- Automated check for control surfaces range of motion and force.
- Confirming sufficient safety clearance for take-off.
    - Note: This is the distance to ensure safety of the operator and other involved persons during takeoff. It is the operator's responsibility to respect the national regulations, e.g. regarding uninvolved people and distance to residential, industrial or commercial areas.
- Automated motor check (completed after commanding takeoff, and before lifting off the ground).

Manual trigger device for parachute

The manual trigger device MTD gives the remote pilot a possibility to terminate the flight manually. In addition it shows with the three indicator LEDs the condition of the parachute and FTS.

All good to go (Ready for take-off):

- Top light constant green: The radio link to the parachute is good
- Middle light flashing green: The parachute is ready for flight
- Bottom light constant green: The battery is good for flight

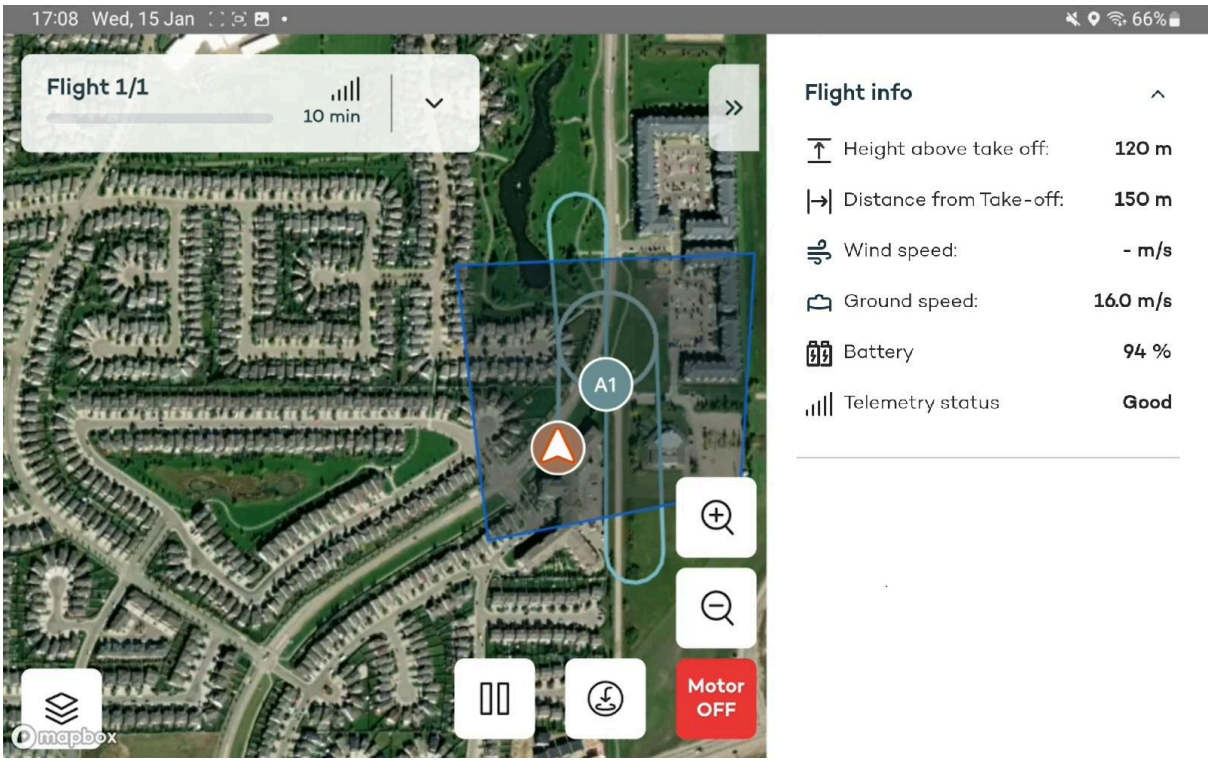
Problem signals (Do not take-off):

- Top light:
    - Purple light - constant or flashing. System starting and connection is pending.
    - Red light: signal is poor or lost.
- Middle light:
    - Purple light - constant or flashing. System starting and connection is pending.
    - Cycling through all colors: Parachute has been activated
- Bottom light:
    - Purple light - System starting.
    - Yellow - Medium battery
    - Red - Constant Low battery. Blinking bad battery

Activation of parachute using the manual trigger

To activate the parachute manually press both of the red buttons on the MTD sides at the same time and hold them down.

