User Manual

swinglet CAM

Revision 2.2 / November 21, 2011

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Contents

1 Package contents

The *swinglet* package contains the following items:

1. one carry case with protecting foam;
2. one *swinglet* with built-in autopilot;
3. two propellers;
4. four propeller attachment rubber bands;
5. two Lithium-Polymer battery packs for *swinglet*;
6. one Lithium-Polymer battery charger and balancer;
7. one remote control including battery pack;
8. one charger for the remote control (including cables);
9. one USB ground station radio module, including a USB cable;
10. one still camera, including memory card, battery and charger;
11. (optional) one laptop including charger and installation CD;
12. printed documentation.

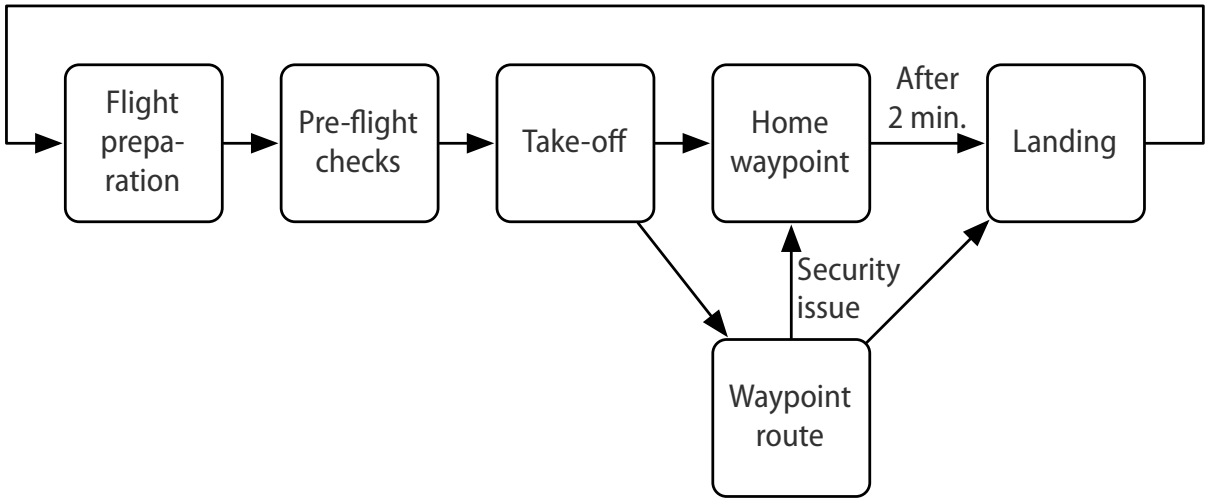
Please verify upon delivery that your package is complete. In case of a missing item, contact senseFly LLC immediately.

Note: This manual refers to the version 1.1.2 of the *swinglet* software. Check the software version included in your package and consult the Release Notes for potential changes included in more recent versions of the software.

2 Operation scenarios

Goal of this section: This section provides a brief overview of how the *swinglet* can be operated.

2.1 Overview



In preparation for each flight, all the batteries should be fully charged and the *swinglet* prepared for flight. This is described in section 'Preparing for flight' on page 9.

A flight always begins with pre-flight checks. It is of utmost importance to cautiously perform pre-flight checks to ensure flight safety. Also, the user must make sure that the environment is sufficiently clear from obstacles for the *swinglet* to be operated. This procedure is described in section 'Executing a photo flight' on page 11.

After take-off, the *swinglet* will, by default, join and circle around the home waypoint, which is automatically set above the position where the *swinglet* is switched into take-off mode. Without further user action, the *swinglet* will land after a predefined holding period (by default 2 minutes) by spiraling around the home waypoint down to the ground.

Alternatively, the *swinglet* can be programmed to follow a specific waypoint route after take-off and to take photos at predefined locations or in a continuous or systematic manner. This can be achieved by programming the *swinglet* using the provided ground station software called *e-mo-tion* (Electronic MOnitoring staTION). This procedure is described in section 'Programming and monitoring the *swinglet* ' on page 19. Automatic flight planning to systematically cover a predefined area is described in section 'Using the automatic flight planning' on page 38.

At anytime, if a security issue arises such as low battery level, strong wind or reaching of the working area boundary, the *swinglet* will try to fly back to the home waypoint at a default height of 75 metres and land after the holding period (unless further action is taken by the user using *e-mo-tion*).

Using a switch on the provided remote control, the user can engage the manual mode. In this mode,

the *swinglet* is directly controlled by the remote control's sticks. Note that this should be done only by experienced RC aircraft pilots. Be aware that the *swinglet* is not a very easy-to-fly aircraft in manual operation because it is lightweight and very dynamic. Switching from automatic mode to manual mode and back can be done at anytime during the flight if the *swinglet* is within range of of the remote control. Switching from manual to automatic should only be done when the *swinglet* is flying straight and level at relatively low speed. See section 'Using the remote control' on page 47 for more infomation.

Caution: The *swinglet* is a small airplane that is not made to fly in rain or strong wind conditions (more than 25 km/h or 7 m/s).

Caution: Any obstacles (such as trees, electrical wires or buildings) within 40 metres of the take-off location may result in a crash during take-off or landing. The *swinglet* must therefore be used only in areas with sufficient clearance.

Caution: In case of a problem occurring during flight, the *swinglet* will fly towards the home waypoint at a height of 75 metres. Therefore, the presence of any taller objects in the working area (hills, buildings, etc.) increases the risk of crash if the safety procedure is triggered by the autopilot.

2.2 Scenario 1: Simple demo flight without ground station

Without any programming, the *swinglet* will, by default, climb to 75 metres above ground after take-off, circling around the home waypoint and landing after the holding period of 2 minutes. During the flight, the *swinglet* will automatically take photos at regular intervals if no computer is connected to it.

Required reading:

1. Parts of section 'Preparing for flight' on page 9
2. Parts of section 'Executing a photo flight' on page 11

2.3 Scenario 2: Preprogrammed photo flight

For photo flights, a waypoint route including photo locations or photo sequences must be programmed into the *swinglet* autopilot. In this scenario, the waypoint route is carefully prepared using the *e-mo-tion* software and saved into the memory of the autopilot. Before take-off – or after take-off when the *swinglet* is on the home waypoint – the *swinglet* can be instructed to start following the route. It will take photos at the programmed locations. If the route includes a landing waypoint, the *swinglet* will execute it. Otherwise, it will follow the route until the battery is low and then will try fly back to the home waypoint for landing.

Caution: It is the sole responsibility of the operator to ensure that the battery level is sufficient for the *swinglet* to be able to fly back to the home waypoint. As a rule of thumb, a mostly level flight with a fully-charged battery should not exceed 25 minutes at an average ground speed of 7 to 10 m/s. High winds or frequent altitude changes will decrease the endurance of the *swinglet*.

In this scenario, the *swinglet* can be monitored using *e-mo-tion*, but will continue to perform its flight even in case of temporary loss of communication (e.g. caused by flying beyond specified range or the presence of radio-frequency interferences).

Required reading:

1. Section 'Preparing for flight' on the next page
2. Section 'Executing a photo flight' on page 11
3. Section 'Programming and monitoring the *swinglet* ' on page 19

2.4 Scenario 3: Interactive photo flight

Caution: Certain actions performed through *e-mo-tion* when the *swinglet* is airborne may lead to unsafe or catastrophic situations. For example, configuring an inadequately low altitude for a waypoint may lead to a crash of the *swinglet*. Therefore, only expert users with a thorough understanding of the system should use the *swinglet* in this way.

It is possible to activate, deactivate and modify waypoints and photo locations while the *swinglet* is in flight using *e-mo-tion*. This allows the user to dynamically re-route the *swinglet* to perform on-demand actions. In this scenario, the *swinglet* flies autonomously but the user constantly monitors the *swinglet* and reprograms waypoints or photo locations as necessary.

Using the *swinglet* according to this scenario requires it to be kept within the communication range of the radio modem (see section '*swinglet* technical specifications' on page 50). A loss of communication might lead to unsafe situations depending on the user's actions.

Required reading:

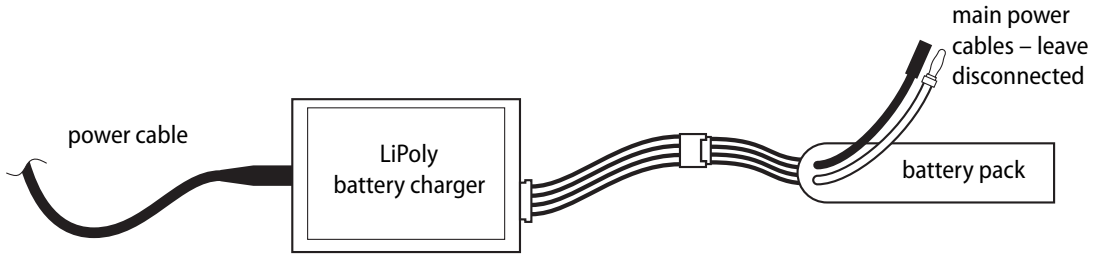
1. Section 'Preparing for flight' on the next page
2. Section 'Executing a photo flight' on page 11
3. Section 'Programming and monitoring the *swinglet* ' on page 19

3 Preparing for flight

Goal of this section: Good preparation is important for a successful photo flight. This section reviews the steps needed to prepare the *swinglet* for flight. The preparation can be done in advance and should preferably be carried out in a place with Internet access and electrical power.

3.1 Charging the swinglet battery packs

When delivered, the battery may not be fully charged. We recommend that you fully charge them before each flight.



To charge a *swinglet* battery pack, connect it to the battery charger as illustrated above. Depending on the charger type, the power cable is either part of a wall adapter power supply or a simple power cable. Make sure that the main power cables are left unconnected. LEDs will indicate the status of the charge. The charger provided with the *swinglet* individually balances the voltage of each of the 3 cells contained in the battery pack. This ensures optimal performance and battery life. Charging can last up to 3 hours, depending on the charge level of the battery and the required cell balancing work. For further information on the charger, refer to the notes written on the charger itself.

Note: The battery packs provided with the *swinglet* are of the following type: LiPoly 1350 mAh 3 cells in series. While alternative chargers may be used to recharge these battery packs, senseFly LLC cannot be held responsible for any consequences. 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.

Caution: If a LiPoly battery is discharged below 3 volts per cell, that is 9 volts for the *swinglet* battery pack, the battery may be irreversibly damaged and it may become dangerous to charge. Therefore, make sure to disconnect the *swinglet*'s battery before it reaches this voltage, which can be monitored in the *e-mo-tion* cockpit (see section 'Monitoring and controlling the *swinglet* status using the cockpit' on page 27.

Note: LiPoly batteries do not exhibit any memory effect. We recommend that you always fully charge them after use even when they are only partially discharged.

3.2 Charging the camera battery

We recommend that you always fully charge the camera battery before flight in order to be sure not to miss photos due to low battery level. Note that, when delivered, the camera battery may not be fully charged.

To charge the camera battery, take it off the camera and insert it into its charger. Plug the charger into a power outlet. The charge LED will light red when charging commences. Once the battery is fully charged, the LED will turn to green. Charging takes approximately 1 hour and 30 minutes.

Note: More information concerning the camera charger can be found in the camera manual on the original Canon CD or the support section of our website.

3.3 Charging the ground station (laptop)

In most cases, a laptop will be used to program and monitor the *swinglet* during the mission. For maximum security, make sure that the laptop batteries are charged before each flight.

3.4 Pre-plan the flight

It is recommended to make a brief pre-planning of the flight at a place with internet connection, in order to have access to online maps.

1. Switch the *swinglet* on by connecting the battery (see section 'Start-up' on page 14).
2. Make sure the ground station computer is connected to the Internet.
3. Start *e-mo-tion* and connect to the *swinglet* (see section 'Connecting to the *swinglet* ' on page 20).
4. Move the map to the area where you plan to fly (see section 'Understanding the map window' on page 22). Note that if the flight area is close-by and the *swinglet* has acquired its GPS localisation, you can use the 'Center on robot' command in the 'Map' menu.
5. Place the waypoints as required and save the list of waypoints to the *swinglet* using the 'Save to autopilot' button in the Waypoint Editor (see section 'Using the waypoint editor' on page 25). Optionally, you may save the list to your local hard-disk by using the 'Export...' button.
6. Quit *e-mo-tion* and disconnect the *swinglet* battery.

