

# Freefly Public

## Pilot's Operating Handbook

### Packing and Handling

-  Astro can become unbalanced and tip over when booms are folded individually. Move opposite pairs together to keep balance.

### Unpacking

Open legs until they click, if needed
Install payload, if needed
Unfold booms, and latch (they will click)
Remove prop protectors
Unfold propellers

### Packing

-  Astro fits in the hard case with payload attached and landing gear extended.

Fold propellers
Install proptectors
Unlatch booms
Fold booms

Remove payload (optional)

Fold legs (optional)

## Flight

### Pilot Handset

Astro ships with [Herelink](#) and is compatible with a [wide variety of control hardware](#). Each has unique inputs. See the documentation for the equipment you're using to become familiar with the buttons/switches involved.

### Arming and Disarming

Astro's propulsion system has two fundamental states: Disarmed and Armed.

State	Definition	Indication
Disarmed	Safe mode, no spinning propellers	Boom LEDS dim
Armed	Aircraft will spin propellers, ready to fly	Boom LEDs bright (100% or user specified level)

 Before arming, ensure people and other obstacles are clear of the propellers. Be prepared for Astro to take off.

Astro can be armed with or without GPS.

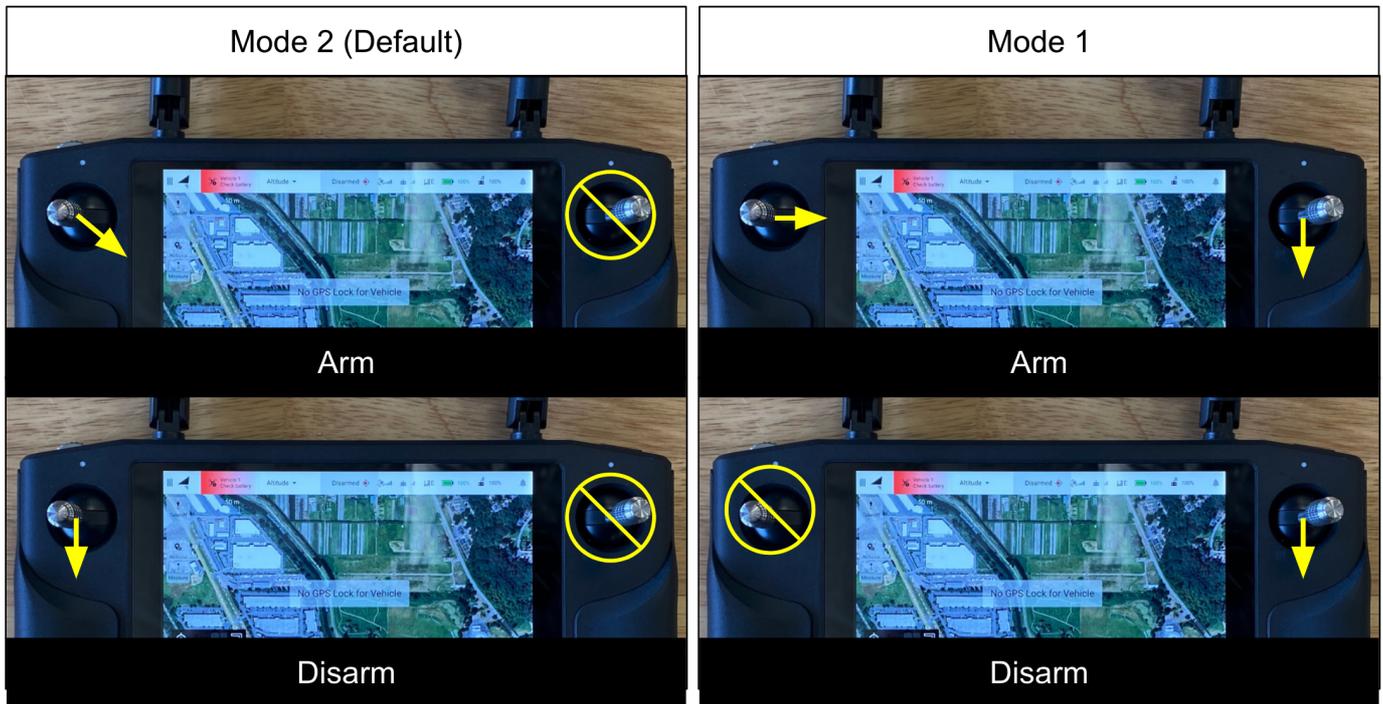
 Pro Tip: Wait for GPS lock even if you don't plan to use Position Mode because Return Mode relies on GPS.

### Normal Procedure

The manual method of transitioning between armed and disarmed state is via the pilot handset throttle stick. (The pilot's handset default configuration is [Mode 2](#).)

State	Input
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Arming (Mode 2)	Hold the throttle stick down and right for 2 second
Disarming	When the aircraft has landed, continue holding th throttle stick down for 2 seconds.



**i** It is not possible to disarm via the normal method while in flight. To disarm during flight, perform an [Emergency Stop](#).

**i** If Astro does not arm, check [Auterion Mission Control \(AMC\)](#) for errors or warnings.

Missions may Arm and Disarm the aircraft automatically. For example, if a mission is started while the aircraft is disarmed on the ground, the aircraft will arm and take off.