5.4 In-flight monitoring



Location, altitude and direction of the drone

The location and movement direction of the drone is indicated with the arrow icon on a map. The altitude is shown as a measure above the take-off point in the side bar which can be opened from the top right corner icon. »
The accuracy of the location is within 2m.

Other flight information

The side bar when opened shows additionally:

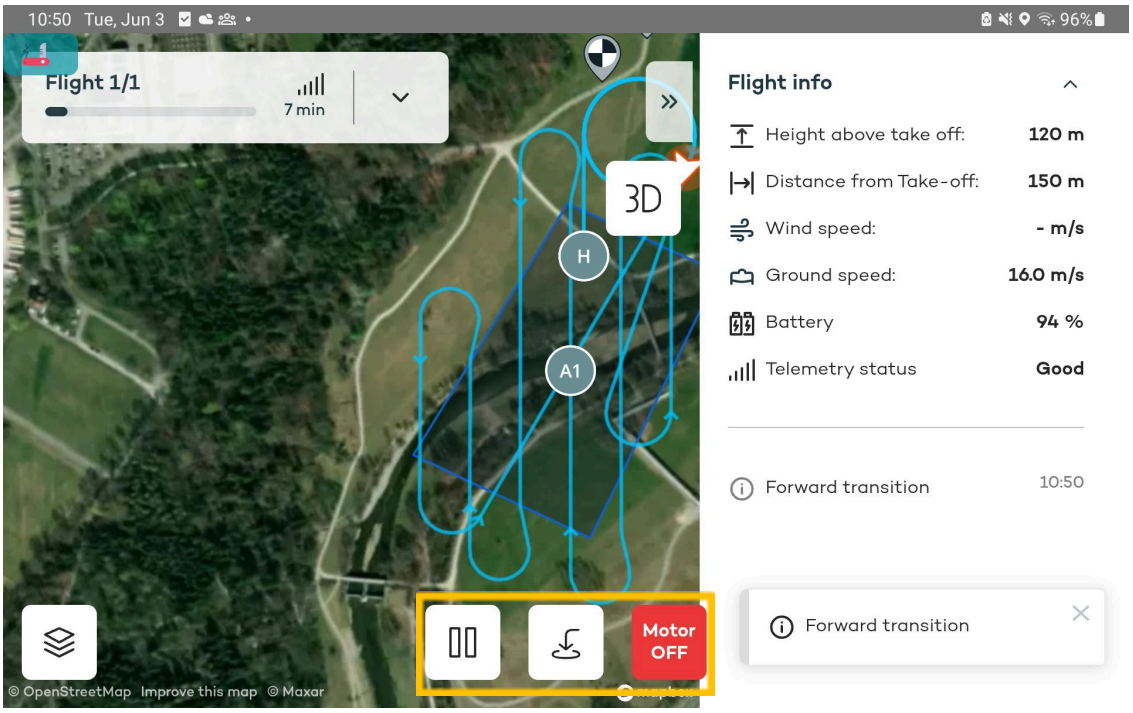
- Height above take-off in meters
- Distance from take-off in meters
- Wind speed in meters
- Drone ground speed in m/s
- Battery level in %
- Telemetry status

5.5 In-flight control and flight modes

Flight Modes

WingtraRAY generally flies fully automated in either hover or cruise modes. Hover is possible for only a short duration during take-off and landing. Majority of the flight WingtraRAY flies like a normal fixed-wing airplane. The change between these two stages is called a transition and this is always automated.