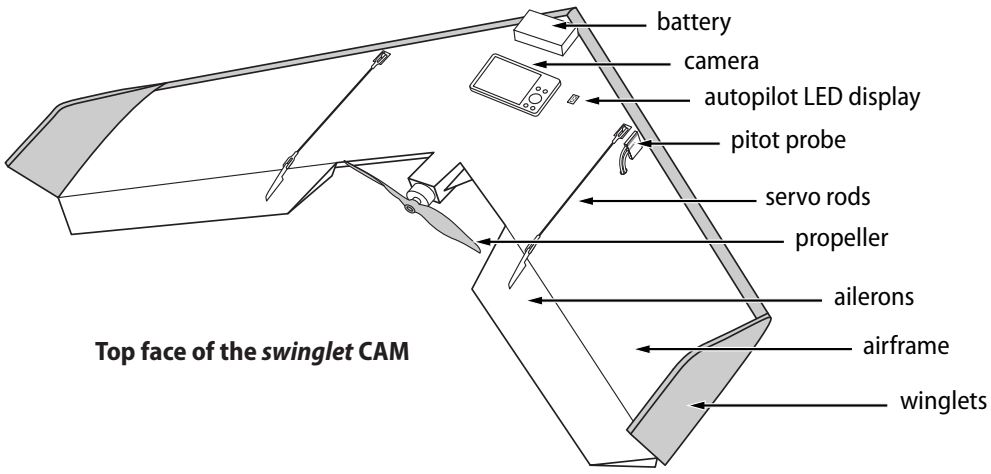
4 Executing a photo flight

Goal of this section:	The section describes the steps that must be performed at the launching site in order to initiate a flight.

This section describes the procedure to operate the *swinglet* during flight. Before initiating a flight, the *swinglet* must be ready for flight - see the previous section for instructions.

By default, the *swinglet* is programmed to fly at a height of 75 metres in cirlces with a radius of 20 metres around the take-off location (see section 'Programming and monitoring the *swinglet* ' on page 19 to change this behaviour). After the holding period of 2 minutes, the *swinglet* will perform a landing within an area with a radius of 20 metres around the take-off location. **Important**: for a safe landing, there should be no obstacles within 40 metres of the take-off location. The zero altitude reference is taken during the startup procedure as soon as the *swinglet* acquires its first GPS fix.

Caution:	Any obstacles (such as trees or buildings) within 40 metres of the take-off location may result in a crash during take-off or landing. Take-off and landing must occur only in areas with sufficient clearance.



Top face of the *swinglet* CAM

4.1 Weather check

Before each flight, you should be aware of the weather conditions. The *swinglet* is a small airplane that cannot fly in 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. Therefore the wind perceived at the surface is not a good reference to estimate the wind at 75 metres height. Cloud velocity, or tall tree movements can help you to estimate the wind speed once you are out in the field.

Caution: The *swinglet* should not be launched if the wind speed exceeds 25 km/h or 7 m/s.

Note: While flying, if the *swinglet* detects that the wind is dangerously strong (over 25 km/h or 7 m/s), it will emit a warning and automatically try to return to its home waypoint at a height of 75 metres. Once the home waypoint is reached, it will initiate landing after 2 minutes of loitering above home location, unless another action is initiated via *e-mo-tion*.

Note: Best photo quality is obtained in low wind conditions (less than 3-4 m/s) and on sunny or bright days.

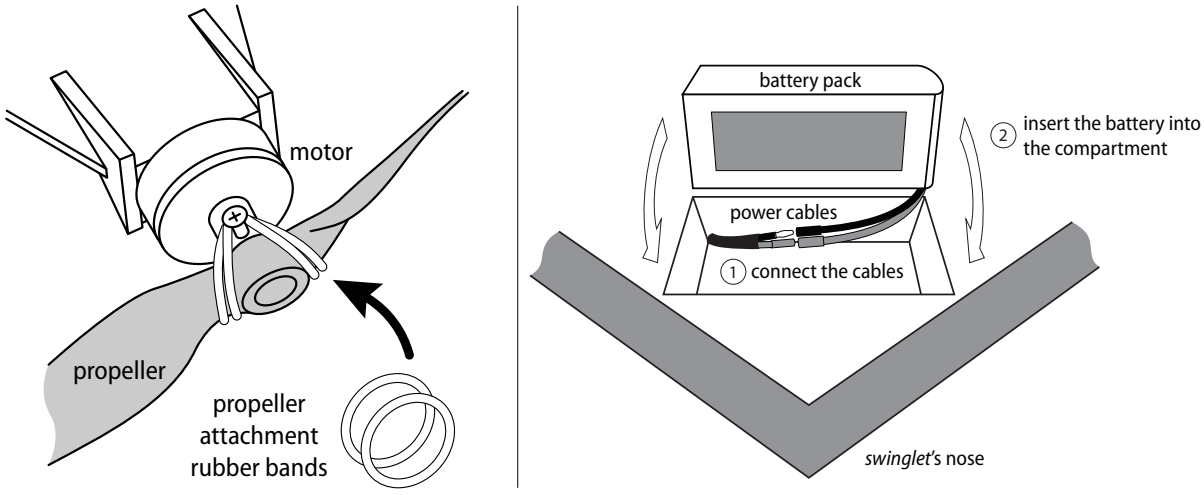
4.2 Terrain check

Select a take-off location that has no obstacles (buildings, rocks, power lines, trees, etc.) within a radius of 40 metres around the take-off position. In case a go home procedure is triggered during flight (either automatically due to a warning or manually using *e-mo-tion*) the *swinglet* will do it at a height of 75 metres. Therefore, the presence of any objects taller than 65 metres in the working area (hills, buildings, trees, etc.) increases the risk of crash.

Note: In case of strong-wind conditions, the *swinglet* may drift even further than 40 metres away from the take-off location when trying to land around the home waypoint. Therefore, it may be wise to plan for even more clearance in the downwind direction.

4.3 Preparing the *swinglet*

The *swinglet* comes ready for flight. The only preparation required before use is the installation of the propeller and of the battery pack.



To install the propeller on the *swinglet*, follow these steps:

1. Insert the propeller on the motor axis. **Important:** the metal ring of the propeller should be on the motor side.
2. Secure the propeller using two attachment rubber bands as illustrated above (left).

After extensive use, the rubber bands may develop cracks. This is normal and is caused by to the aging of the rubber material. For maximum security, inspect the rubber bands regularly and discard them if they show cracks.

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

Note: For storage, it is best to remove the propeller from the *swinglet*. Long-duration strain on the rubber bands may accelerate the aging process.

To install the battery, first make sure that none of the power cables of the *swinglet* are damaged by slightly pulling the connectors while firmly holding the cables. Then, connect the battery pack and insert it into the compartment, as shown by the arrow in the illustration above. Make sure that the battery is well attached to the *swinglet* by applying vertical pressure.

Important: Only connect the battery cables to the *swinglet* when you are ready for start-up. Do not leave the battery connected for extended periods of time when the *swinglet* is on the ground, as this may discharge the batteries below the absolute minimum of 9 volts (beyond this value, the battery pack will be irreparably damaged). When connected and not in flight, the *swinglet* will briefly move its ailerons up and down every minute as a reminder that it is switched on.

4.4 Preflight-check

Before connecting the battery, the *swinglet* must be checked for potential damages as follows.

1. **Airframe**
   Check the foam airframe for cracks or other damage. Verify that the winglets are solidly attached to the airframe.
2. **Propeller**
   Verify that the propeller is attached with two rubber bands. Ensure that the rubber bands do not show cracks or other ageing signs.
3. **Servo rods**
   Verify that the linkage between the servos and the control surfaces are not damaged and firmly attached at both ends.
4. **Pitot probe**
   Verify that the pitot probe is properly attached to the airframe and the two rubber tubes are well in place.
5. **Camera**
   Make sure that the memory card and a fully-charged battery are in the camera before inserting it into the *swinglet* and securing it with the attachment strap.

6. **Battery**
   Verify that a fully-charged *swinglet* battery is in place (see previous section).

Caution: Note that *swinglet* CAM has not been designed to fly without the camera. Attempting to fly without the camera may render the *swinglet* unstable, which may eventually lead to a crash.

Note: For best image quality, make sure that the camera is configured according to Section 'Camera settings' on page 46.

4.5 Start-up

Once the airframe is checked, the *swinglet* can be switched on using the following procedure.

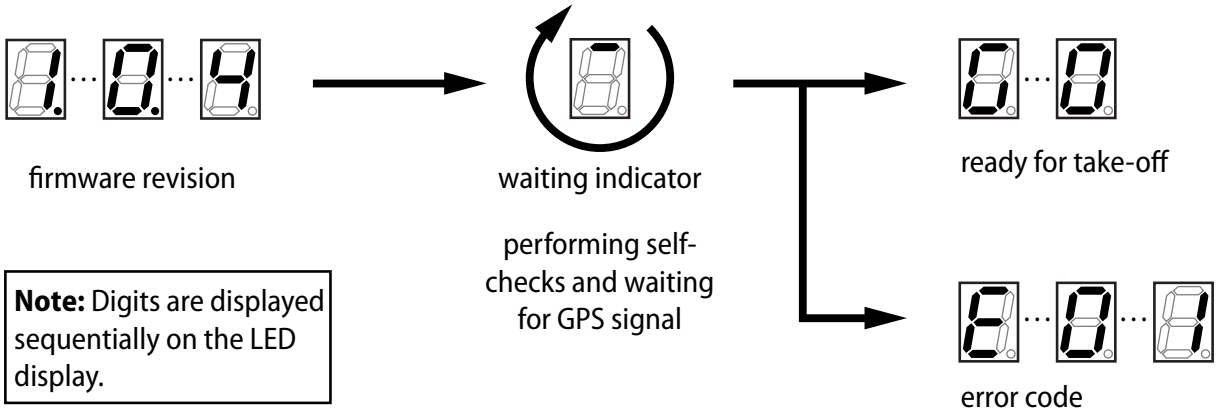
1. Lay the *swinglet* horizontally on the ground in the vicinity of the take-off position, with the top face up. It is important that the *swinglet* is not inclined more than 10 degrees in order to start up properly.
2. Connect the battery to the *swinglet*. **Caution:** Make sure that the colours of the cables match and insert the connectors firmly to the end in order to avoid undesired disconnection when in flight. Take care to keep the propeller area clear, in case it suddenly starts spinning.
3. Wait for the aileron motion and for the 'GO' indication on the autopilot LED display while the *swinglet* performs self-checks and acquires GPS signal. This may last from a few seconds to several minutes in the case of poor GPS signal reception. **Note:** The zero altitude reference is recorded when the GPS fix occurs the first time after startup.
4. Make sure the camera is properly connected. To verify this connection, you can shake the *swinglet* three time up and down (in approx. 3 seconds) while holding it horizontally. The camera should then turn on and the optics should extend below the *swinglet*. Repeat the same movement to switch-off the camera. **Caution:** Always make sure that the optics is retracted (camera switched off) before putting down the *swinglet*. Otherwise, the optics will come into direct contact with the surface, potentially causing irreversible damage.
5. If you plan to use the remote control, switch it to 'Manual'. Move the aileron stick on the remote control to verify proper reception by the *swinglet* and correct servo direction. **Caution:** Always check that the thrust lever is in the low position to prevent the propeller from spinning.

Note: If the remote control is switched on and in manual mode, the ailerons will not move when the self-checks are completed and the GPS fix is acquired.

Once the battery is connected to the *swinglet*, the LED display will show the following information:

1. the firmware revision;

2. a waiting indicator (rotating segment);
3. the 'GO' indication (upon successful completion of the self-checks) or a start-up error code (if a problem has been detected).



Note: Digits are displayed sequentially on the LED display.

Table 1 on the next page summarises the possible start-up error codes.

Note: Other error codes may be displayed after the start-up procedure. See table 4 on page 29 and table 5 on page 30 for more information.

4.6 Establishing communication

Start the software *e-mo-tion* on the laptop and connect to the *swinglet* (see section 'Connecting to the *swinglet* ' on page 20 for more info). The status message should show 'Idle (ready to take-off)' and the map should display the flight plan. Check the flight plan and modify as necessary (see section 'Programming and monitoring the *swinglet* ' on page 19).

4.7 Take-off and flight

Caution: Make sure to keep the propeller area free and firmly hold the *swinglet* with two hands in the 'holding area' as shown in figure below.

Once the *swinglet* shows the 'GO' indicator, it is ready for take-off using the following procedure:

1. Gently shake the *swinglet* back and forth 3 times longitudinally (within approx. 3 seconds). This will switch the motor to full power. **Note:** Once this is done, do not hurry to launch it into the air. If case you want to return to idle mode, just repeat the back and forth three times movement and the motor will stop.
2. Orient the *swinglet* against the wind, with approximately 30 degrees nose up and level wings. Make sure that the take-off direction is free of obstacles (see Section 'Terrain check' on page 12).

