# Lynx M

## Unmanned Aircraft System

## Aircraft Flight Manual

www.SRP.aero

# Record of Revisions

| | |
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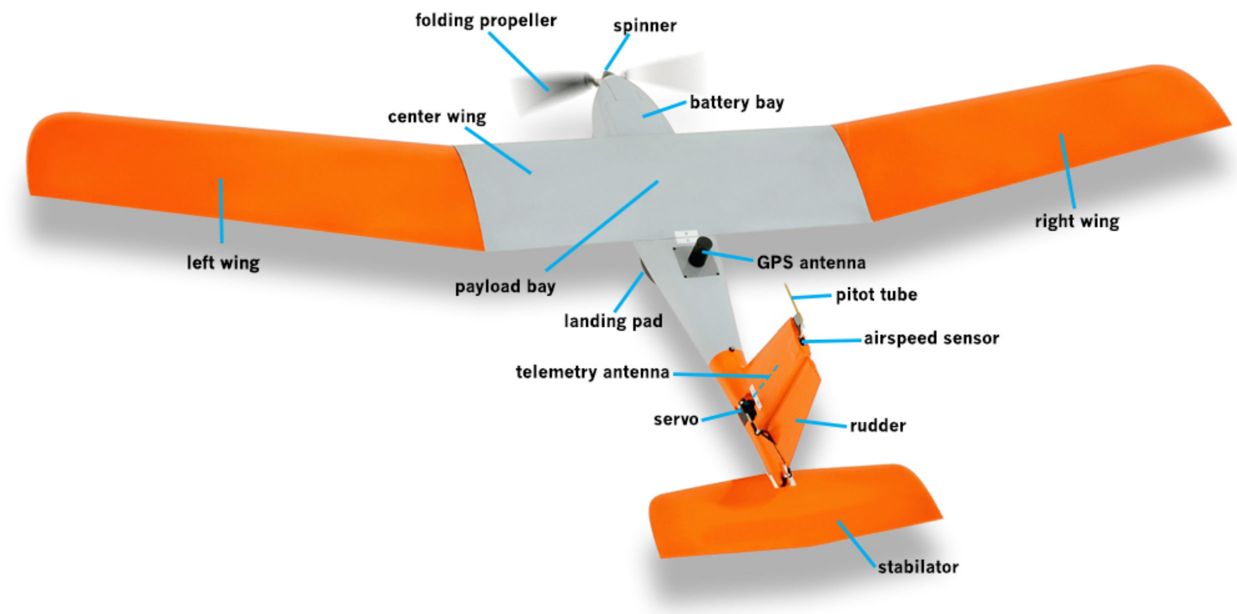
# Table of Contents

# Section 1: General Information and System Description

## Lynx

Lynx is a hand-launched UAS designed for aerial surveying and mapping.




### Airframe

Lynx weights 2 kg without battery or payload and has a 2.3 meter wingspan. The airframe consists of five major parts:

- Fuselage
- Stabilator
- Center Wing
- Right Wing
- Left Wing

The fuselage, wings, and stabilator are constructed of Kevlar over a foam core. Foam landing pads are fitted beneath the fuselage to absorb energy for deep-stall landings. The main airframe components are assembled without tools. Spare parts and sub-components can be replaced in the field using basic tools, supplied in the aircraft's tool kit.

### Flight Control Surfaces

Lynx uses only two control surfaces: a rudder and stabilator. The rudder is a vertical control surface used to roll and yaw the airframe left and right. The stabilator is used to pitch the airframe up and down in order to climb or descend to a desired altitude. For the deep-stall landing, the stabilator will deflect upward, beyond what is used for normal flight, to induce a deep-stall. Both control surfaces are actuated by servo motors.

## Propulsion System

The propulsion system consists of the flight battery, brushless motor, electronic speed controller (ESC), and propeller assembly. The propeller folds back to prevent damage upon landing and is also folded for transport. Lynx uses a high density, rechargeable 9Ah 6S lithium ion (Li-ion) battery. The battery is paired as two 9Ah 3S packs to comply with airline and shipping regulations. Operating voltage is 16.2 to 25.2 volts.

## Takeoff and Landing

Lynx uses a hand launch takeoff. The takeoff is autonomous and activated by pressing the takeoff button on the fuselage to apply full throttle for launch.

