapping information. You can also choose your RTK source from the pull-down menu and click  to Set Up RTK.
- **Sidebar:** The Sidebar is split into several tabs, each with a particular function. The Flight Monitoring tab is used for monitoring the drone while in flight. The Setup Phase tab controls the take-off and landing portions of a flight plan (referred to as the 'setup phase') whereas the Mission Planning tab defines the image acquisition portion of the flight plan (referred to as the 'mission phase'). The last three tabs are used for advanced waypoint planning and parameter setting. You can hide the Sidebar by clicking on its left edge. The Sidebar also contains controls for the simulator when connected to a simulated drone.

Your *eBee RTK's* operating modes

Your *eBee RTK* can operate in several different modes:

Local Base, Precisely Known Coordinates

Create DSMs and orthomosaics with high absolute coordinate accuracy using your precisely measured base station position as a GCP. Useful when a survey has already been done and reference points are already marked out. No post-processing is needed to achieve RTK-level geo-tag accuracy.

- Place your base station on a known reference point.

- In *eMotion*, select the base station, set the reference point and base station height.
- *eMotion* streams correction data to the drone through the ground modem.

Local Base, Unknown or Imprecise Coordinates

Create DSMs and orthomosaics with geo-tagging relative to an approximate base station position, then post-process GNSS data to reach high absolute coordinate accuracy. Useful for green-field surveying when no GCPs have been set, when in-field time is limited or it is impractical to survey beforehand.

- Position your base station in a convenient location.
- Have *eMotion* obtain, or set your base station's approximate position.
- *eMotion* streams correction data to the drone through the ground modem.
- Your base station's position is corrected to a high level of absolute accuracy in post-processing, using raw GNSS/RTK base station and reference station files.

Virtual Reference Station

Create DSMs and orthomosaics using reference station networks to achieve very high precision absolute geo-tags. Used when you want to benefit from the high absolute precision achievable from sophisticated Ntrip networks, or when surveying equipment is unavailable or inconvenient.

- Configure your drone's *eMotion* software to receive VRS/Ntrip correction data (Internet connection and VRS/Ntrip subscription required).
- Correction data is streamed to the drone via its *eMotion* flight control software and ground modem.

Standalone

Use to create maps and DSMs when high relative precision is enough or when RTK corrections are unnecessary or unavailable. Take only the eBee RTK, ground modem and computer and come back with high-quality DSMs and orthomosaics.

- You can operate the *eBee RTK* without RTK corrections. In this standalone mode you can still expect a higher level of absolute coordinate accuracy than a senseFly drone equipped with a standard GPS antenna. See section ‘Onboard GNSS/RTK receiver’ on page 183 for details.



Note: If you select one of the modes that requires a real or virtual base station, and a connection to that base station is unavailable, a take-off veto will be displayed in *eMotion* and the status LED on your drone will start pulsing blue. Section ‘Take-off vetoes’ on page 158 describes the possible messages and the user action that should be taken to remove them.

1.3 Creating a new flight plan

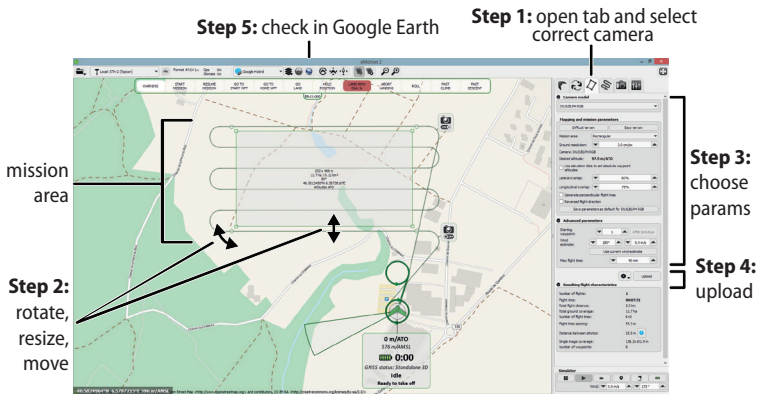
Every mapping flight requires a flight plan, which is a path defined by a set of waypoints, or points in 3D space, and a set of actions that can be performed at or in between waypoints, such as taking images, proceeding to the next waypoint or landing. A flight plan is shown in the Map Area using circles to represent waypoints, lines to represent the flight path and arrows to show the direction of flight. The large circle with a thick border illustrates the working area boundaries within which the *eBee RTK* will always remain. See section ‘Waypoints and their properties’ on page 72 for more information on waypoints and the various symbols presented in the Map Area.

A complete flight plan for an *eBee RTK* is divided into two separate phases: the setup phase and the mission phase. The mission phase includes waypoints and actions related to mapping and capturing images. The setup phase includes waypoints and actions related to take-off and landing. This phase is usually planned

directly in the field and is explained in detail in section 'The setup phase of a flight' on page 51.

1.4 The mission phase of a flight

The easiest way to create a mapping flight for the systematic coverage of an area is to use the automatic mission planning feature of *eMotion*. By simply positioning a rectangle around the area you would like to cover, *eMotion* will generate a mission plan optimised for the ground resolution that you desire.




Note: For more complex terrain and missions, *eMotion* has the ability to set polygonal mission areas of any size and shape, and to automatically adjust waypoint altitudes based on elevation data. These powerful features are described in more detail in section 'Advanced polygonal mission area' on page 77 and section '3D mission planning using elevation data' on page 78, respectively.

Follow these steps to automatically setup waypoints for a mapping mission:

1. Select the Mission Planning tab from the Sidebar. A grey zone will appear in the Map Area to designate the mission area to cover. Information such

as size and position is overlaid on the area. A mission plan, including the required waypoints, is automatically calculated and displayed to preview the mission plan that will be created.

2. Adjust the location, size, and shape of the mission area. The area can be relocated by dragging the gray zone. The four square handles on the edges of the area can be used to resize it and the round handles on the corners of the area can be used to rotate it. As you adjust the area the mission plan preview is continuously updated.
3. Adjust the mapping and mission parameters in the Mission Planning tab to suit your terrain and quality requirements¹. As a first step, *eMotion* provides two predefined set of parameters; 'Easy terrain' are the default parameters designed for simpler terrain, such as mines or agriculture, whereas 'Difficult terrain' is designed for complex areas, such as forests, and provides higher image overlap at the cost of a lower resolution. Be sure to include an estimated wind speed and direction, as this has an effect on the area that can be covered in a single flight. Once again, the mission plan preview will be continuously updated as you modify the parameters.
4. Check the resulting flight characteristics in the tab. Once you are satisfied, upload the mission plan to the simulated drone by clicking the 'Upload' button.
5. Click the  button in the Toolbar to open the flight plan in *Google Earth*^{TM2}. Review the flight plan to ensure that there is sufficient clearance between the flight plan and the ground. Any updates to the flight plan that you make within *eMotion* will be reflected directly in *Google Earth*TM.

¹ see section 'Mission Planning tab' on page 116 for a complete description of available parameters

² see section 'Flight visualization in *Google Earth*TM' on page 80

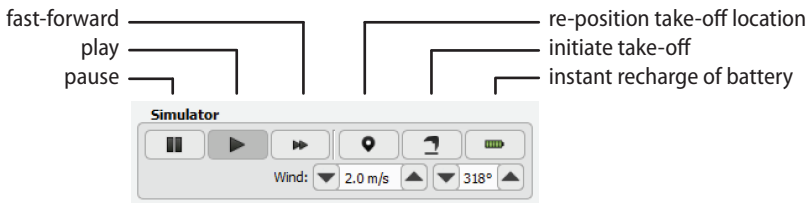


Caution: *eMotion* as well as the automatic mission planning tool are not aware of any obstacles that may exist in the area. In addition, when not using elevation data, the mission planning tool assumes that the mission area is flat and at the same altitude than the take-off location. It is also not aware of any legal restriction (such as minimum or maximum altitude) that may exist in your region. The resulting flight plan should be carefully reviewed in order to avoid any collision with uneven terrain or tall objects such as buildings, and to comply with local regulations.

The final step after you have prepared a flight plan is to save it to a file that you can load into the *eBee RTK* when you are in the field. Select the Setup Phase tab from the Sidebar, click on ‘Save flight plan to file...’, choose a filename and location and click ‘Save’.



1.5 Simulating your flight

Simulating your flight gives you an idea of the position and size of images that will be taken during the flight. In addition, it allows you to learn to use advanced functions, such as in-flight waypoint editing and camera control, without putting your *eBee RTK* at risk³. When *eMotion* is connected to a simulated drone an extra set of buttons appear in the Sidebar:



You can set the take-off location of the *eBee RTK* by clicking on the 📍 icon and placing the point on the map. This simulates the action of switching on the real

³ see section ‘Simulator’ on page 103 for a complete description of the simulator

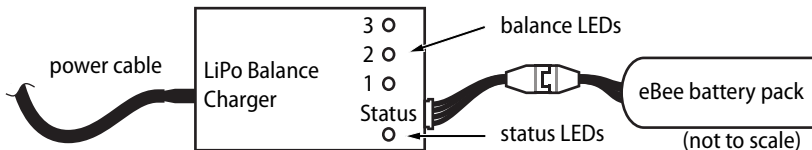
drone and letting it acquire GPS/GLONASS signals. You can test your flight plan by clicking the  icon, simulating a take-off manoeuvre. The *eBee RTK* will then go through its flight plan in the same way it would in the field. You can pause, play or speed up the simulation by clicking the corresponding buttons in the Toolbar. You can monitor the state of the drone while in flight using the Flight Monitoring tab and the Status Panel⁴. You may also monitor the flight in 3D in *Google Earth™* by clicking on the  button in the Toolbar.



Caution: The simulator is a tool designed to aid with flight planning and to familiarise you with the advanced functions of your *eBee RTK*. The simulated physics, however, are basic and do not always accurately reflect the true behaviour of the drone in flight. In particular, estimates of battery level and reactions to wind are difficult to simulate with high accuracy. You should in no case depend on behaviours seen with a simulated drone to be reproduced exactly in real flight.

1.6 Getting ready for a mission

Before leaving for the field to perform a flight, be sure to fully charge all your *eBee RTK* batteries⁵. When delivered, the *eBee RTK* battery may not be fully charged.




To charge an *eBee RTK* battery pack, connect it to the battery charger as illustrated above. During charge, the status LED on the charger is solid red. Charging is complete when the status LED turns green.

The charger provided independently balances the voltage of each of the 3 cells contained in the battery pack to ensure optimal performance and battery life. If

⁴ see section 'In-flight monitoring and control' on page 58

⁵ Consult your payload user manual to know if the payload battery is necessary for the flight

any of the cells is unbalanced, its associated LED will be solid red during charging until it is re-balanced. Charging can take up to an hour, depending on the charge level of the battery and the required cell balancing work. See section 'Proper battery care' on page 151 for more information on maintaining your drone's batteries.

If you plan on performing a flight away from an Internet connection it is useful to preload map tiles by selecting 'Download maps...' from the  File menu. More details on how to take advantage of the various map sources available in *eMotion* can be found in section 'Toolbar' on page 100.

2 Setting up RTK

2.1 Base station compatibility

Standard compatibility - receive only

With built-in support for standard RTK data transmission protocols (see section 'Onboard GNSS/RTK receiver' on page 183), the *eBee RTK* with *eMotion* can receive and process corrections from a wide range of base stations. In standard compatibility mode, your GNSS data logger manages the base station position and data stream and *eMotion* looks after streaming the corrections to the drone.

Enhanced compatibility - send and receive

eMotion also provides drivers that enable enhanced compatibility with a series of popular base stations from leading manufacturers. With this enhanced compatibility, *eMotion* can get and set base station position, display its position on the map and get raw GNSS data files directly from the base station. *eMotion* therefore takes on the role of a data logger and a separate data logger is not necessary. senseFly is constantly working on new drivers and the list of base stations with enhanced compatibility will continue to grow.

2.2 Setting up your GNSS/RTK base station

To enable high-precision navigation and geo-tagging, connect *eMotion* to an RTK-capable base station (not provided in the *eBee RTK* package). Corrections will be sent through the ground modem, and precise geo-tags will be automatically stored alongside your photos in the automatically generated flight logs.

You can set up several base stations in *eMotion*. Once in the field you can then quickly change base station using the Choose RTK Source menu on the *eMotion* toolbar.

Step 1 Connect your base station to the computer on which you installed *eMotion* following your base station manufacturer's instructions. The way you connect depends on your base station make and model. *eMotion* will ac-

cept, for example, serial, Bluetooth and USB connections.

Step 2 Click  RTK Setup on the *eMotion* toolbar.

Step 3 In the Local Bases tab, click Add Base.

Step 4 Enter the Base Name.

Step 5 Choose your base station's manufacturer.

Step 6 From the Connection Type menu, choose the way in which you have connected your base station to your computer (serial, USB or Bluetooth).



Note: If you have several drones connected to *eMotion* using several USB ground modems, they can all take correction data from the same GNSS/RTK base station.

Step 7 From the USB menu, choose the USB Ground Modem connection over which you want to send your base station's RTK corrections.

Step 8 Click OK to add the base station.

2.3 Setting up reference points for your GNSS/RTK base station



Note: All coordinates displayed in *eMotion* are in the global WGS 84 reference frame. This is the reference frame used by GPS satellites. *eMotion* assumes that any coordinate you enter is in the WGS 84 reference frame. If you are using a local or national geoid (MSL) or geodetic coordinate system, you must convert coordinates into WGS 84 before entering them into *eMotion*. The way you do this depends on the geoid and the tools available to you. Online or downloadable conversion tools may be available from your base station's manufacturer or a national geodetic society.

Note that the *eBee RTK* internal GNSS receiver transforms the GLONASS ellipsoid (PZ-90) into WGS 84.

You can set up several reference points in *eMotion*. Once in the field you can then quickly change base station position using the Choose RTK Source menu.


Step 8 Click  RTK Setup on the *eMotion* toolbar.

Step 9 In the  Reference Points panel, click Add Point.

Step 10 Enter the name of the reference point.

Step 11 Enter the Latitude, Longitude and Altitude of the reference point and click OK.



Note: To remove a base station or reference point from the list, click  for the item you want to remove



Note: If you have access to reference station files, it is not essential to have the precise coordinates of your base station. Your *eBee RTK* logs its position relative to the base station with a high degree of precision (using RTK corrections). Once your flight is complete, *eMotion* can calculate your base station's precise position using the raw data stored on your base and reference stations. It can then apply a correction to your drone's position to obtain precise absolute geo-tags for your images. *eMotion* accepts reference station files in RINEX format. See section 'Importing images and flight data' on page 62 for instructions.



2.4 Setting up virtual reference broadcasters



Note: *eMotion* also allows you to configure a series of connections to Ntrip streams from public or subscription-based broadcasters and set up virtual reference stations (VRSs).




Note: A pre-configured set of Ntrip broadcasters is available for use in *eMotion*, and you can configure a connection to your own broadcaster. Before using a subscription-based Ntrip stream, or an Ntrip stream that requires registration, you must first register or subscribe through the stream provider, for example, on their website or by contacting them directly. You cannot register or subscribe using *eMotion*.


- Step 1** Find a suitable Ntrip broadcaster and register or subscribe if necessary before adding the VRS to *eMotion*.
- Step 2** Click  RTK Setup on the *eMotion* toolbar.
- Step 3** In the  Virtual Reference tab, click Add Virtual Reference.
- Step 4** To use a pre-configured stream, choose the broadcaster's server domain from the Server menu. To set up a custom stream, enter the broadcaster's domain in the Server menu.
- Step 5** Enter the port number on which the broadcaster is streaming. This is often port 2101 (set by default), however, the caster device may be streaming on a different port. Check with the broadcaster to confirm.
- Step 6** If you are connecting to a stream that requires registration or subscription, enter your user name and password.



Note: As you enter the broadcaster's domain, the streaming port, your user ID and password, *eMotion* will try and connect to the server. As long as these details are incorrect or incomplete you will see an error message on the dialog. The list of remote streams only appears when you have entered enough correct details to successfully connect to the broadcaster.

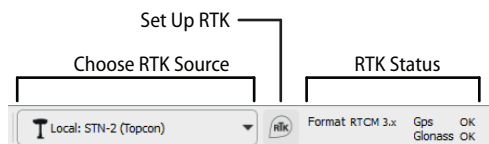
- Step 7** Scroll through the list of streams. Click on a stream to view its details.
- Step 8** Click  . The stream will be added to the list in the Choose RTK Source menu on the toolbar. If you entered a user name and password, these are stored in *eMotion* and will be submitted to the broadcaster when you connect.



Note: To remove a virtual reference, click  for the item you want to remove.

3 Using RTK

Choose the source of your RTK corrections using the menu on the *eMotion* toolbar. The message RTK Source Not Defined appears until you either choose a source or choose to fly standalone.

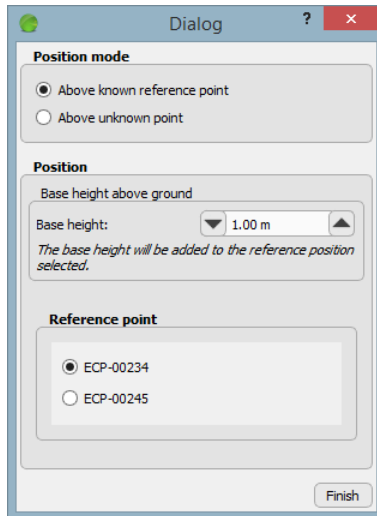


The status of your connection, directly to your base station, or indirectly to a reference station network, is displayed on the toolbar:

- Not sufficient* *eMotion* was not sent the data it needs (position and correction vector)
- Timeout* *eMotion* was getting position and correction data, but is no longer
- OK* All is well; *eMotion* is getting position and correction data as expected

3.1 Using a local base station

- Step 1** Connect your base station to the computer on which you installed *eMotion* following your base station manufacturer's instructions.
- Step 2** Choose your base station from the Choose RTK Source menu on the toolbar.

If your Base Station's Position is Known:

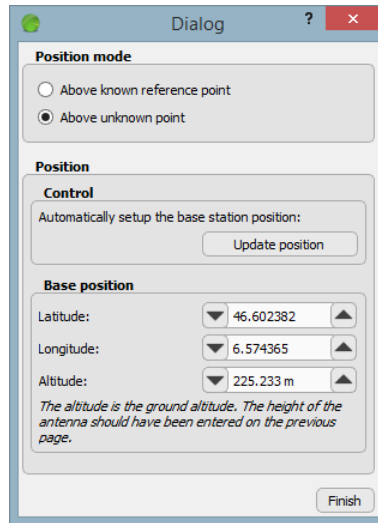
Step 3 Choose Above known reference point.

Step 4 Enter the height above ground of your base station.

Step 5 Select the reference point.

Step 6 Click Finish. A base station icon (📡) appears on your map at the reference point coordinates.

If your Base Station's Position is Unknown or Imprecise:



Step 3 Choose Above unknown point.

Step 4 Click Update position to take coordinates from the connected base station.

Step 5 If you wish to, adjust the coordinates.


Step 6 Click Finish. A base station icon (📶) appears on your map at the base station's coordinates.



Note: The absolute precision of the coordinates obtained from your base station will be greatly improved in post processing.

3.2 Using your *eBee RTK* with a virtual reference broadcaster

Step 1 From the *eMotion* Choose RTK Source menu, select the VRS/Ntrip service you want to connect to for your flight.

Step 2 If a VRS is created, a base station icon () appears on your map at its coordinates.

3.3 Using your *eBee RTK* in standalone mode

If you do not need high-precision absolute image geo-tags, or RTK corrections from a GNSS/RTK base station or Ntrip broadcaster are not available, you can fly your *eBee RTK* in standalone mode.

- From the *eMotion* Choose RTK Source, choose Standalone.

Now that you have chosen your RTK source, or chosen to fly standalone, you can plan your mission and launch your real or simulated drone. See section ‘Creating a new flight plan’ on page 25 to get started).

4 Executing a flight



Goal of this section: This section describes how to prepare your *eBee RTK* for flight, launch, monitor and control from the air, and initiate an autonomous landing.



Note: We recommend that you perform your first flight in a large obstacle-free area and limit the length of the mission in order to familiarise yourself with the *eBee RTK* in flight.

4.1 Weather check

Before each flight, you should be aware of the weather conditions. The *eBee RTK* is a small drone that cannot fly in heavy rain or strong wind conditions. In case of doubt, make sure to check a weather bulletin including wind estimations in the flight area. Note that wind is often stronger at higher altitudes and that the wind perceived at the surface is not always a good reference to estimate the wind at flight altitude. Cloud velocity or tall tree movements can help you to estimate the wind speed once you are out in the field.

Weather forecasts may use various units to measure wind speed. As a reference,

$$1 \text{ m/s} = 3.6 \text{ km/h} = 2.24 \text{ mph} = 1.94 \text{ kts.}$$



Caution: The *eBee RTK* should not be launched if the wind speed exceeds 12 m/s (in other units: 43.2 km/h, 26.8 mph, 23.3 kts).



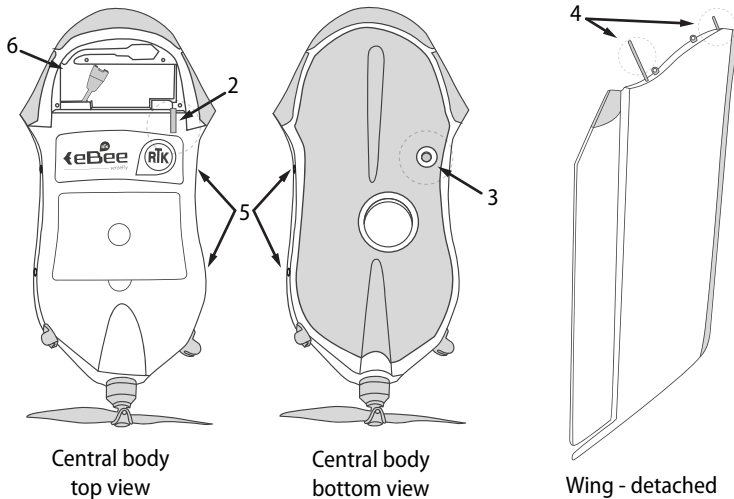
Caution: The *eBee RTK* is not designed to fly in temperatures above 35° C. Avoid exposing the drone to high temperature for prolonged periods of time. In particular, leaving the drone exposed to the sun or in a car should be avoided.

4.2 Preparing the eBee RTK for flight

The eBee RTK's simple design means it can go from the box to being ready for flight in minutes. We recommend that you perform the following 6 steps before every flight to ensure that the platform is best prepared for flight.



Note: Remove the red warning sticker from the motor before your first flight.



Step 1: Perform a general inspection

Visually inspect the drone for damage or wear using the following steps:

1. Check the foam central body and wings for cracks or other damage.
2. Verify that the pitot probe is properly attached to the airframe and that the holes in the probe are free of obstructions.
3. Verify that the ground sensor is free of obstructions and that the sensor's lens is clean.

4. Verify that the wing struts are not split or damaged in any way.
5. Verify that the tubes within the Central Body that hold the wing struts are not cracked or damaged in any way.

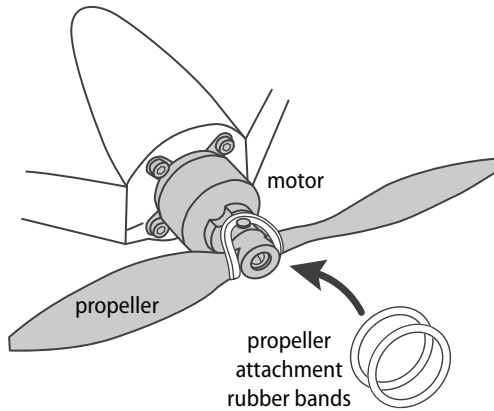


Caution: It is vital to carefully inspect the wing struts and tubes within the Central Body before every flight, as they may cause a crash if they are damaged in any way. This is particularly important if the wings were found separated from the Central Body after a previous flight.

6. Verify that the power cables within the battery compartment are well insulated and not damaged.



Note: A general inspection should be performed before every flight. It is also good practice to perform a full airframe check regularly to keep your *eBee RTK* in good shape. See section 'Full airframe and sensor inspection' on page 147 for more details.



Step 2: Install the propeller

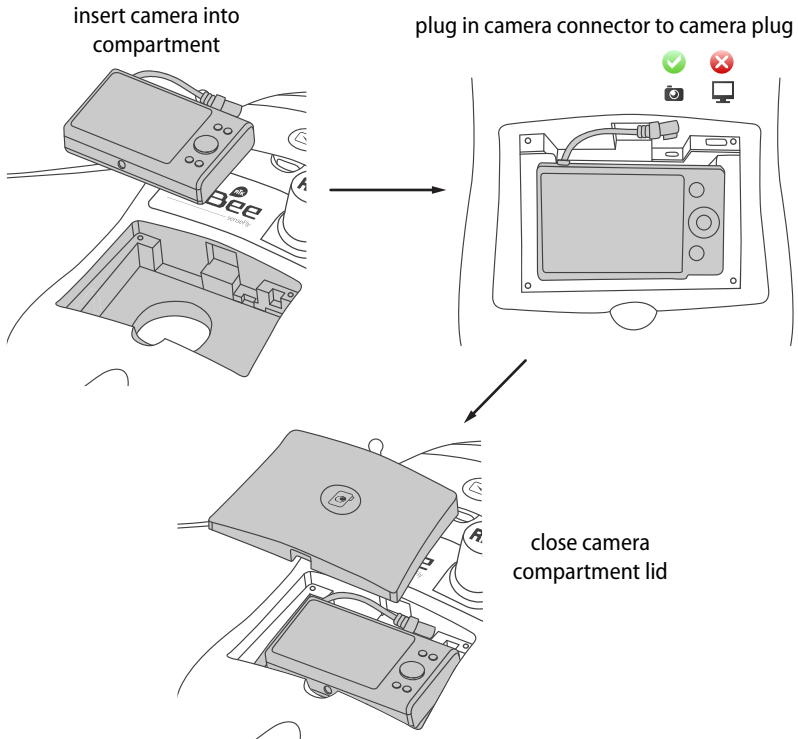
Mount the propeller on the motor axis. Secure the propeller using two attachment rubber bands as illustrated above. Ensure that the propeller is lying flat against the motor mount, and that the rubber bands do not show cracks or any other sign of aging.




Caution: Failure to use two rubber bands may result in the loss of the propeller in flight!



Note: After extensive use, the rubber bands may develop cracks. This is normal and is caused by the ageing of the rubber material. For maximum security, inspect the rubber bands regularly and discard them if they show cracks. 10 spare rubber bands are included in the package.