### Emergency Stop

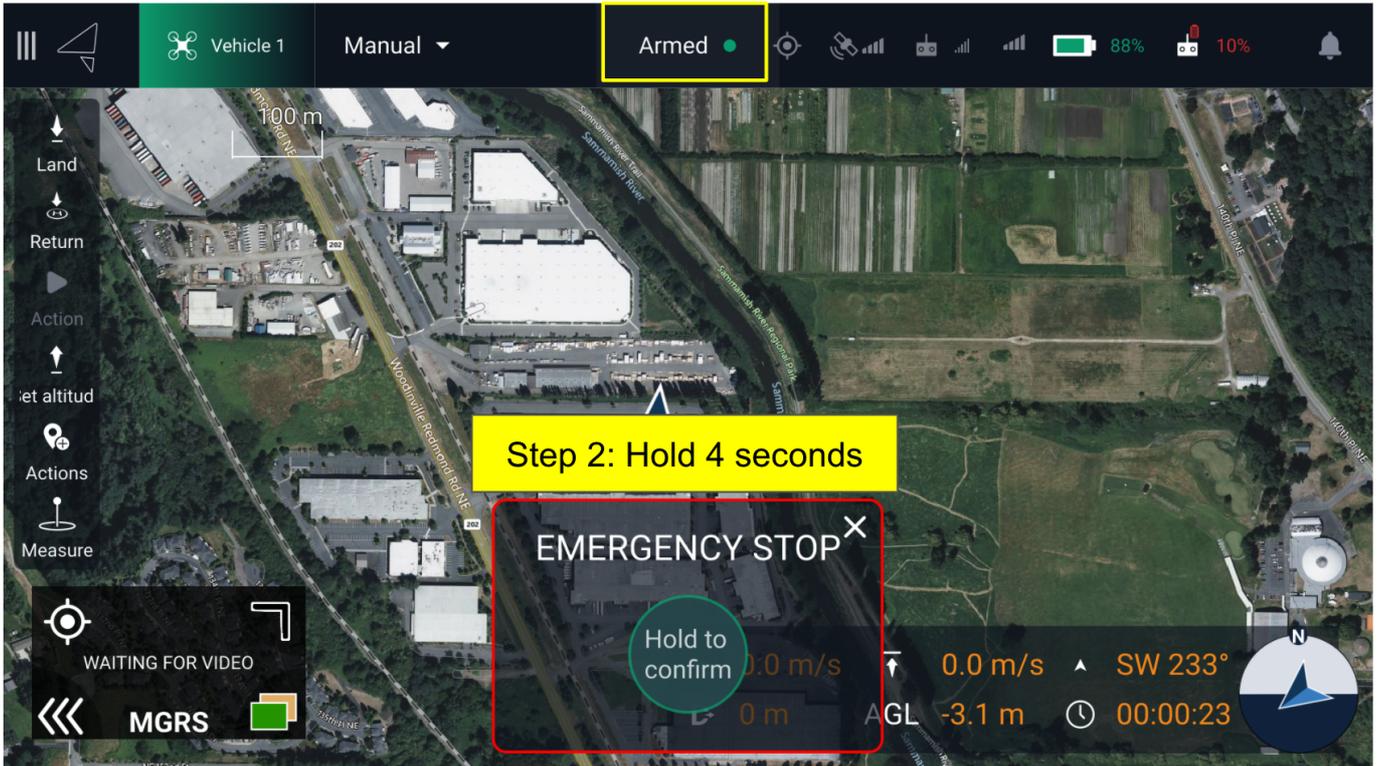
**⚠** Emergency Stop halts the motors immediately, even if the aircraft is in flight. This will cause loss of control and a crash.

#### Emergency Stop - AMC

In AMC Herelink or PC, tap the "Armed" button at top center to display the Emergency Stop dialogue. Hold the Emergency Stop button for 4 seconds. Works on Herelink or PC.

Step 1: Tap

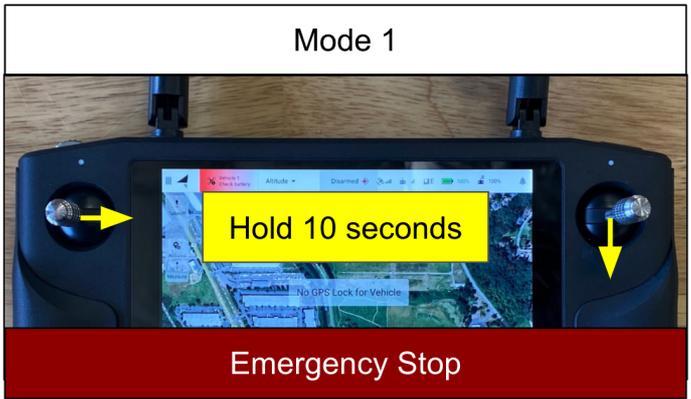
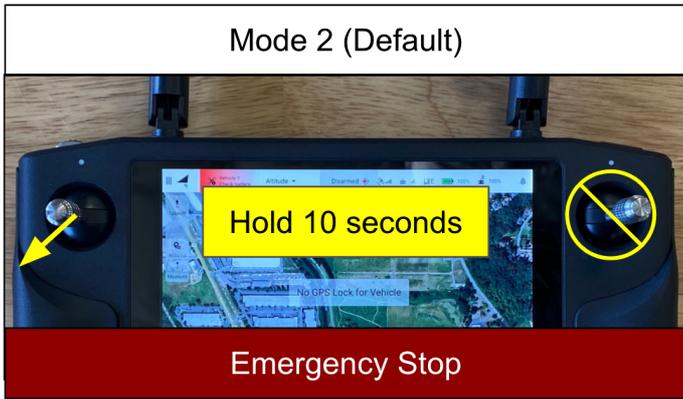
Step 1: Tap



Emergency Stop

Emergency Stop - Manual Override

In Manual Mode, hold throttle stick down and left for 10 seconds.



Advanced Arming Methods

Method	Input
AMC App, Herelink	Tap the Arm button (top center) and hold to confirm
Mission	If a mission starts with the takeoff command, and the aircraft is disarmed, the aircraft will arm itself when the mission is initiated.

**i** Arming via the AMC app in Manual Mode is not recommended. In Manual Mode, the aircraft should be armed while the throttle stick is held at the minimum position. This is difficult to achieve while using an app GIU.

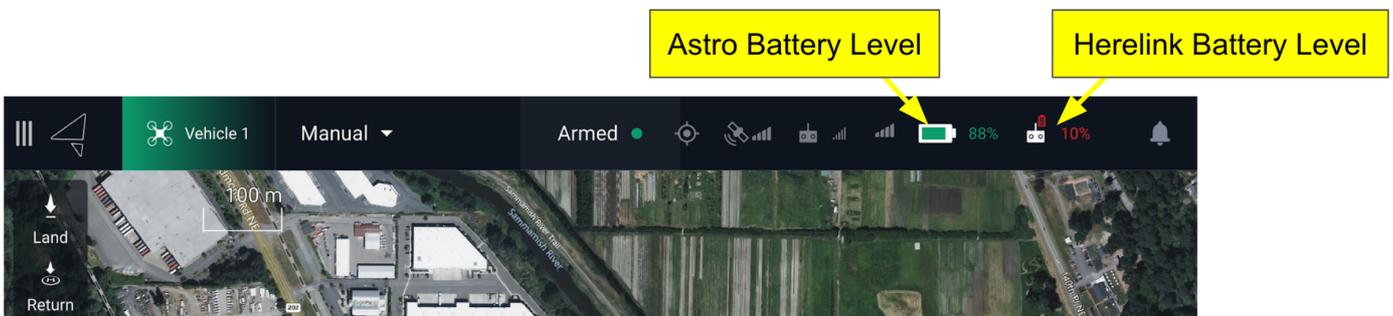
### Advanced Disarm Methods

Under these conditions, Astro will automatically disarm.