The landing is called a deep-stall and enables flights from confined areas. Specifically, a deep-stall is a near-vertical descent caused by deflecting the stabilator upward while in flight to roughly 45 degrees. During the descent, throttle is reduced to zero and pitch is locked at the deep-stall angle. Lynx is steered during the descent by the autopilot or by the safety pilot if landing manually. Unlike a parachute, the deep-stall can be aborted to resume flying as needed.

The wings and stabilator are designed to separate from the fuselage upon touchdown. This is done to minimize damage by dissipating energy when landing on a hard surface. In extraordinary landings, certain breakaway spare parts are designed to fail to prevent damage to airframe components.

## Avionics

Lynx uses the Pixhawk autopilot, running the ArduPilot flight stack. The autopilot contains the following sensors:

- 3-axis gyroscope
- 3-axis accelerometer / magnetometer
- 3-axis accelerometer / gyroscope
- Barometer
- Secondary 3-axis magnetometer
- GNSS
- Digital airspeed

## Payloads

Lynx can carry a variety of swappable cameras. Cameras are triggered inflight by the autopilot while flying a survey mission.

## Communications Equipment

Lynx utilizes two control frequencies. The safety pilot’s controls are transmitted with a handheld transmitter on 2.4 GHz (RC Link). A two-way data radio on 915 MHz is used for communication between the ground control station (GCS) and the aircraft.