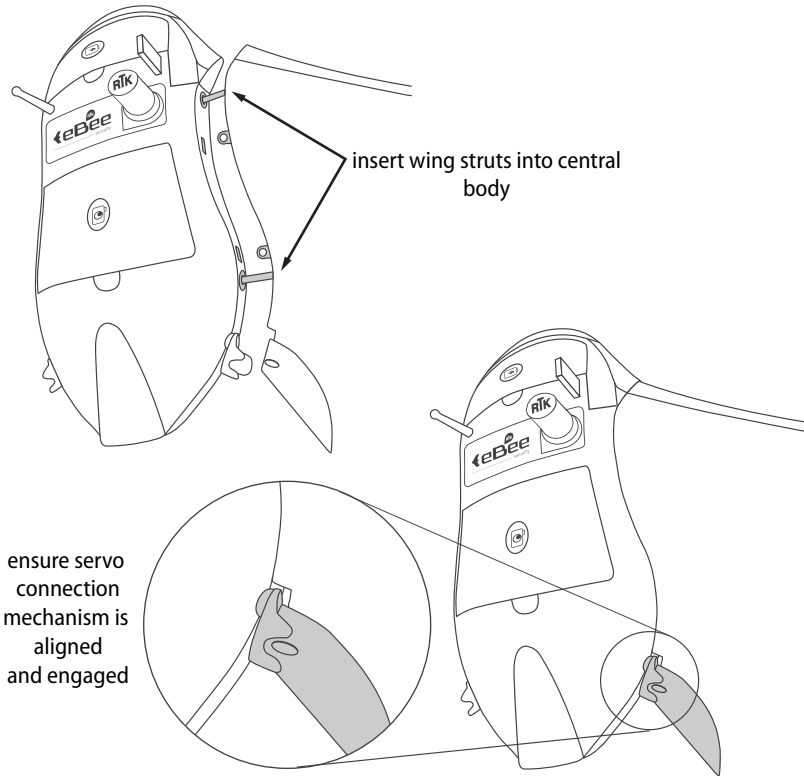
Step 3: Install the camera

Install the camera into the payload bay⁶ within the *eBee RTK* and close the camera compartment lid. If the camera connector is not already connected, plug it into the connector with the  icon on the *eBee RTK*.



Caution: The *eBee RTK* has not been designed to fly without the camera. Attempting to fly without the camera may render the drone unstable, which may eventually lead to a crash.

⁶ Some payloads may require a separate battery or SD card to operate properly. Please refer to the User Manual of the camera or other payload for proper installation instructions.

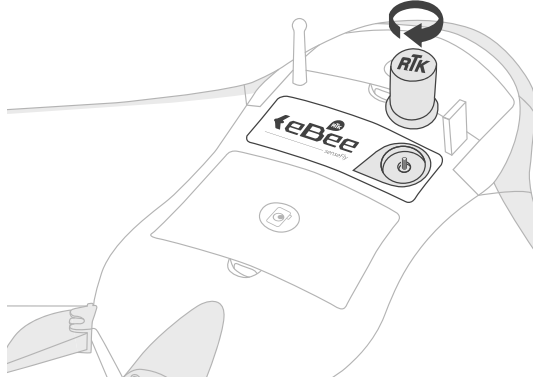


Step 4: Attach the wings

Attach the wings to the central body by inserting the wing struts into the receptacles in the central body. Ensure that the ailerons are properly aligned with the servo connection mechanism before pushing the wings fully into the central body.



Caution: Flying with damaged wing struts or a badly engaged servo connection mechanism may cause erratic flight and ultimately a crash. Be sure to properly inspect and attach the wings before flight.



Step 5: Attach the GNSS/RTK Antenna

Make sure the screw threads on the antenna and on your *eBee RTK* are both undamaged and free of liquid, grit, dust and dirt.

Screw the GNSS antenna onto its connector. Take care not to cross the screw thread. Screw the antenna on firmly with finger force. Do not overtighten.

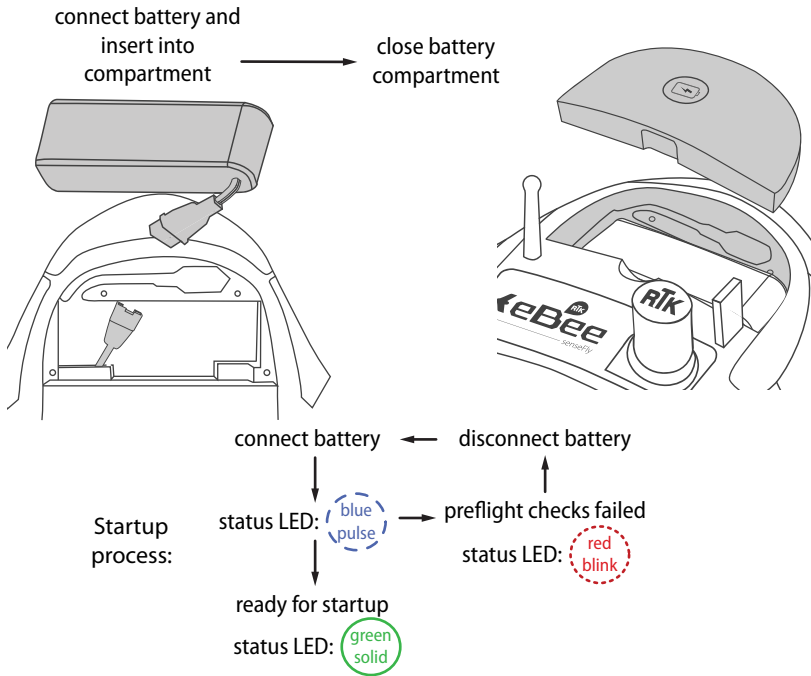
Once screwed on correctly, the initials RTK will be in line with the word eBee.



Note: Your drone will raise a take-off veto and refuse to start its motor if the antenna is not attached. The Section 'Take-off vetoes' on page 158 describes the possible messages and the user action that should be taken to remove them.



Caution: Do not forget to remove the GNSS/RTK antenna before putting the eBee RTK back into its case.



Step 6: Install and connect the battery

Lay the *eBee RTK* horizontally on the ground outside in the vicinity of the take-off location, with the top face up. To install the battery, begin by connecting the power cables to the battery. Insert the connectors firmly to the end in order to avoid undesired disconnection when in flight. Once connected, insert the battery into its compartment and close the compartment lid.



Caution: Take care to keep the propeller area clear, in case it suddenly starts spinning.



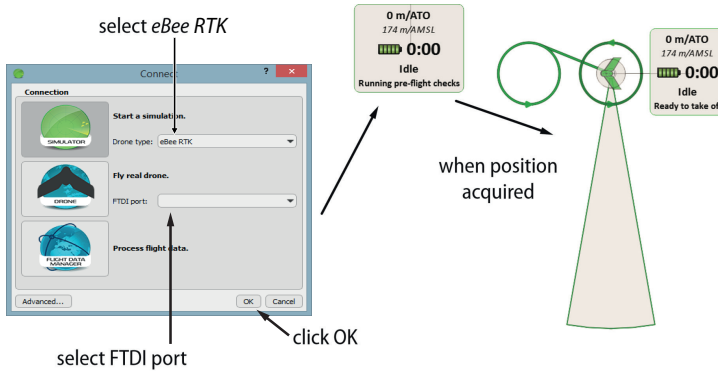
Note: Only connect the battery cables to the drone when you are ready for start-up. Do not leave the battery connected for extended periods of time when the drone is on the ground, as this may discharge the batteries and cause irreparable damage. When connected and not in flight, the *eBee RTK* will briefly move its ailerons up and down every minute as a reminder that it is switched on.

As soon as the battery is connected the *eBee RTK* will perform an automatic self-check of its sensors and acquire GPS/GLONASS signals. Be sure not to move the drone during these tests. It is important that the drone is not inclined more than 10 degrees in order to start up properly. Pre-flight checks may last from a few seconds to several minutes in the case of poor GPS/GLONASS signal reception. As these satellite signals are required for the checks to complete, be sure to place the *eBee RTK* outside with a clear view of the sky.

During the pre-flight checks the status LED will pulse blue. Once the pre-flight checks are complete the *eBee RTK* will flip its ailerons up and down and the status LED will turn solid green to indicate it is ready. You may already connect the drone to *eMotion* (Step 6) before pre-flight checks are complete to get a better idea of the status of the checks.



Note: If there was any problem during the pre-flight checks performed by the drone this will be indicated by a Pre-flight error in *eMotion* as well as a by the status LED blinking red. See section 'Pre-flight errors' on page 155 for a description of possible Pre-flight errors and how to handle them.




Step 7: Connect to eMotion

Start by connecting the USB ground modem to your computer. Then launch *eMotion*, which will display the Connection window. Select the *eBee RTK* connection profile, choose the corresponding FTDI port and click 'OK'.



Note: Every *eBee RTK* is paired with the ground modem it is delivered with, and will only work with that particular modem. The name of the FTDI port corresponding to the ground modem is labelled as '*eBee RTK*-SERIAL', where SERIAL is the serial number of the drone it is paired with.

When a connection is established *eMotion* will display a map and the Status Panel indicating the current state of the drone. If the *eBee RTK* has not yet detected its location the Status Panel will appear in the top right corner of the Map Area with the text 'GPS/GLONASS: Waiting for signals...'. During this time the status LED on the drone will pulse blue.

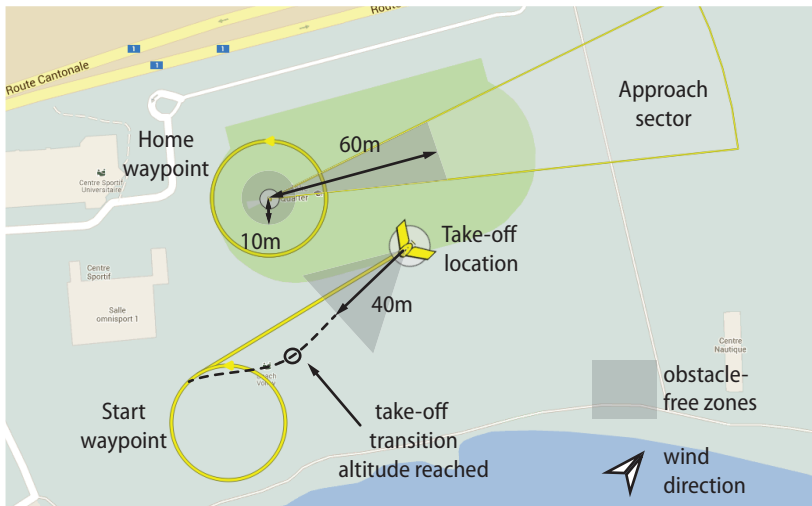
Once your drone has set its position using GPS/GLONASS signals, an icon of the drone will appear at its location on the map. If the drone's location is not on the map you can click the  button from the Toolbar to centre the map on the drone. The drone's status on *eMotion* will be displayed as 'Idle, Ready to take-off' and the status LED will become solid green.

You can now load a flight plan you prepared earlier by selecting the Setup Phase tab from the Sidebar, clicking on 'Load flight plan from file...' and selecting your flight plan file. Alternatively, you can plan the entire mission in the field, following the same process outlined in section 'Planning and simulating a flight' on page 20.

4.3 The setup phase of a flight

The setup phase of a flight includes the waypoints and actions related to the take-off and landing of the *eBee RTK* and includes the following locations:

- **Take-off location:** The point from which the drone is launched, automatically set to the location calculated from GPS/GLONASS signals by the drone when it is launched. This location defines the altitude of 0 m/ATO (ATO stands for above take-off); the altitudes of all other waypoints, when defined in m/ATO, are referenced to the altitude of this location.
- **Start waypoint:** The first point that the drone flies towards when launched (once it reaches the take-off transition altitude).
- **Home waypoint:** The safe point for the drone to circle in case of emergency, as well as its landing position at the end of a flight for both Linear and Circular landings.



It is important to carefully select the take-off location, the Start waypoint and the Home waypoint to ensure your drone remains at a safe distance from obstacles.

The *eBee RTK* should always be launched against the wind. Select a take-off location clear of obstacles (buildings, rocks, power lines, hills, trees, etc.) within a distance of at least 40 m in the upwind direction. Immediately after takeoff it will keep its wings level and climb in the general direction it was launched until it reaches the take-off transition altitude⁷, at which point it will start flying towards the Start waypoint.

By default, the Start waypoint is set to a distance of 80 m West of the initial position of the drone and an altitude of 75 m/ATO. It is good practice to move the Start waypoint close to and upwind from the take-off location to allow a smooth transition between take-off and waypoint-directed flight. You can move waypoints by clicking on them and dragging them within the Map Area⁸.

The Home waypoint is used both as the landing location and as a safety position in case of an In-flight warning. The *eBee RTK* can perform either a Linear or a Circular landing. Linear landing is the default and recommended landing type, especially in high winds. To prepare a Linear landing, place the Home waypoint centre at a location that is at the same altitude as the take-off location and is clear of obstacles in a 10 m radius. Choose one or several approach sectors that are free of obstacles for at least 60 m from the Home waypoint centre. You can drag the approach sector around the Home waypoint and change its width directly in the Map Area or from within the Setup Phase tab. Make the approach sector(s) as wide as possible to maximize the chance that the drone can subsequently land against the direction of the wind. Ensure that the terrain within the approach sector is flat and contains visual contrast to allow the ground sensor to function properly during landing.

When a Linear landing is initiated (either automatically or by pressing the 'Go Land' button in the control bar) the drone will fly towards the Home waypoint, circle the waypoint (at 75 m/ATO by default) to measure the direction of the wind

⁷ By default the take-off transition altitude is set to 20 m. In difficult launch conditions you can set both the take-off heading and the take-off transition altitude in the Setup Phase tab, as described in section 'Setup Phase tab' on page 112.

⁸ see section 'Waypoints and their properties' on page 72 for a more detailed explanation on waypoints and how to modify them

at the landing location and choose an approach direction as much against the direction of the wind as possible. It will then fly downwind in the opposite direction of the approach direction, turn 180° and begin descending in the approach direction until it lands on the ground underneath the centre of the Home waypoint. The approach angle is around 20° and the drone will reverse its thrust if needed to maintain a suitable airspeed during this phase.



Note: There are a number of requirements that must be fulfilled to ensure a successful Linear landing. Section 'Linear landing' on page 86 describes in more detail the Linear landing process and how to properly define approach sectors in more complex terrain. In particular, in the case of strong-wind conditions, low light or low-contrast terrain, the precision of the final landing location around the Home waypoint is reduced. Therefore, it is safer to plan for more clearance, especially along the possible landing axes.

If there are no suitable approach sectors to perform a Linear landing the drone can also perform a Circular landing around the Home waypoint. When initiating a Circular landing around the Home waypoint the drone will switch off its motor and glide down while circling around the Home waypoint at the waypoint's radius. During the Circular landing procedure the drone uses its ground sensor to measure the height above the ground, if the ground is well textured and there is enough light. When it reaches an altitude of 25 m above the ground the drone will level out, estimate the direction of the wind and resume its descent so as to touch down against the wind while remaining on the circle defined by the Home waypoint.



Caution: The ground sensor can only provide usable feedback in daylight conditions above flat terrain that contains enough visual texture. If these conditions are not met the drone cannot ensure a touch-down against the direction of the wind. Landing in the direction of the wind in strong-wind conditions may result in a high landing speed and damage to the *eBee RTK*.

To prepare a Circular landing, place the Home waypoint in a location that has no obstacles within a radius of 50 m (or 20 m more than the Home waypoint radius) to give the drone enough space to land. Ensure that the entire landing area is flat to allow the ground sensor to function properly. By default, the radius of the Home waypoint is 30 m. In high-wind conditions it is recommended to increase this diameter⁹.



Caution: The radius of the Home waypoint, and thus of a Circular landing, can be reduced to 20 m but should only be done in low wind conditions (<3 m/s). Reducing the radius of the Home waypoint below 30 m in moderate- or high-wind conditions can result in damage to the drone when it contacts the ground during a landing. As indicative values, the Home waypoint radius should be set to 30 m for wind speeds below 5 m/s, 40 m for wind speeds between 5-8 m/s, and to 50 m for wind speeds above 8 m/s.



Note: In case of strong-wind conditions, the drone may drift even further than 50 m away from the center of the Home waypoint when performing a Circular landing. Therefore, it is safer to plan for even more clearance in the downwind direction.

By default, the Home waypoint is set to an altitude of 75 m/ATO. In case a Go to Home Waypoint procedure is triggered during flight¹⁰ the drone will, by default, determine the highest altitude between its current altitude and the Home waypoint's altitude, and climb in a circle towards that highest altitude (if required). Once it reaches this highest altitude it will then fly towards the Home waypoint.

Due to this behaviour, the altitude of the Home waypoint should be selected with care; it should be at least 20 m higher than the surrounding obstacles to avoid the risk of a crash, but should not be set too high to reduce the effect of potentially high winds and altitude and to prevent the drone from getting lost. Alternatively, you can change the altitude transition behaviour within the Setup Phase tab. See section 'Waypoints and their properties' on page 72 for more information on alti-

⁹ see section 'Setup Phase tab' on page 112

¹⁰ either automatically due to an In-flight warning or manually using *eMotion*

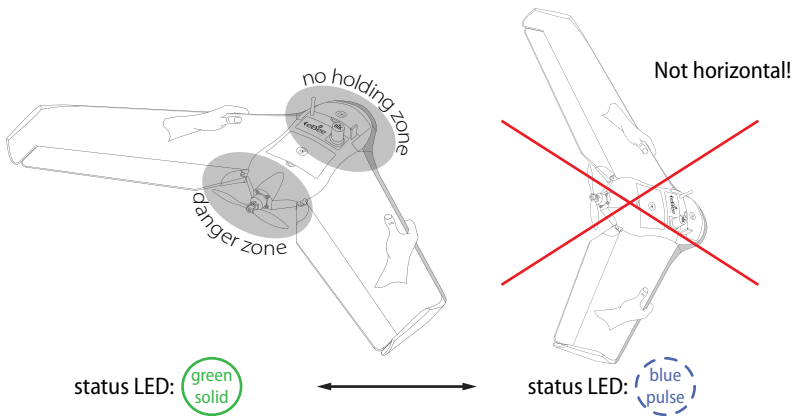
tude transition behaviours and how to modify them.

4.4 Take-off

Once you've planned your mission and the *eBee RTK* status LED is solid green you can launch it using the procedure on the following pages.



Caution: Make sure to keep the propeller area free of all obstructions at all times during the launch procedure.



Step 1: Orient horizontally and against the wind

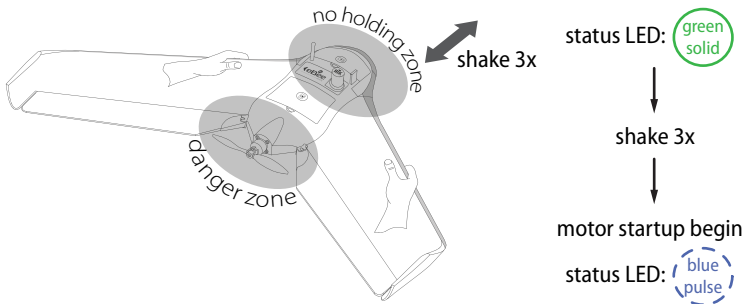
Orient yourself against the direction of the wind, and confirm that the take-off direction in front of you is free of obstacles. Firmly grasp the drone with both hands, one hand on the front of each wing as shown in the figure. Hold the drone horizontally with the nose pointed against the wind and level wings.



Note: If the drone detects a condition that prevents correct take-off a Take-off veto will be displayed in *eMotion* and the status LED will start pulsing blue. Section 'Take-off vetoes' on page 158 describes the possible Take-off veto messages and the user action that should be taken to remove them. For example, if the drone is not oriented horizontally the status LED will start pulsing blue until you re-orient it horizontally, at which point the status LED turns solid green again.



Caution: It is imperative to launch the drone directly against the wind, otherwise it will be unable to gain enough speed during take-off and likely crash. Likewise, launching the drone in high winds above the specified safe wind speed of 12 m/s is dangerous and can result in a crash.

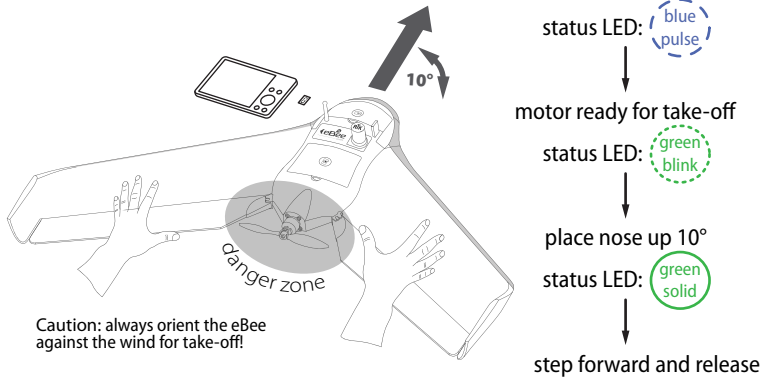


Step 2: Switch the motor on

Shake the *eBee RTK* back and forth 3 times longitudinally (within approx. 3 seconds) to begin the motor power-up sequence. The status LED will pulse blue until the motor is at full power and ready for take-off.



Note: You do not need to hurry to launch the drone. In case you want to shut off the motor, just repeat the back and forth action three times and the motor will stop.



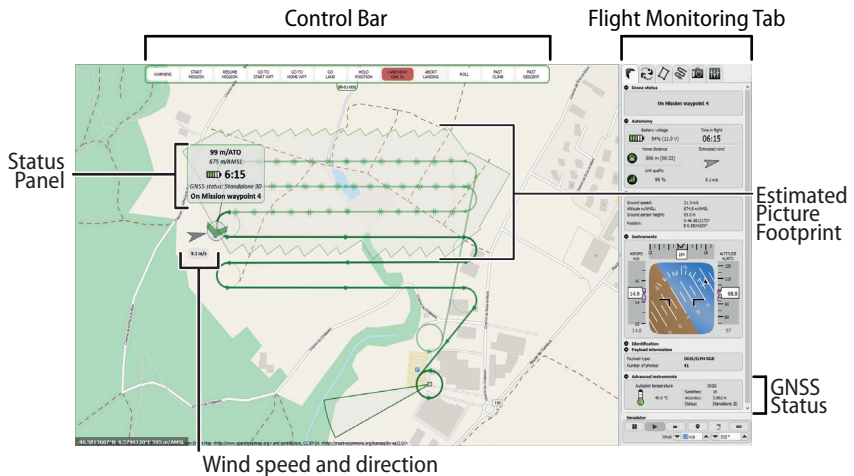
Step 3: Launch the eBee RTK

Once the motor is at full power the status LED will blink green. Orient the drone with approximately 10 degrees nose up and level wings. When the angle is correct the status LED will turn solid green, indicating that the drone is ready for take-off. Launch the drone with a gentle push by walking 1-2 steps forward while releasing it with both hands in a purely forward motion.

After take-off, the drone tries to maintain its initial direction, or follow the directional take-off heading you set, by keeping its wings level with full thrust until reaching the take-off transition altitude, by default 20 m¹¹. At this point, it will switch into waypoint navigation mode and fly towards the Start waypoint. Once it reaches the Start waypoint location and altitude the drone will circle around the waypoint 1-2 times to estimate the wind and calibrate its sensors before starting the mapping mission¹².

¹¹ see section 'Flight Parameters tab' on page 132 to change this parameter

¹² The eBee RTK may also be programmed to wait at the Start waypoint for a command before starting its mapping mission. See section 'Setup Phase tab' on page 112 for more information.



4.5 In-flight monitoring and control

You can monitor and control your drone while in-flight through *eMotion* using the Map Area and the Flight Monitoring tab in the Sidebar.

The Map Area displays the current position of your drone, updated live as the drone executes its flight. A small arrow and infobox show the speed and direction of the wind as measured by the *eBee RTK*. The Status Panel that follows the position of the drone displays basic flight information including battery charge, flight time and altitude, both above the take-off location (ATO) and above mean sea-level (AMSL). This same information is reproduced in the Flight Monitoring tab, along with other useful flight data You can find GNSS status, level of accuracy and the number of visible satellites in the Advanced instruments section at the bottom of this panel.



Note: All waypoints, image locations and flight paths displayed in *eMotion* are a reflection of the data contained within the drone autopilot. If at any point the connection between *eMotion* and the drone is lost, the drone will by default continue its planned flight, including the imaging mission and the selected automatic landing, fully autonomously. If you would like the drone to return to the Home waypoint instead of continuing its mission when it detects a loss of connection you may set the appropriate parameter in the Flight Parameters tab, as described in section 'Flight Parameters tab' on page 132.

During the Mission phase of the flight the *eBee RTK* will automatically take pictures at pre-defined moments based on the parameters that were defined during mission planning. The estimated area captured on the ground is displayed in the form of a continuously-updating polygon in the Map Area.



Note: The *eBee RTK* will not take a picture unless it is in the correct location and altitude. Some reasons for not taking an image are strong head wind, large off-track distance or incorrect altitude. A corresponding message is displayed in the Status Panel if a picture is not taken.

At the top of the Map Area is the Control Bar, which can be used at any time to send commands to your drone as well as to acknowledge warning and failure messages if they occur. During a fully autonomous flight the *eBee RTK* will control its flight autonomously from take-off to landing and you do not need to use any of the control buttons. They can however be useful in unexpected situations to temporarily hold position by pressing the 'HOLD POSITION' button or to send the drone to the Home or Start waypoints with the 'GO TO HOME WPT' or 'GO TO START WPT' buttons, respectively. Alternatively, you can direct your drone to any location by right-clicking in the Map Area and using the contextual menu. We recommend you use the simulator to learn the effects of the buttons on the drone. Detailed descriptions of the buttons and their effects on the drone are described in section 'Control Bar' on page 105.

4.6 Landing

After finishing a mapping mission the drone will, by default¹³, return to the Home waypoint and automatically initiate a landing sequence. During a Linear landing, the drone will land in a straight line according to the process described in section 'Linear landing' on page 86. In case of a Circular landing the drone will land in a circle according to the process described in section 'The setup phase of a flight' on page 51.

Disconnect the battery from the drone before picking it up. We recommend you immediately import the images and flight data after each flight (see section 'Importing images and flight data' on page 62) before putting the *eBee RTK* back in its case for storage. When disconnecting the wings, be sure to pull gently in the axis of the wing struts to prevent damage to the wing struts. Check the wing struts for any damage before putting them into the storage case. Remove the propeller if you don't plan on using the *eBee RTK* for an extended period of time. Remove the GNSS/RTK antenna before putting the central body back into its transport case.

4.7 Potential in-flight errors

The drone can encounter two types of error messages while flying: In-flight warnings and Critical failures. In-flight warnings typically indicate a dangerous situation such as a low battery or strong winds and typically result in a Security action such as a return to the Home waypoint. In-flight warnings appear in blue or yellow in the Flight Monitoring tab. Critical failures occur only when the drone's ability to fly is severely compromised, such as a loss of GPS/GLONASS signals or an empty battery. The situation will be displayed in red in the Status section of the Flight Monitoring tab. When a critical failure arises, the drone will immediately perform an emergency landing.