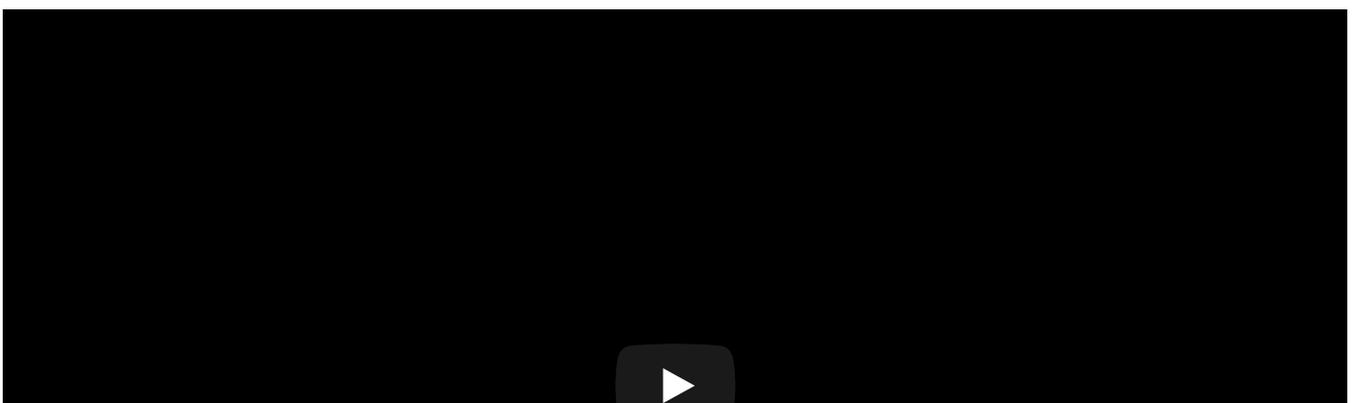
Method	Astro behavior
Ground timeout before taking off	If Astro sits on the ground at idle throttle for 10 seconds, it will automatically disarm.
Land mode	If Astro is in Land Mode, and detects a landing, it will disarm after 2 second. For example, this applies if the last command in a mission is "Land"

### Battery Level

The Herelink indicates battery level in the top menu bar.



### Flight Modes



Astro offers several flight modes, with various levels of assistance to the pilot.

Flight mode can be changed via the pilot's handset and the AMC app on Herelink or PC. See the documentation for the equipment you're using to become familiar with the buttons/switches involved.

 Manual Mode may be necessary to react to emergency situations. Pilots should be proficient in Manual Mode. Position, Altitude, and Return Mode are assistive only and are not a replacement for pilot skill and preparedness.

 Always neutralize the control input sticks on the pilot handset when switching between control modes to prevent unexpected aircraft movement.

## Position

In Position Mode, when the sticks are centered, the aircraft will maintain its position over a point on the ground and maintain altitude, correcting for disturbances.

In Position Mode, the pitch/roll sticks command ground speed. The further upward the pitch stick, the faster Astro will fly forward. When the pitch stick is pulled downward, Astro will fly backward. Similarly for roll in the left and right directions.

The throttle stick commands vertical speed. The further upward the throttle stick, the faster Astro will climb. Conversely, the lower the throttle stick position, the faster Astro will descend. Deflecting the throttle stick left and right controls yaw rate, with the speed of rotation proportional to stick deflection.

 Position Mode requires a strong GPS signal. If a weak signal is present, Astro will not enter Position Mode.

If the signal deteriorates, such as near buildings or under dense tree cover, the aircraft will automatically revert to Altitude mode.

 Flight using Position Mode in areas of degraded GPS signal, such as near buildings or under dense tree cover, is not recommended. The automatic reversion to Altitude Mode can cause unexpected, abrupt changes in flight behavior.

## Altitude

In Altitude Mode, when the sticks are centered, the aircraft will drift with the wind but will attempt to hold a constant altitude using the barometer and GPS.

In Altitude Mode, the pitch and roll sticks control aircraft angle. The further upward the pitch stick, the further Astro will tilt forward. When the pitch stick is pulled downward, Astro will tilt backward. Similarly for roll in the left and right directions. Lateral speed is not controlled by the autopilot.

The throttle stick commands vertical speed. The further upward the throttle stick, the faster Astro will climb. Conversely, the lower the throttle stick position, the faster Astro will descend. Deflecting the throttle stick left and right controls yaw rate, with the speed of rotation proportional to stick deflection.

**i** The aircraft holds altitude above Mean Sea Level (MSL) by default. It is not aware of terrain height changes or obstacles without additional configuration and equipment.

## Return

Return Mode commands Astro to climb to the Return Altitude, fly back to the Home Point in a straight line, and land. Return Mode requires GPS.

Return Altitude is set by the pilot at AMC > Vehicle Setup > Safety. Please note that if Astro is above the Return Altitude when Return Mode is initiated, it will maintain altitude instead of dropping to the return altitude.

The Home Point is set to the GPS coordinates where Astro is armed. Home Point is reset every time Astro is armed.

By default, Return Mode is activated automatically by some Failsafes. [Learn more about Failsafes.](#)

**!** Before every flight, think through the path the aircraft will take if Return Mode is activated, and adjust settings to arrange for safe behavior.

For example, activating Return Mode while flying under an obstacle lower than the Return Altitude will cause a collision when the aircraft attempts to climb to Return Altitude. In some cases, it may be possible to set a lower Return Altitude, and in other cases it may not be possible to use Return Mode.

**i** It is possible to change from Return to Position Mode by moving the sticks, except if Return Mode was activated by low battery failsafe. In that case, press another flight mode button to change out of Return Mode.

## Manual

In Manual Mode, when the pitch and roll stick is centered, the aircraft will attempt to remain level, and will drift with the wind. The aircraft will require constant throttle adjustment to hold altitude.

In Manual Mode, the pitch and roll stick controls aircraft angle. The further upward the pitch stick, the further Astro will tilt forward. When the pitch stick is pulled downward, Astro will tilt backward. Similarly for roll in the left and right directions. Lateral speed is not controlled by the autopilot.

The throttle stick controls motor speed directly. Deflecting the throttle stick left and right controls yaw rate. The speed of yaw rotation is proportional to stick deflection.