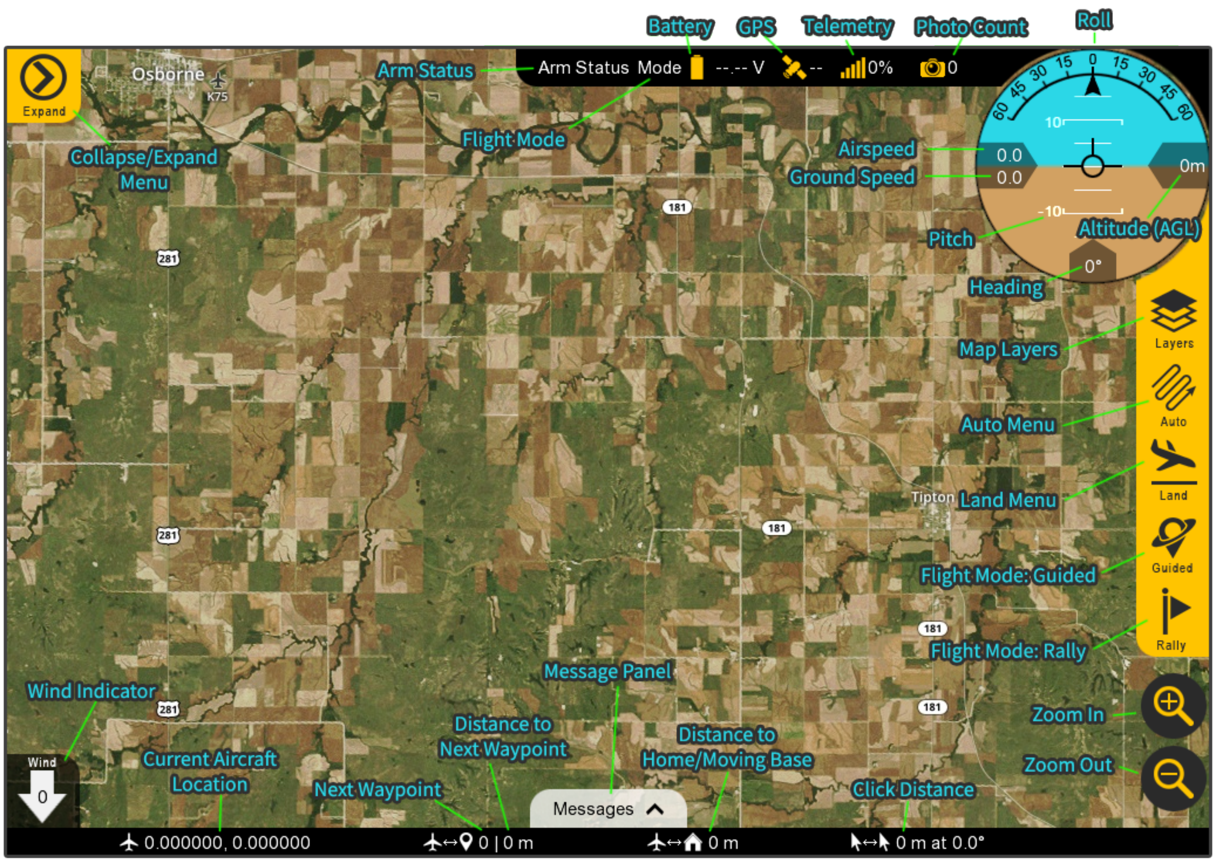
# Swift GCS

The ground control software used with Lynx is Swift GCS. Swift GCS is the operator's interface to the aircraft. Using the GCS, the operator configures the aircraft for flight, plans the mission, uploads/downloads waypoints from the autopilot, and monitors aircraft status and position. Swift GCS is designed to work with touch screen laptops and tablets for improved field use. Standout features include a built-in preflight, point and click waypoint navigation, automatic survey grid generation, built in geo-tagging, support for KML importing (Google Earth overlays), and terrain visualization.

BETA DISCLAIMER: Swift GCS provides a greatly enhanced operational experience with Lynx when compared to the other GCS options available, but it is still in beta testing. If you encounter crashes, bugs or have a feature request please contact support@srp.aero

## Information Displays

Swift GCS has five major displays in addition to the moving map: a Heads-Up Display (HUD), an expandable messages panel, top status bar, bottom status bar, and wind indicator. The HUD displays aircraft attitude information similar to manned aircraft. The messages panel display will show both messages from the autopilot, such as a change in flight modes, and warnings. Active warnings will be highlighted in red. If the warnings panel is collapsed when a new warning activates, it will automatically open. The top status bar displays GPS, telemetry, flight battery, and camera information. The bottom status bar displays the aircraft's current location, distance to the next waypoint, distance from home, and the distance between a user's last two clicks.



## GCS Units

Units of distances and altitudes displayed in Swift GCS are in meters unless otherwise noted as kilometers. Velocities (airspeed, ground speed) are in meters per second (m/s).

## Preflight

Swift GCS features a built-in checklist that guides the user through the preflight process. This is done with a series of manual and automated checks. Each preflight step features an optional expanded information section to help new users and display relevant information.

## Mission Planning

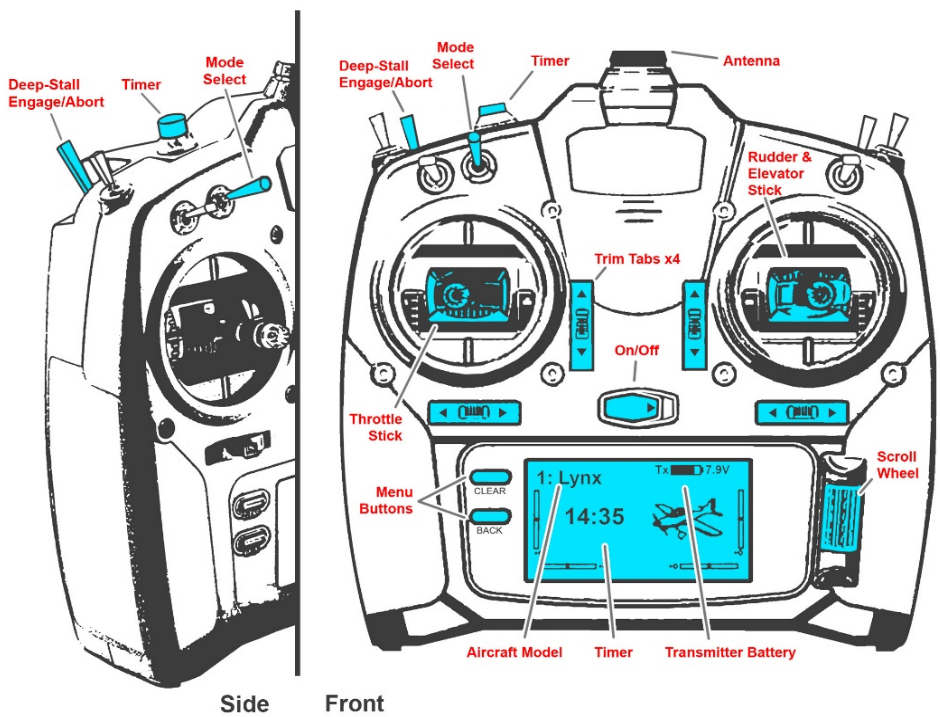
A large portion of the preflight revolves around mission planning. This is done by creating waypoints that the aircraft will fly to or actions to be performed. Waypoints are uploaded to the autopilot via the telemetry radio and can also be uploaded while in flight if a mission needs to be adjusted.