¹³ see section 'Setup Phase tab' on page 112 for information on changing the default behaviours of the drone



Caution: We recommend that you familiarise yourself with the possible in-flight errors to have a better understanding of what happens if they occur in the field. A full list of possible In-flight warnings and Critical failures and the drone's reaction to them is described in section 'In-flight warnings' on page 160 and section 'Critical failures' on page 173.



Note: It is important to keep track of the location of the drone during a Critical failure until the moment it reaches the ground. Its position's coordinates can aid in finding it afterwards. Instructions on how to find a lost drone can be found in section 'Losing and locating your eBee RTK in the field' on page 177.

5 Processing image data



Goal of this section: In this section you will learn how to import images and flight data from your *eBee RTK* and create basic mapping products directly in the field to gauge the quality of the images that you gathered.

5.1 High precision geotagging with the *eBee RTK*

Both your *eBee RTK* and *eMotion* work exclusively in the WGS 84 reference frame:

- Images taken by your *eBee RTK* are geotagged with the precise position of the drone when the image was taken. Geotags derived from GPS and GLONASS signals are recorded in the WGS 84 coordinate system.
- Throughout *eMotion*, coordinates are displayed using the global WGS 84 reference frame. When you enter coordinates in *eMotion*, as latitude, longitude and elevation, they are assumed to be in WGS 84.

In order to create mapping products (for example, DSMs, orthomosaics) in *Post-flight Terra 3D* that have their correct absolute positions with respect to your coordinate system, you must carry out a coordinate transformation:


- Latitude and longitude are converted to x,y coordinates in your coordinate system.
- Elevation (height above ellipsoid) is converted to absolute z coordinate by applying a vertical displacement constant, the Geoid-Ellipsoid Separation.

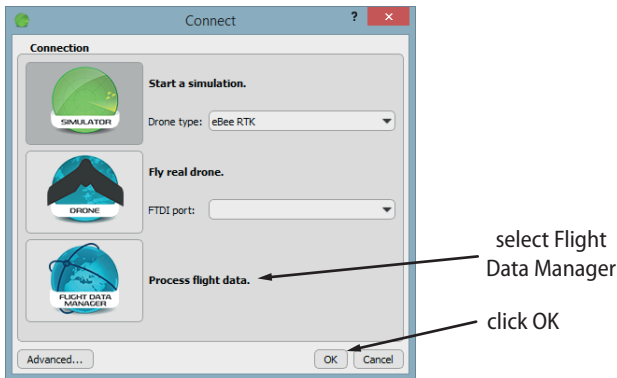
5.2 Importing images and flight data

The next step to creating mapping products, after completing a flight, is to import the raw images and log files to a computer. The *eBee RTK* records flight data

onboard in a special Drone Flight Log file. The Drone Flight Log tracks important information throughout a flight, such as sensor data, location and control inputs. The file is required for assigning location information (geotags) to the images taken by the drone. The file is also required and must be sent to senseFly Ltd in case an issue occurred during the flight¹⁴. A similar eMotion Flight Log file is created within *eMotion* during a flight and serves as a backup in case the Drone Flight Log file cannot be recovered.

If you are using a GNSS/RTK base station, you may also need to import files from the base station and reference stations.

eMotion features a Flight Data Manager to help you transfer and consolidate all the data related to a mapping mission. Open the Flight Data Manager by clicking on the Flight Data Manager icon when you load *eMotion*. Alternatively, click on the  button in the Toolbar and select 'Flight Data Manager...'



The way that *eMotion* processes RTK correction data depends on the way you set up your flight.

If you used a local base station and entered its position into *eMotion*, as your *eBee RTK* was flying, *eMotion* was sending RTK corrections from the base station to the drone through the ground modem. Your drone was logging the precise coordinates of each image it took.

¹⁴ see section 'Reporting a problem with your *eBee RTK*' on page 178

If you used a local base station and didn't have its precise position, you have an extra post-flight processing step to do. *eMotion* will calculate the precise absolute position of your base station using the raw logs from your base station and the raw navigation and observation logs from your reference station. The precisely-measured position of your *eBee RTK* relative to your base station will then be corrected using this calculated absolute base station position to obtain high-precision absolute geo-tags for your images.

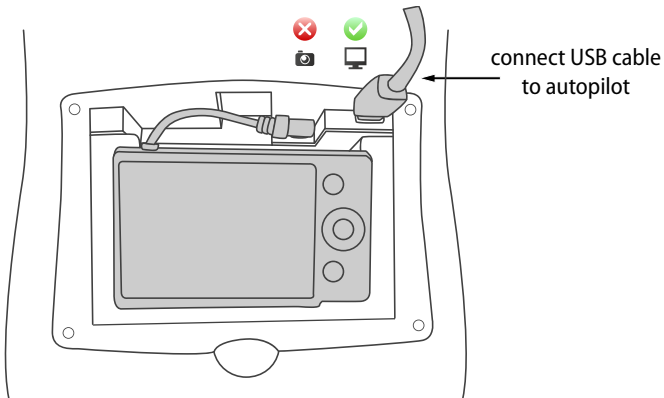
If you used a virtual reference, your Ntrip stream provider will have automatically provided *eMotion* with precise virtual base station coordinates or linked *eMotion* to a fixed reference station. As your *eBee RTK* was flying, *eMotion* was sending RTK corrections, gathered from the Ntrip broadcast, to your drone and your drone was logging the precise coordinates of each image it took.


If you flew your *eBee RTK* in standalone mode, you do not have any RTK corrections; all the flight data you need is stored onboard your drone.

Follow these steps to import data from the drone:

- **Step 1 - Select a flight:** If the flight was monitored from the computer you are using to import images then the flight is saved within the local database. Select the date that the flight took place. A list of flights (including number of images taken) from that date will appear in the combo box, select the one you wish to import.

- **Step 2 - Create a directory:** Choose a directory name that uniquely identifies your flight (e.g. the date, the name of the area, etc.).



- **Step 3 - Prepare data for import:** To import the Drone Flight Log, connect the supplied USB cable to the *eBee RTK*'s autopilot, marked with a  icon. Connect the battery to the drone if it is not already connected. The status LED will become white and a new storage drive will appear on your computer.

To import images, remove the SD card from the camera, insert it into the SD card reader of your computer and select 'Import from SD-card reader'. Alternatively, transfer the images from the camera by lifting it out of its compartment just enough to connect a USB cable to it and turn the camera on. Copy all the images into a temporary folder on your computer. Select 'Import from a specific folder' and choose the temporary folder.

- **Step 4 - Import flight logs:** Confirm that the Drone and eMotion Flight Logs found by the Flight Data Manager are correct. You may select logs manually if they are not correctly detected.
- **Step 5 - Import images:** Confirm that the images corresponding to your flight were found and matched to the Drone Flight Log correctly.
- **Step 6 - import RTK correction files:**



Note: You will only see this step if you used a local base station.

If you used a base station with a known position

- Choose The base was placed over a known point. Click Next to continue.

If your base station's position was unknown, you must import the raw GNSS data from your base station and the raw observation and navigation data from at least one reference station:



Note: If you have a Topcon base station you can import its raw GNSS data through the connection to *eMotion*. Connect your Topcon base station to your computer and choose Import files from base. *eMotion* will look for the raw data files in the default location on the Topcon base station. Once complete, go to step 4 (import reference station files).



Note: Check your base station manufacturer's documentation to make sure that your occupation time is sufficient for the base line length and manufacturer model you are working with.

1. Export the raw GNSS data from your base station to your computer or suitable file server following your base station manufacturer's instructions.
2. In *eMotion*, choose The base station was placed on an unknown location and Import files from local folder.
3. Choose the file format and enter the path to the file, or click Browse and locate the files.
4. Enter the paths to your reference station RINEX observation and navigation files, or click Browse to locate the file on your computer.

Once complete, click Next to continue.

eMotion will process any raw GNSS data you provided and show the result on the next screen. If you don't need to make any modifications to the results of post-processing, click Next. If you do need to make modifications (for example, you have calculated base station parameters outside *eMotion*) you can change them here and click Next.

- **Step 7 - Select outputs:** Choose the output actions to execute and files to create. Geotagging images is necessary to create geoinfo, KML and *Postflight Terra 3D* files.
- **Step 8:** You may now disconnect the drone. Eject the SD-card drive and the drone drive before removing the SD-card and the USB cable, respectively. Disconnect the battery and USB cable from the drone. Insert the SD-card back into the camera, put it back properly into its compartment and ensure that it is turned off. You can now open the KML file in *Google Earth™* or the project in *Postflight Terra 3D* for further processing.

5.3 In-field image quality check

Postflight Terra 3D software¹⁵, available as a free download with the *eBee RTK* package, can be used to rapidly create a Quality Report directly in the field. The Quality Report that is automatically generated as well as the orthomosaic provide immediate feedback on the quality of the images gathered during your mission.

You can open a project for processing in *Postflight Terra 3D* directly from the Flight Data Manager after importing your data by clicking the 'Open project in Terra' button. You will now see the main *Postflight Terra 3D* window. The position of your images will appear as red dots in the Map Area of *Postflight Terra 3D*.

¹⁵ powered by Pix4D, see section 'Installing *eMotion*, *Postflight Terra 3D*, and the ground modem drivers' on page 20 for installation instructions


Quick start guide


Automatic Reconstruction Report generation

The screenshot displays the Postflight Terra 3D software interface. The main window shows a 3D terrain map with numerous red circular markers indicating processing points. On the right side, there are three panels: 'Project Information' (containing project details like name, type, and workspace), 'Layers' (with checkboxes for 'Imagery', 'SCN', 'Processing Areas', 'Aerial Cloud Classification Area', and 'Orthomosaic Area'), and 'Local Processing' (with checkboxes for '1. Initial Processing', '2. Aerial Cloud Classification', and '3. DSM and Orthomosaic Generation', along with a 'Rapid Check' button and a 'Start' button). The 'Local Processing' panel also shows a progress bar at 0% and a 'Resolution (meters): Auto (4.04)'. The 'Map Area' at the bottom shows coordinates: WGS 4 -166.6023827 6.56119, UTM zone 32N -1311250.573, 5163996.260 (m).

Step 1: select 1. Initial Processing, Rapid Check

Step 2: click 'Start'

To create a Quality Report while in the field bring up the local processing panel by selecting 'Local processing' from the 'Process' menu or by clicking the  icon in the Toolbar. Select only the 'Initial project processing' checkbox and the 'Rapid' button. If you wish to create a low-resolution orthomosaic while generating the report, check the 'Orthomosaic and DSM generation' checkbox. Click 'Start' to begin rapid processing.


Postflight Terra 3D will now process the data and produce a report that includes the overall completeness and georeference quality of the images taken during your last mission. You may use this information to decide whether further imaging flights are required while you are still in the field. The quality report will be displayed in a new window (click the  icon in the Toolbar if it does not appear).

5.4 Creating advanced mapping products

Beyond Quality Reports and low-resolution orthomosaics, *Postflight Terra 3D* can generate geo-referenced high-resolution 2D orthomosaics, 3D point clouds, triangle models and DSMs or export to common third-party photogrammetry software such as Bingo, Orima or Inpho. *Postflight Terra 3D* also includes a mosaic and a rayCloud editor, giving you more control on the quality of your final mapping products, as well as measurement tools.

The resulting orthomosaic and DSM may then be imported as custom background map and elevation data layers in *eMotion*¹⁶. This data can be used for advanced flight planning in complex or uneven terrain.



Note: You need to either enable tile set generation OR choose Generate Google Maps Tiles and KML from the Process menu before you can push the tileset into *eMotion* by choosing Send Map to *eMotion* from the Process menu. Alternatively, this data can be imported into *eMotion*; choose Import custom map from *eMotion*'s  File menu.



Note: The best way to learn how to use the various features of *Postflight Terra 3D* is to look at the comprehensive online Knowledge Base at my.sensefly.com

5.5 Transforming coordinates

First, set up the latitude/longitude to x/y transformation...

If you are using a established coordinate system:

Step 1 Choose Select Output Coordinate System from the *Postflight Terra 3D* Project menu.

¹⁶ see section 'Toolbar' on page 100 for more information on importing layers into *eMotion*

Step 2 If you know the coordinate system name, click From List and choose the one you want.

If you know the EPSG code of your coordinate system, click From EPSG and choose the code you want.

If you have the .prj coordinate system syntax file, click From .prj, browse to the location of your file, select the file and click Open.

Step 3 Click OK on the Select Output Coordinate System dialog.

Step 4 *Postflight Terra 3D* will create mapping products in the established coordinate system you chose.

To use a custom local coordinate system:

Step 1 Obtain or create a coordinate system syntax file (with extension .prj).

See senseFly Ltd Knowledge Base article number 73776018 for help with .prj file creation.

Step 2 Choose Select Output Coordinate System from the *Postflight Terra 3D* Project menu.

Step 3 Click From .prj, browse to the location of your .prj file, select the file and click Open.

Step 4 In the Select Output Coordinate System dialog, click OK.

Step 5 *Postflight Terra 3D* will create mapping products in your custom coordinate system.

Next, convert height above ellipsoid to altitude (z)...

Step 1 Choose Image Properties Editor from the *Postflight Terra 3D* Project menu.

Step 2 In the Image Coordinate System section, enter the Geoid-Ellipsoid Separation and click OK.

Step 3 *Postflight Terra 3D* will create mapping products with a vertical displacement to match your coordinate system's altitude.

Part II

Advanced functionalities

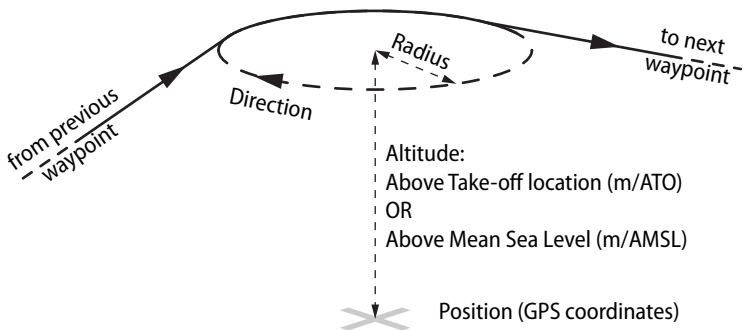
6 Understanding aerial mapping with the *eBee RTK*



Goal of this section: Aerial mapping using the *eBee RTK* is designed to be simple and fully automatic, requiring very little input from the user. Understanding the basics of aerial navigation, however, can help you map more complex terrain and yield higher quality results. This section explains the basics of waypoint-based navigation and the control strategies used by the drone for flight.

6.1 Waypoints and their properties

The *eBee RTK* uses a flight plan consisting of a list of waypoints to navigate. A waypoint essentially consists of a circle about a given position and information that defines how the drone should behave when reaching them. The entire list of waypoints is stored in the drone autopilot and can be remotely edited using *eMotion*.



In *eMotion* every waypoint is defined by the following parameters:

- **ID:** Every mission waypoint has a unique ID, beginning at 1. The *eBee RTK*

can store up to 50 mission waypoints. Setup phase waypoints (Start and Home) do not have an ID.

- **Active:** Indicates whether the waypoint is active or not. Deactivating a waypoint by clicking the checkbox beside its ID will remove it from the current flight plan. Setup phase waypoints (Start and Home) cannot be deactivated.
- **Current:** A status that indicates if the waypoint is currently being circled or navigated toward (indicated by > < around the waypoint's ID). Only one waypoint is marked Current at a time.
- **Change altitude:** This parameter defines the way the drone transitions to the altitude of the current waypoint.
 - **During transit:** The drone will fly in the direction of the current waypoint while simultaneously changing altitude by climbing or descending in a linear fashion. If the required climb or descent rate is beyond physical limits, the drone will reach the destination and keep climbing/descending around the destination waypoint. This is typically used to achieve the best efficiency when the altitude between waypoints is not constrained.
 - **Before transit:** The drone will first climb or descend at its current position until it reaches the altitude of the current waypoint, and then fly in the direction of the waypoint at its altitude. This is typically used for 3D mapping.
 - **Keep highest:** The drone will first determine whether its current altitude or the current waypoint's altitude is highest. If the drone's current altitude is highest, it will first fly towards the waypoint and then descent to the waypoint's altitude in a circular fashion. If the current waypoint's altitude is highest, the drone will begin by climbing at its current position until it reaches the waypoint's altitude and then fly towards the waypoint. This is typically useful to avoid hitting the terrain in mountainous landscapes and, in particular, for the Home waypoint when the mission altitude is below the take-off location.

- **Altitude:** The altitude of the waypoint above the altitude reference. The waypoint is considered 'reached' only when the drone starts circling about it at the waypoint's altitude.
- **Altitude reference:** The reference point of the Altitude value. When set to m/ATO, the Altitude value is an Above Take-off (ATO) altitude. When set to m/AMSL, the Altitude value is a Above Mean Sea Level (AMSL). The altitudes of Setup phase waypoints (Start and Home) are always set to m/ATO.
- **Turn direction:** The direction with which the drone circles around the waypoint (clockwise or counter-clockwise).
- **Radius:** The distance at which the drone circles around the waypoint.



Note: The *eBee RTK* has a limited turning radius. Setting this parameter lower than 20 m may cause the drone to significantly deviate from its desired flight path.

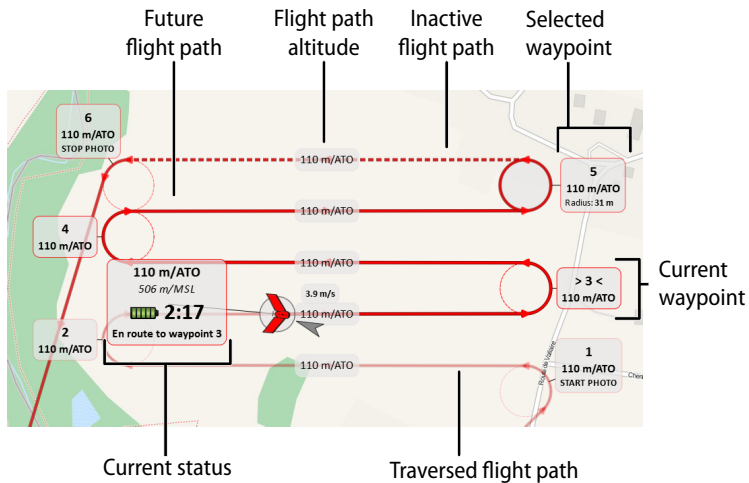
- **Auto-next:** Indicates whether the drone should remain on the waypoint upon reaching it (until a new command is received) or automatically continue to the next active waypoint.
- **Action:** The action (if any) to be performed upon reaching the waypoint. Supported actions include starting and stopping Continuous photo mode¹⁷. Setup phase parameters (Start and Home) do not have associated Actions.
- **Position (coordinates):** The precise latitude and longitude of the centre of the waypoint.

Waypoints are represented in the Map Area as circles with their actual radius and an arrow to indicate their direction. The flight path of the drone around and in between waypoints is drawn as a line of varying opacity; the path ahead of the drone's current position is dark, becoming lighter the further it is from the current position in the flight plan. The path already traversed is a uniform light colour.

¹⁷ see section 'Camera tab' on page 127

If a waypoint's Auto-next parameter is disabled, the path directly after it will be dashed, indicating that a command must be sent for the flight to continue.

Clicking a waypoint in the Map Area will display its characteristics (waypoint ID for mission waypoints or name for setup waypoints, altitude, radius and action) and will select it for modification. It will also activate the Mission Waypoints tab and highlight the selected waypoint.



You can modify the waypoint's parameters directly in the Map Area using your mouse using the following actions:

- **Position:** Change the position by left-clicking on the waypoint and dragging it around on the map. By default the waypoint snaps to a position in-line with the current flight lines before and after the waypoint. Hold down the 'Alt' button while dragging to disable the snapping feature.
- **Turn direction:** Hold down the 'Shift' button while left-clicking on a waypoint to toggle its turn direction.
- **Radius:** Modify the radius by left-clicking on the waypoint's perimeter and dragging it.

- **Altitude:** Hold down the 'Ctrl' button while left-clicking on the waypoint and moving the mouse up or down to increase or decrease the altitude of the waypoint, respectively.
- **Create new waypoint:** Right-click anywhere in the Map Area that does not contain a symbol to bring up the context menu, then select 'Add waypoint here' to add a new waypoint.
- **Context menu:** Right-click on a waypoint to bring up the context menu. You can then select the following options:
 - **Go to:** Select while the drone is in flight to make this the current destination waypoint.
 - **Auto-next:** Toggle the Auto-next parameter of the waypoint.
 - **Reverse turn direction:** Toggle the Turn direction parameter of the waypoint.
 - **Change altitude:** Set the transition behaviour of the drone when flying towards the selected waypoint.
 - **Remove waypoint:** Remove the selected waypoint.

Any modification will be sent directly to the drone to update its onboard waypoint list. If the message is not acknowledged by the drone (for example due to a temporary loss of communication link), the waypoint will move back to its previous position on the map to accurately reflect the current waypoint list status within the drone's autopilot.



Note: Modification of flight plan parameters can cause the drone to react in unexpected ways. In particular, the drone may have trouble following its flight path when the radius is set very low or if there is high wind. We highly encourage you to test your entire flight plan using the simulator to get familiar with the drone's behaviours before going out into the field.


6.2 Advanced polygonal mission area

The mission area defines the area of interest where the *eBee RTK* will take photos. It appears as a grey rectangle when you select the 'Mission planning' tab and to calculate the flight plan of the drone. For many cases the rectangular-shaped mission area provides the simplest way to quickly create a flight plan. It can be modified as described in section 'The mission phase of a flight' on page 26.

For more complex areas *eMotion* has the option of using polygonal-shaped missions areas. Begin by converting a rectangular area into a polygonal area by setting the 'Mission area' type to 'Polygonal' in the 'Mission planning' tab or by right-clicking on the area and selecting 'Convert to polygon'.


A polygonal mission area is set slightly differently than a rectangular mission area:

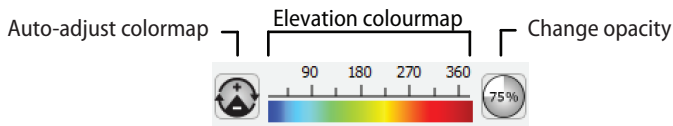
- The edges of the rectangle now become vertices of the polygon. Left-click on a vertex to drag and reposition the vertex.
- Left-click and drag anywhere on the edge of the polygon to create a new vertex and reposition it.
- Right-click on vertex and select 'Remove vertex' to remove a vertex. Alternatively, hold down the 'Ctrl' button and left-click on a vertex to remove it.
- Left-click and drag on the dark-grey area within the polygon to reposition the entire polygon.
- Left-click and drag the circle on the corner of the light-grey rectangle surrounding the polygon to rotate the direction of the resulting flight lines.

You may also set a polygonal mission area directly from a KML file containing a polygon, such as those created by *Google Earth™*. Simply click on the  icon in the 'Mission planning' tab, select 'Load mission area from KML file' and choose a KML file that contains the desired polygon.

6.3 3D mission planning using elevation data

eMotion has the ability to take into account elevation data to set the altitude of mission waypoints and the resulting flight lines of a mapping mission. This not only improves the resulting ground resolution but also increases mission safety (particularly in uneven terrain) by keeping a more even height between the drone and the ground.

You can display elevation data by clicking on the  button in the Toolbar. *eMotion*'s default Improved SRTM elevation data will be downloaded as tiles from senseFly Ltd servers and overlaid above the map as a colourmap¹⁸. You can adjust the scale and opacity of the colourmap by using the associated buttons in the bottom-right corner of the Map Area.



Caution: *eMotion*'s default Improved SRTM elevation data uses a 3 arc-second (approx. 90 m resolution) digital elevation model derived from the SRTM (Shuttle Radar Topography Mission) dataset version 2.1 combined with other data sources (ASTER GDEM, SRTM30, cartographic data, etc.). This data covers nearly all emerged land except the territories below 56° S latitude and the territory of the Russian Federation above 60° N latitude. This data may contain inaccuracies of several meters, and does not contain data on obstacles such as buildings or trees. We highly recommend that you check your flight plan thoroughly in *Google Earth™* and ensure sufficient clearance between the flight plan and the ground. SenseFly Ltd provides no guarantee regarding the accuracy of the elevation data and it is the operator's sole responsibility to ensure a safe flight trajectory and altitude.

¹⁸ *eMotion* must be connected to the internet. Once downloaded, elevation tiles are cached and can then be used off-line.

Activate the 3D mission planning feature by selecting the 'Use elevation data to set absolute waypoint altitudes' parameter in the 'Mission Planning' tab. Elevation data is used to adjust every mission waypoint altitude as follows:

1. The flight planner uses elevation data to find the maximal terrain elevation under the current waypoint, the previous waypoint and the flight line that connects the two.
2. This maximum value is increased by the target altitude value, and the result is set as the altitude of the current waypoint.

The altitude of every waypoint can always be manually adjusted in the Mission Waypoints tab. By default, the 'Change altitude' parameter for the first mission waypoint is set to 'Keep highest'. For all other mission waypoints the 'Change altitude' parameter is set to 'Before transit' so that the drone climbs or descends to the altitude of the next waypoint (and thus the next flight line) before transiting and taking pictures.

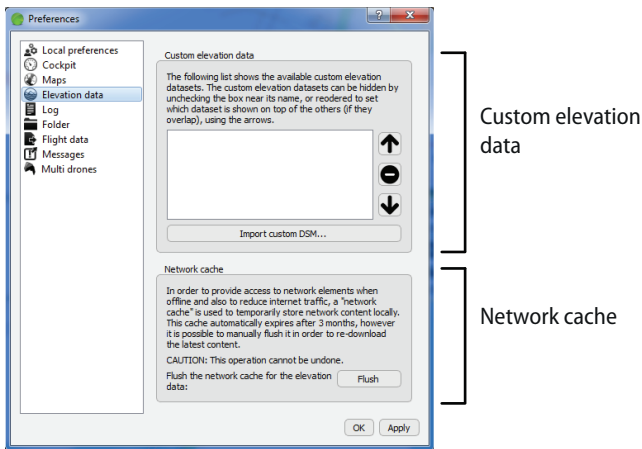
It is important to understand that even if each flight line can have a different altitude, the altitude is constant along a given flight line. If the terrain altitude is uneven along a flight line, the resulting imagery will have varying ground resolution and overlap. When the mission planner computes the altitudes of flight lines it tries to ensure that the required amount of overlap is achieved, possibly leading to a lower ground resolution in some areas. During flight planning the range of ground resolution computed by the mission planner is displayed. For optimal results, it is best to set the orientation of the flight lines as parallel as possible to the terrain's contour lines.

One way to increase the resolution and accuracy of the elevation data is to fly a first mission at high altitude and then create a dataset using *Postflight Terra 3D*. You can then automatically import the data into *eMotion* by selecting 'Send DSM to eMotion' from the 'Process' menu within *Postflight Terra 3D*. The dataset can then be enabled using the ☰ menu in the Toolbar. *eMotion* will use this custom dataset (wherever it is available) to set waypoint altitudes instead of its default Improved SRTM elevation data.