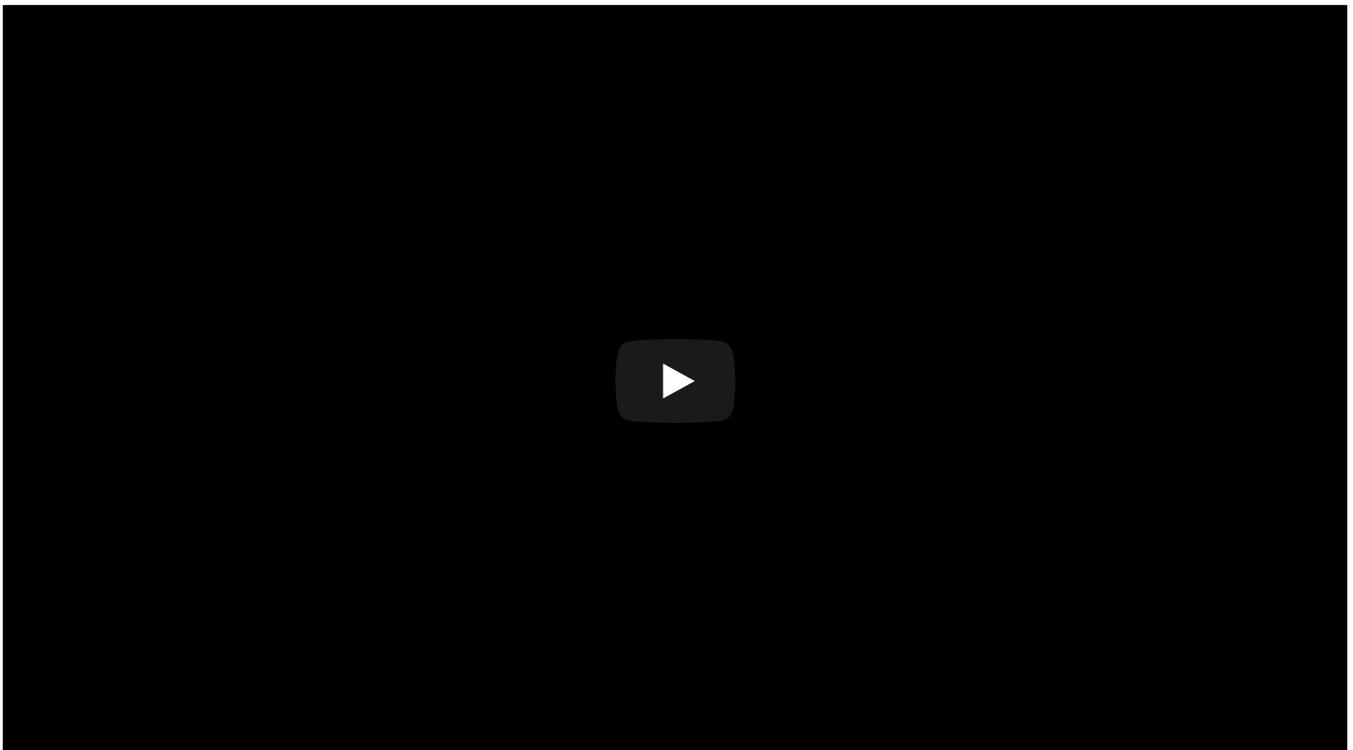
### Manual Mode Settings

The hover throttle setting controls how much thrust Astro produces the amount of thrust Astro produces when the throttle stick is centered. The default setting of 34% will hover the aircraft with for zero payload. A setting of approximately 40% will hover with 1500 grams of payload.

Adjust this setting by in AMC Herelink or PC:

1. Enable Advanced Mode (tap logo top left many times)
2. Vehicle Setup > Tuning

### Learn Manual Mode



See <http://freeflysystems.com/astro/training> for more videos.

### Mission

Mission mode allows Astro to execute a predefined autonomous waypoint missions that have been uploaded to the flight controller via AMC. For more information on all the different options and abilities built

into the Mission Mode, see the AMC docs, sections such as:

- [Planning a mission](#)
- [Flying a mission](#)
- [Remove a mission from the aircraft](#)

 Moving the sticks will cause a change to Position Mode. This makes it easy for the pilot to take control if needed.

 Astro must have a GPS lock before takeoff to set a valid home position in order to start a mission. Mission mode will be unavailable if the aircraft took off before GPS lock was achieved. Operator must land and rearm with GPS lock to enable.

## Takeoff

Takeoff Mode arms the aircraft, automatically climbs to the Takeoff Altitude, and enters [Hold Mode](#) (a.k.a. loiter or hover).

Takeoff Mode can be engaged via the button in the AMC app Fly view, optionally changing Takeoff Altitude via the slider, then holding/sliding to confirm. Takeoff Mode can also be engaged during a mission, for example as the first command.

 Takeoff Mode requires GPS lock.

 Moving the sticks while in Hold Mode (i.e. after the aircraft has finished climbing) will cause a change to Position Mode. This makes it easy to take control without pressing the Position Mode button.

## Land

Land Mode causes Astro to descend and land directly below the position where Land Mode is engaged. Once on the ground, Astro will disarm.

Land mode can be engaged via the button on the AMC app Fly screen and holding to confirm.

Land Mode is often the last command in a mission. Land Mode can also be engaged by a failsafe, such as low battery level, or loss of signal.

 Land Mode requires GPS, when engaged manually.

When Land Mode is engaged by a failsafe, and GPS is not available, the autopilot behavior will be similar to Altitude Mode and the aircraft may drift horizontally as it descends.

 Moving the sticks will cause a change to Position Mode, unless Land Mode is engaged by a Failsafe (e.g. critical battery level). See [Safety and Failsafes section](#) for more detail.

When activated by a low battery failsafe, Return and Land Mode cannot be overridden by stick movement. They can be overridden by pressing a flight mode button (e.g. Position).

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## Taking off

Position Mode is best for taking off in most cases, as it offers the most stabilization. However it is certainly possible to take off in Altitude , Manual, and Mission modes as well.

For 5 seconds after takeoff, the maximum pitch and roll angle is reduced to 12 degrees.

After takeoff, promptly climb out of ground effect (i.e. to 3 feet / 12 meters of altitude) to avoid snagging landing gear on the ground.

### in Position and Altitude Mode

After arming, allow the throttle stick to return to center. The propellers will remain at idle. When ready to take off, raise the throttle stick. The propellers will spin up and the aircraft will take off.