List of all flight modes	
Fully automated - Mission mode	This is the normal mode where WingtraRAY flies the planned flight fully automated from take-off to landing.
Fully automated -Return To Home RTH	WingtraRAY will automatically fly back to and land at the take-off position.
Semi-automated -Pause and Loiter then descend or ascend	During cruise flight the pilot can command WingtraRAY to pause and stay in a loiter circle and then either to increase or decrease the altitude in the circle in steps.
Semi-automated -Pause hover and reposition sideways for landing	During the landing phase when WingtraRAY has automatically initiated the transition to vertical hover and landing the pilot can pause the vertical descent and reposition the drone a few meters sideways to avoid landing on dangerous areas or obstacles.
Mitigated flight modes Flight Termination System -Motor OFF (Tablet control) -Manual Trigger device (separate radio)	The pilot can shut off the power to the motors of WingtraRAY at all times. If the parachute module is installed this will activate the parachute. The parachute module also comes with a separate radio for manual triggering of the FTS/PRS.
Note None of the flight control modes requires lights for controllability of the drone to conduct safe flights. WingtraRAY is limited to flights only during daytime and the level automation is high, preventing the remote pilot from needing to see anything else except the drone location and its relation to ground and other aircraft.	



Your interaction options

When flying the following in-app controls are enabled for use by the pilot. Going from left to right the first highlighted button is the “Pause and loiter” command which will cause WingtraRay to enter into a loiter circle at the position the aircraft was when the button is pressed.

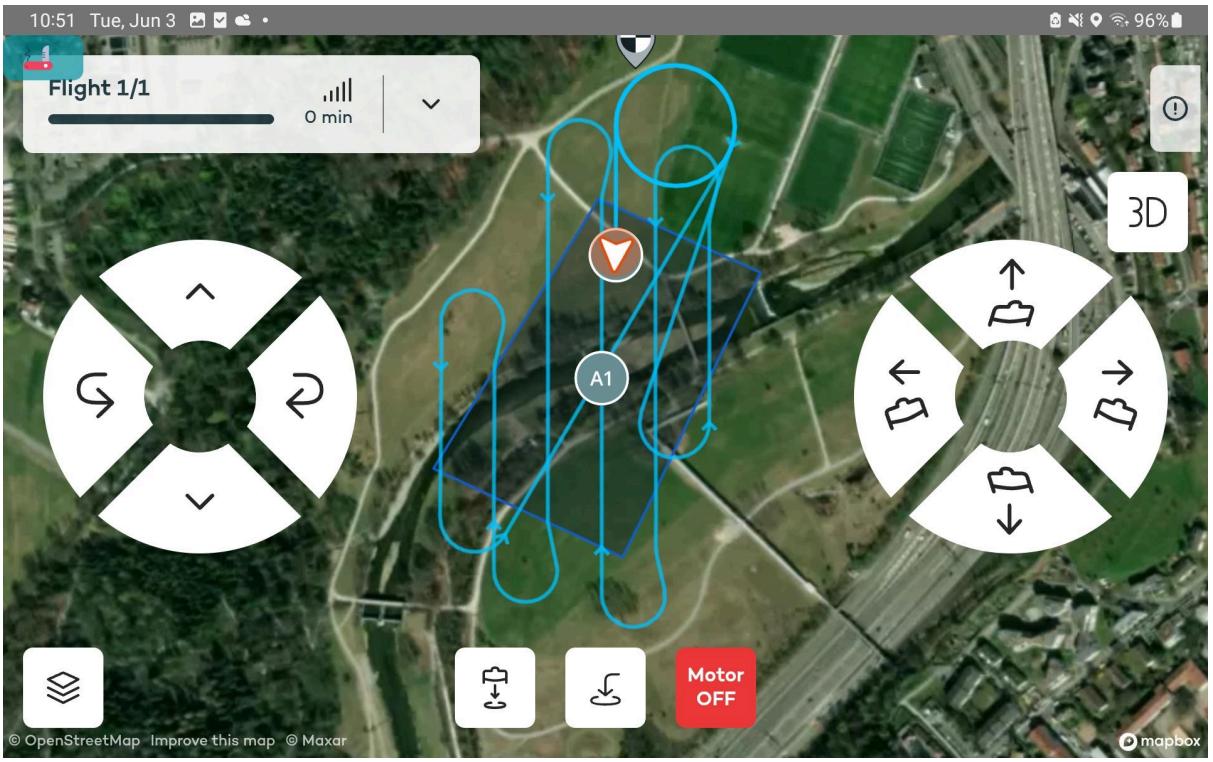
The second button is Return To Home which will initiate this function.