Note: It is recommended to visually compare imported elevation datasets with the default Improved SRTM elevation layer of *eMotion* in order to detect possible mismatches. This comparison should be done with a colourmap opacity value of 100%.

More advanced controls of imported datasets are available in the 'Elevation data' panel of the Preferences pane of the menu. From this panel you can add, remove, activate/deactivate or reorder overlays. *eMotion* uses the top-most elevation data layer to calculate altitude for each waypoint and flight line, with *eMotion's* default Improved SRTM elevation dataset always considered the bottom layer.



6.4 Flight visualization in Google Earth™

eMotion includes an interface with *Google Earth™* to help with flight plan verification and visualization, particularly in uneven terrain. Clicking on the button in the Toolbar will open *Google Earth™* and zoom to the current position of the drone. The current position of drone, its planned trajectory, the working area circle and all waypoints currently uploaded to the drone (including Take-Off, Start

and Home) are displayed within *Google Earth™*. Any changes to waypoints or flight parameters within *eMotion* are updated accordingly within *Google Earth™*.

The interface with *Google Earth™* is particularly useful to check the drone's trajectory with respect to obstacles in the area¹⁹. The flight plan is projected onto the ground in a darker colour, giving you an idea of the distance between the flight path and the ground. If you connect to a simulated drone you can simulate the entire flight and follow the drone within *Google Earth™*.



Note: To use this feature *Google Earth™* has to be installed on the ground station PC, as described in section 'Installing *eMotion*, *Post-flight Terra 3D*, and the ground modem drivers' on page 20. We recommend to use the latest version of the *Google Earth™* software.



Caution: A flight trajectory visualized in *Google Earth™* represents the planned trajectory. The real flight trajectory can be different from the planned due to flight conditions such as strong wind.

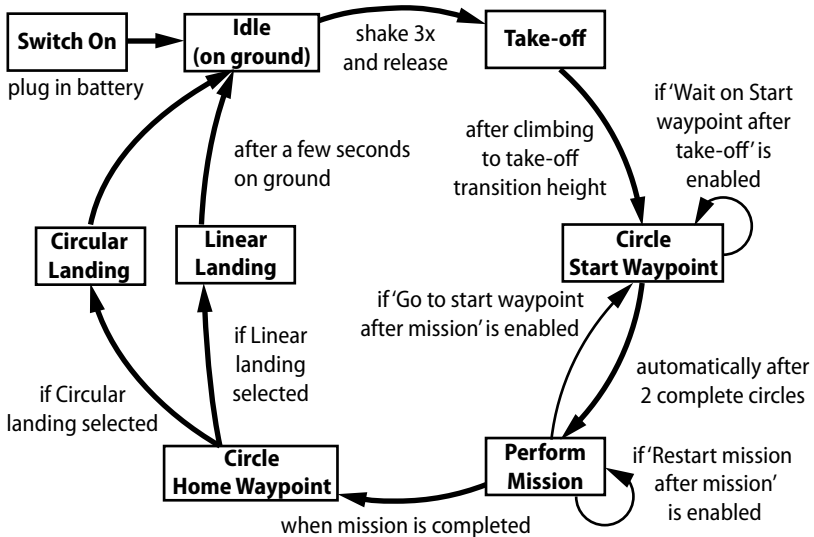


Caution: The terrain data within *Google Earth™*, including hills and buildings, may contain significant errors. When planning flights over uneven terrain be sure to keep sufficient distance between the flight plan and the terrain.

¹⁹ While checking flight plans in *Google Earth™* is a good safety practice, senseFly Ltd provides no guarantee regarding the accuracy and completeness of the *Google Earth™* terrain model.

6.5 Autonomous controller and modes of flight

Autonomous operation modes



Manual and emergency modes



During a typical flight the autonomous controller on the *eBee RTK* will switch between various modes depending on its flight plan and the commands that it receives from the Control Bar²⁰. The controller changes between modes during a typical mission as shown in the figure above, and as described in more detail in the following list:

- After being switched on and running pre-flight checks the drone will enter Idle mode until it is ready to be launched. Shaking the drone back and forth

²⁰ see section 'Control Bar' on page 105 for details on the Control Bar

three times initiates the take-off procedure²¹ and changes to the Take-off mode.

- After take-off the drone climbs with level wings²², gaining altitude until it reaches the take-off transition altitude, by default 20 m²³ above the take-off location. At this point the drone heads for the Start waypoint and changes to Circle Start Waypoint mode.
- Once it reaches the Start waypoint, the drone circles the waypoint several times to estimate the strength of the wind. Once it calculates the estimated wind the drone either:
 - heads towards the first mission waypoint, if 'Start mission' is selected in the 'After take-off' panel of the Setup Phase tab, and changes to Perform Mission mode.
 - continues circling the Start waypoint until a command is received from the Control Bar (typically a 'START MISSION' command that is sent once a flight plan is finalized).
- While in Perform Mission mode the drone flies between all enabled mission waypoints, taking images of the ground below. Once it reaches the final mission waypoint the drone either:
 - heads towards the Home waypoint, if 'Land' or 'Go to Home waypoint' is selected in the 'After mission' panel of the Setup Phase tab, and changes to Circle Home Waypoint mode.
 - heads towards the Start waypoint, if 'Go to Start waypoint' is selected in the 'After mission' panel of the Setup Phase tab, and changes to Circle Start Waypoint mode.
 - heads towards the first mission waypoint, if 'Restart mission' is selected in the 'After mission' panel of the Setup Phase tab, and remains in Perform Mission mode.

²¹ as described in section 'Take-off' on page 55

²² or in a given direction when using the Directional take-off feature described in section 'Setup Phase tab' on page 112

²³ see section 'Flight Parameters tab' on page 132 for details on changing this altitude

- Once it reaches the Home waypoint (if in Circle Home Waypoint mode) the drone will either:
 - begin a Linear landing procedure (as described in section ‘Linear landing’ on page 86) and change to Linear Landing mode, if ‘Land’ is selected in the ‘After mission’ list and ‘Linear landing’ is selected in the Landing type list of the Setup Phase tab.
 - begin a Circular landing procedure and change to Circular Landing mode, if ‘Land’ is selected in the ‘After mission’ list and ‘Circular landing’ is selected in the Landing type list of the Setup Phase tab.
 - circles the Home waypoint and remains in Circle Home Waypoint mode until a command is sent.
- After completing a landing procedure and detecting that it has successfully landed, the drone changes to Idle mode.
- Turning on the remote control will cause the drone to enter either Assisted Manual or Full Manual mode, depending on the setting in the Flight Parameters tab²⁴. Turning off the remote control will return the drone to its previous mode.
- Clicking the ‘HOLD POSITION’ button in the Control Bar at any time will cause the drone to start circling its current position and change to Hold Position mode until it receives a new command from the Control Bar. Alternatively, right-clicking in the Map Area and selecting ‘Hold here’ will direct the drone towards the selected position and then circle around that position in Hold Position mode. This mode is also enabled automatically after certain In-flight warning or Critical failure conditions²⁵.
- Clicking the ‘LAND NOW’ button in the Control Bar three times in quick succession will cause the drone to initiate a Circular landing procedure at its

²⁴ see section ‘Manual control of the eBee RTK’ on page 136 for information on the various manual control modes

²⁵ see section ‘Troubleshooting’ on page 154 for a full list of In-flight warning and Critical failure conditions and the subsequent reactions of the drone

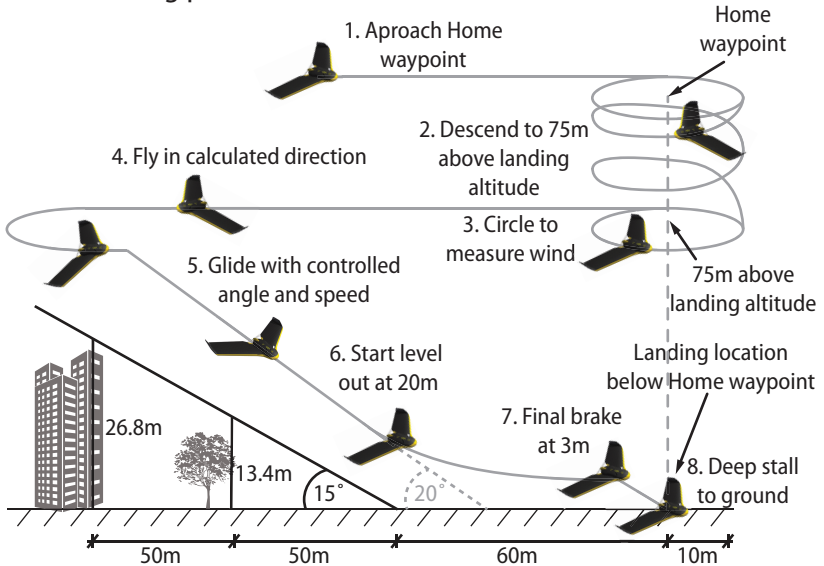
current location with its motor disabled and change to Emergency Landing mode.

6.6 Linear landing

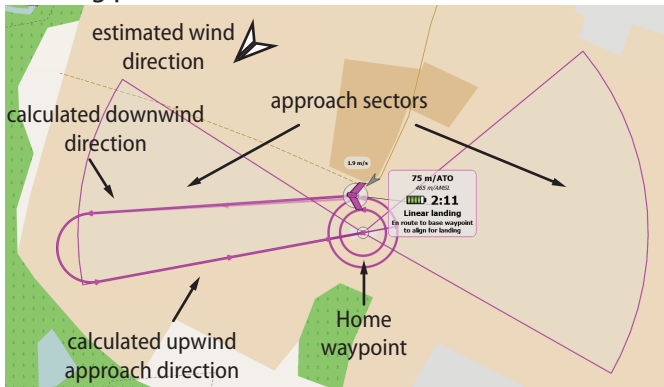
A typical Linear landing follows these steps:

1. The *eBee RTK* flies towards the Home waypoint (defined by the user within *eMotion*; default altitude is 75 m above the landing altitude). The altitude change behaviour between the current location and the Home waypoint depends on the 'Altitude change' parameter of the Home waypoint. By default, it is defined as 'Keep highest', which means that the drone will fly at the highest altitude between its current altitude and the Home waypoint's altitude, climbing in a spiral first if needed.
2. Once the Home waypoint is reached the drone circles the waypoint and descends to a fixed altitude of 75 m above the landing altitude.
3. The drone circles to estimate the wind speed and direction. An approach direction is then calculated as close to the upwind direction as possible within the allowable approach sectors (defined by the user within *eMotion*).
4. The drone flies downwind against the approach direction. After flying for a sufficient distance it turns around to align itself with the approach direction.
5. The drone glides down in the approach direction at a controlled speed and descent angle of approximately 20° , braking by spinning its propeller in reverse if necessary.
6. When the drone detects a height of around 20 m to the ground it begins to level out its descent.
7. When the drone detects a height of around 3 m to the ground it performs a final brake to reduce its speed and lifts its nose.
8. The drone then glides for the final few metres in a deep stall until it lands.

Linear landing procedure, seen from the side



Linear landing procedure, seen from above within *eMotion 2*



The Linear landing process uses an optical-based sensor to detect the proximity of the ground. A number of conditions on the environment and the positions of the Home waypoint and approach sectors must be met in order for the ground sensor to function correctly and ensure the accuracy of the Linear landing:

- If the Linear landing location is not at the same altitude as the Take-off location you must adjust the Landing altitude parameter in the 'Setup Phase' tab, as the drone uses this altitude to level out and slow down before landing (Steps 6-8). Enable the 'Land at a different altitude than take-off' checkbox and set the altitude as an absolute value in AMSL.



Note: When 'Land at a different altitude than take-off' is enabled the Home waypoint's altitude will be converted to AMSL instead of ATO (by default 75m above the landing location).



Caution: Incorrectly setting the altitude of the Linear landing location will decrease the accuracy of the Linear landing and may result in damage to the *eBee RTK*.

- A Linear landing can only be performed over flat terrain. Ensure that the ground is flat and at the same altitude as the Linear landing location for a distance of at least 100 m from the Linear landing location within every approach sector. It is also recommended to have flat terrain in the opposite direction of every approach sector in case a Linear landing is aborted in its final stages.



Caution: Attempting a Linear landing on sloped terrain, the top of a roof or the edge of a cliff or any other terrain that is not flat will likely result in false detection of the height above the ground during the approach and may result in damage to the *eBee RTK*. In particular, landing downhill may cause a large overshoot and should always be avoided.

- Ensure that there are no obstacles within 60 m of the Linear landing location within all approach sectors and within a radius of 10 m around the Linear landing location. If there are some obstacles in the distance, ensure that the top of the obstacles is at no more than a 15° angle from the point 60 m from the Linear landing location, as indicated in the figure on page 87. It is also recommended to not have any obstacles in the opposite direction of all approach sectors, in case the Linear landing is aborted before completion.



Caution: It is not recommended to perform Linear landings between tall obstacles, as they may disturb the GPS/GLONASS signals your *eBee RTK* needs to be able to navigate.

- In order to limit the ground speed when landing and to achieve the best landing accuracy, the *eBee RTK* should only perform a Linear landing against the direction of the wind. Approach sectors should be as large as possible and in as many directions as possible to allow the drone to select the optimal approach direction based on its estimate of the wind. If all of the available approach sectors are in the direction of the wind an In-flight warning²⁶ will appear in *eMotion* when the drone calculates its trajectory (Step 3).



Caution: If the drone performs a Linear landing in the direction of the wind during strong wind conditions or with certain In-flight warnings or Critical failures it may not be able to slow enough during its descent. It will likely overshoot the Home waypoint location and land at a high speed, potentially resulting in damage.

- The ground sensor must have sufficient light and texture to accurately detect the height above the ground. Ensure that the ground sensor lens is clear of dirt or other obstructions. Only attempt Linear landings in full daylight conditions. Ensure that there is high-contrast surfaces in all the ap-

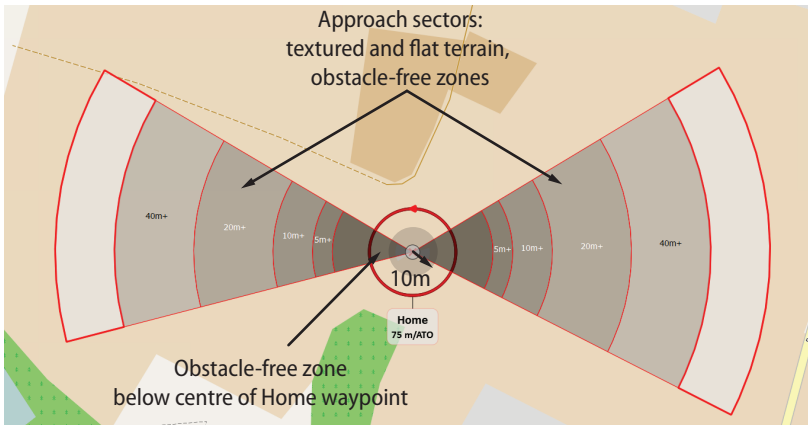
²⁶ see section 'In-flight warnings' on page 160

Advanced functionalities

proach sectors. Do not define approach sectors over low-texture surfaces such as large bodies of water, snow or sand.

- During a Linear landing the drone requires sufficient energy to slow down its descent and perform its final brake (Steps 5-7). If the Linear landing option is active and the battery descends below 20% an In-flight warning will appear²⁷ in *eMotion*.

To enable Linear landing select 'Linear landing' from the 'Setup Phase' tab. A single approach sector appears around the Home waypoint. Rotate and resize the approach sector to define the directions around the Home waypoint that are completely clear of obstacles. You can add additional approach sectors from within the 'Setup Phase' tab. These approach sectors will be used by the drone to plan its landing path while taking into account the wind. Defining multiple possible approach sectors can increase the chance that the drone selects a favourable landing against the direction of the wind. Be sure that there are also no obstacles in a 10 m radius circle around the Home waypoint, as the Linear landing process may be effected by wind or positioning imprecision of the on-board GNSS receiver.



²⁷ see section 'In-flight warnings' on page 160



Note: The *eBee RTK*'s ground sensor can typically begin detecting ground proximity at a distance of 40 m. If the drone reaches an estimate altitude of 20 m/ATO (as estimated using the on-board GNSS receiver and pressure sensor) without a signal on its ground sensor it assumes there is a malfunction with the ground sensor. This may be due to insufficient light or contrast in the environment, dirt on the sensor's lens assembly or a Linear landing location at a different altitude than the Take-off Location. In this case the drone performs the braking and stall manoeuvre at an altitude of 20 m instead of 3 m. This increased time while stalled can greatly reduce the accuracy of the final landing position and damage to the drone.

If the Linear landing process is aborted (by clicking on the 'ABORT LANDING' button in the Control Bar) before completion the drone will turn on its motor in full thrust and gain altitude while continuing in a straight line in its approach direction. Once the altitude of 40 m/ATO is reached the drone will turn towards the Home waypoint and continue climbing until it reaches an altitude of 75 m/ATO. It then continues circling until it receives a further command.



Caution: Do not abort a Linear landing if there are obstacles in the approach direction behind the Home location, as the drone will continue flying in a straight line after an abort sequence while it gains altitude and may collide with those obstacles.



Caution: It is not recommended to abort a Linear landing when the battery is low, as the drone may not have enough power to attempt a second landing.

6.7 Flying multiple drones at the same time

Operating multiple drones at the same time enables the coverage of larger areas in a shorter amount of time. This can be useful when the mission time must be kept short, for example because of varying lighting conditions. To enable multi-

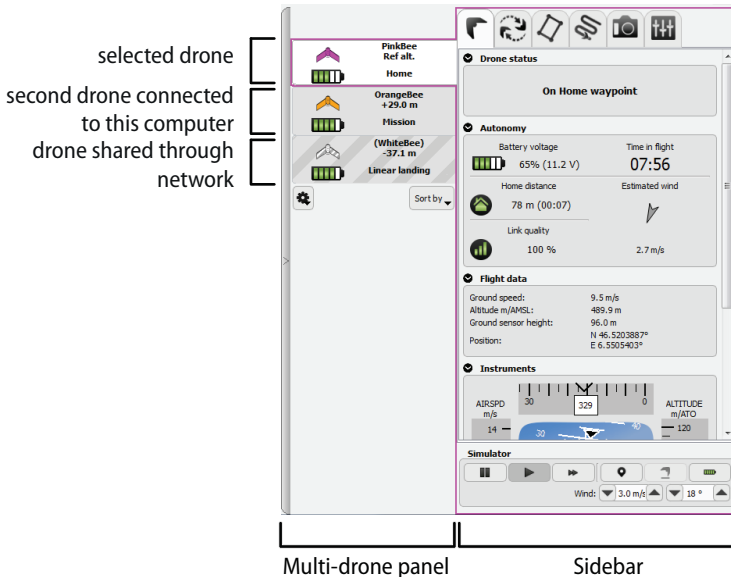
drone operation *eMotion* provides the following:

- When more than one drone is connected at a time, a dedicated interface called the Multi-drone panel is displayed to monitor each drone and switch between them.
- A number of settings are offered to keep relevant flight configurations (such as the Start and Home waypoint) synchronised between all connected drones.
- Missions that require more than one flight can be automatically split and uploaded individually among all connected drones.
- A new Control Bar appears at the bottom of the Map Area. Commands sent using the buttons in this Control Bar, such as 'START MISSION' or 'GO LAND,' are sent to all the drones currently connected to your computer.
- Collision avoidance is provided by *eMotion*²⁸. This is done by automatically changing the altitude of the Start and Home waypoints for each drone in order to separate them. Also, the drones are automatically put on hold when there is a collision risk during the mission.

When connecting to more than one drone at a time (real or simulated), a dedicated Multi-drone Panel is displayed next to the Sidebar. Each drone is displayed with its name, battery level and status and can be selected. The rest of the Sidebar and its various tabs are associated to the currently selected drone, as indicated by the colour of the frame. The multi-drone interface also displays the relative altitude of all drones with respect to the selected drone. Since this is a relative altitude, a value close to 0 m means that a drone is at the same altitude as the currently selected drone. Right-clicking on a drone's tab in the Multi-drone Panel allows you to disconnect the drone or change its colour.

²⁸ if the option is selected in the Multi-drones preference pane

Understanding aerial mapping with the eBee RTK




One advantage of flying multiple drone drones at once is to cover more area in less time. *eMotion* can automatically upload a multi-flight mission to all connected drones in a single click. To achieve this, follow this procedure:

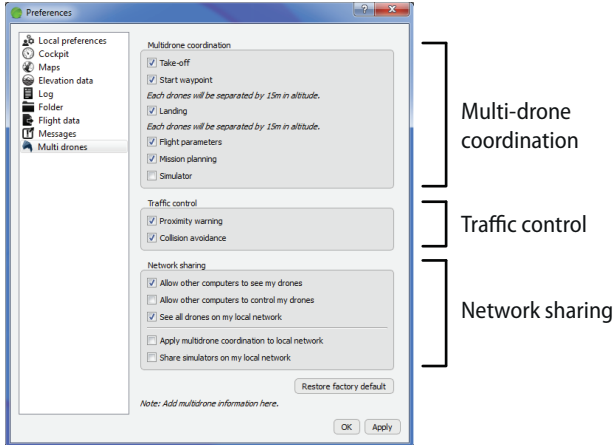
1. Go to the Mission Planning tab and prepare the required mission area (this can be done with any of the connected drone selected). Make sure that the number of flights required matches the number of connected drones. If needed, the 'Max flight time' option can be lowered to force the mission planner to split the mission in several flights (see section 'Mission Planning tab' on page 116).
2. Select 'Upload to all' from the drop-down list of the 'Upload button'.



Note: You can only split a mission between drones of the same model and that are using the same camera.

Advanced functionalities

Clicking on the  icon in the Multi-drone panel allows you to either connect a new drone or to bring up the Multi-drones preferences pane.



eMotion provides Multi-drone coordination options to synchronise various waypoints and parameters among connected drones:

- **Take-off:** Synchronising the take-off applies specifically to Directional take-off heading and transition altitude.
- **Start waypoint:** When the Start waypoint is synchronised, *eMotion* will use the same location and altitude for the Start waypoint of each connected drone. Every modification to the Start waypoint of one drone is thus transferred to all other drones. To prevent collisions between drones, *eMotion* will automatically create a stack by incrementing the altitude of each drone that is currently circling the Start waypoints to ensure a 15 m separation. The base altitude of the Start waypoint, which is the altitude of the lowest drone in the stack, can be set in the Multi-drone Panel.
- **Home waypoint and landing:** Similarly to the Start waypoint, when the Home waypoint is synchronised *eMotion* will use the same Home waypoint

for all connected drones. A stack will also be created to avoid collisions between multiple drones circling the Home waypoint.



Caution: As *eMotion* defines the Start and Home waypoints in ATO. It is therefore critical for **all drones to take off from the exact same location** to achieve altitude separation and collision avoidance over these two waypoints.

- **Flight parameters:** This option will synchronise all the parameters in the 'Flight parameters' tab across all drones. This includes the Working area radius and ceiling, take-off transition altitude, Security action parameters, etc.
- **Mission planning:** This option will share the same Mission Area among all connected drones.
- **Simulator:** When checked, repositioning a simulated drone on the map will reposition all simulated drones at the same time.

In addition to the altitude separation on the Start and Home waypoints described above, *eMotion* provides two traffic control mechanisms to help avoid collision between drones in flight:

- **Proximity warning:** When enabled, a visual and audible warning will be emitted if two drones are on a trajectory potentially leading to a collision in less than 7 seconds.
- **Collision avoidance:** When enabled, *eMotion* will constantly monitor the trajectory of the connected drones and automatically put one drone in a temporary hold pattern (similar to the HOLD POSITION function, see section 'Control Bar' on page 105) until it is safe to resume the flight. Priority is given to drones with the lowest battery level, engaged in a landing procedure or with an active error or warning.



Caution: All collision avoidance mechanisms are implemented by *eMotion* on the ground computer. The drones' autopilot do not communicate between themselves and do not have knowledge of each other's positions. It is therefore critical to **keep all drones connected to *eMotion* at all times and remain well inside communication range.**



Note: While *eMotion* strives to avoid all collisions, the operator is ultimately responsible to ensure flight safety. In particular, situations involving more than two drones in converging trajectories may not always be handled automatically in a fully safe manner. It is recommended to use slightly different altitudes for each drone when flying more than two drones at a time to limit the risk of collision.

In more advanced scenarios you may wish to share the position and even the control of a drone across a local area network. *eMotion* provides the following Network sharing options:

- **Allow other computers to see my drones:** All computers that are running *eMotion* and are connected to the same network will be able to display the position, status and other parameters of the drones connected to your computer.
- **Allow other computers to control my drones:** All drones currently connected to your computer are not only displayed, but can be fully controlled by other computers running *eMotion* on the same network.
- **See all drones on my local network:** Check this box to display the position and other parameters of drones connect to other computers on the same network.
- **Apply multi-drone coordination to local network:** Check this box to synchronise all the selected parameters in the Multi-drone coordination preferences across all drones that are connected to the same network (provided that they have checked the 'Allow other computers to control my drones' option).

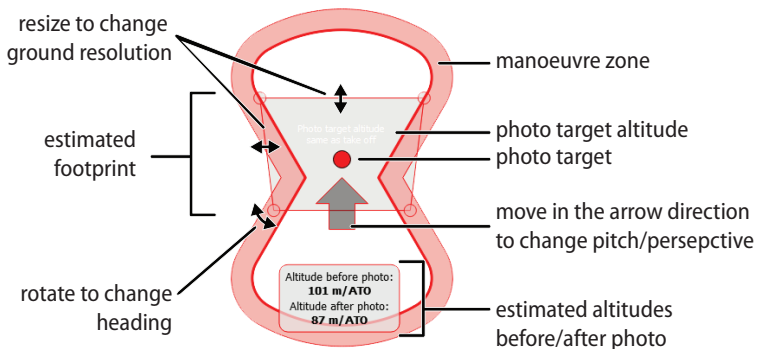
- **Share simulators on my local network:** If this box is checked, all Network sharing options apply to both real and simulated drones connected to your computer. In unchecked, they only apply to real drones.

6.8 Individual photo targets and oblique imagery

In some cases it may be interesting to take oblique photographs of objects, for example to provide a nice image for documentation or to increase the quality of 3D models that contain vertical facades and surfaces. *eMotion* includes a tool for defining photo targets with a specific distance, heading and pitch angle. The drone can then orient itself and capture the image using a patent-pending pitch-down manoeuvre.

Capturing an oblique image can be done easily by following these steps:

1. Add a new photo target by clicking on the **+** button in the Camera tab. Use the cross-hairs to place the photo target on the location of interest in the Map Area. You may also right-click anywhere in the Map Area and select 'Add photo target here' from the contextual menu. The photo target will appear as a circle in the Map Area with an estimated image footprint, a manoeuvre zone and a status panel with estimated altitudes before and after the image is taken.