### in Manual Mode

After arming, hold the throttle stick down and centered. When ready to take off, raise the throttle stick slowly. The propellers will accelerate as soon as the throttle stick moves. As the throttle approaches the mid-point of, there will be enough thrust to take off. Continue raising the throttle to achieve a brisk takeoff.

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## Landing

Position Mode is best for landing in most cases, as it offers the most stabilization. However it is certainly possible to land in Altitude and Manual modes as well. The aircraft behaves a little differently in each mode.

 Do not hand catch Astro. The aircraft is designed to be landed on hard flat surfaces. Hand catching can result in serious injury or death.

In Position and Altitude Modes, at altitudes below 7 meters, the maximum vertical speed is reduced to 0.7 m/s (from the normal value of 2 m/s).

Astro will disarm automatically after the autopilot detects a landing. Landing detection brings together input

from several sensors to determine when it is safe to disarm.

⚠ If landing is not detected (i.e. the props do not stop after touchdown), perform the [Emergency Procedure for Landing Detector Failure](#).

### in Position Mode

Bring the aircraft to a hover > 2 meters over the spot where landing is desired. Pull the throttle stick straight down, without pitch, roll, or yaw commands. After touchdown, hold the throttle stick down until Astro disarms and the propellers stop.

At altitudes below 2 meters, maximum pitch/roll angle is reduced to 12 degrees. This prevents abrupt maneuvers that might cause a tipover.

⚠ Pitch, Roll, or Yaw commands very near the ground can cause crashes or tip-overs.

### in Altitude Mode

Landing in Altitude Mode is different than Position Mode because the pilot is responsible for managing lateral velocity. The autopilot will control the throttle to manage the descent rate.

Bring the aircraft to a hover > 2 meters over the spot where landing is desired. Give minimal pitch and roll commands to minimize both lateral speed and minimize pitch/roll angle. Pull the throttle stick down. After touchdown, hold the throttle stick down until Astro disarms and the propellers stop.

At altitudes below 2 meters, pitch/roll angle limits are reduced to 12 degrees degrees. This reduces likelihood of abrupt maneuvers that might cause a tipover.

### in Manual Mode

Landing in Manual Mode is different than Position or Altitude Mode because the pilot is responsible for managing vertical velocity as well as lateral velocity.

Bring the aircraft to a hover > 2 meters over the spot where landing is desired. Give minimal pitch and roll commands necessary to minimize both lateral speed and minimize pitch/roll angle. Reduce throttle to allow the aircraft to descend slowly.

As the aircraft nears the ground and enters ground effect, the pilot will often need to reduce throttle to keep the aircraft descending. Once touchdown is achieved, the operator should reduce throttle to zero promptly so that it settles on the ground instead of possibly bouncing or dragging the gear. Hold the throttle stick down until Astro disarms and the propellers stop.

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## Missions

The mission workflow includes planning (or selecting a pre-planned mission), uploading the mission to the aircraft, and flying the mission.

## Plan

Auterion Mission Control (AMC) Plan view facilitates mission creation and modification. [AMC documentation](#) covers the GUI and usage.

## Upload

Uploading sends the mission to the aircraft. This is done from AMC Plan view.

The aircraft can have one mission loaded at a time.

After upload completes, verify successful transfer by selecting Download and comparing the downloaded mission to the uploaded mission.

## Fly

Start missions from AMC Fly view. When a mission has been uploaded to the aircraft, AMC Fly view will show a prompt to begin the mission. If a prompt is not shown, open the [Action Menu](#) and select "Start Mission".

 Starting a mission can cause the aircraft to arm itself and takeoff without any further pilot input. Before starting a mission, ensure that the aircraft is clear of obstacles in the propeller arc and flight path.

If a mission is interrupted (for example by the pilot commanding a pause), the Fly view will prompt to resume the mission. If a prompt is not shown, open the [Action Menu](#) and select "Resume Mission".

 Moving the sticks will cause a change to Position Mode. This makes it easy for the pilot to take control if needed.

## Battery Changes

Battery changes require pilot action. Missions have no awareness of battery status. It is the pilot's responsibility to determine the appropriate time for battery change, and ensure the aircraft is on the ground before the batteries are exhausted.

The pilot may activate Return Mode or manually fly the aircraft to a place where a fresh set of batteries can be hotswapped in. To hotswap batteries, remove one discharged pack from the drone and replace it with a charged pack. Enable the pack by pressing the power button twice, then replace the other discharged pack. Enable the second charged pack if it does not show "Hotswap" on the battery display screen.

The pilot may also adjust the [Low Battery Failsafe settings](#) to activate Return Mode automatically at a level appropriate for the mission.

Upon landing, AMC will offer an option to "Resume Mission from Waypoint #". This will modify the mission by removing the waypoints already visited.

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## Tuning

Astro is pretuned by Freely, and can be flown without changes.

⚠ We recommend against changing low-level control parameters. Changes there could cause instability or control issues which could result in a crash.

ℹ [Loading default parameters](#) or known-good presets will allow you to quickly return Astro to a functional and safe state if there is ever uncertainty about changes to the tuning properties.

Changing low-level parameters requires activating [AMC Advanced Mode](#). Then, navigate to Vehicle Setup > Parameters.

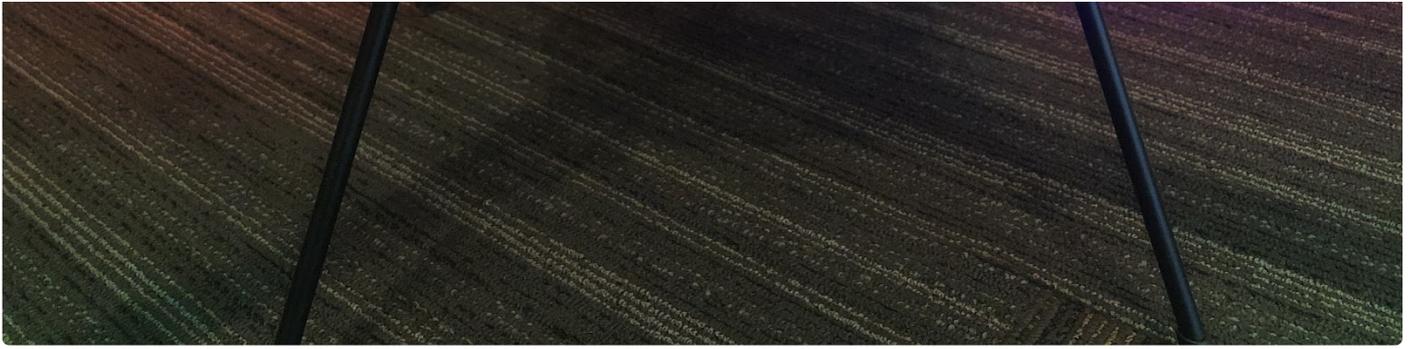
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## Status Indicator LED

There are 5 total status LEDs on the Astro. The 4 LEDs at the end of each boom show constant lights in most circumstances. By default, the rear two boom LEDs are red, and the front two boom LEDs are green. These LEDs will blink as the battery gets low, and blink quickly if there is an error.