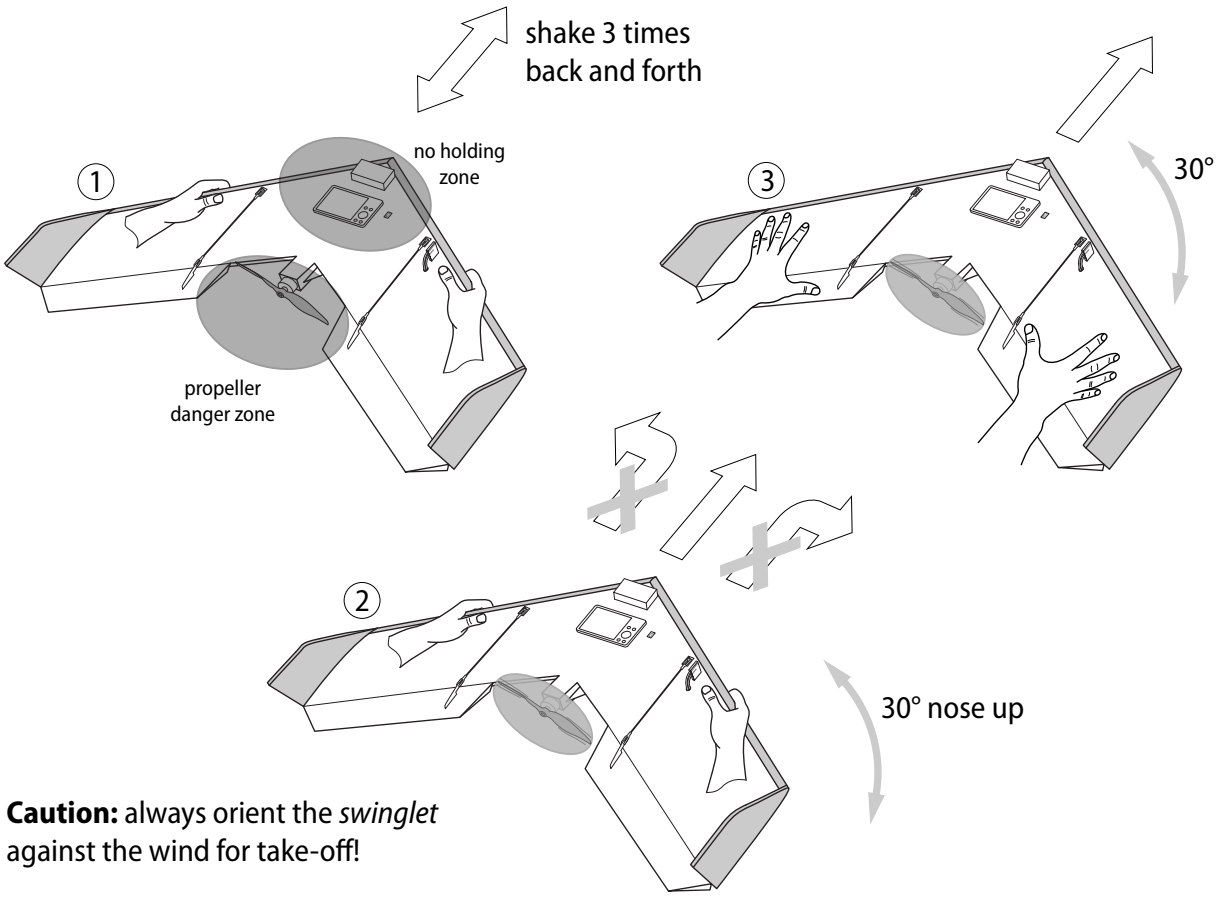
Table 1: List of start-up error codes

Label	Error code	Action
Memory write error	E01	Disconnect and reconnect the battery. Contact senseFly LLC if this error occurs repeatedly.
Memory read error	E02	
Memory data error	E03	
Battery low	E04	Recharge the battery or use another battery.
Attitude sensing error	E05	Make sure the *swinglet* is placed horizontally on the ground with the top facing up, disconnect and reconnect the battery. If this error occurs repeatedly, contact senseFly LLC.
Airspeed error	E06	Verify that the pitot probe and the rubber tubes are well in place. Disconnect and reconnect the battery and make sure that the *swinglet* is not exposed to significant wind until start-up is completed.
Barometer error	E07	
Navigation error	E08	Contact senseFly LLC if this error occurs repeatedly.
Unknown error	E99	

3. Release the *swinglet* by gently accompanying it with the two hands symmetrically placed on either side in a purely forward motion, as illustrated below. **Note:** If the wind is calm, it is best to increase the initial launch speed. This can be achieved by walking 1-2 steps forward before releasing it.

It is unsafe to take off if the battery voltage is below 11 volts. In this case, the *swinglet* will not start its motor and will display a LOW BAT error. If this happens, the battery should be changed before commencing the start-up procedure. If any other warning has happened before take-off (such as LOSS OF FIX) and has not been acknowledged using *e-mo-tion*, the the motor will not start. See section 'Monitoring and controlling the *swinglet* status using the cockpit' on page 27 for more information.

Caution: The *swinglet* must be launched against the wind for it to be able to take off. Launching the *swinglet* along the wind or with cross-wind may result in a crash.



Caution: always orient the *swinglet* against the wind for take-off!

Note: The home waypoint position is updated to the take-off location each time the swinglet is switched into take-off mode. However, the zero altitude reference is defined at startup when the GPS fix occurs and will remain the same until the *swinglet* is switched off. See section 'Setting the *swinglet*'s parameters' on page 33 for information about resetting the zero altitude reference.

Caution: The procedure to initiate take-off by shaking the *swinglet* forces the autopilot to enter into flight mode. If the remote control is used for a manual take-off without following the take-off procedure, the *swinglet* will not enter into flight mode and will crash when switched to autonomous mode or if the RC link is lost.

After take-off, the *swinglet* maintains its initial direction with full thrust until reaching a height of 30 metres (see section 'Setting the *swinglet*'s parameters' on page 33 to change this parameter). At this point, it will switch into waypoint navigation mode. See section 'Programming and monitoring the *swinglet* ' on page 19 for further information about programming a flight plan including photo sequences or photo locations.

Note: The *swinglet* automatically calibrates its air speed sensor in flight to compensate for any drift due to temperature variations. To ensure an optimum performance of this calibration, the *swinglet* should execute at least two complete orbits on a waypoint at the beginning of every flight.

4.8 Landing

When landing is initiated (manually or automatically after 2 minutes of loitering around the home waypoint), the *swinglet* will switch off its motor and glide down to the ground by circling around the home waypoint. After touch-down, the *swinglet* will automatically switch back to idle mode after a few seconds of inactivity.

4.9 Processing flight data

Once the *swinglet* has landed, the images taken during the flight can be downloaded to a computer. To download the images, connect the camera to a computer using the provided USB cable. For more information, check the camera user manual on the original Canon CD or the support section of our website.

You can export KML and GPX files based on the telemetry data logged during the flight by using *PostFlight Suite* provided by senseFly LLC. KML files can be opened in Google Earth and contain a 3D rendition of the flight trajectory. GPX files also contain the trajectory data and are compatible with most software capable of dealing with GPS-acquired geographic data.

Using *PostFlight Suite*, you can also geotag the images acquired during the flight. The process of geotagging images consists of writing the GPS coordinates of the position at which the image has been taken into the image file. *PostFlight Suite* also allows supports uploading images to senseFly LLC's online image processing service *PostFlight Services*[1], which produces georeferenced orthoimages and DEMs. Alternatively, several other programs and web services can use geotagged images to position images on a map or to create georeferenced mosaics.

[1] `http://www.sensefly.com/support/postflight-services`

5 Programming and monitoring the *swinglet*

Goal of this section: For most flights, the *swinglet* must be programmed and monitored using the ground station software. This section describes the use of *e-motion*, the ground station software provided with the *swinglet*.

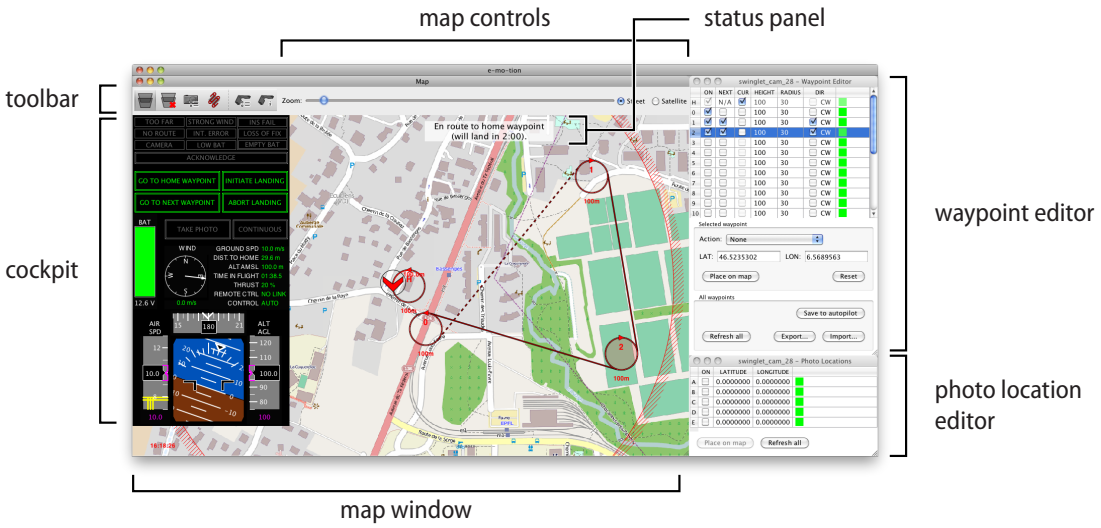
5.1 About *e-mo-tion*

e-mo-tion (Electronic MOnitoring staTION) is the user interface of the *swinglet*. Its main functions are to:

- monitor and control the status of the *swinglet*;
- program the flight plan and photo locations;
- display the position of the *swinglet* and navigation information;
- modify the flight plan during the flight;
- display status and error messages.

See section 'Installing *e-mo-tion* and the radio module drivers' on page 44 for information on the installation of *e-mo-tion* and the drivers for the USB ground station radio module.

Note: For convenience, we cover everything related to flight programming and monitoring in this section. For information on using the camera and acquiring photos, see section 'Taking pictures with the *swinglet* CAM' on page 36.



The main screen of *e-mo-tion* is split into three windows:

- the map window (see section 'Understanding the map window' on page 22);
- the waypoint editor (see section 'Using the waypoint editor' on page 25);
- the photo location editor (see section 'Using the photo location editor' on page 37);

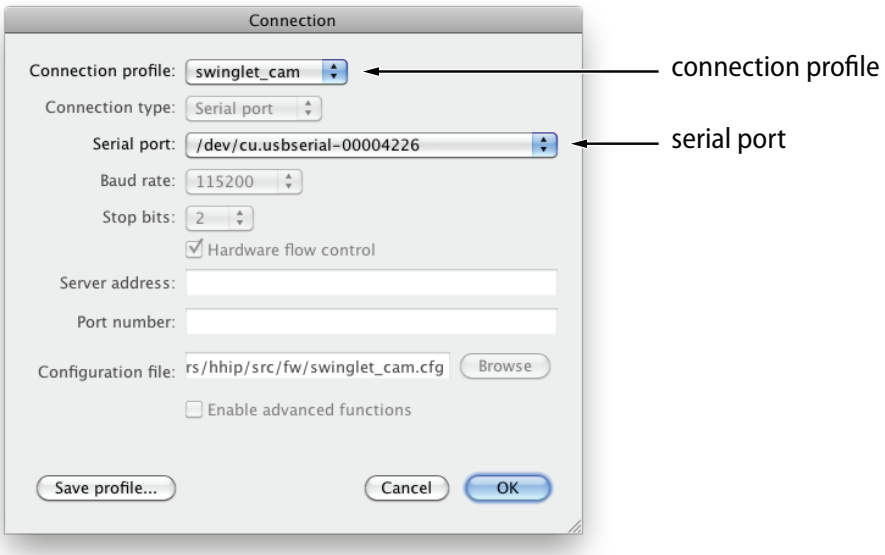
The map window contains the following items:

- the cockpit (see section 'Monitoring and controlling the *swinglet* status using the cockpit' on page 27);
- the toolbar, which provides access to several functions and dialogue boxes;
- the status panel, which indicates the current action being taken by the *swinglet*.

To access the main screen, *e-mo-tion* must first be connected to the *swinglet*.

5.2 Connecting to the *swinglet*

Before connecting to the *swinglet*, the USB radio module must be properly connected to the computer. *e-mo-tion* can then be started and will display the connection dialogue box.



To connect to the *swinglet*, use the 'swinglet_cam' connection profile to automatically configure the connection options. The only option that must be manually set is the serial port. On Mac OS X, the name of the serial port corresponding to the USB ground station radio module starts with 'cu.usbserial'. On Windows, the COM port corresponding to the USB ground station is labelled with 'Digi PKG-U Serial Port Adapter' (or 'MaxStream PKG-U Serial Port Adapter').

Note: On Windows, the operating system will configure the drivers the first time the USB ground station radio module is connected. It may be necessary to disconnect and reconnect the radio module for it to function properly after this initial configuration phase.