2. Select the desired heading and pitch angles of the image by rotating the image footprint and moving the photo target arrow, respectively. The estimated image footprint can help you choose the required angles. You can also set the angles manually in the 'Photo targets' section of the Camera tab.
3. Define the desired ground resolution at the photo target within the Camera tab. You can also adjust the ground resolution by resizing the photo footprint in the Map Area.



Caution: Be sure to define a ground resolution that is high enough to allow the drone to recover from its pitch manoeuvre by paying close attention to the 'Minimum altitude after photo' parameter. We recommend that you do not define parameters that result in an 'Minimum altitude after photo' of less than 30 m, in particular when selecting a high pitch angle.

4. Define the altitude of the photo target, if it is not the same as the take-off altitude. You may use elevation data to define this altitude by enabling the 'Use elevation data to set absolute photo target altitudes' checkbox.

Repeat the above steps to define multiple photo targets. After launching your drone, click on the 'Begin sequence' button in the Camera tab at any time to begin taking the images. The *eBee RTK* will fly to the location of the first photo location, measure the wind above the location, and perform a dive (pitching down) manoeuvre to take the oblique photo. It will perform this for all photo targets until it has completed the entire sequence.

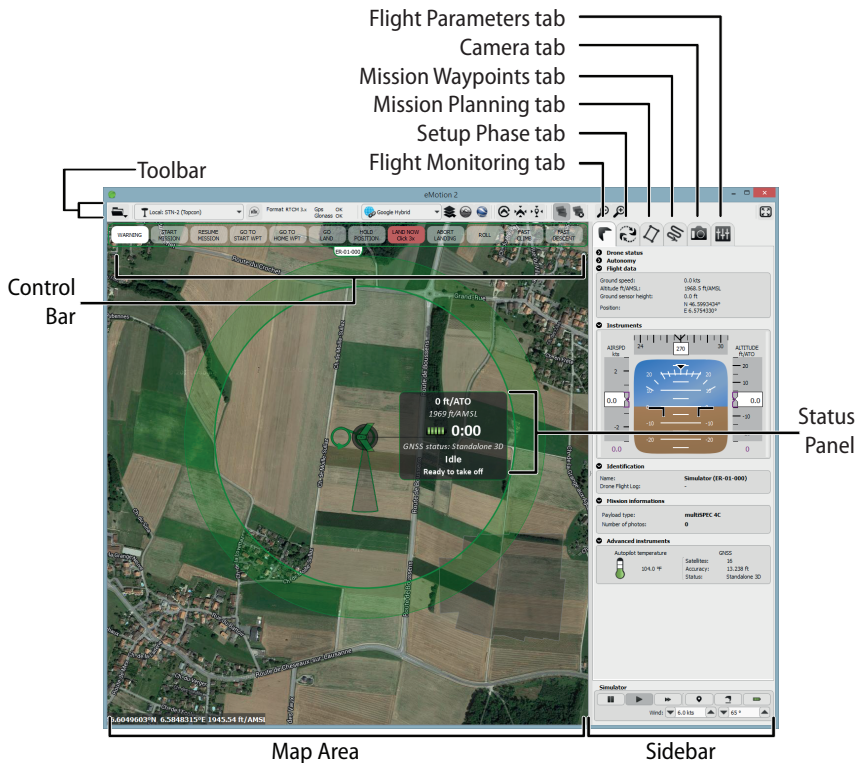
Taking a series of oblique images of the same photo target at regular heading and pitch intervals allows you to create a higher quality 3D model of a photo target. You can use the 'New photo target increment' to define a desired increment angle. Clicking on the **+** button will then add a new photo target at the same location as the previous target but with an incremented pitch and heading value.

A more detailed description of all the available options for taking images of individual photo targets can be found in section 'Camera tab' on page 127.

7 eMotion in-depth guide



Goal of this section: eMotion is a powerful tool designed specifically to work with your senseFly Ltd mini-drones. This section includes a comprehensive guide to all the functionalities in eMotion to help you plan, simulate and monitor your next mapping flight.




Status Panel

Map Area

Sidebar

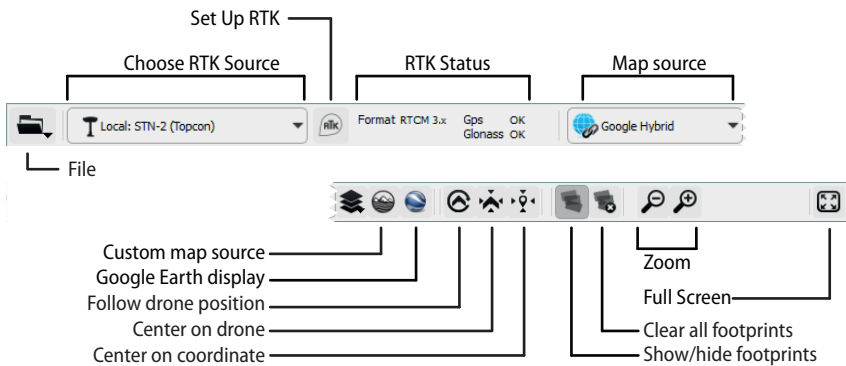
Advanced functionalities

The main *eMotion* interface is composed of a Map Area, a Toolbar and a Sidebar²⁹. The Map Area displays the current location of the *eBee RTK*, a Status Panel with important information on the drone's current status, and a Control Bar used to send commands to the drone (section 'Control Bar' on page 105).



The Toolbar above the Map Area includes the  File menu, controls for selecting the source of map data, the display of picture footprints and various other controls (section 'Toolbar').

The Sidebar is separated into six individual tabs that are used during different phases of planning and monitoring a flight. The Sidebar tabs can be hidden at any time by clicking on the left-hand edge of the Sidebar. Each tab is described in detail in the following chapter. The Sidebar also contains controls for the Simulator (section 'Simulator' on page 103)





7.1 Toolbar






²⁹ for an overview of the *eMotion* interface see section 'The *eMotion* interface' on page 21

You can access the File menu by clicking on the  button in the Toolbar. From this menu you can connect to or disconnect from a drone, access the Flight Data Manager, change *eMotion* preferences or import custom maps. Clicking the  icon will launch *Google Earth™* and display the current flight trajectories of drones connected to *eMotion*, as described in detail in section 'Flight visualization in *Google Earth™*' on page 80.

You can access RTK setup and choose your RTK correction source from the Choose RTK Source menu.



You can select the background map source from the drop-down list in the Toolbar, and adjust its zoom level using the  and  buttons. *eMotion* can use many sources of commercially available and custom mapping information. Tiles from map sources with the icon  are downloaded by *eMotion* from the Internet as required and locally cached on the hard drive. Due to regulatory restrictions, map sources with the icon  cannot be saved locally and are not recommended for use in the field.

If you anticipate the use of *eMotion* in conditions where connecting to Internet is impossible, you can preload the map data by selecting 'Download maps..' from the  File menu. Follow the instructions in the dialog box to select the zone of interest, map tile source and start downloading.

eMotion can also import and display custom layers which may include KML files, custom map tiles and elevation data. To import a KML file, select 'Import KML..' from the  File menu and select your KML file. The resulting layer will now be available in the Toolbar by clicking on the  icon, and can be clicked to display or hide it. *eMotion* can display lines, polygons, paths and points saved in KML format.



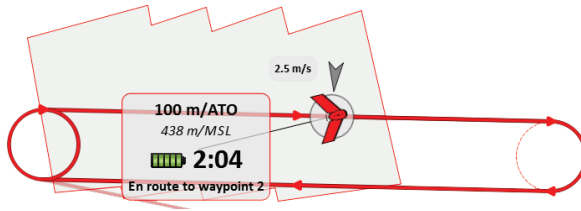
Note: KML files, including associated icons or images included within them, are not copied to the *eMotion* directory and will no longer appear in *eMotion* if the original KML files are deleted.



Custom map tiles can also be added as a layer in *eMotion*. Select 'Import custom map..' from the  File menu and select the folder that contains the tile set. The tile set will then appear in the list of layers in the Toolbar, accessible by clicking the  button.



Note: If you use *Postflight Terra 3D* (see section 'Processing image data' on page 62), a tile set can be generated for each project that is directly compatible with *eMotion*. You can therefore create your own map background using the *eBee RTK*. You can generate the tile set by selecting 'Generate Google Maps tiles and KML' from the 'Process' menu within *Postflight Terra 3D*.

Whenever the *eBee RTK* takes a picture, *eMotion* records the location and orientation of the drone and computes the approximate span of the photo on the ground (or 'footprint'). All the footprints taken by a drone are added to a shaded polygon outlined with the drone's colour and displayed in the Map Area. This polygon represents an estimate of the area that has been photographed by the drone.



The footprints can be shown or hidden using the  button. When hidden, the footprints are kept in memory and new photos continue to be recorded, but nothing is displayed in the Map Area. Footprints for all drones remain in the memory of *eMotion*, even when a drone is disconnected or *eMotion* is shut down. Clicking on the  button removes all footprint polygons from the Map Area the memory of *eMotion*. New picture footprints will be created for subsequent pictures that are taken.



Note: Clearing or hiding the footprints has no influence on what is logged by *eMotion* and on-board the drone during the flight, such as the information required to geotag the images after the flight.

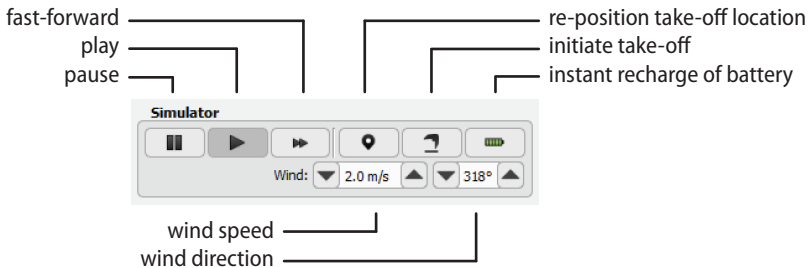


Note: The footprints displayed on the map are only an approximate estimation of the actual ground coverage of the corresponding image. Cross-wind may introduce errors in the orientation of the displayed footprint compared to the actual coverage, whereas inaccurate elevation data may result in inaccurate footprint size.

The Toolbar also contains buttons for centering the Map Area on the current position of the drone (📍 button), on a searchable location or coordinate (📍+ button) or to continually follow the position of the drone while it is in flight (📍 button). Finally you can view eMotion in full-screen mode by clicking the 🖥️ button.

7.2 Simulator

Familiarising yourself with your eBee RTK and its features will allow you to more efficiently plan and execute mapping flights, saving you time and improve your imaging results. The Simulator in eMotion is designed to help you test the various features of the drone and to better prepare a mapping mission before performing it in the field. Several simulated drones can be connected at the same time, allowing you to test multi-drone functionalities.



The Simulator bar appears at the bottom of the Sidebar of eMotion when you connect to a simulated drone. The simulated drone will go through the same pre-flight checks as a real eBee RTK, after which it will update the Home to its current position (typically the last position that was used within the simulator) and the

Start waypoint to 80 m West of the Home waypoint. The various buttons available in the Simulator bar are described in table 1 .

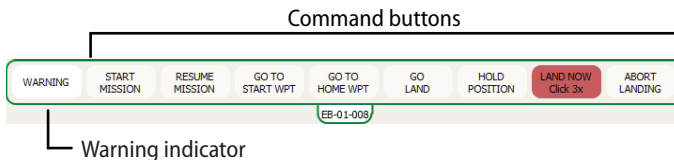
Feel free to modify the wind speed, waypoint positions and other parameters in the Toolbar and the various tabs of the Sidebar in *eMotion* to see their effect on the *eBee RTK* while it is in flight. Also be sure to explore the effects of the various buttons in the Control Bar on the behaviour of your drone. Don't be afraid to push the boundaries! Aborting a flight or causing an emergency landing in the simulator will better prepare you for unexpected circumstances while in the field.

Table 1: Simulator bar buttons

Button	Description
Pause	Clicking the pause button will pause the simulation and thus stop the drone while in flight. This can be useful when you wish to change parameters or waypoints while the drone is already in flight. Note: this is a simulated action that is not possible with the real <i>eBee RTK</i>. Instead of pausing while in flight we recommend that you use the 'HOLD POSITION' function to better simulate real flight conditions.
Play	Clicking the play button returns the simulation to actual speed from the pause or fast-forward conditions.
Fast forward	Clicking this button increases the speed of the simulation to 4x actual speed. This allows you to shorten the time required to simulate a complete mission.

Re-position take-off location	Clicking this button and then clicking on a location in the Map Area simulates the action of connecting the battery to the drone in a new location. The drone is returned to the ground at the new location and runs through its pre-flight checks before entering Idle mode.
Initiate take-off	Clicking this button simulates a take-off procedure, including the motor power-up sequence and the hand launch ³⁰ .
Instant recharge of battery	Clicking this button will instantly recharge the battery of the drone. Note: This is a simulated action that is not possible with the real eBee RTK while it is in flight.
Wind speed and direction	These fields are used to input a simulated wind speed and direction. A random wind speed and direction is set when eMotion connects to a simulated drone.

7.3 Control Bar



³⁰ see section 'Take-off' on page 55 for a description of the take-off procedure

Advanced functionalities

The Control Bar includes buttons for sending commands to the drone and for acknowledging warnings while it is in flight. Certain buttons can only be used during specific flight modes³¹.

The Command buttons allows the operator to directly control the drone while it is in flight. The various buttons are described in table 2 .

Table 2: Control Bar Buttons

Button	Available	Action
WARNING ³²	Active warning	For yellow In-flight warnings, button text changes to 'ACK WARNING' and clicking will acknowledge the current warning. For red Critical failures, button text changes to 'CRITICAL FAILURE' and cannot be clicked.
START MISSION	No active Security action	Fly towards the first active waypoint in the waypoint list and start the mission from the beginning.
RESUME MISSION	Not in Perform Mission mode	Return to the last position reached during the mission and continue the flight plan.
GO TO START WPT	No active Security action	Fly towards the Start waypoint, circle and wait for next command.
GO TO HOME WPT	Anytime	Fly towards the Home waypoint, circle and wait for next command.

³¹ see section 'Autonomous controller and modes of flight' on page 82 for more information on flight modes

³² see section 'Troubleshooting' on page 154 for a full description of In-flight warnings and Critical failures that may occur

GO LAND	Anytime	Fly towards the Home waypoint and initiate landing procedure.
HOLD POSITION	No active Security action	Create a virtual waypoint at the current location and altitude, circle around this point and wait for next command.
LAND NOW Click 3x	Anytime	Initiate a Circular landing around a 20 m radius waypoint at the current location. Must be clicked 3 times in quick succession to be engaged.
ABORT LANDING	During Circular Landing, Linear Landing, or Emergency Landing mode (if no active Critical failure)	Circular or Linear landing: abort current landing procedure, return to the altitude of the Home waypoint, circle the Home waypoint and wait for next command. Emergency landing: (only available if there is no active Critical failure) abort current landing procedure, return to the location where the Emergency landing was triggered, circle and wait for next command.

7.4 Flight Monitoring tab

The screenshot shows the Flight Monitoring tab interface with the following sections and data:

- Drone status:** Idle, Ready to take off
- Autonomy:** Battery voltage: 99% (12.5 V), Time in flight: 00:00, Home distance: 0 m (---), Estimated wind: A, Link quality: 100%, 0.0 m/s
- Flight data:** Ground speed: 0.0 m/s, Altitude m/AMSL: 598.0 m, Ground sensor height: 0.0 m, Position: N 46.5965412° E 6.5806205°
- Instruments:** AIRSPD m/s: 270, ALTITUDE m/RSD: 0.0, 0.0
- Identification:** Name: Simulator (EB-01-009), Drone Flight Log: -
- Payload information:** Payload type: IXUS/ELPH RGB, Number of photos: 0
- Advanced Instruments:** Autopilot temperature: 40.0 °C, GNSS Satellites: 8, Accuracy: 4.150 m, Status: Standalone 3D

The Flight Monitoring tab can be used to monitor the *eBee RTK* during a mapping mission and is the default tab that is displayed when you click anywhere on the map area that does not have a symbol. The tab is split into the following sections:

- **Drone Status:** The status of the plane keeps you informed on what the drone is currently doing. This can include mission actions such as 'Taking photo' or 'Going to waypoint' as well as warning or failure messages such

as 'Out of working area' or 'High wind'³³.



Note: The most important status and warning messages are reproduced in the Status Panel in the Map Area, and thus remain visible even when the Sidebar is hidden.

- **Autonomy:** The battery level displays the current charge and voltage of the battery. As the battery's charge level decreases, the voltage decreases as well. A fully charged battery has a voltage of 12.6 V and is fully discharged when it reaches about 9 V³⁴.

This section also displays the total time in flight, the straight-line distance to the Home waypoint, the estimated time required to return to the Home waypoint (based on estimated wind strength) and the quality of the radio data link between the ground modem and the drone. The strength and direction of the wind estimated by the drone is displayed with an arrow.



Caution: Lithium polymer batteries are chemical devices whose performance depends on a number of parameters, including temperature, lifetime, number of cycles, mechanical integrity, etc. Estimating the remaining capacity of a battery can thus be tricky and the displayed value may occasionally be inaccurate. It is the operator's responsibility to monitor battery voltage and flight time in addition to the battery level to make sure that endurance is sufficient to complete the mission.

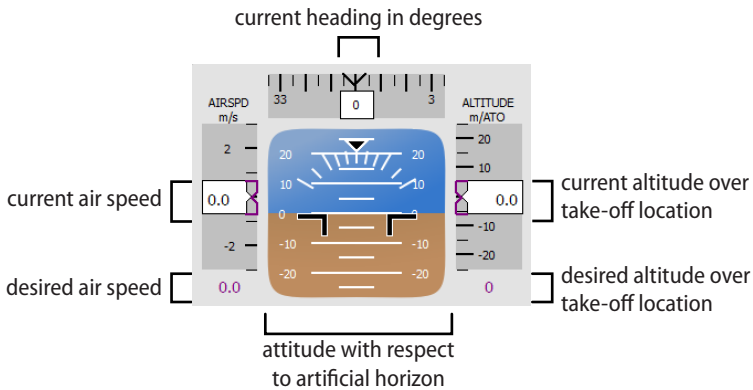
- **Flight data:** This section includes additional information that may be useful during the flight, including ground speed and height, altitude Above Mean Sea Level (AMSL) and the absolute position detected by the GNSS receiver on-board the *eBee RTK*.

³³ see section 'Troubleshooting' on page 154

³⁴ see section 'Proper battery care' on page 151



Note: The ground sensor height indicates the height above the ground detected by the ground sensor. The sensor can typically detect distances below 60 m, depending on available light and surface contrast.



- **Instruments:** This display mimics the classical primary flight display used in manned aircraft. The column on the left displays the current air speed of the *eBee RTK* as well as the desired air speed, in metres per second. The column on the right displays the drone's current altitude over take-off location, as well as the desired altitude over the take-off location, in metres. The bar at the top displays the current heading of the drone³⁵. North is indicated as 0°, East as 90°, South as 180° and West as 270°.
- **Identification:** This displays the serial number of your *eBee RTK* and the number of the Drone Flight log for the current flight. This number can be used as a reference when importing flight data after a flight³⁶.
- **Payload information:** This section displays the payload currently selected and the number of photos that has been taken since take-off³⁷.

³⁵ this feature is only accurate when in flight

³⁶ see section 'Importing images and flight data' on page 62

³⁷ see section 'Camera tab' on page 127 for instructions on changing the payload type

- **Advanced Instruments:** This section displays the current internal temperature of the drone, the number of GPS/GLONASS signals detected and the estimated accuracy of the the position.

7.5 Setup Phase tab

The screenshot shows the 'Flight Setup' tab with the following sections and controls:

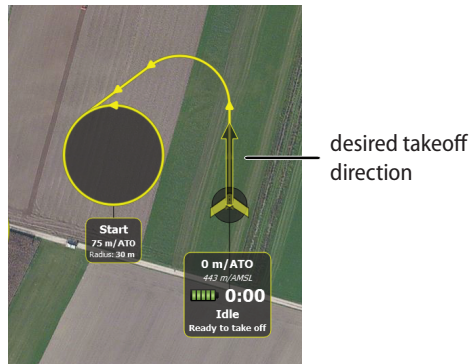
- Take-off parameters:** Includes 'Take-off parameters' (checked), 'Activate directional take-off' (checked), 'Directional take-off heading' (0°), and 'Transition altitude' (20 m/ATO).
- Start waypoint:** Includes 'Start waypoint' (75 m/ATO), 'Change altitude' (During transit), 'Altitude' (75 m), 'Turn direction' (Anticlockwise), 'Radius' (30 m), 'Longitude' (32.9039731), and 'Latitude' (24.0083517).
- After mission and take-off actions:** Includes 'After take-off' (Start mission) and 'After mission' (Land).
- Home waypoint:** Includes 'Home waypoint' (75 m/ATO), 'Landing type' (Linear landing), and 'Landing location altitude' (0 m/ATO).
- Landing:** Includes 'Landing location altitude' (0 m/ATO), 'Altitude reference' (m/ATO), and a button to 'Set absolute landing altitude based on elevation data'.
- Approach sectors:** Includes 'Heading' (0°), 'Span' (20°), and an 'Add a sector' button.
- Setup phase reset:** Includes a 'Reset all setup phase parameters' button.
- Flight plan actions:** Includes 'Reset flight plan', 'Load flight plan from file...', 'Save flight plan to file...', and 'Save flight plan in drone' buttons.

The Setup Phase tab is used to define the setup phase of a flight plan. This phase includes the definition of the Home and Start waypoints and the actions to be taken before and after the mission phase of the flight plan.

The Setup Phase tab is divided into the following sections:

- **Take-off parameters:** You can predefine a take-off heading and transition

altitude. To enable this feature, expand the 'Take-off parameters' box and check the 'Activate directional take-off' check box. A new arrow is now displayed on the map. This arrow defines the take-off heading, the drone will try to stay on the track defined by the arrow.



You can now grab the arrow on the map in order to modify the take-off heading. Furthermore you can also pre-set the take-off direction and the take-off transition altitude in the Setup Phase tab.

Default value: Unchecked, Heading: 0° , Transition altitude: 20m/ATO



Caution: Setting the take-off transition altitude too low may cause the drone to perform a change of direction too early and may result in a crash. Setting the take-off transition altitude too high may cause the drone to drift sideways after take-off if there is too much wind.

- **Start waypoint:** Here you set the position, change altitude parameter, altitude above take-off (m/ATO), turn direction and radius of the Start waypoint. You can set the location by clicking the 📍 button and clicking on the desired location in the Map Area.

Default values: Change altitude: During transit, Altitude: 75 m/ATO, Turn direction: anticlockwise, Radius: 30 m, Location: 80 m West of the position calculated from satellite signals on start-up

- **After take-off:** You can either command the drone to start the mission phase immediately after reaching the Start waypoint or to wait for a command from *eMotion*. This second option is useful if you want to modify the flight plan while the drone is already in flight.

Default value: Start mission

- **After mission:** Use this panel to select the action you wish the drone to execute once it completes the mission phase. The *eBee RTK* can either automatically go to the Home waypoint and land, go to the Home or Start waypoint and wait for a command or to restart the mission phase.

Default value: Land

- **Home waypoint:** Here you set the position, change altitude parameter, altitude (in m/ATO or m/AMSL if 'Land at a different altitude than take-off' is selected), turn direction and radius of the Home waypoint. You can set the location by clicking the 📍 button and clicking on the desired location in the Map Area.

Default values: Change altitude: Keep highest, Altitude: 75 m/ATO, Turn direction: anticlockwise, Radius: 30 m, Location: position calculated from GPS/GLONASS signals on start-up

- **Landing:** With this panel you can choose between a Circular landing or a Linear landing on the Home waypoint. If you select 'Linear landing' the panel expands to show options on approach sectors. You can define up to four approach sectors, each of which has a heading and a span, either by dragging in the map area or by manually setting parameters in the panel. See section 'Linear landing' on page 86 for details how to correctly select the Home waypoint and approach sectors.

Default value: Linear landing, Approach sectors: single sector with a Heading of 0° and Span of 20°

- **Landing location altitude:** You can also configure the altitude of the landing location if it is different from the Take-off altitude. Expand the 'Landing location altitude' panel and select an altitude in m/AMSL or in m/ATO. It is also possible to predefine the landing altitude based on elevation data by clicking on the 'Set absolute landing altitude based on elevation data' button. This button will pre-set the altitude each time it is clicked (i.e. if the landing position is changed, the altitude is not automatically pre-set based on the Improved SRTM model, the user has to press the button each time that the landing position is changed).

Default value: Landing location altitude: 0 m/ATO

- **Setup phase reset:** Pressing the 'Reset all setup phase parameters' will reset the Home and Start waypoints to the take-off location and reset the rest of the parameters on the tab to factory defaults. Clicking the 'Reset all waypoints and photo targets' will remove all the waypoints and photo targets in the currently loaded in the drone.
- **Flight plan actions:** A complete flight plan includes all the Setup phase (Start and Home waypoints, Take-off and Landing parameters, etc.), Mission phase (waypoints), Camera (camera model, photo targets, etc.) and Flight (working area radius and ceiling, Security actions, etc.) parameters. The 'Reset flight plan' resets the current flight plan to default parameters³⁸. The 'Load flight plan from file...' and 'Save flight plan to file...' buttons load and save the current flight plan (both setup and mission phases) to a XML file for later reuse. You can also save the current flight plan to the eBee RTK's on-board memory by clicking the 'Save flight plan in drone' button. Once a flight plan is saved in the drone's memory, it will become the default flight plan the next time the drone is started and appear in eMotion upon connection. The drone also keeps track of its last waypoint during a flight; you can thus resume an incomplete flight after changing batteries.

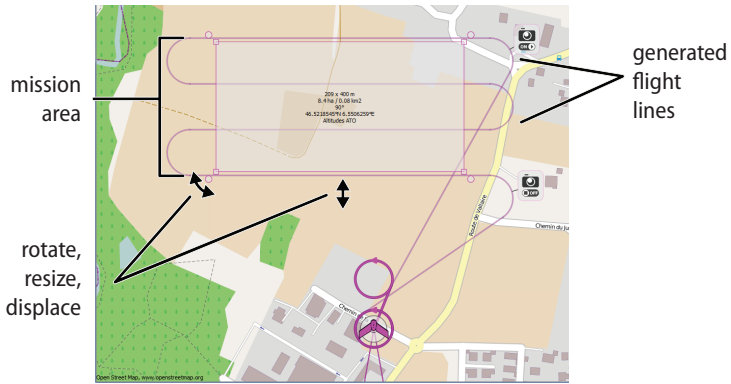


Note: It is not necessary to save a flight to the autopilot in order to fly! This is an advanced option meant to reduce the preparation time required when the same flight is performed many times.