The aircraft status indicator uses a multi-color LED to communicate aircraft status on the ground. It is located on the front-left boom of the aircraft, as pictured below in blue. See the table for complete information.





Color	Meaning	Detail
Solid Blue	Armed, No GPS Lock	Indicates vehicle has been armed and has no position lock from the GPS. Position, Mission and Return flight modes are not available.
Pulsing Blue	Disarmed, No GPS Lock	Indicates vehicle is disarmed and has no position lock from the GPS. Position, Mission and RTL flight modes will not be available until GPS lock is acquired.
Solid Green	Armed, GPS Lock	Indicates vehicle has been armed and has position lock from the GPS. All flight modes are available.
Pulsing Green	Disarmed, GPS Lock	Indicates vehicle is disarmed and has position lock from the GPS. All flight modes will be available.
Solid Purple	Failsafe Mode	Indicates an error has been encountered during flight and the vehicle will activate the Failsafe Action (Return To Launch by default).
Solid Amber	Low Battery Warning	Indicates a battery voltage below threshold.
Flashing Red	Error / Setup Required	Indicates an error, typically an issue with sensor calibration or autopilot configuration.

## Limitations

### Flight Control

For all flight modes except Manual, at altitudes below 2 meters, tilt angle is reduced to 12 degrees and vertical speed is reduced to 0.7 m/s.

The purpose is to prevent tipovers on landing, but has the side effect of reducing speed if flying below the takeoff point (e.g. surveying from a high vantage point). We are working to correct this behavior.

### Environment

#### Temperature

Ambient Temp (°C)	50				
	40				
	30				
	20				
	10				
	0				
	-10				
	-20				
			0	500	1000
		<b>Payload (grams)</b>			
Hot	Avoid hover or aggressive flight				

**Normal** Have fun!

**Cold** Keep batteries above 10 °C

Astro can operate between -20 and 50 C. Position mode and survey flying are normal throughout the range. However, care is needed to operate at low and high temperatures.

Yellow region: Hovering and aggressive flights may give overtemp warnings. Follow the warning instructions.

Blue region: If batteries become too cold, state of charge will decline quickly and aircraft will enter Return or Land mode. Keep batteries warm, above 10 °C at takeoff, then self-heating will keep them warm.

#### Tips for operating in hot environments

At high temperatures, the limiting factors are motor and battery temperatures. AMC will display a warning if the motors or batteries become too hot. Heed the warnings! Astro operates normally in forward flight up to 15 m/s with full payload of 1500 grams.

Cooling air is your friend. The motors get much more cooling air in forward flight than at a hover. Overheat errors may occur when hovering because there is less airflow, or when flying aggressively because heating increases with current.

Batteries may require cooling before charging. Bring an extra set of batteries and chargers to enable continuous flying. If you connect batteries to the charger while cooling, they will automatically begin charging as soon as they have cooled sufficiently.

Keep equipment out of direct sun, Herelink especially. Herelink will shut down if it overheats, and it does not give a warning.

#### Tips for operating in cold environments

At low temperatures, battery cell temperature is the limiting factor. When the cells themselves are below 10 °C (ambient air can be down to -20 °C), the built-in battery management system's (BMS) state of charge (SoC) algorithm has reduced accuracy. The SoC may decrease to zero suddenly. If this happens, [low battery failsafes](#) (RTL and Land) will be triggered, causing the aircraft to climb or descend suddenly.

These failsafes can be over-ridden by selecting another flight mode (over-ride by moving the sticks is not available during failsafe). The battery will not cut off power output in the air, however low temperatures generally reduce capacity which will reduce flight time.

If the batteries are 10 °C or warmer at the start of a flight, heating from discharge will keep them warm enough to fly.

To keep batteries warm, charge them in a heated environment and store them in an insulated container (a cooler works well).

#### Wind

In [high wind](#), Astro will give a warning.

Flying Astro in high wind is not advised. If the wind speed is a significant fraction of Astro's top speed, control authority will be diminished in all flight modes.

When Astro is not flying, fold the props and install protectors. If the wind blows through open props, it can cause them to spin up dangerously.

## Rain and Dust

Astro can operate in moderate rain (approximately 3 mm per hour). [USGS has a guide \(scroll to bottom\)](#) to help translate between forecasts like "shower" or "drizzle" to accumulation amount.

Battery connectors cannot be mated while wet or containing debris. We recommend compressed air to clean the connectors.

Tips for operating in Rainy and Dusty environments.

Rain in particular increases the risk of electrical malfunction because it can lead to short circuits

Dust carries a risk of mechanical malfunction because it can enter the motors and obstruct rotation.

Both of these conditions carry increased risk of malfunction and danger. It is difficult to judge the exact amount of precipitation, and the amount can vary without warning during the course of a flight. Therefore, we recommend avoiding situations that endanger people.

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## Radio Interference

Operating with a weak signal, whether due to interference or long range, can cause loss of link with the aircraft, which will engage failsafes. If you anticipate a weak signal situation, double check that failsafes are set appropriately.

### Range

Range is approximately 2 km in ideal conditions, no interference and the Herelink patch antenna pointed toward Astro.

Range can be reduced by radio frequency interference from other Astros or sources like wifi networks. Obstacles like trees and buildings dramatically reduce range.

### Multiple Aircraft

The Herelink controller as configured for Astro permits 4 aircraft to fly simultaneously in close proximity. If more aircraft are present, interference can cause loss of radio link and control.

## Systems

## Power

Power is provided by two Freefly SuperLight batteries. Learn more about SuperLight batteries in their wiki.

 Use only Freefly SuperLight batteries. Use of other batteries will likely cause damage to Astro and the batteries.