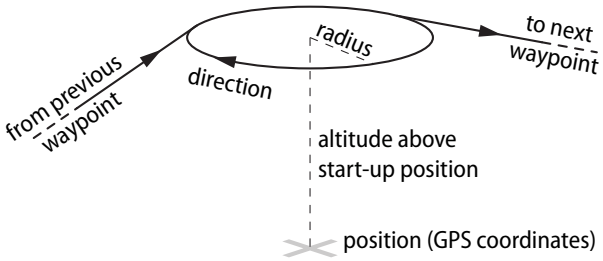
After acknowledging the connection option by clicking the 'OK' button, *e-mo-tion* will connect to the *swinglet* and display its status.

Caution: Connecting to the *swinglet* through *e-mo-tion* should never take place during flight.

On occasion, it may happen that the connection fails. In this case, 'NO CONNECTION AVAILABLE' will be indicated in red in the status panel in the map window. This can be due to an interference that occurred during the connection process. If this happens, quit and relaunch *e-mo-tion*, disconnect and reconnect the *swinglet*'s battery and restart the connection process. Contact senseFly LLC in case of repeated connection problems.

5.3 General principles of operation

The *swinglet* uses waypoints to navigate. It will either circle around them or navigate on a straight line when switching from one active waypoint to the next. The entire list of waypoints is stored in the *swinglet* autopilot and can be remotely edited using *e-mo-tion*. All modifications made to the waypoint list will be lost when the *swinglet* is switched off, unless the list is explicitly saved into the autopilot using the corresponding button in the waypoint editor (see Section 'Using the waypoint editor' on page 25).



A waypoint essentially consists of a circle about a given position. Its trajectory is defined by the following parameters:

1. the GPS coordinates about which to circle;
2. the radius of the circle;
3. the direction of the circle (clockwise or counter-clockwise);
4. the altitude above the startup position.

Table 2: Waypoint parameters

Label	Description
Active	Indicates whether the waypoint is active or not. The *swinglet* will never navigate to an inactive waypoint. If no waypoint is active, the *swinglet* will raise a NO ROUTE cautionary warning (see table 5 on page 30) and remain on the home waypoint.
Auto next	Indicates whether the *swinglet* should remain on the waypoint upon reaching it or automatically continue to the next active waypoint.
Action	Indicates which action the *swinglet* should execute upon reaching the waypoint (see table 3 below for a list of possible actions).

Note: By default, after take-off, the *swinglet* flies to the home waypoint, which is automatically created at the position where the *swinglet* is started (see section 'Start-up' on page 14) and updated when the *swinglet* is switched into take-off mode (see section 'Take-off and flight' on page 15).

In addition to these parameters, waypoints also contain information that defines how the *swinglet* should behave when reaching them. They are listed in table 2 and table 3.

Note: Some of the behaviours described above occur upon reaching the waypoint (for example, the 'Auto next' and the 'Action' functions). The waypoint is considered 'reached' only when the *swinglet* circles about it at the waypoint's altitude. If the *swinglet* reaches the waypoint's position before the waypoint's altitude, it will keep circling about the waypoint until the altitude is attained, irrespective of the waypoint's settings.

5.4 Understanding the map window

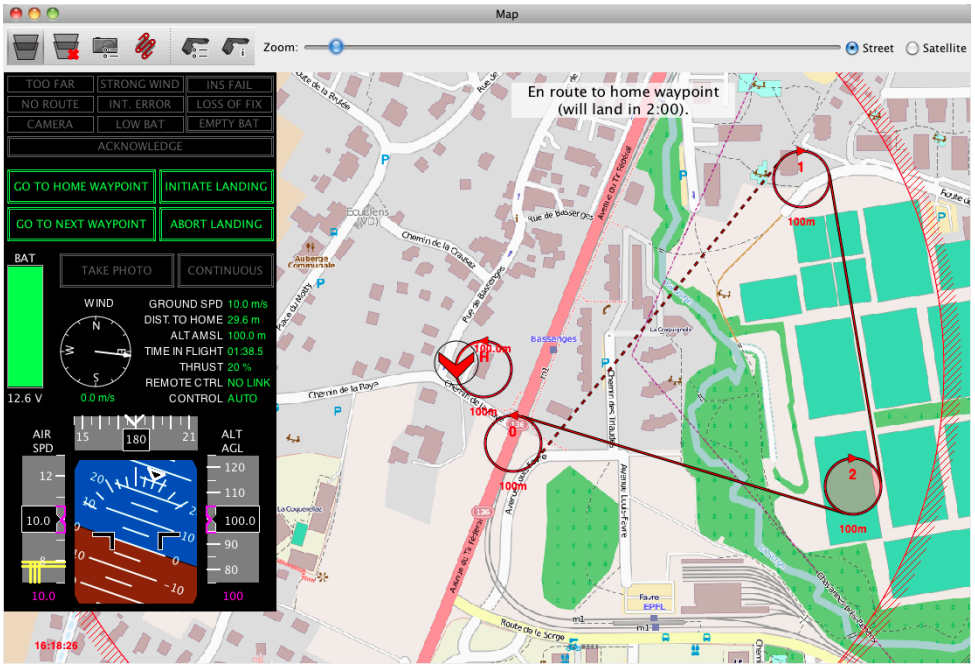
The map window provides an overview of the current position of the *swinglet* as well as its waypoint route. The top part of the window contains buttons to adjust the zoom level of the map and to select between a street view or a satellite imagery view. In addition to these two types of map background, the map window has the possibility to display custom imagery provided by the user (see section 'Adding custom imagery to the map window' on page 46 for more information).

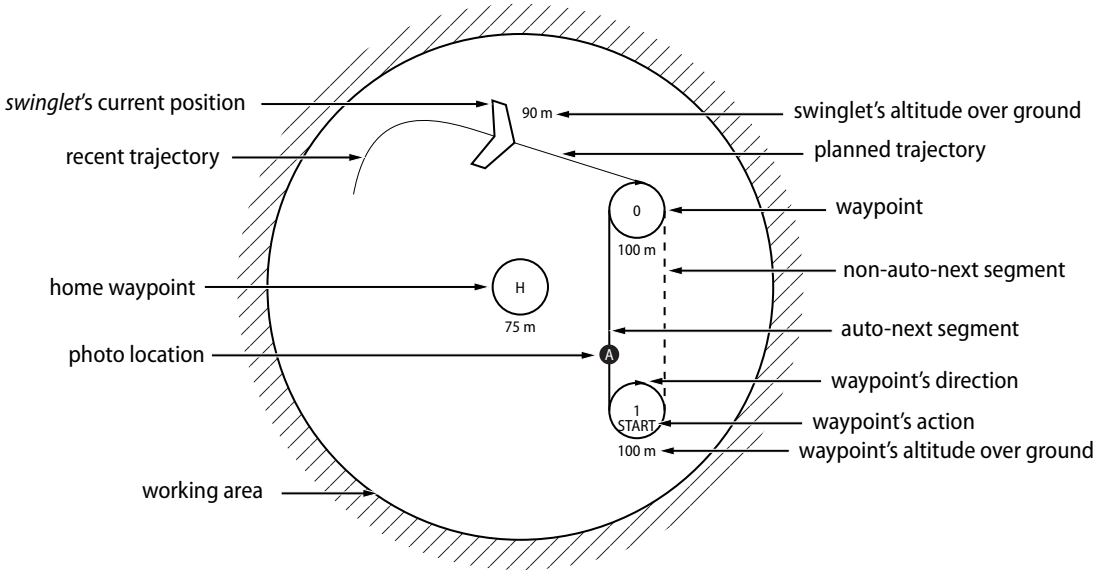
Moving around the map is done by clicking and dragging at any place not occupied by a symbol (such as a waypoint or the *swinglet* symbol). Zooming in and out of the map is done using the slider at the top or using the mouse wheel (if your mouse has one). Alternatively, the map can be set to automatically follow the *swinglet* by selecting the 'Auto-center' item of the 'Map' menu. Selecting this item again deactivates this feature. To centre the map on the *swinglet* once, without following it, use the 'Center on robot' item of the 'Map' menu. The map can be scrolled to an arbitrary location by using the 'Center on coordinate' item of the 'Map' menu and entering the target GPS coordinates.

Table 3: Waypoint actions

Label	Description
Landing	Upon reaching the waypoint, the *swinglet* will initiate landing, as if the INITIATE LANDING button had been clicked (see section 'Monitoring and controlling the *swinglet* status using the cockpit' on page 27). Note that the *swinglet* will remain on the waypoint for landing even if the waypoint is set as 'Auto next'.
Go home	Upon reaching the waypoint, the *swinglet* will navigate and stay at the home waypoint, eventually landing if no further action is taken by the user.
Photo sequence	When the *swinglet* navigates between two waypoints whose action is 'Photo sequence', it will take pictures repeatedly (see section 'Taking pictures with the *swinglet* CAM' on page 36). Note that both waypoints must be marked as 'Photo sequence' for the *swinglet* to take pictures.
Start continuous photo	Upon reaching the waypoint, the *swinglet* will engage the continuous photo mode (see section 'Taking pictures with the *swinglet* CAM' on page 36).
Stop continuous photo	Upon reaching the waypoint, the *swinglet* will disengage the continuous photo mode (see section 'Taking pictures with the *swinglet* CAM' on page 36).

Note: The map data (street or satellite view) is downloaded by *e-mo-tion* from the Internet as required and locally cached on the hard drive. If you anticipate the use of *e-mo-tion* in conditions where connecting to Internet is impossible, you can preload the map data by scrolling and zooming into the target region beforehand when you are connected to the Internet.





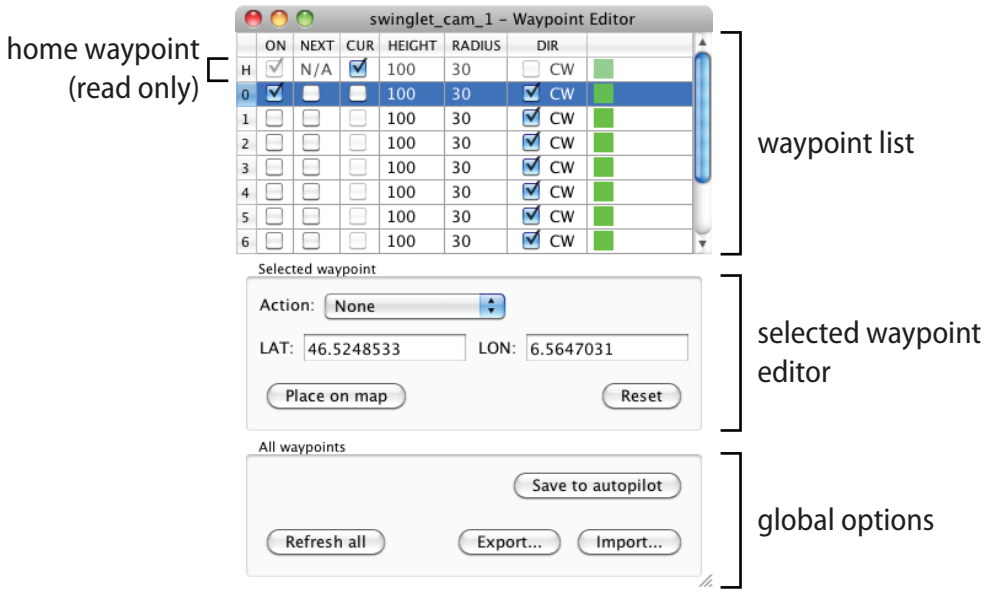
The illustration above describes the various symbols displayed on the map and their meaning. Waypoints are represented as circles with their actual radius, as well as their index number (or 'H' for the home waypoint) and their altitude above start-up position. Segments connecting waypoints are drawn with a solid line if the originating waypoint is set as 'Auto next'. Otherwise, the segment is drawn as a dashed line. The recent trajectory of the *swinglet* is displayed with a thin line and the *swinglet* is connected to its immediate destination waypoint with a straight thin line. The large circle with a hatched border illustrates the working area boundaries beyond which a TOO FAR cautionary warning will be issued (see table 6 on page 32). Finally, photo locations are displayed with a solid dot and labelled with a letter.

The waypoints and photo locations can be moved around by dragging them on the map (see section 'Taking pictures with the *swinglet* CAM' on page 36 for information on photo locations). This will directly send a message to the *swinglet* to update its onboard waypoint list. If the message is not acknowledged by the *swinglet* (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 autopilot.

Note: Clicking on a waypoint will automatically select the corresponding line in the waypoint editor (see next section).

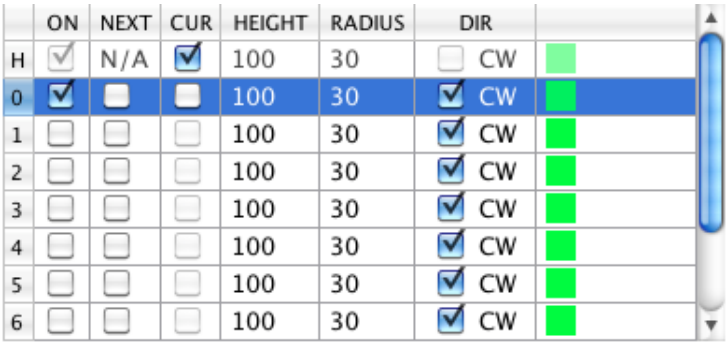
5.5 Using the waypoint editor

This section explains how to program waypoints and photo locations and how to activate a waypoint route.