³⁸ this action is only available when the drone is not in flight

7.6 Mission Planning tab

The Mission Planning tab is used to automatically define a set of waypoints based on a mission area and a set of image parameters. Clicking on this tab will make a grey box appear in the Map Area that represents the mission area to be mapped. You can modify this area's location, size and rotation using the handles around it, as explained in section 'The mission phase of a flight' on page 26.



Note: The quality of the output orthomosaic is usually lower on the outer edges of the area that is photographed, as there is less overlap between images. The area photographed is thus always calculated to be bigger than the mission area selected so as to ensure maximum image overlap within the mission area itself.



Note: If there is no flight plan overlaid on the mission area rectangle then the mission is too large and cannot be flown by the *eBee RTK*. This can be for two reasons: either the distance between two waypoints is too long for the drone to cover in a single flight, or the waypoints are too far from the Take-off and landing locations.

The screenshot shows the Mission Planning interface with four panels highlighted by brackets on the left:

- Mapping and mission parameters:** This panel includes options for 'Difficult terrain' and 'Easy terrain', a 'Mission area' dropdown set to 'Rectangular', 'Ground resolution' set to '4.0 cm/px', 'Camera: DJIUS,ELPH', 'Desired altitude above elevation data: 130.0 m', a checked box for 'Use elevation data to set absolute waypoint altitudes', 'Lateral overlap' at 60%, 'Longitudinal overlap' at 70%, and checkboxes for 'Generate perpendicular flight lines' and 'Reversed flight direction'. A 'Save parameters as default' button is at the bottom.
- Advanced parameters:** This panel includes 'Starting waypoint' set to '1', 'Wind estimate' set to '0°', 'Max flight time' set to '40 min', and an 'Upload' button.
- Mission plan actions:** This panel is currently empty.
- Resulting flight characteristics:** This panel displays summary statistics:

Number of flights:	1
Flight time:	00:07:13
Total flight distance:	5.5 km
Total ground coverage:	12.0 ha
Number of flight lines:	640
Flight lines spacing:	73.7 m
Mean flight lines altitude above elevation data:	132 m (4.1 cm/px)
Max flight lines altitude above elevation data:	137 m (4.2 cm/px)
Min flight lines altitude above elevation data:	130 m (4.0 cm/px)
Distance between photos:	40.8 m
Single image coverage:	184.3x135.9 m
Number of waypoints:	8
Elevation data sources:	Improved SRTM

The Mission Planning tab is divided in several panels. The first panel, **Mapping and mission parameters**, contains the parameters that define the requirements of a particular mission:

- Difficult terrain:** Clicking this button will fill in preset values to the rest of the parameters. The Difficult terrain preset is meant for imaging terrain with complex features such as forests. High image overlap is recommended to increase the amount of features that can be matched between images, though at the cost of lower image resolution (due to higher altitude).
- Easy terrain (default):** This preset is meant for simple terrain such as quarries or agricultural areas where high-resolution images can be taken with

relatively low image overlap.



Note: The preset values are recommended settings that have demonstrated good results when images are then used in *Postflight Terra 3D* to create orthomosaics. Do not hesitate, however, to modify these parameters to suit the particularities of the terrain you are mapping or the local regulations and airspace constraints.

- **Mission area:** You can select either a rectangular mission area for simple terrain (as described in section 'The mission phase of a flight' on page 26) or a polygonal mission area for more complex terrain (as described in section 'Advanced polygonal mission area' on page 77).

Default value: Rectangular

- **Ground resolution:** The target ground resolution to be achieved, expressed in centimetres per pixel. This parameter is directly linked to the flight altitude: a higher resolution (few cm/px) requires a lower altitude, while a lower resolution (many cm/px) requires a higher one.

Default value: 4.0 cm/px

- **Camera:** The camera payload that is currently selected³⁹. Make sure the correct camera model is set in the flight planner to correctly calculate the required flight line spacing and distance between photos.
- **Desired altitude:** The target altitude value is the desired altitude above the ground at which the drone will take images. It is automatically calculated based on the Ground resolution and the characteristics of the on-board camera.

³⁹ see section 'Camera tab' on page 127 for details on changing the camera type



Note: eBee RTK has a minimum distance between images that depends on wind strength and direction. The maximum longitudinal overlap depends on this minimum distance as well as the calculated altitude and the camera model. If the calculated altitude is too low the drone may not be able to achieve the required longitudinal overlap. This will be indicated by a ⚠ icon. Flying at an altitude of less than 40 m is potentially dangerous and will be indicated by a ❌ icon.

- **Use elevation data to set absolute waypoint altitudes:** Checking this box will enable the flight planner to adjust the absolute altitudes of all mission waypoints based on elevation data. This advanced planning mode is described in detail in section '3D mission planning using elevation data' on page 78.

Default value: disabled

- **Lateral overlap:** The percentage of overlap between the ground coverage of pictures from adjacent flight lines. For most mapping purposes, a minimum of 50% is usually required. Higher coverage values may increase the mapping quality but will increase the flight duration.

Default value: 60 %

- **Longitudinal overlap:** The percentage of overlap between the ground coverage of pictures taken consecutively in the same flight line.

Default value: 70 %

- **Generate perpendicular flight lines:** Checking this box creates a second pass over the desired area perpendicular to the first pass. This option will significantly increase the overall image overlap and therefore improve the resulting map quality in *Postflight Terra 3D*. It is particularly useful for difficult terrain at the cost of doubling the required flight time.

Default value: disabled

- **Reverse flight direction:** By default, the flight planner will design a flight in which the drone begins a mission at the farthest waypoint and finishes

closer to the Home waypoint. Checking this box reverses the order of the planned mission waypoints. Be cautious, however, to ensure that there is enough reserve battery to return to the Home waypoint at the end of the mission.

Default value: disabled

- **Save parameters as default:** Clicking this button will save the current parameters of the Mission planning tab as the default ones in *eMotion*.

The next panel contains advanced parameters used by the flight planner:

- **Starting waypoint:** The waypoint ID of the first waypoint used to implement the mapping mission, as organized in the Waypoint list in the Mission Waypoints tab. This option is useful when including more than one mission area into a single flight. The default value for a new mission is 1. When planning for a second area to be covered in the same flight, the 'After previous' button sets the starting waypoint after the waypoints used for the previous area.

Default value: 1

- **Wind estimate:** The estimated wind speed and direction. Incorrectly setting the windspeed affects the estimated flight time of the *eBee RTK* and may cause it to return to Home before completing the desired flight plan. Clicking the 'Use current wind estimate' button will copy the wind speed currently estimated by the drone to the Wind estimate field.

Default value: direction: 0°, speed: 0 m/s

- **Max flight time:** This parameter sets the maximum estimated flight time for a single flight. If the flight planner estimates a longer flight time for the currently-selected Mission area it will split the mission into two or more flights.

Default value: 40 min

The third panel, **Mission plan actions**, includes the 'Upload' button which is used to upload the resulting mission waypoints to the autopilot. If there are multiple

flights required this button becomes a drop-down list, and you can upload each flight individually.



Caution: Clicking 'Upload' will directly modify the waypoints required for the flight plan in the *eBee RTK*. If the drone is flying towards or around one of these waypoints, its navigation will be affected to reflect the new waypoint parameters.

Clicking the 'More' button reveals several more options:

- **Load mission area...:** Click to load a previously-saved mission area and parameters from an Auto Flight Planner (.afp) file.
- **Save mission area...:** Click to save the current mission area and parameters to an Auto Flight Planner (.afp) file. This can be useful for example to map the same area with different image and mission parameters, or to save and restore a large mapping mission that requires multiple flights. Note that this saves only the mission area shape and location along with the associated mission and image parameters, not the actual list of waypoints that is then generated or the camera payload model used to calculate the mission plan.
- **Load last used mission area:** Clicking will load the last mission area that was successfully uploaded to an *eBee RTK* autopilot, whether it was a real or simulated one. This option is useful when you want to repeat your last mission and did not explicitly use the 'Save mission area...' button.
- **Load mission area from KML file:** Use this option to load a polygonal mission area directly from a KML file (produced in *Google Earth™* for example).
- **Load mission area from map object:** Use this option to load a polygonal mission area from a previously-imported map object (see section 'Toolbar' on page 100).
- **Reset mission area:** Clicking will reset the mission area to the default rectangular size and reposition it in the centre of the Map Area. It will also reset

all mapping and mission parameters to their last saved default values⁴⁰.

- **Restore factory settings:** Click to restore all the parameters of this tab to their default settings.

The last panel of this tab displays the characteristics of the flight(s) resulting from the selected image parameters:

- **Number of flights:** The resulting number of flights that must be performed to cover the chosen mission area. If the mission area cannot be mapped in a single flight, *eMotion* will split it into the minimum possible number of flights. The estimated distance that can be covered in a flight is calculated assuming a fully charged battery and an accurate wind estimate.
- **Flight time:** This is the estimated flight time for *each* of the flights.
- **Total flight distance:** The total distance that will be flown during *all* of the flights.
- **Total ground coverage:** The total area that will be mapped during *all* of the flights.
- **Number of flight lines:** The total number of flight lines in the mission phase of the flight plan, not including flight lines to and from the Take-off or landing locations. The second number represents the flight lines perpendicular to the first number.
- **Flight lines spacing:** The required distance between parallel flight lines, calculated using the Lateral overlap and Ground resolution parameters.

⁴⁰ Default values for mapping and mission parameters are set by clicking the 'Save parameters as default' button.



Note: If the flight line spacing is low enough to cause your drone to overshoot the beginning of a flight line, *eMotion* will automatically switch to an alternating flight line pattern. Your drone will fly along every other flight line, then return to fill in the gaps. If the spacing becomes too small even for an alternate flight lines, a ⚠️ will appear beside this parameter to indicate the warning. You can remove this warning by decreasing the Lateral overlap or the Ground resolution.

- **Mean flight lines altitude above elevation data:** Mean altitude difference between all flight lines and the ground altitude, based on the top-most elevation data layer (3D flight planning only).
- **Max flight lines altitude above elevation data:** Maximum altitude difference between a flight line and the ground altitude, based on the top-most elevation data layer (3D flight planning only).
- **Min flight lines altitude above elevation data:** Minimum altitude difference between a flight line and the ground altitude, based on the top-most elevation data layer (3D flight planning only).
- **Distance between photos:** The required distance between each consecutive photo taken in the same flight line, calculated using the Longitudinal overlap, Ground resolution and Camera model parameters. The wind also has an influence as the ground speed increases with back wind.



Note: The *eBee RTK* has a minimum distance between photos that depends on the wind speed and direction. If the calculated distance that is too short will be indicated with a ⓘ icon. This is not critical for the flight, but it may reduce the longitudinal overlap of the images. Consider reducing the ground resolution (fly higher) to achieve the selected longitudinal overlap, or reduce the longitude overlap itself to remove this notice.

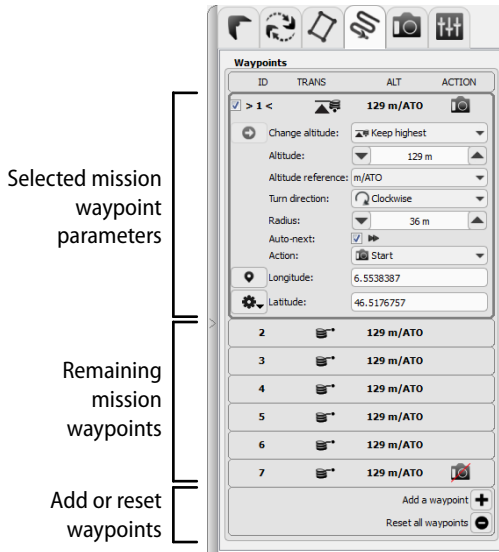
- **Single image coverage:** The estimated ground area covered by a single

image, based on the Altitude over take-off location parameter (assuming flat terrain).



- **Number of waypoints:** The total number of waypoints to cover the mission area.
- **Elevation data sources:** The elevation data sources being used to calculate the altitudes of the waypoints. This can be either the default 'Improved SRTM' within *eMotion* or imported custom data sets, depending on which one is activated and is at the top of the list in the 'Elevation data' Preference pane.

The flight characteristics are updated automatically as you modify the mission area in the Map Area or the parameters in the first panel.

7.7 Mission Waypoints tab



The Mission Waypoints tab contains a list of all mission waypoints currently on the drone autopilot. It can be used for finer control of individual waypoints in the current mission. The list of waypoints displays the ID, Change altitude parameter, Altitude and Action related to each mission waypoint.

Clicking on a mission waypoint in the list or in the Map Area will expand the panel to display all the parameters related to that waypoint. These parameters are explained in detail in section 'Waypoints and their properties' on page 72. Changes made to the selected waypoint are sent to the drone immediately after selecting an item in the popup menu or upon hitting the 'Enter' key in the text fields. You can reposition the waypoint by clicking the  button and then clicking at the desired position in the Map Area. You can make the selected waypoint the current waypoint by clicking the  button.



Caution: Any change to the waypoints or their parameters are directly sent to the drone and may therefore impact its flight behaviour. We recommend that you take great care before modifying waypoints while the drone is in flight.

You can add new waypoints by clicking the **+** button or by right-clicking on the Map Area and selecting 'Add waypoint here'. Clicking the **-** button will remove all mission waypoints from the drone.



Note: All modifications made to the waypoint list will be lost when the drone is switched off, unless the list is explicitly saved into the autopilot using the 'Save flight plan in drone' button in the Setup Phase tab (see Section 'Setup Phase tab' on page 112).

7.8 Camera tab

The screenshot shows the Camera tab interface with the following sections and controls:

- Camera model:** A dropdown menu currently showing 'DJI S/ELPH'.
- Individual photos:**
 - Photo sequence control:** Includes 'Start sequence' and 'Stop sequence' buttons.
 - Photo targets:** A table with columns for ID, Resolution, Heading, and Pitch. Below the table are controls for:
 - Change altitude: Includes a 'Keep highest' checkbox and a 'Minimum altitude after photo' field set to '87 m/ATO'.
 - Ground resolution: Set to '3.1 cm/px'.
 - Distance: Set to '101 m'.
 - Heading: Set to '0°'.
 - Pitch: Set to '-10°'.
 - Altitude reference: Set to 'm/ATO'.
 - Target altitude: Set to '0 m/ATO'.
 - Latitude: Set to '24.0106'.
 - Longitude: Set to '32.9043'.
 - New photo target increment:** Includes 'Add a photo target' (+) and 'Reset all photo targets' (-) buttons. Below are 'Heading increment' and 'Pitch increment' fields, both set to '0°'.
 - Automatically reset targets altitude based on elevation data
- Camera control:** Includes 'Take photo now' and 'Continuous photo sequence' (set to 'Auto').
- Camera parameters for mapping:** Includes 'Pitch angle' (set to '7°'), a checkbox for 'Use manual parameters' (unchecked), and 'Distance between photos' (set to 'Automatic').

The camera tab is an advanced tab that can be used to precisely control the functioning of the camera. It also contains controls for taking oblique imagery. It is split into several sections: 'Camera model', 'Photo targets', 'Camera control', and 'Camera parameters for mapping'.

The 'Camera model' section is used to define the camera or payload currently connected to the *eBee RTK*. The list contains all payloads currently supported on the *eBee RTK*.

The 'Photo targets' section allows you to program a set of photo targets that the drone will capture with an oblique angle. You can define a photo target location, distance to the object and the heading and pitch of the photograph. The drone will then automatically calculate a flight plan in order to capture the photo with the desired parameters.

- **Photo sequence control:** Clicking the 'Start sequence' button will send the drone to the first photo target location and subsequently take images of all the photo targets currently in the 'Photo targets' list. Clicking the 'Stop sequence' will send the drone back to the Home waypoint.
- **Photo targets:** This panel contains the list of photo targets to be taken in a sequence. Clicking the **+** button will add a new photo target. You can set the location by using the cross-hairs and clicking in the Map Area. By default, the location of a new photo target is the same as the previous one in the list. Clicking the **⊖** will remove all photo targets from the sequence list. Each photo target has the following properties:
 - **Change altitude:** The way the drone transitions to the altitude of the current photo target. This parameter is set to 'Keep highest' for all photo targets and cannot be modified.
 - **Minimum altitude after photo:** This is the calculated minimum altitude the drone will reach at the end of a photo capture manoeuvre, based on the desired ground resolution.
 - **Ground resolution:** The desired ground resolution in the centre of the image that will be pointed at the photo target position.
 - **Distance:** The calculated straight-line distance between the drone and the photo target, and the defined pitch angle. For a given distance, as the pitch angle increases, the distance to the ground decreases.
 - **Heading:** The heading angle with respect to North of the photo target.

- **Pitch:** The pitch angle with respect to vertical of the photo target.
 - **Altitude reference:** The altitude reference of the photo target altitude, either ATO or AMSL.
 - **Target altitude:** The altitude of the photo target.
 - **Position (Coordinate):** The precise latitude and longitude of the centre of the waypoint.
- **New photo target increment:** This panel makes it easier to make a series of oblique photos of the same target with a regular angle increment in order to aid reconstruction of a 3D model. Every new Photo target that is added using the **+** button will be placed at the same location as the previous one, but with an increment in heading and pitch angles defined by the 'Heading increment' and 'Pitch increment' parameters, respectively.
Default value: Heading increment: 0°, Pitch increment: 0°
 - **Automatically reset target altitude based on elevation data:** Check this box to use elevation data to set the absolute photo target altitudes. If this box is unchecked, photo targets are presumed to be at the same altitude as the take-off location.
Default value: disabled

The 'Camera control' section has the following functions:

- **Take photo now:** Clicking this button will send a command to the drone to take a single picture at its current location. This command can be sent during the mission phase of a flight plan.



Note: The 'Take photo now' button has no effect during Take-off, Circular landing, Linear landing and Emergency landing modes.

- **Continuous photo sequence:** These radio buttons define how the drone is taking images. When the default option 'Auto' is selected the drone will start and stop continuous photo shooting based on the actions associated

with mission waypoints. Selecting 'On' overrides waypoint actions and enables continuous shooting. Conversely, selecting 'Off' will override waypoint actions and disable continuous shooting.

Default value: Auto

The 'Camera parameters for mapping' section is used to define detailed parameters related to the camera and has the following functions:

- **Pitch angle:** By default the *eBee RTK* takes images at a default estimated pitch angle of 7° relative to the horizon. This angle provides the best compromise between image quality and flight endurance. In some cases, however, you may wish to change this value to suit your imaging needs.

Increasing this angle to 15° provides a slightly more perspective view of a building. Note, however, that a higher pitch angle will cause the drone to slow down every time it takes an image, losing altitude and decreasing flight time and longitudinal overlap.

Decrease the pitch angle down to 0° can capture more vertical images of the ground if mapping precision at low altitudes is of utmost importance. However, decreasing this angle will cause the drone to lose altitude with each image taken, requiring it to return to the target altitude before taking another image, once again decreasing both flight time and longitudinal overlap between images.


Default value: 7°

- **Distance between photos:** Check the 'Use manual parameters' box to manually set the distance between photos in the direction of flight. This option may be used to override the automatic settings based on altitude and longitudinal overlap.

Default value: Unchecked, Distance between photos: Automatic

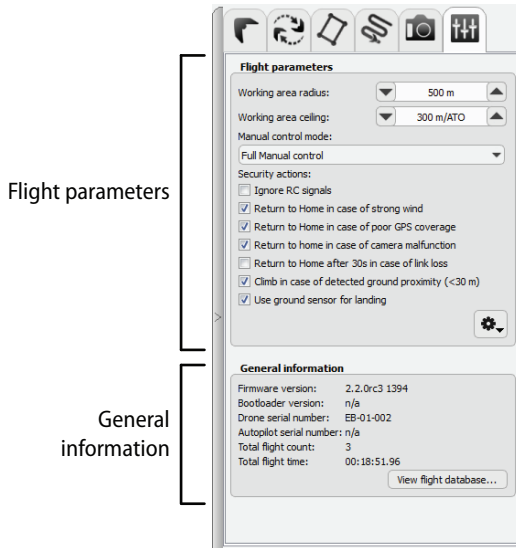


Note: Depending on the altitude and the wind the desired distance between images may not always be achievable. The minimum distance with no wind and at sea level is around 35-40 m.

Clicking the  button will provide further options:

- **Save parameters as default in drone:** Saves the currently-set camera parameters to the *eBee RTK*'s autopilot's memory.
- **Restore factory parameters:** Returns the parameters to their default values and automatically send them to the drone's autopilot.

7.9 Flight Parameters tab



The Flight Parameters tab includes some advanced functions that govern the overall behaviour of the drone while in flight. It is separated into two sections: 'Flight parameters' and 'General information'. The 'Flight parameters' section includes the following items:

- **Working area radius:** This is the radius of the working area around the take-off location. Flying outside of this area will create a warning and cause the drone to return to the Home waypoint.

Default value: 500 m

- **Working area ceiling:** This is the maximum altitude above the take-off location at which the drone can fly. Flying above this altitude will create a warning and cause the drone to return to the Home waypoint.

Default value: 300 m/ATO

- **Manual control mode:** Selects between Full Manual control and Assisted Manual control when the remote control is turned on⁴¹.

Default value: Full Manual control

- **Security actions:** The next checkboxes are used to disable certain Security actions⁴².

- **Ignore RC signals:** Checking this option will result in the drone ignoring any signals coming from a remote control (RC) transmitter on the ground.

Default value: unchecked



Caution: In certain regions it is illegal to disable the remote control connection between the drone and the operator on the ground. Please check the laws in your region before enabling this option.

- **Return to Home in case of strong wind:** Checking this box will enable the Security action related to high wind strength (return to Home waypoint). Un-checking this box will disable the Security action, however the drone will continue to estimate the wind strength and direction and the In-flight warning will continue to appear.

Default value: checked



Caution: The *eBee RTK* is not designed to fly in winds above 12 m/s. Flying in high-wind conditions increases the chances of a crash that may damage the drone and is done at your own risk.

- **Return to Home in case of poor GPS/GLONASS coverage:** Checking this box will enable the Security action (return to Home waypoint) related to poor GPS/GLONASS signal coverage. Un-checking this box will disable the Security action, however the In-flight warning will continue to appear.

Default value: checked

⁴¹ see section 'Manual control of the *eBee RTK*' on page 136 for more information

⁴² see section 'In-flight warnings' on page 160 for more information on Security actions related to specific In-flight warnings

- **Return to Home in case of camera malfunction:** Checking this box will enable the Security action (return to Home waypoint) related to a camera malfunction. Un-checking this box will disable the Security action, however the In-flight warning will continue to appear.

Default value: checked

- **Return to Home after 30s in case of link loss:** Checking this box will enable In-flight warnings and Security actions related to a loss of the communications uplink between *eMotion* and the drone (return to Home after 30 s of link loss). Un-checking this box disables both the In-flight warning and the Security action and will result in the drone continuing on its flight path even if it does not re-connect with *eMotion*.

Default value: unchecked

- **Climb in case of detected ground proximity (<30 m):** The *eBee RTK* features a ground sensor that continuously checks the presence of the ground. If this box is checked and the ground sensor detects a height above the ground of less than 30 m, the drone will climb to a safe height of 60 m before continuing the mission.

Default value: checked

- **Use ground sensor for landing:** The *eBee RTK* uses its ground sensor together with its estimate of the wind speed during its landing manoeuvre to calculate the ideal moment to perform a final brake and enter deep stall. If this box is unchecked the drone will ignore the ground sensor during its approach and will assume that the landing location is precisely at the same altitude as indicated in *eMotion*. This will result in a landing precision that is decreased and dependent on the strength of the wind.

Default value: checked



Note: Un-checking this feature is only recommended when performing a linear landing in uneven terrain where the height measured by the ground sensor during approach would imply an undesired approach slope correction.

Clicking the 'More' list will provide further options:

- **Save parameters as default in drone:** Saves the currently-set flight parameters to the *eBee RTK*'s autopilot's memory.
- **Restore factory parameters:** Returns the flight parameters to their default values and automatically sends them to the drone's autopilot.

The 'General information' section displays information specific to your *eBee RTK*. This includes the current firmware and bootloader versions loaded into the autopilot, the serial numbers of the airframe and the autopilot, the total number of flights performed by drone and the total time spent in the air.



Note: The flight counter is incremented every time the take-off procedure is initiated by shaking the *eBee RTK* back and forth 3 times, even if take-off is subsequently aborted.

Clicking 'View flight database...' will bring up a window that presents a summary of all the flights performed by the drone using this computer.

8 Manual control of the *eBee RTK*



Goal of this section: This section describes how to use the remote control to manually control the drone, either in Full Manual or Assisted Manual modes.



Caution: Operation of the *eBee RTK* in either Assisted or Full Manual mode requires the skills of an experienced RC aircraft pilot. SenseFly Ltd cannot be held responsible for damage caused by manual control of the drone. Any damaged caused by manual control of the drone will void the warranty.

8.1 Enabling manual control

By default, the *eBee RTK* flies autonomously and does not need the provided remote control to be operated. However, by using the remote control, it is possible to override the drone's autopilot by switching to one of two available manual modes: Full Manual or Assisted Manual. In Full Manual mode the sticks of the remote control directly set the motor power and the angle of the ailerons of the drone. In Assisted Manual mode the sticks of the remote control are used to set the speed, turn rate and climb or sink rate.



Note: Ensure that the 'Ignore RC signals' option in the Flight Parameters tab is unchecked⁴³, otherwise the drone will ignore the commands from the remote control and remain in autonomous operation mode.

Turning on the remote control will cause the drone to change to either Assisted Manual or Full Manual mode, depending on the 'Enable assisted manual control' setting in the Flight Parameters tab⁴⁴ of *eMotion*. Turning off the remote control will cause the drone to return to the last autonomous operation mode it was in

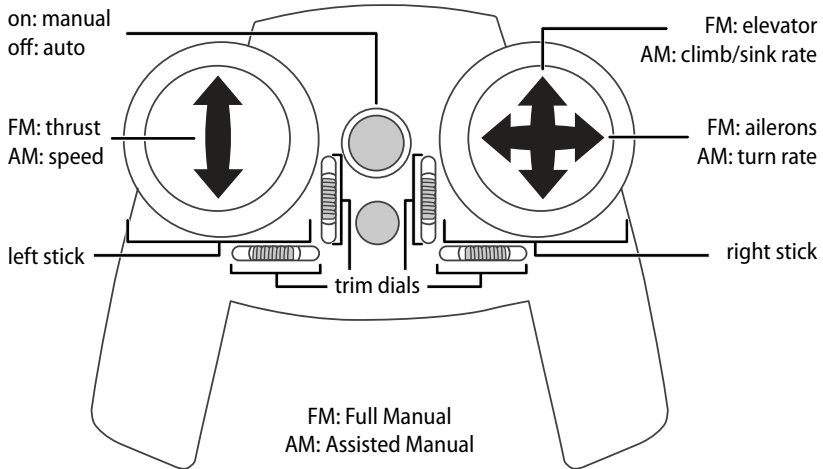
⁴⁴ see section 'Flight Parameters tab' on page 132 for more details on this setting

before Manual mode was enabled.