Last button is the Motor OFF function which will after a secondary confirmation request swipe shutting off the propulsion causing the drone to fall to the ground or to launch the parachute if equipped with one.

Repositioning WingtraRay at landing

WingtraRay has a landing accuracy of 2m. Therefore, automatic landing is the preferred option when flying with WingtraRay. However, if the landing spot is blocked or WingraRay deviates a lot from the intended location, the in-app controls can help reposition and safely land the drone.

By pressing the pause button during landing, WingtraRay will stop, stabilize itself mid hover in place. You can then command the next movements, using the in-app controls, as described below. There is a time limit of 2 minutes for the drone to hover before it will automatically continue to land again.



With the left-side buttons, you can command WingtraRay to move up and down or control the orientation along its axis.
The right-side controls will move WingtraRay laterally left, right, forward or backwards.

After adjusting the landing position as wanted you can land the drone by simply pressing down on the arrow on the left-side control or;
Press the Play icon.

Pressing the RTH icon will cause the drone land at the original take-off position

6 Safety

The following sections extensively describe the features ensuring safe operation of the WingtraRay.

The safety and reliability of the WingtraRay is ensured through the following safety features and procedures:

- Operator intervention through controls, see chapter 5.5
- Navigation system redundancies
- Technical safety features, see details in chapter 6.2
- Mandatory pre-flight checks in Section 5.3
- Operator safety precautions, see chapter 6.1

In addition to the critical safety features for each flight, the WingtraRay monitors the health of different components and suggests timely maintenance or inspection tasks to the operator, before a safety critical level is reached for these components. This applies to the following components:

- Deterioration in motor and propeller performance
- Batteries ageing beyond a critical level (this is done by a battery management system, which also protects the cells from events like deep-discharge or short-circuit)
- Unexpected load on powered servo motors on the ground
- Parachute maintenance interval reminder

In addition to that the safety and reliability of the system is ensured through thorough qualification of all software and hardware features on component and system level.

6.1 Operator safety precautions

A drone is a tool for professionals that can be a safety risk if not used properly. Make sure you always respect the operational guidelines & limitations (chapter 7) of your system to ensure the safety of material and people.

For the safe operation of the WingtraRay first you should be familiar with the safety parameters explained in chapter 5.1.7.

- **For operations over people in the United States see the required settings and operational limitations in chapter 13**

- **For operations in Europe within the open category A3 and STS-02 permit flights see the required settings and operational limitations in chapter 14.**

In addition to the safety parameters always stick to the following safety precautions:

- Keep distance from the propeller: The propeller spins at high speeds and can cause injuries if they get into contact with skin.
- Power off the WingtraRay before handling it
- Never fly with a damaged drone or any damaged equipment
- Never fly without the nose cone

6.2 Technical safety features

There are several scenarios where WingtraRay will take action by itself and engage a specific failsafe routine during flight. Many components have redundancy such as the batteries, Inertial Measurement Units IMUs, GNSS and barometers. Most component degradations and failures have automated detection and procedures mitigating the events.

6.2.1 Return-to-home (RTH)

RTH causes the drone to come back to the take-off point and land automatically.

RTH is triggered automatically in these scenarios:

- low battery
- one failed battery
- wind speed exceeds 12 m/s for 30 seconds.
- telemetry connection is lost for longer than the set connection loss time safety parameter
- actuator failure or other sensor failures
- camera stops being responsive

If drone is not equipped with a parachute:

- Automatic RTH will be triggered in case the Geobarrier or Flight Termination barrier is violated.

If drone is equipped with a parachute:

- Automatic RTH will be triggered in case the Geobarrier is violated.

The factors that affect the RTH time are: absolute altitude of take-off location, distance to the home position, wind speed, wind direction, transition altitude, and mission design. RTH can also be triggered manually from the control tablet.