The primary way to edit waypoints is through the waypoint editor. The waypoint editor is split into three sections:

- the waypoint list contains all the waypoints currently stored into the *swinglet* autopilot;
- the selected waypoint editor displays the details of the waypoint that is currently selected in the list;
- the global options section offers options that apply to the entire list of waypoints.

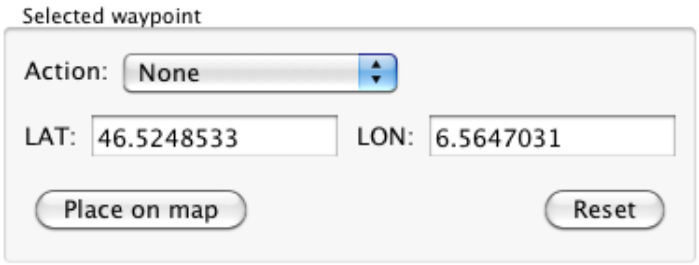


	ON	NEXT	CUR	HEIGHT	RADIUS	DIR
H	☑	N/A	☑	100	30	☐ CW
0	☑	☐	☐	100	30	☑ CW
1	☐	☐	☐	100	30	☑ CW
2	☐	☐	☐	100	30	☑ CW
3	☐	☐	☐	100	30	☑ CW
4	☐	☐	☐	100	30	☑ CW
5	☐	☐	☐	100	30	☑ CW
6	☐	☐	☐	100	30	☑ CW

The waypoint list contains all the waypoints currently stored in the *swinglet* memory. The list shows the following information.

- The column 'ON' shows whether the waypoint is active or not.
- The column 'NEXT' shows whether the Auto next parameter of the waypoint is set.
- The column 'CUR' shows which waypoint the *swinglet* is flying towards or circling about.
- The columns 'HEIGHT' and 'RADIUS' show the altitude and radius parameter of the waypoint.
- The column 'DIR' shows the direction of the waypoint (clockwise if the checkbox is ticked, counter-clockwise otherwise).
- The colour indicator in the last column shows whether the modifications made to the waypoints have been successfully transmitted to the *swinglet*.

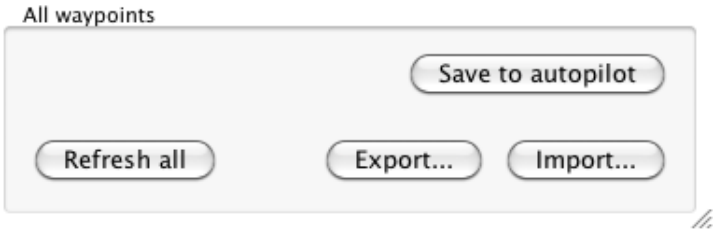
To change a waypoint's parameters, the check boxes in the list can directly be clicked. To modify the HEIGHT or RADIUS, first double-click on the parameter before modifying its value. Each modification is directly sent to the *swinglet*.



In the selected waypoint editor, additional parameters of the selected waypoint can be inspected and modified. Changes made to the selected waypoint are sent to the *swinglet* immediately after selecting an item in the popup menu or upon hitting the 'Enter' key in the text fields. See table 3 on page 23 for a description of the possible waypoint actions.

In addition to changing the parameters of the selected waypoint, the selected waypoint editor has the following functions:

- By clicking the 'Place on map' button, the selected waypoint will be activated and positioned at the desired position by clicking on the map (see section 'Understanding the map window' on page 22).
- The 'Reset' button reverts the selected waypoint to a default state.



The global option section provides functions that apply to the entire list of waypoints.

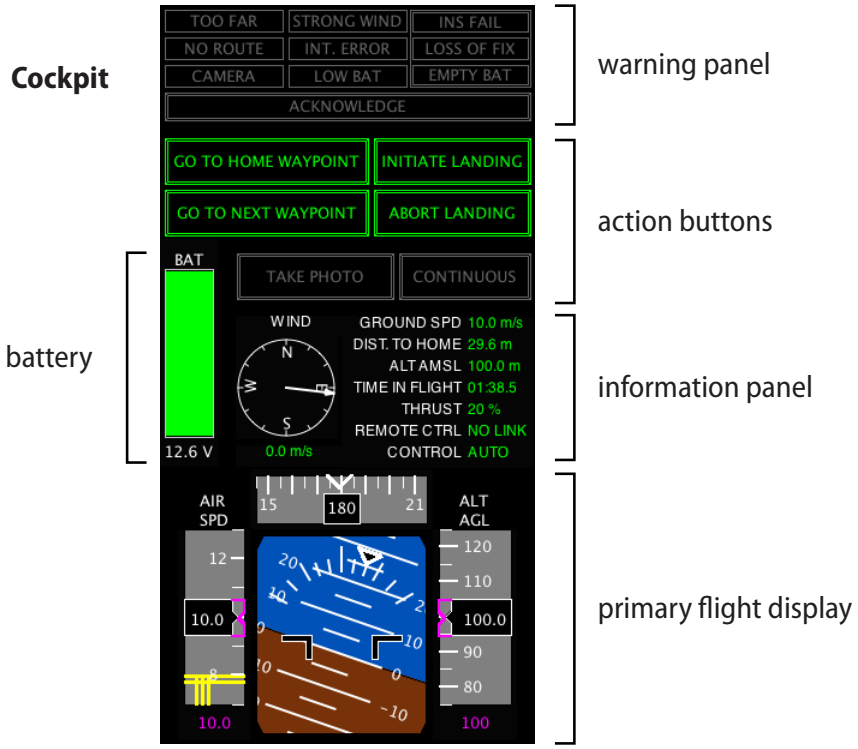
- The 'Save to autopilot' button instructs the *swinglet* to save the currently defined route. Once a route is saved in the permanent memory, it will become the default route the next time the *swinglet* is started.
- The 'Refresh all' button downloads the complete waypoint route from the *swinglet* to the monitoring software in order to ensure that the data displayed corresponds to the data used by the *swinglet*.
- The 'Export' and 'Import' buttons saves the current waypoint route in an XML file for later reuse.

Caution: Do not use the 'Save to autopilot' button while the *swinglet* is in flight as it may temporarily affect the autopilot, which may compromise flight safety.

5.6 Monitoring and controlling the *swinglet* status using the cockpit

The cockpit is the central place to monitor and control the *swinglet* when in flight. It contains the following panels:

- the warning panel;
- the battery level;
- the action buttons;
- the information panel;
- the primary flight display.



The battery level displays the current 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. A fully discharged battery has a voltage of about 9 V.

Note: With a fully charged battery, the *swinglet* will fly for about 30 minutes. Frequent altitude changes, presence of wind, use of old batteries and/or frequent photo acquisition may significantly reduce the flight endurance. Therefore, the battery level should be monitored carefully to ensure that enough charge remains for the intended flight.

Note: The battery voltage does not depend only on the charge level, but also on the motor power and the outside temperature. It is normal for the voltage to drop when the *swinglet* uses its motor at high power, such as during take-off. Likewise, batteries perform better at medium or high air temperature and it is normal to observe lower voltage in cold weather. In this case, flight time may also be slightly reduced.

The warning panel includes a set of cautionary warnings that light up in yellow and a set of emergency warnings that light up in red. The following table lists the possible emergency warnings, along with error codes displayed by the LED display on the *swinglet*.

When an emergency situation arises, the *swinglet* will immediately perform an emergency landing. For a LOSS OF FIX situation, the *swinglet* does not have the ability to navigate. The emergency landing thus consists of gliding down to the ground around a large circle, at a slow speed and with the

Warning panel

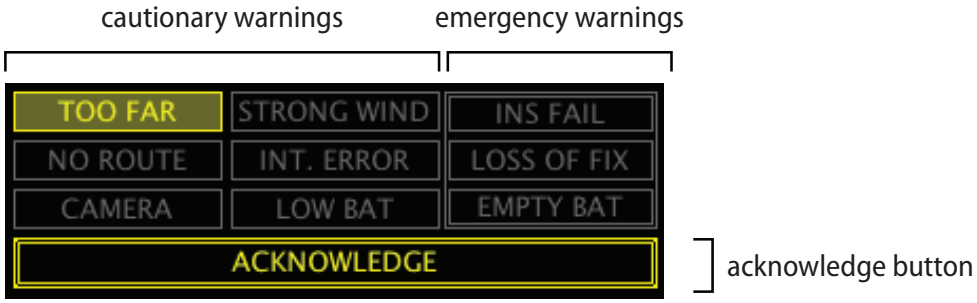


Table 4: Possible emergency warnings

Label	Error code	Description
LOSS OF FIX	E30	The GPS position (or 'fix') is no longer available, which makes it impossible for the *swinglet* to navigate.
EMPTY BAT	E31	The battery is completely empty.
INS FAIL	E32	An INS (Inertial Navigation System) failure is occurring, which makes it impossible for the *swinglet* to stabilise itself.

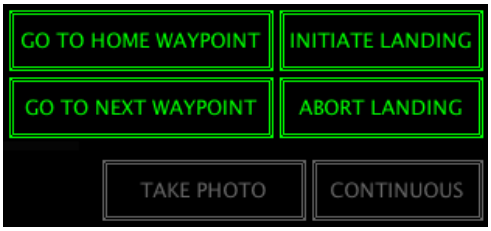
motor off. In an EMPTY BAT situation, the *swinglet* switches off its motor and will perform an emergency landing at a slow speed along the planned flight path. In an INS FAIL situation, the *swinglet* cannot stabilise itself anymore and thus cannot achieve a gliding emergency landing. In this case, the *swinglet* will fully deflect its ailevons with the motor off, which will result in an uncontrolled descent (deep stall or spin). This procedure is designed to limit the speed on impact with the ground (the vertical speed is less than 10 metres per second) and reduce the amount of lateral drift in case of wind. If the emergency condition disappears, e.g. the GPS fix is reacquired in the case of a LOSS OF FIX situation, the *swinglet* will abort the emergency landing and will navigate back to the home waypoint at the altitude of 75 metres. A red frame will be visible around the emergency warning displays to indicate that an emergency warning has occurred. To clear it and allow the *swinglet* to navigate back to its route, the acknowledge button must be clicked.

In case of a security issue, the corresponding cautionary warning lights up in yellow. If the severity of the issue warrants it, the *swinglet* will abort its current navigation plan and fly towards the home waypoint. Once the home waypoint is reached and without further action from the user, the *swinglet* will land after the holding period of 2 minutes. To resume normal navigation, the acknowledge button must first be pressed to clear the cautionary warning. Table 5 on the following page lists the possible cautionary warnings, along with error codes displayed by the *swinglet* LED display.

Table 5: Possible cautionary warnings

Label	Error code	Description
TOO FAR	E21	The *swinglet* has passed the boundary of the working area, which is set by default to 500 metres from the home waypoint. See section 'Setting the *swinglet*'s parameters' on page 33 for information on changing this parameter.
NO ROUTE	E22	No waypoint is active.
CAMERA	E27	An error has occurred with the camera, indicating that the camera may be out of battery or improperly connected to the *swinglet*.
STRONG WING	E24	The wind is too strong for the *swinglet* to navigate safely.
INT. ERROR	E26	An internal error occurred. If this error arrises repeatedly, contact senseFly LLC.
LOW BAT	E23	The battery level is too low to pursue safe navigation. This error may also happen during take-off procedure if the battery is not fully charged.
WARNING	E25	An emergency situation (see Table 4 on the preceding page) is occurring or has occurred in the past.

Action buttons



The action buttons allows the operator to directly control the *swinglet* while it is in flight.

The GO TO HOME WAYPOINT button instructs the *swinglet* to join the home waypoint immediately. The GO TO NEXT WAYPOINT button instructs the *swinglet* to fly towards the next active waypoint. If the *swinglet* is currently on the home waypoint or the last active waypoint, it will join the first active waypoint.

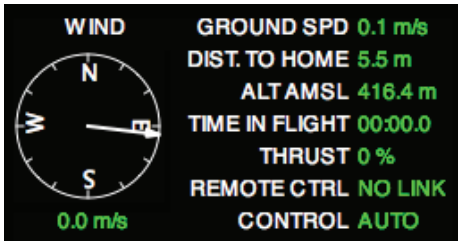
The INITIATE LANDING button instructs the *swinglet* to initiate the landing phase. If the *swinglet* is flying around a waypoint, it will remain on that same waypoint and follow a descending spiral (in

gliding mode, with motor off) until it reaches the ground or the ABORT LANDING button is clicked. If the *swinglet* is flying between waypoints, it will immediately initiate a descent along the planned route. If it reaches the next waypoint before the ground, it will follow a descending spiral on that waypoint until it reaches the ground.