Caution: We recommend that you only turn the remote control on when it is held by a pilot ready to take manual control of the drone, and that you turn it off when putting the remote control down.

Manual control of the *eBee RTK* can be achieved at any time if the drone is within range of the remote⁴⁵.



Caution: The remote control is preconfigured for use with the *eBee RTK*. In particular, the trim dials, used to finely adjust the position of the drone's ailerons, are calibrated to ensure optimal flight characteristics and should not be adjusted. Changing the remote control's configuration, including the trim settings, may compromise the flight characteristics of the drone. If, for any reason, the preset settings should be lost, contact your *eBee RTK* reseller.

⁴⁵ see section 'Drone specifications' on page 181 for the range of the remote control

8.2 Pre-flight testing of the remote control

If you plan to use the remote control during a flight we recommend that you first test it on the ground. Ensure that the *eBee RTK* is set to Full Manual mode⁴⁶ and follow these steps:

1. Check that the left stick on the remote control is in the low position to prevent the propeller from spinning.
2. Turn on the remote control.
3. Turn on the *eBee RTK* by connecting the battery. Once the drone detects the signal from the remote control it will change to one of the manual modes.



Caution: The motor of the *eBee RTK* is now controlled by the remote control and will begin spinning if the left stick is pushed up. Always keep the area around the propeller clear of obstacles and body parts to prevent injury.

4. Move the right stick on the remote control to verify proper reception by the drone and correct servo direction.
5. Turn off the remote control for take-off.



Note: If the remote control is switched on while it is performing pre-flight checks the ailerons will not move when the checks are completed and the GPS/GLONASS signals are acquired.

For more information on using the remote control, refer to the original user manual available in the downloads section of the senseFly Ltd website⁴⁷.

⁴⁶ see section 'Enabling manual control' on page 136

⁴⁷ <http://www.sensefly.com/support/download>

8.3 Full Manual mode

Full Manual mode allows you to have direct control over the *eBee RTK*'s actuators, overriding all control from the on-board autopilot. The left stick controls the thrust. For safety reasons, the left stick should remain at the lowest position at all times, except during flight.

The right stick controls the elevator and the ailerons in the same way as a typical aircraft control stick (or the joystick with a flight simulator). Note that the drone uses its ailerons to fulfil the functions of both ailerons and elevator in a classical airplane. When the ailerons function in the same direction, they act as the elevator. When the function in opposite motion, they act as ailerons.

We recommend you perform a standard take-off procedure in autonomous mode and only switch to Full Manual mode when the drone is in the air. If you wish to take-off in Full Manual mode, however, you must use the following steps:

1. Prepare the drone for flight as described in section 'Preparing the *eBee RTK* for flight' on page 41 while keeping the remote control turned off and the left stick at its lowest position.
2. Turn on the remote control. You now have manual control over the main thrust motor and the servo-motors.



Caution: The motor of the drone is now controlled by the remote control and will begin spinning if the left stick is pushed up. Always keep the area around the propeller clear of obstacles and body parts to prevent injury.

3. Firmly grasp the *eBee RTK* horizontally with level wings using both hands, one hand on the front of each wing. Shake the drone back and forth 3 times longitudinally (within approx. 3 seconds). The status LED will pulse blue while the drone's autopilot performs a start-up sequence. As the motor is now controlled by the remote control, it will not begin spinning. Once the sequence is complete, the status LED will turn green (solid or blinking, depending on the angle at which you are holding the drone).



Caution: Taking off without performing the motor power-up sequence will result in the *eBee RTK* staying in Idle mode during the entire flight and is not recommended. The drone will no longer be able to enter automatic mode while in flight and must land using manual control.

4. The *eBee RTK* is now ready for manual take-off. Orient yourself into the wind, and confirm that the take-off direction in front of you is free of obstacles. We recommend that you take off at full power and into the wind by setting the left stick to its highest position and releasing the drone when the status LED is solid green.

8.4 Assisted Manual mode

In Assisted Manual mode the sticks on the remote control set the desired speed, turn rate and climb or sink rate. These commands are then transferred to control signals for the individual actuators by the autopilot based on feedback from its sensors. This control scheme simplifies control of the *eBee RTK*.



Caution: Though it may be easier to fly the *eBee RTK* manually when in Assisted Manual mode it remains dangerous and should be used with care. In particular, the pilot must still be aware of obstacles in the area, the altitude of the ground, the inversion of control commands when the drone is flying towards the pilot and the distance between the drone and the pilot. We recommend that you only try Assisted Manual mode when in a large open space with no obstacles and low wind.

In this mode the left stick is used to set the desired speed of the *eBee RTK*. Setting the left stick between 10% and 100% sets a desired speed between 10.5 and 20 m/s. Setting the stick below 10% turns off the motor, allowing the drone to slowly descend in a glide. The drone may even engage reverse thrust to limit its speed during descent.

The right stick is used to set the direction of flight of the *eBee RTK*. Moving the stick

left or right will set a left or right roll angle of up to 45°/s, respectively. Moving the stick down will set a climb rate of up to 3.5 m/s. Moving the stick up will set a sink rate of up to 3.5 m/s. Releasing the right stick at any point will return the drone to a straight flight path at a constant altitude.

It is not possible to take-off in Assisted Manual mode. You may only switch to Assisted Manual mode after completing the standard take-off procedure⁴⁸.



Caution: There is no clear indication during the take-off procedure that the *eBee RTK* will change to Assisted Manual mode rather than Circle Start Waypoint mode after the take-off transition altitude is reached⁴⁹. For this reason we recommend that you do not turn on the remote control unless you are ready to manually control the drone right after take-off.

To perform a manual landing we recommend the following procedure:

1. The drone should always perform a linear landings into the wind. Face the downwind direction and confirm that there are no obstacles in an area of at least 100 m downwind and a width of 20 m in either direction from downwind.
2. Set the drone to an altitude of around 50 m from the landing altitude by moving the right stick up or down.
3. Fly downwind until the drone is around 100 m away from the landing location.
4. Turn the drone upwind and towards the landing location by moving the right stick left or right.
5. Set the speed to a low value by moving the left stick down to around 25% of its maximum value.
6. Bring the drone closer to the ground by controlling the sink rate with the right stick. Keep the drone descending until it is around 5-10 m from the ground.

⁴⁸ as described in section 'Take-off' on page 55

7. Once the drone is around 5-10 m from the landing location, cut motor power using the left stick and allow the drone to glide down to the ground.

Part III

**Maintenance, Repair and
Troubleshooting**

9 Maintenance and repair of the *eBee RTK*



Goal of this section: This section describes how to update accompanying software and on-board firmware, keep your drone in good working condition and perform small repairs such as cracks in the air-frame.

9.1 Updating the *eBee RTK* software

Occasionally, senseFly Ltd releases a software upgrade for the *eBee RTK* to provide additional features to our users or to correct potential issues. As of version 2.0.2, *eMotion* will check for new versions during start-up⁵⁰ and will display a message with update instructions if a new version is available. We recommend, however, that you check the senseFly Ltd website regularly for updates to ensure you have the latest version of the software.




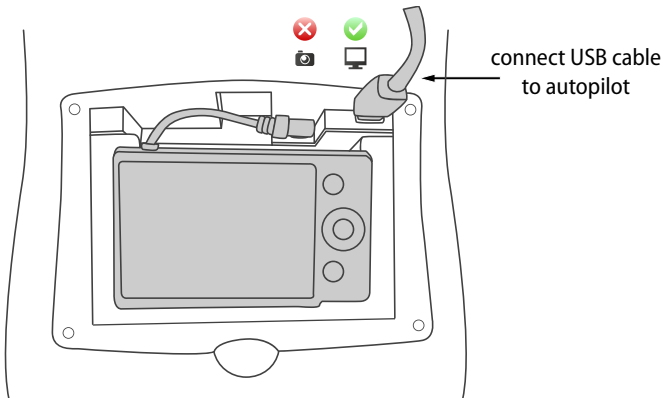
Caution: We are constantly working to improve the performance of our products and we are dedicated to providing our customers with the newest software as soon as it becomes available. Since the highest level of flight safety can only be achieved with the latest software release, senseFly Ltd can only offer warranty service for products that have been properly updated.


To upgrade *eMotion* or *Postflight Terra 3D* to the latest version, download the installer from the senseFly Ltd website and follow the standard install procedure (see section 'Installing *eMotion*, *Postflight Terra 3D*, and the ground modem drivers' on page 20). It is not necessary to uninstall previous version of *eMotion* before installing the new one.

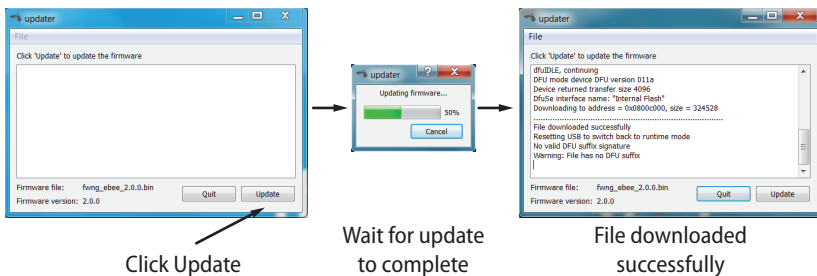
Every version of *eMotion* is packaged with an accompanying firmware revision which must be installed on the drone before it can be used. To upgrade the firmware of the *eBee RTK* follow these steps:

⁵⁰ provided that there is an internet connection

1. Connect the battery to the drone.
2. Connect the USB cable between the computer on which you installed *eMotion* and the autopilot of the *eBee RTK* as shown in the figure. The connector is beside the camera connector and is marked with a  icon. The status LED will turn white as soon as you connect the cable.



3. Click the  icon and select 'Updater eBee RTK...'⁵¹.
4. Click 'Update' to begin the updating process. Wait until the process is complete, which is indicated by the text 'File downloaded successfully'.



Note: You may need to install a driver the first time you upgrade your firmware. The driver will be installed automatically but may cause the firmware update to fail. If this is the case, retry the update process by clicking 'Update' again, without disconnecting the battery or cable from the drone or closing the 'Updater eBee RTK' program.

⁵¹ also available in the 'eMotion' folder in the Start menu in Windows

5. Disconnect the USB cable and the battery.

It is important that both the drone and *eMotion* have the same software version for them to work properly together. Make sure that you keep both up-to-date. To check which version of *eMotion* you have installed, use the 'About eMotion...' item in the 'Window' menu. The *eBee RTK* firmware version can be seen in the Flight Parameters tab once connected (see section 'Flight Parameters tab' on page 132).

9.2 Cleaning and storage

Use a damp cloth to wipe off dirt from the *eBee RTK*. In order to avoid structural deformation of the wing, it is recommended to store the drone either in its transport case or on a flat surface at room temperature.



Caution: Never bring the *eBee RTK* into direct contact with water, as this may damage the electronics within the drone airframe.

9.3 Full airframe and sensor inspection

Beyond the general airframe inspection that is performed before every flight, we recommend that you perform a full airframe and sensor inspection regularly to keep your drone in good operating condition.



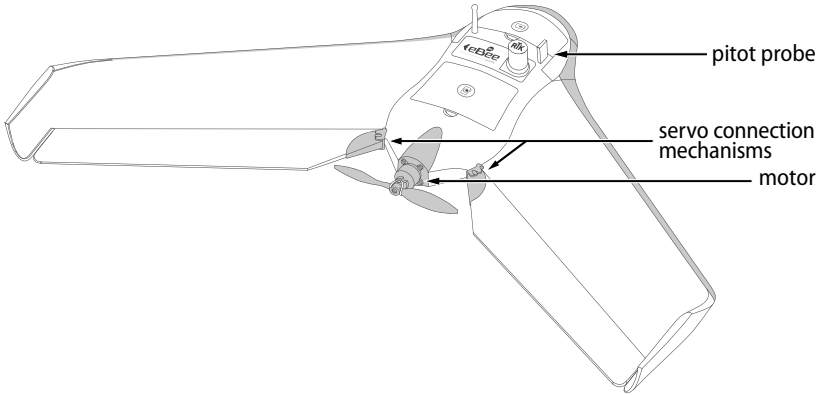
Caution: The autopilot, sensors and actuators within the Central Body of the *eBee RTK* are specially calibrated and should only be modified by your *eBee RTK* reseller. Opening the Central Body of the *eBee RTK* will void the warranty.

The inspection includes the following checks:

Check 1: Motor and Servos

The *eBee RTK* uses a brushless DC motor to turn its propeller and generate thrust. The servos are the two actuators connected through a servo connection mechanism to both ailerons. Damaged actuators can prevent the drone from flying

correctly and thus it is important to ensure their proper functioning.



To check the actuators, follow these steps:

1. The motor must be clean and spin smoothly without friction to function correctly. Ensure that there is no sand or other obstructions within the motor. If there is something blocking the motor from spinning smoothly blow some air through the motor to dislodge the obstruction.
2. Make sure the left stick of the remote control is all the way down to keep the motor off⁵². Place the *eBee RTK* at the edge of a flat surface and keep the area around the propeller clear.



Caution: The propeller on the *eBee RTK* spins at high speeds and can cause deep cuts if it comes into contact with exposed skin. Always wear gloves and glasses when any work is done requiring the battery to be connected to the drone.

3. Switch the drone on by connecting the battery.

⁵² see section 'Manual control of the *eBee RTK*' on page 136 for details on using the remote control

4. Connect to *eMotion*. Ensure that 'Manual control mode' is set to 'Full Manual control' and that the 'Ignore RC signals' setting is not checked⁵³.
5. Switch the remote control on.
6. Move the right stick on the remote control and check the aileron motion. The ailerons must smoothly and quickly follow the stick. When the stick is not moved, the ailerons must stay still. When travelling from one end to the other, fast or slow, the ailerons must smoothly follow without twitching.
7. Hold down the drone against the flat surface with one hand to prevent it from moving. Gently move the left stick on the remote control to spin up the motor and propeller. The motor should run smoothly without making excessive noise.
8. When done, switch the remote control off.

In case of doubt, take a short video and follow the instructions in section 'Reporting a problem with your *eBee RTK*' on page 178 for advice.

Check 2: Inertial sensors

The inertial sensors are used by the autopilot to compute the attitude (i.e. its orientation in space) of the drone. The attitude is displayed by the artificial horizon in the Flight Monitoring tab of *eMotion*. To check the inertial sensors, follow these steps:

1. Switch the *eBee RTK* on by connecting the battery and connect to *eMotion*.
2. Put the drone on a flat surface (typically an office floor) and check that the artificial horizon is level.
3. Take the drone with your hand and put it in different orientation. Make sure that the artificial horizon displays the corresponding orientation.

The artificial horizon should follow smoothly the motion of the *eBee RTK* and it should not drift when the drone is not moving. In case of doubt, take a short video

⁵³ see section 'Flight Parameters tab' on page 132 for more details on these settings

and follow the instructions in section 'Reporting a problem with your *eBee RTK*' on page 178 for advice.

Check 3: Barometric pressure sensor

The barometric pressure sensor is used to measure the altitude from the take-off location. To check it, follow these steps:

1. Switch the *eBee RTK* on by connecting the battery and connect to *eMotion*.
2. Move the drone from your feet to above your head (about 2 m altitude variation).
3. Check the altitude on the vertical bar right of the artificial horizon or in the Status Panel next to the drone icon on the map).

The displayed altitude should follow the drone motion, i.e. if the drone is raised by 2 m, the altitude reading should increase by about 2 m. When the drone is not moving, the altitude reading may slowly drift by up to ± 10 m.

Check 4: Air speed sensor

The air speed sensor is connected to the pitot probe by a pair of tubes. To check it, follow these steps:

1. Visually check the pitot probe. Make sure that it is properly fixed to the airframe and that both tubes are properly attached and not damaged). The holes in the probe must be clear and free of dirt or other small obstructions.
2. Switch the drone on by connecting the battery and connect to *eMotion*.
3. Gently blow into the front opening of the pitot tube from a distance of around 5 cm. The airflow direction should match the natural flow experienced in flight.
4. Check the air speed displayed on the vertical bar left of the artificial horizon.

At rest, the displayed air speed should be close to zero (it may drift up to about 2 m/s). When blowing in the pitot probe there should be an air speed indicated in the 'Flight Monitoring' tab of *eMotion* that should easily reach values above 8 m/s.

Check 5: Ground sensor

The ground sensor is composed of a high-speed optical sensor and a lens assembly. The lens assembly must be clean and unobstructed for the sensor to work correctly.

9.4 Repairing the *eBee RTK* airframe

Small repairs of cracks in the airframe can be done using contact glue such as UHU® POR glue. Take care to use only contact glues that are specifically designed for Expanded Polypropylene (EPP). If you have doubts about the extent of the damage, always contact your *eBee RTK* reseller to verify if the damage can be easily repaired by yourself or if you need to send your drone in for repair to.



Caution: Never fly your *eBee RTK* if it has cracks in the airframe.

9.5 Proper battery care

Proper care of your *eBee RTK*'s battery is important to prevent damage to your drone and to maximize flight time. With a fully charged battery, the drone will fly for about 40 minutes. Frequent altitude changes, presence of wind, use of old batteries and/or frequent photo acquisition may significantly reduce the flight endurance. Batteries perform better at medium or high air temperature and it is normal to observe shorter flight times in cold weather.

The *eBee RTK* is powered by a Lithium Polymer (LiPo) battery composed of three cells connected in series. A single LiPo cell can have a range between 3 V (empty) and 4.2 V (full) in its normal operating range. This results in an empty battery voltage of 9 V and a fully-charged battery voltage of 12.6 V. A well-balanced and healthy battery should have all three cells at a voltage very close to each other and between 3 and 4.2 V.

The charger delivered with your drone automatically checks for healthy voltages of all three cells and only attempts charging if they are within limits. If the cells

are out of balance, the charger will take care of balancing them. If the charger detects a voltage outside of the allowable range it will indicate an error either by flashing the status LED red, or by the LED staying off. This means that the battery is over-discharged and should be discarded.



Caution: The batteries delivered with your drone are designed to be charged with the charger delivered with your *eBee RTK*. senseFly Ltd cannot be held responsible for any consequences resulting from using a different charger. In particular, using a charger improperly configured or designed for other types of batteries may lead the battery pack to be permanently damaged or to catch on fire.

LiPo batteries do not exhibit any memory effect. We recommend that you always fully charge them after use even when they are only partially discharged. When not using the battery store it in the carrying case provided with your drone. Avoid leaving the battery in direct sunlight.



Caution: If any of the cells of your battery pack are overly discharged the battery may be irreversibly damaged and becomes dangerous to charge. If the battery grows beyond its regular size or if any of the cells are punctured it is also likely damaged and should be discarded. Forcefully charging a damaged battery may lead it to take fire. **Do not attempt to charge an over-discharged or damaged battery. Dispose of the battery safely.**

9.6 Proper antenna care

Proper care of your *eBee RTK*'s GNSS/RTK antenna is important to prevent loss or damage to it or the connector on your drone. Your *eBee RTK* receives GNSS signals through the antenna, and will not fly without it.

Take care not to drop the antenna when removing it from the flight case and while fitting it to your drone.

Make sure the screw threads on the antenna and on your *eBee RTK* are both un-

damaged and free of liquid, grit, dust and dirt.

Do not to cross the screw thread. Screw the antenna on firmly with finger force.

Do not overtighten.

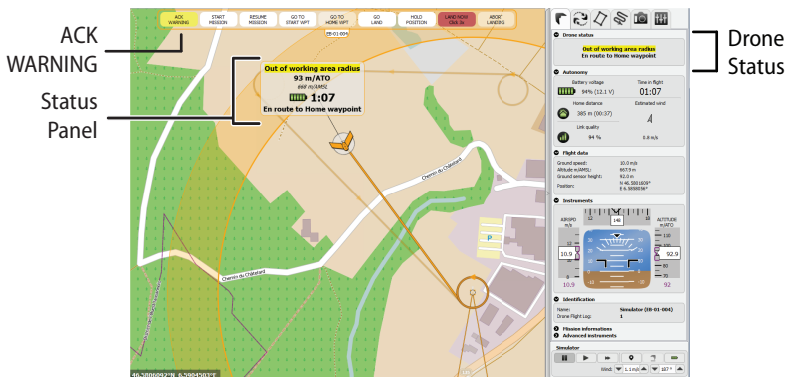
For replacement antennas, please contact senseFly Ltd.

10 Troubleshooting



Goal of this section: This section describes the various error messages that may be displayed during start-up or while the *eBee RTK* is in flight and provides some tips on solving the simplest problems. In the case of a more serious problem, this section describes how to prepare the required data on the problem and report it to your *eBee RTK* reseller.

The *eBee RTK* can generate several types of error messages depending on its flight mode. Some of these messages are minor and simply need to be acknowledged through *eMotion*, whereas others require more specific action from the user. As long as the drone is connected to *eMotion*, error messages will appear in the Status Panel in the Map Area, as well as in the Drone Status panel of the Flight Monitoring tab.



Error messages are divided into four categories: Pre-flight errors, Take-off vetoes, In-flight warnings and Critical failures.

10.1 Pre-flight errors

As soon as the battery is connected to the drone it performs a series of pre-flight checks to thoroughly test its on-board systems. The start-up process is described in detail in section 'Preparing the *eBee RTK* for flight' on page 41. If an error occurs during these pre-flight checks the status LED will blink red and a description of the error will appear in *eMotion*. In most cases, re-connecting the battery will suffice to remove the error. Table 3 presents all the Pre-flight errors that may occur and possible actions to fix the error. If the problem is related to the firmware in the on-board autopilot, try re-loading the firmware using instructions in section 'Updating the *eBee RTK* software' on page 144. If an error persists after reconnecting the battery several times we recommend you report the problem by following the instructions in section 'Reporting a problem with your *eBee RTK*' on page 178.

Table 3: Pre-flight errors

<i>eMotion</i> text	Description and User action
Incorrect firmware detected	There is an error with the current version of the firmware in the <i>eBee RTK</i> 's autopilot. User action: Re-load the correct firmware ⁵⁴ .
Battery too low for take-off	The battery level is too low to perform a take-off. User action: Re-connect a fully-charged battery.
Drone flight log memory full	The memory card used to store the Drone flight log is full. User action: Empty the memory card by following the instructions in section 'Importing images and flight data' on page 62.

⁵⁴ see section 'Updating the *eBee RTK* software' on page 144

<p>Pitot malfunction</p>	<p>A high airspeed was detected while on the ground. User action: Be sure to protect the drone from the wind and re-connect the battery. If the problem persists, perform Check 4 in section 'Full airframe and sensor inspection' on page 147. If this does not solve the problem contact your <i>eBee RTK</i> reseller.</p>
<p>High current</p>	<p>A too high current was detected, which may be caused by an internal problem. User action: Re-connect the battery. If the problem occurs twice, contact your <i>eBee RTK</i> reseller.</p>
<p>Magnetometer malfunction</p>	<p>There is an error with the drone's magnetic field sensor. User action: Re-connect the battery. If the problem persists, contact your <i>eBee RTK</i> reseller.</p>
<p>EEPROM malfunction</p>	<p>There is an error with the memory chip of the drone's autopilot. User action: Re-connect the battery. If the problem persists, contact your <i>eBee RTK</i> reseller.</p>
<p>Barometer malfunction</p>	<p>There is an error with the drone's barometer. User action: Be sure to place the drone on a flat surface, reconnect the battery and do not move the drone until pre-flight checks are complete. If the problem persists, perform Check 3 in section 'Full airframe and sensor inspection' on page 147. If this does not solve the problem contact your <i>eBee RTK</i> reseller.</p>

<p>De-calibrated INS or Attitude malfunction</p>	<p>The orientation sensors were not calibrated correctly. User action: Be sure to place the drone on a flat surface, reconnect the battery and do not move the drone until pre-flight checks are complete. If the problem persists, perform Check 2 in section 'Full airframe and sensor inspection' on page 147. If this does not solve the problem contact your <i>eBee RTK</i> reseller.</p>
<p>Ground sensor malfunction</p>	<p>There is an error with the drone's ground sensor. User action: Ensure that the ground sensor on the bottom of the drone is clear of debris and is not damaged, then re-connect the battery. If the problem persists, perform Check 4 in section 'Full airframe and sensor inspection' on page 147. If this does not solve the problem contact your <i>eBee RTK</i> reseller.</p>
<p>Invalid flight controller gains</p>	<p>There is an error with the firmware in the drone's autopilot. User action: Re-connect the battery. If the problem persists, contact your <i>eBee RTK</i> reseller.</p>

10.2 Take-off vetoes

After successfully completing pre-flight checks the status LED becomes a solid green to indicate that the drone is ready for take-off. At this point the *eBee RTK* continues to monitor its sensors and battery level. If at any point the drone detects a condition that prevents it from beginning the automatic take-off procedure it displays a Take-off veto in *eMotion* and the status LED changes to a blue pulse. Once the Take-off veto is cleared the status LED returns to a solid green colour to indicate that the drone is ready for take-off.

Table 4 on the next page presents all the Take-off vetoes that may occur and possible actions to remove the veto. If a veto persists after performing the suggested action, we recommend you report the problem by following the instructions in section 'Reporting a problem with your *eBee RTK*' on page 178.

Table 4: Take-off vetos

<i>eMotion</i> text	Description and User action
Drone not horizontal (roll or pitch)	The <i>eBee RTK</i> must be held horizontally with level wings to initiate take-off. User action: Hold the drone horizontally.
Motor is blocked	Excessive current was detected from the motor. User action: Check that the propeller is mounted correctly and that the motor is freely turning and try the take-off procedure again.
Battery too low for take-off	The drone requires a fully-charged battery for the take-off procedure. User action: Change the battery.
Wings not detected	The drone's wings are not attached correctly or the wing struts are damaged. User action: Ensure that the wings are fully inserted into the main body and that the wing struts are not damaged, as described in section 'Preparing the <i>eBee RTK</i> for flight' on page 41.
USB cable detected	The <i>eBee RTK</i> has detected a USB cable connected to the drone's autopilot. User action: Remove the USB cable before take-off.
RTK source not defined	You have chosen a flight mode that requires RTK correction data, but none is available. User action: Check that your GNSS/RTK base station is powered on and connected to the computer that is running <i>eMotion</i> . Check that you have selected the correct base station connection type and parameters in <i>eMotion</i> . Check that you have set up and, if necessary, logged in to your VRS stream.

10.3 In-flight warnings

While it is in flight the *eBee RTK* can generate two types of errors: warnings and failures. In-flight warnings occur when there is an event that requires user attention but does not compromise the drone's ability to continue flying.

When an In-flight warning is activated the warning will appear in yellow in *eMotion* and cause the 'WARNING' button in the Control Bar to change to 'ACK WARNING', turn yellow and activate. The drone will then perform a Security action depending on the active In-flight warning. Some In-flight warnings simply need to be acknowledged by clicking on the 'ACK WARNING' button. Others require action by the user before the warning is cleared and the drone can return to full functionality. The full list of possible In-flight warnings and required User actions can be found in table 5 on the following page.