The aircraft evaluates battery level from the State of Charge (e.g. 72%), not voltage (e.g. 23 Volts).

The battery voltage bus runs between 18 and 25.2 volts. Connection to battery voltage is available via the [I/O panel](#).

In an emergency, the aircraft is capable of flying and landing safely on one battery.

It is not possible to power the aircraft via the USB-C port.

 Bench Mode: Astro will only arm (i.e. spin the motors) if 2 batteries are installed. When powering Astro for non-flying purposes (e.g. benchtop testing), connect only one battery.  
Bench mode is not a substitute for the absolute safety of removing propellers.

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## Motors, Drives, and Propellers

Astro features the F45 motor found on Alta 6 and 8 but with a larger 21 inch plastic prop. A larger prop was introduced to increase flight times given the lower nominal payload limit on Astro as compared to our larger drones.

The Freefly-developed motor drive is known internally as the Astro100 drive and is the fastest response field oriented control drive that we have ever tested. This response time is critical to achieving precise flight characteristics even with large props. The Astro100 drive can accelerate and decelerate the prop much faster than the original F45 drive used on Alta aircraft.

The props are 21" fiber reinforced plastic props which help lower vibration and and increase flight time.

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## WiFi

### Configure and Enable / Disable

1. Open AMC Herelink or PC
2. Power Astro

3. If using PC, connect to Astro with USB cable
4. Navigate to AMC > Vehicle Setup > WiFi

Wifi Mode	Function
Station	Astro connects to another wifi network
Access Point	Astro creates a wifi network. Other devices can connect.

### Connect to Astro via wifi

1. [Enable wifi and select Access Point mode.](#)
2. Enter SSID and password in the wifi settings of your device.

## LTE

### Configure and Enable / Disable

1. Open AMC Herelink or PC
2. Navigate to Vehicle Setup > Cellular

### Hardware Disable

Gain access the SIM via the [SIM card maintenance procedure.](#)

### Frequencies and Compatibility

At launch, the LTE modem will work in North America only. Other regions coming soon.

Region	4G LTE Bands	Radio Spec Sheet
North America	B2, B4, B5, B13, B17	<a href="https://www.sierrawireless.com/products-and-solutions/embedded-solutions/products/hl7588-accessory-board/">https://www.sierrawireless.com/products-and-solutions/embedded-solutions/products/hl7588-accessory-board/</a>
EMEA/Australia	Cat-4: B1, B3, B7, B8, B20, B28	<a href="https://www.sierrawireless.com/products-and-">https://www.sierrawireless.com/products-and-</a>

## Changing SIM / Service Provider

When switching SIM cards, try leaving the APN field blank. It should be automatically detected. If not, here are a few suggestions.

Carrier	APN
T-mobile	iot.tmowholesale, fast.t-mobile.com
Orange	orange.m2m.spec
Verizon	see: <a href="https://www.verizon.com/support/knowledge-base-46578/">https://www.verizon.com/support/knowledge-base-46578/</a>

In most cases, check the "Allow Roaming" box.

After changing the SIM, reboot both the aircraft and AMC.

## Onboard Computer

Processor: 1.8 GHz Quad Cortex-A53

Memory: 4 GB RAM

## Landing Sensor

The landing sensor is an IR Diode rangefinder with a range capability of approximately 9m.

This sensor is not appropriate for terrain following.

## Normal Procedures

## Checklists



Astro Checklists and EPs - v5.pdf 35KB

PDF

We also offer this checklist as a [Google Sheet template](#) to make customization easy. For example you might want to, add procedures for your payload or region. Maybe you want to change paper size or layout.

### Quick Checklist

Item	Action
Booms and Legs	Unfold and lock
Props and Motors	Check for free rotation
Payload	Install
Controller	Power on
Batteries	Latch and power on
Return mode	Set altitude
Fly!	

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## Sensor Calibration

It is not necessary to perform calibrations as a matter of course. Often a calibration will not be required even if the aircraft is relocated a long distance (e.g. by air travel). Compass handling in particular has been improved as compared to past PX4 implementations. For example, shortly after takeoff, the aircraft automatically performs a compass calibration.

In general, sensor calibration should be unnecessary. There are times when it may be required:

- If the magnetic field strength in the operating area is significantly different than where it was calibrated. If the aircraft appears to have the wrong heading on the ground, makes a large move after takeoff, or flies crooked for a few seconds, those are indicators you should do a compass calibration.
- If the drone has a significant ferrous or magnetic payload installed, it may be required to perform calibration with the payload installed to improve performance.
- If the operating temperature is very hot or cold, it may be required to do a gyro and accelerometer calibration to get best performance. In those cases, power on the aircraft and allow it to sit for 10 minutes in ambient conditions to allow the electronics to warm up, then do gyro and accel cal as directed by AMC. A warning about high accelerometer bias is an indication to do this.
- after doing a full parameter reset, it is usually wise to recalibrate.

Use AMC to calibrate the sensors. [See AMC docs](#) for the GUI details.

Mount your payload
Open AMC on Herelink
Mount Astro batteries and activate
Navigate to AMC > Vehicle Setup > Sensors
Follow directions in <a href="#">AMC docs</a> to calibrate sensors

## Emergency Procedures

### General Guidance

Human safety must be the top priority. Aircraft can be replaced. People cannot. Always prioritize the safety of yourself and others over the preservation of aircraft or equipment.

Emergency situations are dynamic events, that will not often conform perfectly to the categories listed below. A thorough understanding of aircraft systems, proficiency in piloting the aircraft, and sound judgment will allow you to bring about the best possible outcome in an emergency.

The likelihood of an emergency can be reduced substantially through [proper aircraft maintenance](#), use of [checklists for normal procedures](#), and careful pre-flight planning. The likelihood of a safe flight often depends on the diligence of the pilot, both before taking off and during operation.

In general, if an emergency occurs, three basic actions can be applied to most situations:

1. Maintain aircraft control — Small emergencies can quickly escalate if the pilot is distracted attempting to troubleshoot the problem. Always maintain visual contact with the aircraft during an emergency to reduce the likelihood of losing orientation.
2. Analyze the situation — Once the aircraft is stabilized, assess the cause of the emergency.
3. Take appropriate action — In many cases, the appropriate action will be to land the aircraft as soon as possible.

### Return Mode

Do not be over-reliant on [Return Mode](#) in emergency situations. The cause of the emergency may degrade performance or disable Return Mode. For example, loss of GPS disables Return Mode.