Landing can be aborted using the ABORT LANDING button at any time. In this case, the *swinglet* will climb to the route altitude and follow the current waypoint route. If the button is pressed while the *swinglet* is landing on the home waypoint, it will remain on the home waypoint and climb back to its nominal altitude (75 metres).

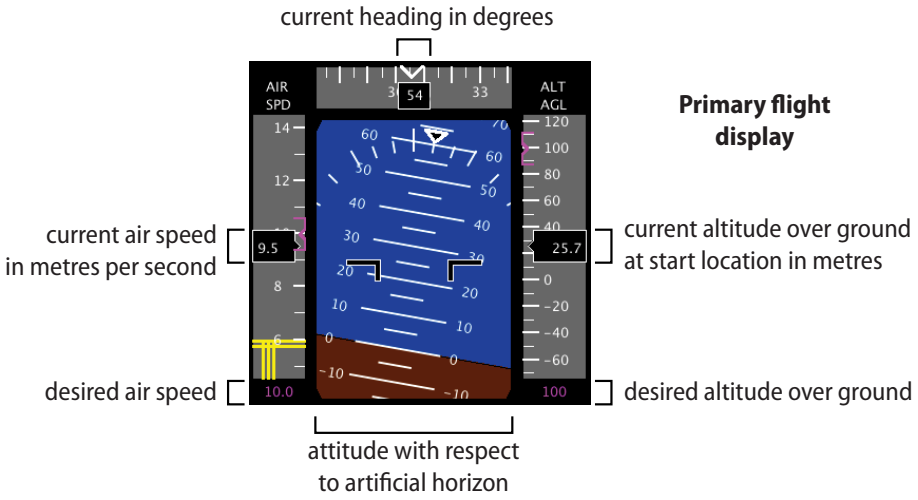
See section 'Taking pictures with the *swinglet* CAM' on page 36 for more information on the TAKE PHOTO and CONTINUOUS buttons.

Information panel



The information panel contains information about the *swinglet* and the wind. Table 6 on the following page describes the information that it displays.

Note: The wind direction and speed estimated by the *swinglet* is valid only if the *swinglet* recently performed at least one complete circle around a waypoint. The precision decreases if the *swinglet* flies along straight trajectories for extended periods of time. It is therefore adviseable to let the *swinglet* navigate several times around a waypoint at the beginning of every flight.



The primary flight display shows the current flight parameters of the *swinglet*.

Table 6: Information panel content

Label	Description
WIND DIR	The arrow shows the direction of the wind as measured by the *swinglet*.
WIND SPD	Wind speed in metres per second.
GROUND SPD	Speed of the *swinglet* with respect to the ground. Note that the *swinglet* always attempts to regulate its flight speed with respect to the air. Ground speed is provided for information only.
DIST. TO HOME	Horizontal distance between the current location and the home waypoint.
ALT AMSL	Altitude above mean sea level. Note that the *swinglet* always regulates its altitude with respect to the ground level at the start-up location. Altitude above mean sea level is provided for information only.
TIME IN FLIGHT	Time elapsed since take-off in minutes and seconds.
THRUST	Motor power currently applied shown as a percentage of the full thrust.
REMOTE CTRL	'ON' if the remote control signal is received or 'NO LINK' otherwise. Note that this reflects proper signal reception independently of whether the remote control is in automatic or manual mode.
CONTROL	'MAN' when the *swinglet* is controlled manually (i.e. the remote control signal is received and the autopilot switch is set to manual) or 'AUTO' when the *swinglet* operates autonomously.

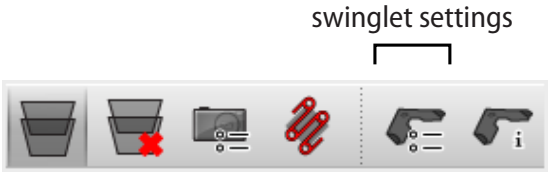
The column on the left displays the current air speed of the *swinglet* as well as the desired air speed. Both values are in metres per second.

The column on the right displays the *swinglet*'s current altitude over take off position, as well as the desired altitude over take the startup position. Both values are in metres. The desired altitude over ground depends on the configuration of the current waypoint (see section 'Using the waypoint editor' on page 25).

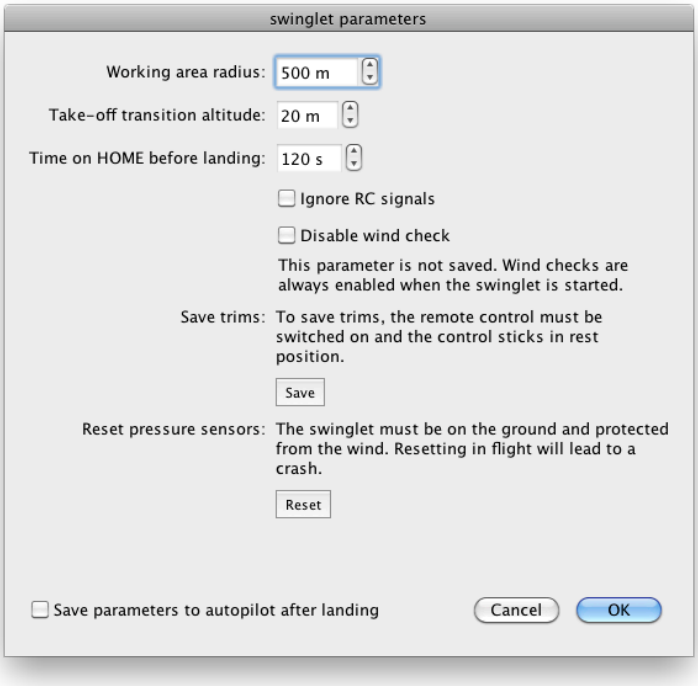
The bar at the top displays the current heading of the *swinglet* in degrees. North is indicated as 0 degrees, East as 90 degrees, South as 180 degrees and West as 270 degrees.

Note: Starting in version 1.1.2, a compact cockpit is available to accommodate small screens. This layout is accessible by choosing the 'swinglet_cam_compact' connection profile. Although the layout is somewhat different than the default layout described in this section, it displays the same information.

5.7 Setting the *swinglet*'s parameters



The parameters of the *swinglet* can be modified in the 'swinglet parameters' dialogue box, which is accessible using the corresponding button in the toolbar. The parameters that can be modified are listed in table 7 on the following page.



The parameters are applied to the *swinglet* as soon as the 'OK' button is clicked and will be applied immediately. They are, however, not saved by default and will be reset to default values when the *swinglet* is switched off. In order to save the parameters permanently to the autopilot, check the 'Save parameters to autopilot' button before acknowledging the dialogue box.

Table 7: *swinglet* parameters

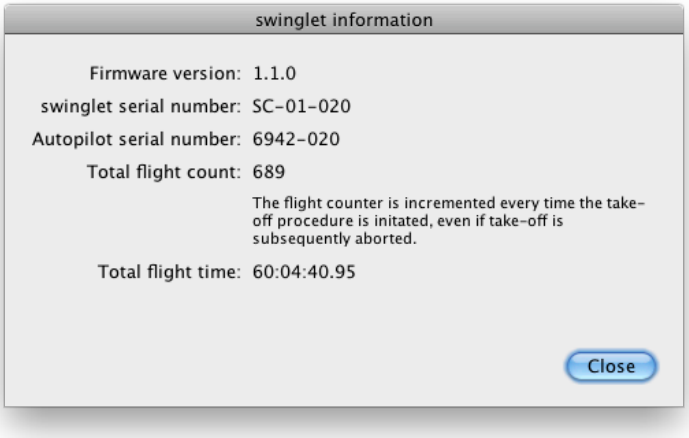
Parameter	Description
Working area radius	Radius around the home waypoint (in metres) that defines the working area. When the *swinglet* crosses its boundary, a 'TOO FAR' cautionary warning is generated (see section 'Monitoring and controlling the *swinglet* status using the cockpit' on page 27).
Take-off transition altitude	Altitude above start-up location (in metres) where the *swinglet* will switch from take-off flight phase to regular navigation.
Time on home before land	Time (in seconds) after which the *swinglet* will automatically land once it has reached the home waypoint.
Ignore RC signals	Controls whether signals from the remote control are taken into account (see section 'Using the remote control' on page 47). Reception of RC signal may be disabled if the remote control is not used and third-party signals perturb the *swinglet*.
Disable wind check	Controls whether the wind check is active or not. If disabled, 'STRONG WIND' cautionary warnings will not be generated (see section 'Monitoring and controlling the *swinglet* status using the cockpit' on page 27). Note that this may lead to the complete loss of the *swinglet* in case of strong wind.
Save trims	Resets the internal trim values of the *swinglet* based on the signals currently sent by the remote control.
Reset pressure sensors	Resets the reference value of the speed and altitude sensors to the current value.

Caution: 'Save trims' and 'Reset pressure sensors' are advanced functions that should be used only if instructed by senseFly's engineers. By default, these functions are not visible. To enable them, the 'Enable advanced functions' button must be checked when connecting to the *swinglet* (see section 'Connecting to the *swinglet* ' on page 20).

Caution: By default, the *swinglet* is configured with appropriate parameters. Changing the parameters may affect the behaviour of the *swinglet* and should be done only by experienced users.

5.8 Getting information about the *swinglet*

Information about the *swinglet* can be obtained in the 'swinglet information' dialogue box, which is accessible using the corresponding button in the toolbar. The dialogue box displays the firmware version, the serial number for both the *swinglet* and autopilot, the total number of flights as well as the total time of flight.



6 Taking pictures with the *swinglet* CAM

Goal of this section:	This section describes the various ways in which photo flights can be planned and executed. Photo flights range from the acquisition of individual images to systematic area coverage, which allows the creation of georeferenced orthomosaics and DEMs (see section 'Processing flight data' on page 18.

6.1 Triggering picture acquisition

The *swinglet* automatically switches the camera on or off depending on the flight phase. Under normal flight conditions, the camera is switched on after take-off, when the *swinglet* reaches 45 metres or more above the start-up location. The camera is then switched off in case any of the following events occur:

- take-off is requested by shaking the *swinglet* three times;
- the *swinglet* descends to 35 metres (or less) above the start-up location (see section 'Configuring the picture acquisition' on page 41 to change this parameter);
- the *swinglet* (automatically or manually) initiates a landing.

The status of the 'TAKE PHOTO' button in the cockpit reflects the status of the camera. The button is enabled (blue) when the camera is on and disabled (grey) otherwise.

The *swinglet* CAM offers four possibilities for taking pictures:

- manual clicking on the 'TAKE PHOTO' button in the cockpit;
- define specific photo locations along the flight path (see section 'Using the photo location editor' on the next page);
- photo acquisition between two PHOTO SEQUENCE waypoints (in this case, each of them should be defined as 'Photo sequence', see table 3 on page 23);
- enabling the CONTINUOUS mode to trigger continuous photo acquisition along every transition between waypoints.

When taking a picture, the *swinglet* always proceeds according to the following sequence of actions independently of how the picture was triggered:

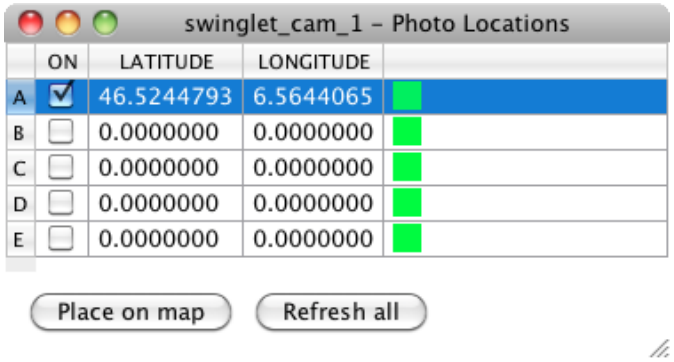
1. the motor is first cut off to avoid vibrations;
2. a level position is maintained;
3. the camera shutter is triggered to take a photo;

4. the regular navigation resumes.

To enable the CONTINUOUS mode, click on the 'CONTINUOUS' button in the cockpit (see section 'Monitoring and controlling the *swinglet* status using the cockpit' on page 27). The status of the button reflects whether the CONTINUOUS mode is enabled or not. When the CONTINUOUS mode is enabled (blue), every waypoint acts as if it was a PHOTO SEQUENCE waypoint. This means that the *swinglet* will repeatedly take pictures along the transition between the waypoints. This is valid for every waypoint except the home waypoint.

Note: During a photo sequence or when crossing a photo location, the *swinglet* may decide not to take a photo for flight safety reasons. This can happen if the *swinglet* has not reached the altitude set in its flight plan, if it is facing strong wind, if the camera is not switched on, if the *swinglet* is too far from the planned path, or if its heading is not aligned with its planned flight direction. The *swinglet* will however always take a photo when clicking on the 'TAKE PHOTO' button.