The In-flight warnings marked with a * can have their Security actions disabled, whereas the In-flight warnings marked with a ** can have both the warning and the Security action disabled. See section 'Flight Parameters tab' on page 132 for instructions on disabling warnings and Security actions.



Caution: The Security action for most In-flight warnings is to fly back to the Home waypoint (if Circular landing is selected) or the Home waypoint (if Linear landing is selected). As soon as this Security action is triggered the drone will fly in the direction of the selected landing waypoint while climbing or descending to the waypoint's altitude. It is thus important to ensure that there are no obstacles above the altitude of the selected landing waypoint within the entire flight area to prevent a collision resulting from this Security action.

Table 5: In-flight warnings

<i>eMotion</i> text	Description and Security action
<p>Failure occurred: (failure description)</p>	<p>This warning ensures that the user is aware that a Critical failure has occurred even if it is no longer active⁵⁵.</p> <p>Security action: The <i>eBee RTK</i> flies towards the Home waypoint at an altitude defined by the Home waypoint's Change altitude parameter (by default, set to 'Highest').</p> <p>User action: Ensure that the failure condition is no longer present before acknowledging the error and continuing normal operation.</p>
<p>Low battery</p>	<p>The remaining battery level is too low to continue the flight plan.</p> <p>Security action: The <i>eBee RTK</i> flies towards the Home waypoint at an altitude defined by the Home waypoint's Change altitude parameter (by default, set to 'Highest') and automatically initiates an expedited landing procedure (without performing a full wind estimation) once it reaches the waypoint.</p> <p>User action: Land as soon as possible. Re-charge the drone battery before performing another flight.</p>

⁵⁵ see section 'Critical failures' on page 173 for a description of possible Critical failures

<p>Drone flight log malfunction</p>	<p>There is an error saving data to the on-board memory card which will prevent the images from being geo-tagged. Images may still be geo-tagged using the eMotion Flight Log file but may be less precise. Security action: The drone continues normal flight. User action: Land as soon as possible. Once on the ground, connect to the on-board memory card as described in section 'Importing images and flight data' on page 62 and re-format the memory card.</p>
<p>Flight controller malfunction</p>	<p>The flight controller has encountered an unexpected state, such as an incorrect waypoint type. Security action: The drone flies towards the Home waypoint at an altitude defined by the Home waypoint's Change altitude parameter (by default, set to 'Highest'). User action: Land as soon as possible and re-start the drone. If the problem persists, contact your <i>eBee RTK</i> reseller.</p>
<p>Camera sync malfunction</p>	<p>There is a problem with the wiring of the on-board camera. Security action: If required parameter set in the Flight Parameters tab, the drone flies towards the Home waypoint at an altitude defined by the Home waypoint's Change altitude parameter (by default, set to 'Highest'). Otherwise it continues its mission without taking further images. User action: Land as soon as possible and re-start the drone. Reset the camera settings as described in section 'Resetting default camera settings' on page 176.</p>

<p>Camera power malfunction</p>	<p>The camera is no longer responding, most likely because it is no longer powered.</p> <p>Security action: If required parameter set in the Flight Parameters tab, the drone flies towards the Home waypoint at an altitude defined by the Home waypoint's Change altitude parameter (by default, set to 'Highest'). Otherwise it continues its mission without taking further images.</p> <p>User action: Land as soon as possible. Check the cable connection between the camera and the drone and charge all the batteries before performing another flight.</p>
<p>Barometer malfunction</p>	<p>The barometer used to sense the current altitude is malfunctioning.</p> <p>Security action: The drone flies towards the Home waypoint at an altitude defined by the Home waypoint's Change altitude parameter (by default, set to 'Highest') using altitude calculated from GPS/GLONASS signals only, potentially causing large fluctuations in altitude.</p> <p>User action: Land as soon as possible and perform Check 3 in section 'Full airframe and sensor inspection' on page 147.</p>

<p>Motor malfunction</p>	<p>The motor is drawing too little or too much current. This may be caused by damaged wires or connectors leading to the motor or by sand or other debris within the motor.</p> <p>Security action: The drone attempts to re-start the motor. If the first attempt fails a Failure: Motor malfunction Critical failure is announced⁵⁶.</p> <p>User action: Land as soon as possible and perform Check 1 in section 'Full airframe and sensor inspection' on page 147.</p>
<p>Battery malfunction</p>	<p>The sensor used to measure the battery voltage and current is registering invalid values, indicating that the sensor is de-calibrated or damaged.</p> <p>Security action: The drone flies towards the Home waypoint at an altitude defined by the Home waypoint's Change altitude parameter (by default, set to 'Highest').</p> <p>User action: Land as soon as possible and re-start the drone. If the problem persists, contact your <i>eBee RTK</i> reseller.</p>

⁵⁶ see section 'Critical failures' on page 173

<p>Airspeed malfunction</p>	<p>The differential pressure sensor used to measure airspeed is registering invalid values. This may be due to a damaged sensor or to a clogged pitot probe.</p> <p>Security action: The drone flies towards the Home waypoint at an altitude defined by the Home waypoint's Change altitude parameter (by default, set to 'Highest') at a constant thrust value instead of controlled speed, potentially resulting in low or high flight speeds depending on wind. Once it reaches the Home waypoint it initiates a landing procedure.</p> <p>User action: Try to provide a maximum amount of approach sectors to ensure that the drone can land against the direction of the wind. Land as soon as possible and perform Check 4 in section 'Full airframe and sensor inspection' on page 147.</p>
<p>Low airspeed</p>	<p>Detected airspeed is unusually low or close to zero. This may be due to a collision with the ground or a clogged airspeed sensor.</p> <p>Security action: The drone shuts off its motor and tries to continue its mission.</p> <p>User action: If the warning is due to a clogged airspeed sensor it may be due to moisture in the air. Try commanding the drone to descend closer to the ground and out of any cloud cover.</p>

Overspeed	<p>Detected airspeed is unusually high, possibly due to a loss of control.</p> <p>Security action: The drone applies a 50% reverse thrust to try to slow down.</p> <p>User action: Keep track of the drone's position in case it is unable to slow back down to a regular air-speed.</p>
Ground sensor malfunction	<p>The ground sensor used to detect the proximity of the ground is malfunctioning.</p> <p>Security action: The drone continues normal flight.</p> <p>User action: Land as soon as possible and perform Check 5 in section 'Full airframe and sensor inspection' on page 147.</p>
Wings detection malfunction	<p>The sensor used to detect the presence of the wings malfunctioning.</p> <p>Security action: The drone continues normal flight.</p> <p>User action: Land as soon as possible and inspect the wing struts as described in section 'Preparing the eBee RTK for flight' on page 41.</p>

<p>Temperature out of working levels</p>	<p>The temperature sensor on the drone is registering internal temperatures of less than -50°C or more than 90°C. This may occur in extremely hot or cold environments or if the on-board autopilot is damaged.</p> <p>Security action: The drone flies towards the Home waypoint at an altitude defined by the Home waypoint's Change altitude parameter (by default, set to 'Highest').</p> <p>User action: Land as soon as possible. If the outside temperature is above 35°C or below -10°C, disconnect the battery and wait until the temperature changes to within these limits.</p>
<p>Above working area ceiling</p>	<p>The drone has passed the vertical boundary of the working area, defined by the working area ceiling. This may occur if waypoint altitudes are set close to or outside the working area or due to strong wind.</p> <p>Security action: The drone flies towards the Home waypoint at an altitude defined by the Home waypoint's Change altitude parameter (by default, set to 'Highest'). It also turns off its motor as long as it remains above the working area ceiling.</p> <p>User action: Limit the altitude of all waypoints to less than the working area ceiling.</p>

<p>Out of working area radius</p>	<p>The drone has passed the lateral boundary of the working area, defined by the working area radius. This may occur if waypoints are set close to or outside of the working area or due to strong wind.</p> <p>Security action: The drone flies towards the Home waypoint at an altitude defined by the Home waypoint's Change altitude parameter (by default, set to 'Highest').</p> <p>User action: Limit the planned flight path within the working area boundaries.</p>
<p>Far outside of working area</p>	<p>The drone has passed far outside of the working area. This may be caused by very high winds or due to mechanical failure.</p> <p>Security action: The drone tries to orient itself in the direction of the Home waypoint and begins descending immediately until it lands on the ground or returns within the working area.</p> <p>User action: Keep track of the location of the drone during landing. If the drone lands outside of view follow the instructions in section 'Losing and locating your <i>eBee RTK</i> in the field' on page 177.</p>

<p>Poor GPS/GLONASS coverage*</p>	<p>GPS/GLONASS signal coverage is low. This may be due to mountains or tall buildings blocking satellite signals. If coverage degrades any more a Critical failure will be activated and an emergency landing will be initiated⁵⁷.</p> <p>Security action (if enabled): The drone flies towards the Home waypoint at an altitude defined by the Home waypoint's Change altitude parameter (by default, set to 'Highest').</p> <p>User action: If this occurs once or twice, click 'ACK WARNING' and continue normal flight. If this warning appears more often, land as soon as possible and wait for better conditions for satellite signal reception. Alternatively, move away from objects that may disturb satellite signals such as mountains or cellular antennas.</p>
-----------------------------------	---

⁵⁷ see section 'Critical failures' on page 173

<p>Data uplink lost** (if enabled)</p>	<p>This warning occurs if the <i>eBee RTK</i> does not receive any data from <i>eMotion</i> for more than 30 s. This can be due to a large distance between drone and ground station, a problem with the USB ground modem, antenna positioning or interference. Having lost RTK corrections during this period, your drone will geotag images with less accurate, interpolated values until the connection returns.</p> <p>Security action (if enabled): The drone flies towards the Home waypoint at an altitude defined by the Home waypoint's Change altitude parameter (by default, set to Highest).</p> <p>User action: Try to improve radio signal quality by following the instructions in section 'Improving radio signal communication' on page 176.</p>
<p>Ground proximity detected** (if enabled)</p>	<p>The ground sensor on the drone has detected a ground height above the ground of less than 30 m during normal flight. Note: this feature should not be depended on for avoiding obstacles, as the ground sensor may fail to detect obstacles in certain environmental conditions⁵⁸.</p> <p>Security action (if enabled): The drone circles the current position while climbing to an altitude of 60 m above the detected ground height. Once this altitude is reached the drone continues towards the next waypoint but sets the waypoint's target altitude at 60 m above the last detected ground height.</p> <p>User action: Ensure that there are no obstacles such as hills or buildings higher than the waypoints of your flight plan.</p>

⁵⁸ see section 'Linear landing' on page 86

<p>Ground proximity not detected landing precision decreased**</p>	<p>The ground sensor on the <i>eBee RTK</i> was unable to detect the proximity of the ground during a Linear landing procedure. This may be due to an obstruction in the sensor, low ambient light or low contrast in the environment⁵⁹.</p> <p>Security action: The drone continues the Linear landing procedure but will initiate its final brake at an estimated altitude of 20 m instead of 3 m (assuming the Linear landing location is at the same altitude at the Take-off location), resulting in decreased precision in the landing location.</p> <p>User action: Be ready for the drone to overshoot its planning Linear landing location by preparing a larger obstacle-free zone around the location.</p>
<p>Back wind, landing precision decreased*** (in blue)</p>	<p>There are no approach sectors available against the direction of the wind. The <i>eBee RTK</i> has calculated a Linear landing approach direction in the direction of the wind.</p> <p>Security action: The <i>eBee RTK</i> continues normal flight.</p> <p>User action: Add a new approach sector against the direction of the wind, if possible, abort the landing and try landing again. If not, be ready for the <i>eBee RTK</i> to overshoot its planning Linear landing location by preparing a larger obstacle-free zone around the location.</p>

⁵⁹ see section 'Linear landing' on page 86

Strong wind*	<p>The wind is too strong for the <i>eBee RTK</i> to navigate safely.</p> <p>Security action (if enabled): The <i>eBee RTK</i> flies towards the Home waypoint at an altitude defined by the Home waypoint's Change altitude parameter (by default, set to 'Highest').</p> <p>User action: Land as soon as possible and wait for better flight conditions.</p>
Cannot maintain altitude	<p>The <i>eBee RTK</i> cannot maintain the altitude that is commanded by the flight controller. This may be due to a damaged motor, airframe or ailerons or a strong vertical wind.</p> <p>Security action: The drone continues normal flight.</p> <p>User action: If the condition persists during a flight, land and wait for the wind to decrease, as explained in section 'Weather check' on page 40. If the problem occurs in low-wing conditions perform Check 2 in section 'Full airframe and sensor inspection' on page 147.</p>

<p>Pitch or Roll instability</p>	<p>The orientation sensors on the <i>eBee RTK</i> detected unusually high pitch or roll values even after performing stabilization. This may be due to strong winds or damaged airframe.</p> <p>Security action: The drone continues normal flight while trying to stabilize the pitch as much as possible.</p> <p>User action: If the condition persists during a flight, land and wait for the wind to decrease, as explained in section 'Weather check' on page 40. If the problem occurs in low-wing conditions perform Check 2 in section 'Full airframe and sensor inspection' on page 147.</p>
----------------------------------	---

10.4 Critical failures

A critical failure is an error that occurs in flight that prevents the continuation of normal flight. This is the most serious type of error that can occur with the *eBee RTK*, and is indicated in red in *eMotion*. The 'WARNING' button in the Control Bar changes to 'CRITICAL FAILURE', becomes red and cannot be acknowledged. When a critical failure occurs flight is aborted and the drone initiates an Emergency action in which it is immediately directed to the ground. The Emergency action for each Critical failure is designed to minimize the airspeed and thus impact energy with the ground using the sensors that are still functioning.

Table 6 on the following page describes the critical failures that may occur and what action is taken by the drone. In some cases it may be possible to manually control the drone using the remote control⁶⁰. If such a critical failure occurs that results in an Emergency landing we recommend that you keep track of the drone's

⁶⁰ see section 'Manual control of the *eBee RTK*' on page 136

last known position in the air and in *eMotion* if possible and follow the instructions in section 'Losing and locating your *eBee RTK* in the field' on page 177.

Table 6: Critical failures

<i>eMotion</i> text	Description and Emergency action
<p>Failure: loss of GPS/GLONASS signals</p>	<p>Your <i>eBee RTK</i> can no longer calculate its position, making it impossible for it to know where it is and thus to navigate. Emergency action: The drone turns off its motor, sets a bank angle and glides in a large circle towards the ground. If there is a strong wind the drone may be pushed far from its current position. If satellite signals are re-acquired the drone will abort the landing procedure and go to the Home waypoint.</p>
<p>Failure: empty battery</p>	<p>The battery is completely empty. Emergency action: The drone turns off its motor and glides towards the ground in the direction of the Home waypoint. This error is always preceded by a Low battery In-flight warning.</p>
<p>Failure: INS malfunction</p>	<p>There is a failure with the orientation sensors which makes it impossible for the drone to stabilise itself and thus initiate a gliding emergency landing. Emergency action: The drone turns off its motor and fully deflects its ailerons which results in an uncontrolled descent with limited impact energy (deep stall or spin).</p>

<p>Failure: motor malfunction</p>	<p>The motor is not working even after an attempted re-start commanded by a Motor malfunction In-flight warning.</p> <p>Emergency action: The drone orients itself in the direction of the Home waypoint and glides towards the ground while continuously trying to re-start the motor. If motor re-start is successful the drone cancels the landing and flies towards the Home waypoint at an altitude defined by the Home waypoint's Change altitude parameter (by default, set to 'Highest').</p>
<p>Failure: CPU Overload</p>	<p>The autopilot processor is overloaded and can no longer control flight. The drone turns off its motor and fully deflects its ailerons which results in an uncontrolled descent with limited impact energy (deep stall or spin).</p>

10.5 Resetting default camera settings

In case of unwanted configuration changes, the camera can be re-configured to a suitable state. Please refer to your camera user manual in the download section of our website for the procedure.

10.6 Improving radio signal communication

You may occasionally lose the data connection between *eMotion* and your *eBee RTK* while in the field. Whether there is a loss in uplink or downlink communication, the drone will continue flying along its Flight Plan and should re-establish the connection as it flies closer to the base station or changes direction.

If the drone stops receiving messages from *eMotion* (uplink direction) for more than 30 s you will see a 'Data uplink lost' In-flight warning appear in *eMotion*. If for safety reasons you would like the *eBee RTK* to automatically return to the Home waypoint when this warning appears, select the corresponding option in the Flight Parameters tab⁶¹.

If there are no more messages received by *eMotion* from the drone (downlink direction), a 'Data downlink lost' message will appear in *eMotion*. If there is still an active uplink connection you may still command your drone to return to the Home waypoint using the Control Bar.

Data connection range can be effected by many external factors such as antenna height, terrain and obstacles or radio interference. We recommend the following tips to improve the range of your connection in the field:

1. Place the USB ground modem as high as possible (for example, on top of a car, ladder or nearby building). A height of at least 2 m is recommended.
2. Ensure that the USB ground modem's antenna is pointing straight up.
3. Disable any 2.4 GHz-based communication devices (or put them into 'Airplane mode') in the vicinity of the USB ground modem. This includes all

⁶¹ see section 'Flight Parameters tab' on page 132 for more details

Wifi and Bluetooth devices such as the ground station computer or mobile phones.

The strength of the connection between the drone and *eMotion* is indicated in the Flight Monitoring tab⁶². The three LEDs next to the antenna on the ground modem also indicate the strength of the connection. The connection is strongest when all three LEDs are a solid red, and weakest when a single LED is blinking.

10.7 Losing and locating your *eBee RTK* in the field

We recommend that you write your address and phone number on your *eBee RTK* (by putting your business card on top of the camera for example) in case it gets lost and subsequently found by a third party. In case you lose your drone in the field for whatever reason, whether from a loss of communications, a Critical failure or an accidental collision, use the following steps to try to recover it:

1. Do not disconnect the connection in *eMotion*! If it is simply out of communication range the drone should reconnect automatically as it returns to the Home waypoint after completing its mission.
2. Note the last known location of the drone in *eMotion* by printing the screen or writing down the location displayed in the Flight Monitoring tab.
3. Move towards this last known direction with the computer running *eMotion* in the hope of regaining a connection. Be sure to take the remote control with you as well.
4. If you have reached the last known location of your drone and have not yet found it, turn on the remote control.
5. Try moving both the control sticks around. If the drone is within range it may start making noise with its main motor or servo motors.
6. Try moving downwind from the last known location in case the drone was pushed by the wind while still in the air.

⁶² see section 'Flight Monitoring tab' on page 108

10.8 Reporting a problem with your *eBee RTK*

If there is a problem with your *eBee RTK*, whether it is a software malfunction, damaged airframe or any other problem, we recommend the following actions:

1. If there is an error message displayed in *eMotion*, begin by checking section 'Troubleshooting' on page 154 to see if there is a solution to the particular message.
2. Check the on-line Questions & Answers section on senseFly Ltd's website⁶³ to see if there is a solution to your problem.
3. If you have still not found a solution, contact your *eBee RTK* reseller. Please include the following information with your inquiry:
 - The serial number of your drone, in the format EB-XX-XXX. You can find this number inside the battery enclosure.
 - A short description of the problem.
 - The Drone Flight Log file of the flight that had a problem⁶⁴.
 - The *eMotion* Flight Log file of the flight that had a problem. You can find this file in the `eMotion/logs/` directory which is created in My Documents on Windows.
 - Photos or video of the *eBee RTK* airframe, if required.



Note: In order to provide support, senseFly Ltd may request the flight log files for inspection.

⁶³ technical support can be found at <http://www.sensefly.com/support/>

⁶⁴ see section 'Importing images and flight data' on page 62 for information on retrieving this file from the *eBee RTK*

Part IV

Specifications

1 Software requirements

eMotion has the following minimum software requirements:

<i>Operating system</i>	Windows XP / Vista / 7 / 8
<i>Hardware</i>	1.6 GHz processor 2 GB RAM 500 MB free storage space
<i>Screen</i>	recommended resolution: 1920×1080 visible outdoors

Postflight Terra 3D has the following minimum software requirements:

<i>Operating system</i>	Windows XP / Vista / 7 / 8, 64-bit only
<i>Hardware</i>	1.6 GHz processor (2 GHz Intel i5/i7/Xeon recommended) 4 GB RAM (16 GB recommended for large projects) 10 GB free storage space (1 TB recommended for large projects)
<i>Screen</i>	min. resolution: 1024×768

2 Drone specifications

	<i>Size</i>	Wingspan: 96 cm Wing area: 0.25 m ²
<i>Weight without camera and battery</i>		approx. 0.46 kg
<i>Nominal take-off weight (approx.)</i>		0.73 kg (1.61 lbs) (with standard camera & battery)
	<i>Material</i>	EPP foam, carbon structure & composite parts
	<i>Battery</i>	3-cell Lithium-Polymer (0.14 kg)
<i>Nominal endurance (flight time)⁶⁵</i>		40 minutes (with standard camera)
	<i>Camera</i>	IXUS/ELPH 16 MP still camera
	<i>Propulsion</i>	Electric brushless motor Nominal static thrust: 0.63 kgf (6.2 N)
<i>Nominal cruise speed</i>		40-90 km/h (11-25 m/s or 25-56 mph)
	<i>Wind resistance</i>	up to 45 km/h (12 m/s)
<i>Max. single flight coverage⁶⁶</i>		8 km ² (3 mi ²) (on a single battery charge)

⁶⁵ can vary greatly depending on external factors such as wind, altitude change and temperature.

⁶⁶ calculated based on the following test conditions: GSD of 30 cm (11.8 in) per pixel, no wind, moderate air temp. (18 C/64.4 F), new fully-charged battery, flight altitude of 1,000 m (3,280 ft) above ground & take off at approx. sea level from centre of coverage area.

Specifications

<i>Communication devices</i>	Ground modem: <ul style="list-style-type: none">● Frequency: 2.4 GHz● Range⁶⁷: approx. 3 kmUp to 3 km (1.9 miles)● Certification: FCC Part 15.247, IC RSS210, CE Remote control: <ul style="list-style-type: none">● Frequency: 2.4 GHz● Range: approx. 1 km● Certification: CE, FCC
<i>Navigation</i>	Up to 50 waypoints
<i>GSD (per pixel)</i>	Down to 5 cm (2.0 in)
<i>Absolute horizontal accuracy</i>	Down to 3 cm (1.2 in) (no GCPs required)
<i>Absolute vertical accuracy</i>	Down to 5 cm (2.0 in) (no GCPs required)
<i>Relative orthomosaic/ 3D model accuracy</i>	1-3 times GSD
<i>Carry case dimensions</i>	55 x 45 x 25 cm (21.6 x 17.7 x 9.8 in)

⁶⁷ can vary greatly depending on external factors such as cruise altitude, presence of obstacles and radio-frequency interference.

3 Onboard GNSS/RTK receiver

<i>Number of channels</i>	226
<i>Signal tracked</i>	GPS: L1, L2 GLONASS: L1, L2
<i>Onboard RTK correction</i>	20 Hz
<i>Upstream correction</i>	1 Hz
<i>RTK data transmission protocols</i>	RTCM-3.x, RTCM-2.x
<i>Geotag accuracy (typical)</i>	Standalone: H: 1.2 m (3.9 ft), V: 1.8 m (5.9 ft) RTK: H:15 mm, V: 20 mm (relative to base station)
<i>Acquisition time</i>	Hot start: <10 s Warm start: <35 s Cold start: <60 s Reacquisition: <1 s

Glossary

AMSL Above Mean Sea Level

Your *eBee RTK*'s altitude can be shown and set in *eMotion* using ATO or AMSL. Your drone uses the EGM96 mean sea level standard for navigation.

ATO Above the Take-off Altitude

Your *eBee RTK*'s altitude can be shown and set in *eMotion* using ATO or AMSL. Altitudes in ATO are relative to the place your *eBee RTK* started its motor just before take-off.

DSM Digital Surface Model

A 3D digital representation of a surface.

FTDI Future Technology Devices International

A Scottish semiconductor device company specialising in Universal Serial Bus (USB) technology. FTDI cables allow serial connections through a USB cable. *eMotion* uses FTDI technology to connect to the ground modem. You can often connect a computer to a GNSS base station using FTDI.

GCP Ground Control Point

A location or object on the ground that has precisely known coordinates. GCPs are used to improve the precision of DSMs created from photogrammetric analysis of a series of images.

geo-reference A data point associated with a specific location on the earth's surface.

GNSS Global Navigation Satellite System

A network of satellites that transmit signals that GNSS receivers can use to calculate their position on the Earth. GPS (Global Positioning System) and GLONASS are examples of GNSS systems.

GSD Ground Sampling Distance

The distance measured on the ground between pixel centres in an image

or DSM. The smaller the GSD, the higher the spatial resolution of the image. For example, a GSD of 5 cm means that one pixel in the image represents 5 cm on the ground.

mosaic A single map or terrain model created from several map sections that have been placed side-by-side and merged together.

MSL Mean Sea Level
the average level of the surface of the Earth's oceans; a close approximation of the surface in gravitational equilibrium.

Ntrip Network Transport of RTCM data over IP
A protocol used to transport RTK correction data over the Internet. RTK receivers feed RTK corrections to Ntrip servers or casters. These then encapsulate the data inside TCP packets and stream it across the Internet.

orthomosaic A single, corrected image constructed either from several images taken from different angles, or from several orthophotos. Distortions due to different camera positions, ground curvature and relief are corrected for so that the image displays accurately in the given map projection.

photogrammetry A technique in which measurements taken from photographs are used to reconstruct a 3D surface or a series of points in space.

point cloud A set of data points within a coordinate system.

rayCloud A feature unique to *Postflight Terra 3D* that combines the 3D point cloud with the original images. Multi ray matching with the rayCloud extends the stereo view triangulation and increases the accuracy of 3D point estimates while providing a full understanding of 3D results.

RINEX Receiver Independent Exchange Format
A data format used for storing and exchanging satellite navigation system data.

Specifications

RPAS Remotely Piloted Aircraft System

A term used for drones or UAVs, the software and technology they use to navigate.

RTCM Radio Technical Commission for Maritime Services

An international organisation that standardises transmission protocols that allow for RTK positioning, for example, RTCM 2.x and RTCM 3.x. They also publish the Ntrip standard.

RTK Real Time Kinematics

A technique used to enhance the accuracy of coordinates calculated from GNSS signals.

triangle model An approximate representation of a surface, constructed from connected triangles.

UAS Unmanned Aircraft System

A term used for drones or RPASs, the software and technology they use to navigate.

UAV Unmanned Aerial Vehicle

Another term for drone.

VRS Virtual Reference Station

A reference station that does not exist on the ground, but instead is created by combining correction data (delivered over Ntrip) from several real reference stations. VRS RTK corrections relative to this virtual reference station can then be made as if it were a real reference station.