RTH safety parameters are detailed in chapter 5.1.7

6.2.2 Safety landing / hover down

This failsafe forces WingtraRay to perform a back transition and land from the point the landing is triggered. It is triggered in the following cases:

- if the position of WingtraRay cannot be defined, in the case of GNSS loss for many seconds. In that case, WingtraRay will first fly back towards the take-off point for some seconds using only the internal navigation unit. If an accurate position estimation cannot be regained within 30 seconds of the loss, the emergency landing will be executed on the spot.
- Failure of one control surface servo in cruise flight. This will cause the drone to back transition and land immediately on the spot.

6.2.3 Parachute activation

When WingtraRay is equipped with the parachute module. The Flight Termination System cuts the power to the drone and simultaneously activates the parachute in several different scenarios. The parachute has a minimum deployment altitude of 30m which it requires to have sufficient time to open up and slow down the drone.

The parachute will automatically activate if the system detects a power outage or propulsion failure or a rapid fall of the drone. Also if the optional flight termination barrier is crossed the parachute will be activated.

The parachute can also be manually activated by the pilot by using either the tablet command for flight termination or by using the parachute manual trigger device.

6.3 Battery Charging

The drone is powered by two Li-Ion batteries with 99.9 Wh capacity. The batteries are self-plugging and can be locked by means of a twist-lock at the front of the drone.

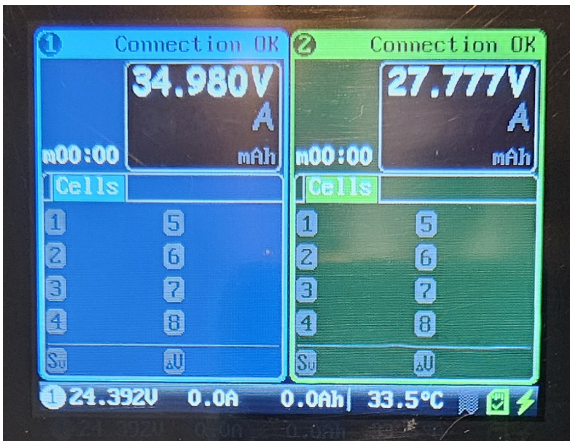
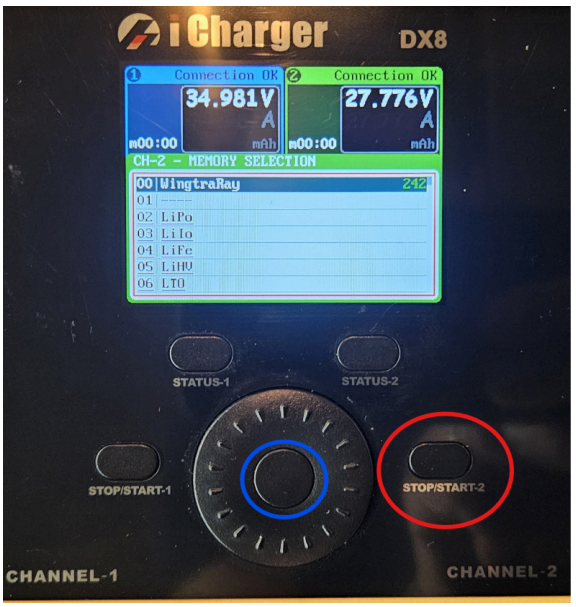
To charge the batteries, a charger including a battery dock is provided as per below.

	Dual channel iCharger DX8
	AC-DC adapter with universal AC input and XT90 DC output

	Battery dock for two flight batteries with XT60 connectors to connect to DX8 charger

Batteries should be fully charged before being used.
To charge the batteries, follow the steps as outlined below.

1.		Connect the AD/DC adapter to the DX8 charger using the XT90connector on the back of the charger. Connect the battery dock to the two XT60 outputs of the DX8 charger. Plug the AC/DC adapter into mains.

2.		Add the batteries. Make sure they are fully plugged in
3.		Upon connecting the batteries, the charger displays the battery voltages and indicates “Connection OK”
4.		By pressing the **STOP/START** button (for channel 1 or 2), a menu of available charging profiles is displayed. Profile 00 - WingtraRay is marked per default. Next, press **Enter** to select the profile 00 - WingtraRay. Please note: Choosing any other profile will lead to abortion of the charging process.