6.2 Using the photo location editor



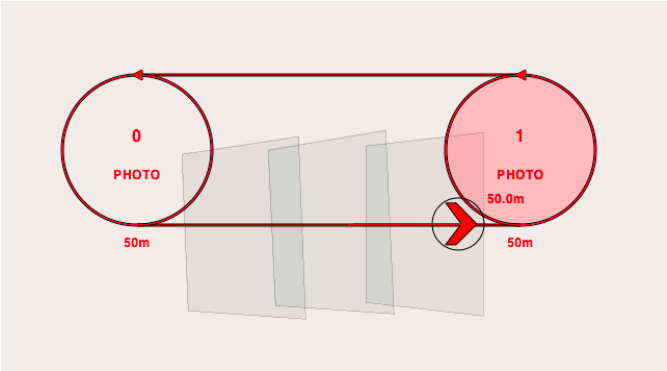
The photo location editor allows the operator to enable and to edit the locations at which the *swinglet* will take a picture. The list shows the following information.

1. The column 'ON' shows whether the photo location is active or not.
2. The columns 'LATITUDE' and 'LONGITUDE' show the GPS coordinate of the photo location.
3. The colour indicator in the last column shows whether the modifications made to the waypoints have been successfully transmitted to the *swinglet*.

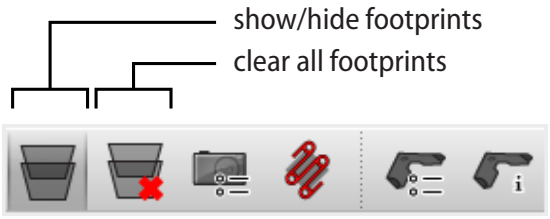
In addition to the parameter display in the list, the 'Place on map' button allows the operator to place the selected photo location by clicking on a position on the map. Finally, the button 'Refresh all' downloads the complete list of photo locations from the *swinglet* to the monitoring software, in order to ensure that the data displayed corresponds to the data stored inside the *swinglet*.

Note: The photo locations are not part of the *swinglet*'s flight plan. This means that the *swinglet* will not navigate to a photo location. The waypoint route must cross each active photo locations in order to take photos at these positions.

6.3 Using the picture footprint display



Whenever the *swinglet* takes a picture, *e-mo-tion* records the location and orientation of the *swinglet* and computes the approximate span of the photo on the ground (or 'footprint') and displays it in the map window.



The display of the footprints can be controlled using two buttons on the toolbar. The footprints can be shown or hidden using the corresponding button. When hidden, the footprints are kept in memory and new photos continue to be recorded, but nothing is displayed on the map. Clicking on the 'clear all footprints' button removes all the footprints recorded so far from the memory. Footprints for subsequent photos will continue to be recorded.

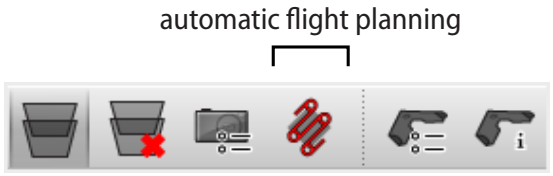
Note: Clearing or hiding the footprints has no influence on what is logged by *e-mo-tion* during the flight, such as the information required to geotag the images after the flight.

Note: Since the ground is assumed to be flat and to have the same altitude as the start-up location, the footprints displayed on the map are only an approximate estimation of the actual ground coverage of the corresponding image. Cross-wind may also introduce errors in the orientation of the displayed footprint compared to the actual coverage.

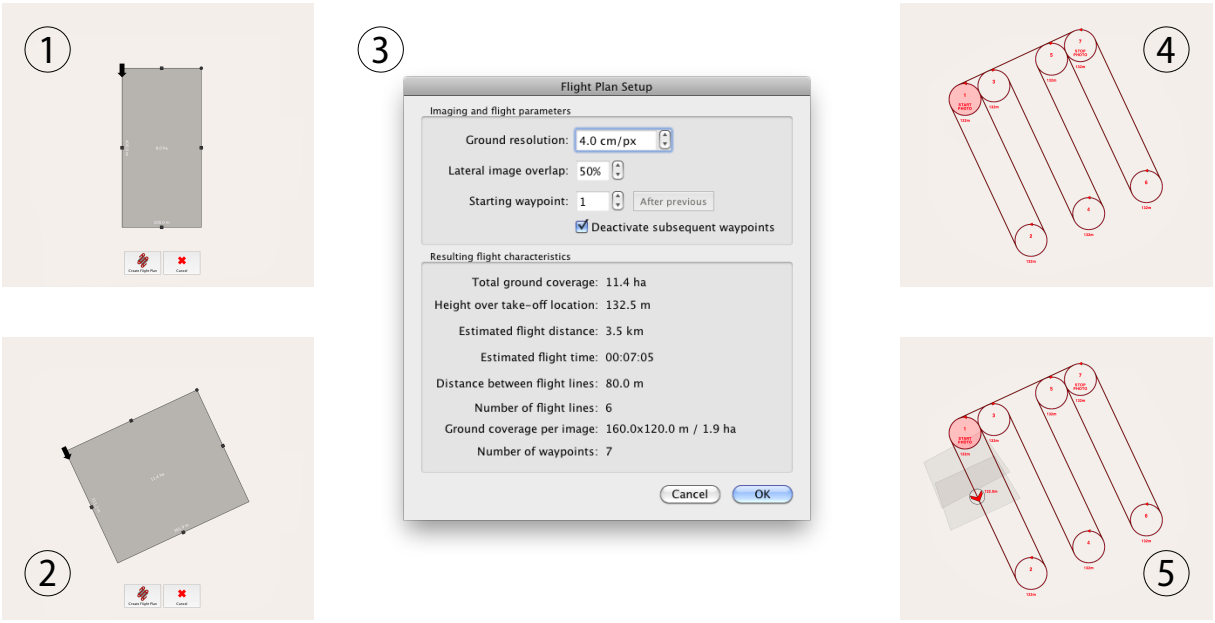
6.4 Using the automatic flight planning

Creating flight plans for systematic coverage of an area to be mapped is tedious and error prone. The automatic flight planning feature of *e-mo-tion* automates this process by configuring the waypoints to cover a designated area with a given ground resolution and lateral overlap. See section 'Processing

flight data' on page 18 for information on how to process the images acquired during a systematic coverage using *PostFlight Services* or other software.



To initiate the automatic flight planning, click the corresponding button in the toolbar.



Follow these steps to automatically setup the waypoints:

1. When the automatic flight planning button is clicked, a grey zone is displayed on the map to designate the target area to cover.
2. Adjust the location of the target area using the handles around it. The area can be relocated by dragging the grey zone. The four square handles can be used to resize the area and the round handle can be used to rotate it. The black arrow indicates the direction in which the *swinglet* will start the coverage.
3. When the target area is correctly positioned, click on the 'Create Flight Plan' button at the bottom of the map window. This will display the 'Flight Plan Setup' dialogue box.
4. In the 'Flight Plan Setup' dialogue box, enter the desired parameters and click 'OK'. The flight plan will be calculated and the waypoints configured accordingly.
5. Launch the *swinglet* and direct it towards the first waypoint of the flight plan.

Table 8 lists the parameters that can be modified in the 'Flight Plan Setup' dialogue box. Whenever the chosen parameters result in a flight plan that cannot be achieved by the *swinglet*, because it would exceed its endurance, for example, a warning icon is displayed next to the problematic parameter.

It is good practice to use an initial waypoint close to the take-off location in order to let the *swinglet* circle a few times at the beginning of the flight. The waypoint 0 is typically used for this. For this reason, the default starting waypoint index is 1 in the 'Flight Plan Setup' dialogue box. An added advantage of this practice is that the *swinglet* will automatically fly back to waypoint 0 after the flight plan is executed and stay there until landing is requested (assuming auto-next is not enabled for this waypoint).

Table 8: Auto flight planning parameters

Parameter	Description
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 centimetres per pixel) requires a lower flight altitude, while a lower resolution (many centimetres per pixel) requires a higher flight altitude. Note that this parameter is dependent upon the type of camera installed on the *swinglet*. This is automatically taken into account by *e-mo-tion* based on the factory-programmed camera information.
Lateral image 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.
Starting waypoint	The number of the first waypoint used to implement the flight plan. By default, waypoint 1 is used to leave the waypoint 0 as a convenient holding point for the beginning and the end of the mission. When planing 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.
Deactivate subsequent waypoints	If this option is enabled, any active waypoint after those used for the flight plan will be deactivated.

Note: The longitudinal overlap is configured and achieved independently from the automatic flight planning. See section 'Configuring the picture acquisition' for more information.

Note: For its overlap calculation, the automatic flight planning assumes that the ground is flat and has the same altitude as the start-up location. Actual lateral overlap and/or ground resolution may vary if the terrain is not flat.

Caution: When clicking 'OK' in the 'Flight Plan Setup' dialogue box, the waypoints required for the flight plan will be directly modified in the *swinglet*. If the *swinglet* is flying towards or around one of these waypoints, its navigation will be affected.

Caution: The automatic flight planning is not aware of any obstacle that may exist in the area. The resulting flight plan should be carefully reviewed in order to avoid any collision with uneven terrain or tall objects such as buildings.

6.5 Configuring the picture acquisition

The parameters for the picture acquisition can be edited in the 'Camera parameters' dialogue box, which is accessible using the corresponding button in the toolbar. Table 9 on the next page describes the parameters that can be modified.

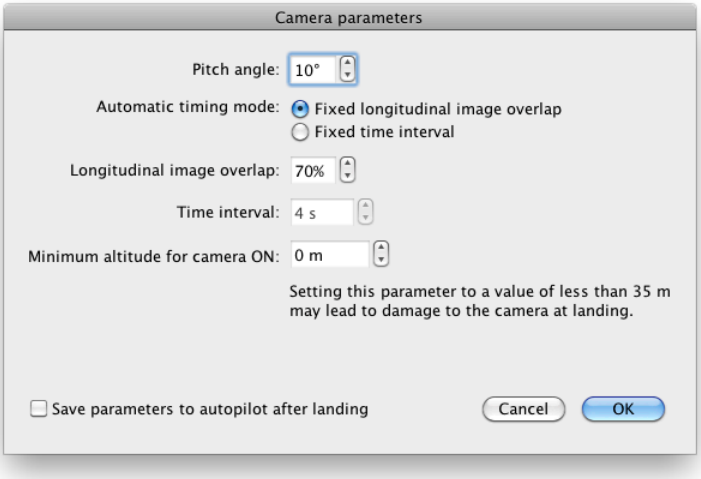


Table 9: Camera parameters

Parameter	Description
Pitch angle	Pitch angle (in degrees) used during the photo capture process. A small positive angle (about 10 degrees) limits the loss of altitude while the motor is off (see section 'Triggering picture acquisition' on page 36).
Automatic timing mode	This parameter selects the method that *swinglet* uses to trigger pictures. Triggering can be setup such as to achieve either a fixed longitudinal overlap or a fixed time interval. When fixed longitudinal overlap is selected, the *swinglet* automatically adjust the delay between two subsequent photos in order to obtain a given longitudinal overlap.
Longitudinal image overlap	The longitudinal overlap percentage used when the timing mode is set to fixed longitudinal image overlap.
Time interval	The time interval used when the timing mode is set to fixed time interval.
Minimum altitude for camera ON	The altitude below which the camera is switched of by the *swinglet*.

The parameters are applied to the *swinglet* as soon as the 'OK' button is clicked and will be in use immediately. They are however not saved by default and will be reset to default values when the *swinglet* is switched off. In order to save the parameters permanently to the autopilot, check the 'Save parameters to autopilot' button before acknowledging the dialogue box.

Note: To compute the delay between photos when the timing mode is set to fixed longitudinal overlap, the *swinglet* assumes that the ground is flat and has the same altitude as the start-up location. If the ground is not flat, the actual overlap may vary. Also, a minimum delay of about 4 seconds is required, so the desired overlap may not always be achieved, especially at low altitude (typically below about 100 metres).

Caution: Setting the minimum altitude for camera ON to values below 35 metres may lead to the *swinglet* reaching the ground with the camera switched on and its optics deployed. This may damage the camera.

7 Maintenance and repair of the *swinglet*

Please contact senseFly LLC if you have questions for maintenance or repair of your *swinglet*. Our customer service can help you if you need support.

7.1 Storage

In order to avoid structural deformation of the wing, it is recommended to store the *swinglet* either in its transport case or on a flat surface at room temperature. Avoid exposing the *swinglet* to high temperature for prolonged periods of time. In particular, leaving the *swinglet* exposed to the sun in a car should be avoided.

7.2 Cleaning the *swinglet*

Use a damp cloth to wipe off dirt from the *swinglet*.

Caution: Never bring the *swinglet* into direct contact with water.

7.3 Repairing the *swinglet* 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).

Note: If you have doubts about the extent of the damage, always contact senseFly LLC to verify if the damage can be easily repaired by yourself or if you need to send your *swinglet* for repair to senseFly LLC.