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## Error and Warning Indication

The aircraft communicates the presence of errors and warnings primarily through Auterion Mission Control

(AMC) [status indicators](#) on Herelink or PC. Many messages are accompanied by an audible message (e.g. "Return Flight Mode"). Additionally, Astro boom LEDs will flash when the battery level is low.

Status messages, including errors and warnings, are stored in Flight Logs. After any emergency, review the log to determine the source of the problem.

If the meaning of an error or warning is not clear, please [contact Freefly Support](#). Share as much detail as possible, including [sharing the flight log](#).

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## Checklists

The [Astro checklists](#) contain emergency procedure checklists.

Some situations are discussed in more detail below.

### Loss of Orientation

If orientation is lost, neutralize inputs and activate position mode. Then work to identify the front of the aircraft.

We recommend identifying the front of the aircraft via a "guess and check" method of small roll right inputs alternating with yawing the aircraft 90 degrees at a time. We recommend a roll input rather than pitch because at a distance it is easier to see lateral motion than fore/aft motion.

If it is not possible to identify orientation, and it is safe to activate Return Mode, do so. By default in Return Mode, after climbing, the aircraft will yaw to put the front toward the direction of flight.

Resume flying or land as necessary.

### Unexpected Aircraft Behavior

If Astro behaves unexpectedly, do the following: neutralize inputs, activate Position Mode, and observe the aircraft. If it is still flying in an uncommanded manner in Position or Altitude Mode, switch to Manual Mode.

In some cases, unexpected behavior is due to degraded GPS signal or erroneous sensor readings (e.g. compass error). In such cases, Return Mode may not behave reliably. Manual Mode does not rely on these sensors.

Land as soon as possible.

### Landing Detector Failure

If the aircraft touches down, but hops back up into the air several times, or sits on the ground with the props continuing to spin, the autopilot may not have detected a landing. Climb and retry landing with a greater downward velocity.

 Landing the aircraft firmly will give the accelerometers and gyroscopes a sufficient contrast between flight and landing.

If landing is unsuccessful in Position and Altitude mode, land in Manual Mode.

If landing is unsuccessful in Manual Mode, perform an [Emergency Stop](#) with the aircraft on the ground or as close as possible.

TODO: Check flight > landing section. Does it explain how landing is detected?

## Loss of GPS

If GPS is lost, flight modes that rely on GPS (Position, Return, Mission, etc) will not be available. If the aircraft is in one of these modes when GPS is lost, the autopilot will switch to Altitude Mode.

 It is the pilot's responsibility to be proficient with Altitude and Manual Mode, and to have the aircraft configured to behave safely if GPS is lost.

Examples of behavior without GPS:

- If GPS is not available upon arming, no Home Point is set, and Return Mode is not available. Even if GPS becomes available while flying, Return Mode will not be available.
- If the pilot commands Return Mode, the aircraft will remain in Altitude or Manual Mode, and an error will be displayed on the pilot handset.
- If Land Mode is activated (e.g. by a failsafe), the aircraft will descend as though in Altitude mode, maintaining level attitude but drifting with the wind. (Land mode cannot be activated by the pilot because Land Mode requires GPS).
- If GPS is lost during a mission, the aircraft will display a warning and switch flight mode to either Altitude Mode or Manual Mode, depending on the degradation of the signal.
- If GPS is providing altitude information (e.g. while using RTK GPS), and GPS is lost, the ability of Altitude Mode to accurately maintain altitude may be affected.

## RC Loss of Signal (LOS)

RC Loss of Signal (LOS) can occur if the pilot handset signal is degraded or stops, or if Astro does not receive the signal due to distance or interference (e.g. from obstacles or other radio signals).

If the signal is lost longer than the RC Timeout, a failsafe action will be triggered. The RC Timeout is quite short by default: 0.5 seconds. The pilot may not have time to react before the the failsafe action is activated. The failsafe action by default is Return Mode.

If the signal is lost, check pilot's handset power and [antenna orientation](#). Antenna orientation is especially important when Astro is far from the pilot.

If the signal is recovered, the pilot will be able to take control via moving the sticks or pressing a flight mode button.

 RC Loss of Signal (LOS) is differentiated from Data Link Loss. LOS refers to the stream of SBUS

data containing the pilot's inputs. Data Link refers to the stream of MavLINK messages. Astro routes both data streams through a single radio system. Please note that the AMC app needs to be in the foreground on the Herelink during operation; Data Link will fail after 30 seconds and trigger a failsafe if the AMC app is closed or running in the background.

## Loss of Video Signal

Loss of Video Signal can occur if the aircraft flies out of range or if it flies behind an object that interrupts the signal. Maintaining visual contact is the preferred method to re-establish control of the aircraft, either with the pilot seeing the aircraft, or by the use of a visual observer.

Yawing the aircraft can help signal reception if the body of the aircraft is blocking the line of sight between the transmitter and receiver antennas.

If video signal or visual contact cannot be re-established, enable Return Mode to bring the aircraft back to signal reception range.

 It is the responsibility of the pilot to see and avoid other aircraft, people, or obstacles. Always maintain direct line of sight with Astro during flight, use visual observers as operations require, and follow local regulations regarding see-and-avoid requirements.

## Emergency Stop

As a last resort, if it is not possible to land or control the aircraft, perform an [Emergency Stop](#). If performed while flying, this will cause the aircraft to crash. Perform the Emergency Stop as far away from people as possible.

 Emergency Stop is a last resort. It will cause a loss of control and a crash.

## Failsafes

Failsafe behavior and settings are configured in AMC. The [AMC documentation](#) covers each failsafe and related settings in detail.

Some failsafes are discussed briefly below.

 We strongly recommend using the default settings, changing only Return Altitude, unless you are an expert user and have tested the effect of changes thoroughly.

## Low Battery

Battery level is evaluated from the State of Charge (SoC, e.g. 72%), not voltage (e.g. 23 Volts).

As the battery level becomes low, the autopilot can take action. The default settings do not interfere until the battery becomes quite low. Additionally, low battery failsafes have no knowledge of the aircraft's position or distance from the Home Point. This means it is the pilot's responsibility to be aware of the battery level and ensure the aircraft is on the ground.

State	SoC (default)	Action (default)
Warning	20%	Warning: Flash boom LEDs
Critical	15%	Return Mode
Emergency	6%	Land Mode

**i** When activated by a low battery failsafe, Return and Land Mode cannot be overridden by stick movement. They can be overridden by pressing a flight mode button (e.g. Position).