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

8 Appendix

8.1 Installing *e-mo-tion* and the radio module drivers

Windows XP/Vista/7

To install *e-mo-tion* on Windows, simply execute the provided installer and follow the on-screen instructions. The *e-mo-tion* software will be available in the 'Start' menu.

Drivers for the USB ground station radio module will automatically be installed by the installer. In case a problem arises after first connecting the radio module to the computer, you may need to point Windows to the driver directory for reinstallation. In this case, Windows should be redirected to the following directory:

```
C:\Program Files\e-mo-tion\driver\
```

Note: The provided Windows drivers are not signed. A warning may therefore be displayed during installation and should be accepted.

Mac OS X 10.5/10.6

To install *e-mo-tion* on Mac OS X, simply execute the provided installer and follow the on-screen instructions. The *e-mo-tion* software will be available in the 'Applications' folder and the drivers for USB ground station radio module will be automatically installed.

8.2 Updating the *swinglet* software

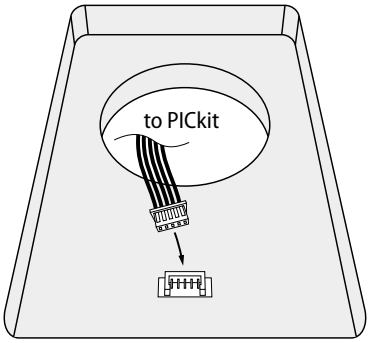
Occasionally, senseFly LLC releases a software upgrade for the *swinglet* CAM to provide additional features to our users or to correct potential issues. This section describes the procedure to upgrade the *swinglet*'s firmware and the *e-mo-tion* ground station software. To proceed, you will need a update bundle from senseFly's support web page or provided by senseFly on a CD. You will also require the PICkit 2 USB programmer included in the swinglet transport case to transfer the firmware data from a computer to the *swinglet*.

To upgrade *e-mo-tion* to the latest version, follow the standard install procedure (see section 'Installing *e-mo-tion* and the radio module drivers'). It is not necessary to uninstall previous version of *e-mo-tion* before installing the new one.

To upgrade the firmware of the *swinglet*, perform the following steps:

1. Disconnect the battery of the *swinglet* and remove the camera from its compartment.
2. Connect the PICkit 2 USB programmer to the connector in the camera compartment and to a USB port on your computer.
3. Launch the provided 'swinglet CAM Updater' software (located in the upgrade bundle on Mac OS X or in the 'Start' menu after installing *e-mo-tion* on Windows).

4. In 'swinglet CAM Updater', click the 'Update' button.



It is important that both the *swinglet* and *e-mo-tion* have the same software version for them to work properly together. Make sure that you keep both up-to-date. To check the *e-mo-tion*'s version, use the 'About e-mo-tion...' item in the 'Window' menu on Windows or the 'About e-mo-tion' item in the 'e-mo-tion' menu on Mac OS X. The *swinglet* firmware's version can be checked on the LED display at startup (see section 'Start-up' on page 14) or in the *swinglet* information dialogue box once connected (see section 'Getting information about the *swinglet* ' on page 35).

Caution: We are constantly working to improve the performance of our products and 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 LLC can only offer warranty service for products that have been properly updated.

8.3 Accessing the flight log

As soon as the *swinglet* takes off and until it lands, *e-mo-tion* logs flight data. This data is saved in the 'log' subdirectory of the 'e-mo-tion' directory. The 'e-mo-tion' directory is created in 'My Documents' (on Windows) or 'Documents' (on Mac OS X). In order to provide support, senseFly LLC may request the log files for inspection. In particular, the warranty may be void if the log files reveal inappropriate use (e.g. if the crash occurred while the *swinglet* was manually controlled or due to high wind).

Caution: *e-mo-tion* can log flight data only if it is connected to the *swinglet*. Since log files are needed for senseFly LLC to provide support and warranty, it is recommended to connect to the *swinglet* for every flight.

Note: After regular use of the *swinglet*, the flight logs will accumulate and may use a significant amount of disk space. Old log files may be deleted to save space.

8.4 Camera settings

The configuration of the camera is critical for the acquisition of quality images. In case of unwanted configuration changes, the camera can be configured to a suitable state using the following procedure.

1. Restore default settings ('Reset All…' in 'Camera Settings' menu)
2. Switch to 'Program' mode (middle position of the program selector switch)
3. Deactivate the flash (left of the multipurpose controller)
4. In the 'Shooting settings' menu:
   (a) Set 'AF Frame' to 'Center'
   (b) Set 'AF-assist Beam' to off
   (c) Set 'Red-Eye Lamp' to off (in the 'Flash Settings…' sub-menu)
   (d) Set 'Review' to off
   (e) Set 'IS Mode' to off
5. In the 'Camera Settings' menu:
   (a) Set 'Mute' to on
   (b) In the 'Power Saving…' sub-menu:
      i. Set 'Auto Power Down' to off
      ii. Set 'Display Off' to 3 minutes

For more information, refer to the camera manual on the original Canon CD or the support section of our website.

8.5 Adding custom imagery to the map window

In addition to the satellite imagery and street view mode of the map window (see section 'Understanding the map window' on page 22), *e-mo-tion* has the capability to display custom imagery provided by the user. This imagery must have the form of a hierarchical tile set following the web tiling standard. Such tile set can be created from any georeferenced imagery using a third-party software such as 'MapTiler'[2]. The folder containing the hierarchical tile set should be placed in the `e-mo-tion/tiles/` subdirectory of the `My Documents` directory on Windows or the `~/Documents` directory on Mac OS X. Note that you may have to create the `tiles` folder first. Several tile sets can be present and they can be named arbitrarily. The resulting file hierarchy would thus be the following:

```
[My] Documents/e-mo-tion/tiles/MyCustomTileSet/18/...
[My] Documents/e-mo-tion/tiles/MyCustomTileSet/17/...
[My] Documents/e-mo-tion/tiles/MyCustomTileSet/16/...
...
```

[2] `http://www.maptiler.org`

```
[My] Documents/e-mo-tion/tiles/MyOtherTileSet/18/...
...
```

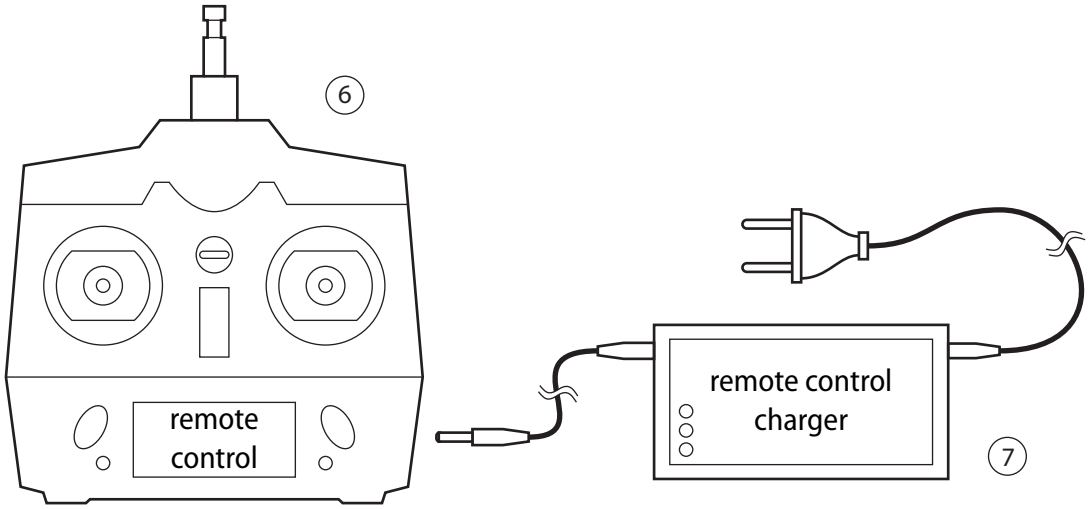
When creating the tile set, make sure that at least zoom level 18 is generated, with zoom level 19 as well if possible, since this is typically needed for precise flight planning with the *swinglet*. In 'MapTiler', the 'Google Maps compatible' option should be selected to generate a tile set compatible with *e-motion*.

Note: If you use *PostFlight Services* (see section 'Processing flight data' on page 18), a tile set will be generated for each project. This tile set can be viewed in Google Earth and is directly compatible with *e-mo-tion*. You can therefore create your own map background using the *swinglet* CAM.

8.6 Using the remote control

Caution: The remote control is preconfigured for use with the *swinglet*. Changing the remote control's configuration may compromise its functionality with the *swinglet*.

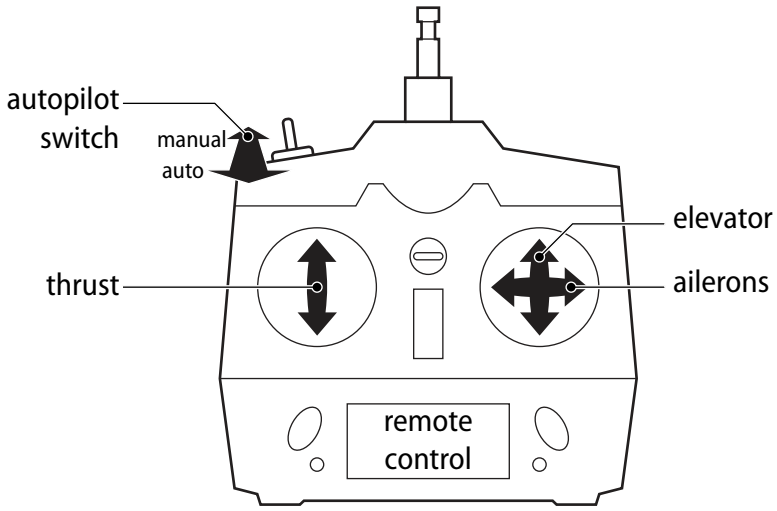
When switched on, the remote control provided with the *swinglet* displays the battery voltage. A voltage of 9.5V or below indicates a low battery charge.



To recharge the remote control (6), follow these steps:

1. Switch the remote control (6) off.
2. Connect the remote control to its charger (7) according to the illustration above.

During charge, a red LED will be on. Once the charge is completed, the LED will switch to green.



Note: The remote control is equipped with Ni-MH batteries that are subject to the 'memory effect'. To ensure optimal performance and battery life, recharge the remote control only when the batteries are fully discharged. Leaving the remote control on until it beeps can help to completely discharge the batteries.

Caution: Manually controlling the *swinglet* requires the skills of an experienced RC aircraft pilot. The manual operation of the *swinglet* is not recommended. SenseFly LLC cannot be held responsible for the use of the *swinglet* and its consequences.

By default, the *swinglet* flies autonomously and doesn't need the provided remote control to be switched on. However, by using the remote control, it is possible to override the onboard autopilot by switching to manual mode. In this mode, the *swinglet* is directly controlled using the remote control's sticks.

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 *swinglet* is actually equipped with two 'ailevons' that collectively function as ailerons and elevator. When the ailerons function in the same direction, they act as the elevator. When the function in opposite motion, they act as ailerons.

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 top left switch controls whether the signal from the remote control should override the autopilot. When the switch is pulled towards the user, the *swinglet* will function fully autonomously. When the switch is pushed away from the user, the remote control will completely override the autopilot. Manual control of the *swinglet* can be achieved at any time if the *swinglet* is within range of the remote (see section '*swinglet* technical specifications' on page 50).

The remote control has been preprogrammed to match the *swinglet* airframe and autopilot. If, for any reason, the preset settings should be lost, contact senseFly. For more information on using the remote control, refer to the original user manual reproduced below).

Note: As the remote control may reduce the range of the USB radio module, we recommend that the remote control is switched off when not in use.

8.7 *swinglet* technical specifications

Size	Wingspan: 80 cm Wing area: 0.22 m^2
Weight	500 g
Battery	3-cell Lithium-Polymer Capacity: 1350 mAh
Endurance[1]	Approx. 30 minutes
Range[2]	Up to 20 km
Propulsion	Electric brushless motor Nominal static thrust: 0.45 kgf (4.4 N)
Flight speed	Nominal cruise speed: 10 m/s
Communication link[3]	Remote control: • 35 MHz, range: approx. 1 km (s/n: up to SC-03-xxx) • 2.4 GHz, range: approx. 1 km (s/n: SC-04-xxx and higher) Data: 2.4 GHz, range: approx. 1.5 km
Navigation	up to 20 waypoints
Photos	up to 5 photo locations

[1] Endurance can vary greatly depending on external factors such as wind, altitude change and temperature.
[2] Range can vary greatly depending on external factors such as wind, altitude change and temperature.
[3] Range of communication can vary greatly depending on external factors such as cruise altitude, presence of obstacles and radio-frequency interferences.

8.8 *e-mo-tion* requirements

Operating system	Windows XP / Vista / 7 Mac OS X 10.5 or later
Hardware	1 GHz processor 1 GB RAM 500 MB free space
Screen	min. resolution: 1280×900 (1024×768 with the compact cockpit) visible outdoors