## Moving Base

Swift GCS is capable of reading the GPS position from a GPS equipped laptop or tablet and displaying it on the map. This is referred to as moving base and can be quite useful for situational awareness while in the field, especially if are moving around. If moving base is enabled, your position will be indicated on the map with a pedestrian icon. The bottom status bar will now indicate the distance the aircraft is from the base, rather than the distance from home.

# Handheld Transmitter

The handheld transmitter is used to fly Lynx manually or in an autopilot assisted flight mode. Additionally, it is used for the following: preflight checks, changing autopilot modes, initiating or aborting a deep-stall landing, steering during a deep-stall landing, and stopwatch timer.



# Navigation Control

Lynx can be controlled in two ways: manually or under autopilot control. The safety pilot determines who is in control with a mode switch on the handheld transmitter and can therefore override the autopilot in flight if desired. Manual control bypasses the autopilot and allows for full range of aircraft movement. In autopilot controlled mode, the autopilot is navigating and commands are sent with Swift GCS.

## Changing Autopilot Modes

Default autopilot modes on the handheld transmitter are set to auto and rally. In addition to changing autopilot modes using the handheld transmitter, users can also change modes with Swift GCS. However, the mode cannot be effectively changed if the transmitter is set to manual.

| | Mode Switch (down position) | Mode Switch (middle position) | Mode Switch (top position) | Manual Deep-Stall |
|---|---|---|---|---|
| **Flight Mode** | Manual | Rally | Auto | n/a |
| **Who's in Control** | Safety Pilot | Operator | Operator | Safety Pilot |
| **Result** | Manual Control | Autopilot Control | Autopilot Control | Manual Steering |

# Safety Devices

Lynx is fitted with a variety of safety devices to protect crew members on the ground and the aircraft inflight.

## Throttle safety key

The throttle safety key adds an extra layer of protection against propeller strikes during preflight. The key, located on the left side of the fuselage, will prevent the motor from spinning when inserted. This will stop throttle commands from both the safety pilot and autopilot. When the key is removed, a red light will illuminate on the side of the fuselage and the motor will emit an audible arming tone. The motor will only arm with zero throttle commanded prior to removing the key. Always reinsert the safety key before setting the aircraft down. **As with any safety device, nothing can replace safe equipment handling. Always keep the throttle down on the handheld transmitter unless needed.**

## Arming Checks

Lynx is armed as a preflight step. Arming gives the autopilot the authority to command throttle. You will only be able to arm if the aircraft passes a list of onboard sensor checks.

## Takeoff Button

The auto takeoff is activated by pressing the takeoff button on the fuselage after the aircraft is armed. Pressing the takeoff button will only apply throttle if the autopilot is armed and the safety key has been removed. Conversely, pressing the button again will stop the motor if you want to abort the takeoff. Always reinsert the safety key before setting the aircraft down.

## Battery Monitor

The battery monitor displays the flight battery voltage and reports it to the GCS allowing the operator to determine when to land.

## Manual Control
Lynx provides pass-through manual control of flight surfaces via a dedicated IO processor. This allows the safety pilot's inputs to bypass the main autopilot outputs and control loops. If the main autopilot locks up or loses power, the IO processor is powered independently and will allow the aircraft to be flow manually.

## Low Voltage Cutoff and Current Limiter
The ESC has a low voltage cutoff and current limiter that limits the flight battery from being overly discharged.

# Failsafes

## Rally
There are several failsafe mechanisms present on Lynx that will automatically activate to return the aircraft to a specified location. All failsafes will change the flight mode to rally regardless of what the previous flight mode was. Once in rally mode the aircraft will proceed to the nearest rally point that is within 5km, or proceed to the home location. If using a rally point, the aircraft will try to climb or descend enroute to the rally point's altitude. Alternatively, if heading towards home, the aircraft will fly to an altitude of 100 meters above home.

## Battery Failsafe
A battery failsafe will activate once the flight battery has been below 16.7V for more than 5 seconds. This gives the operator a very small margin (approximately 5 minutes) to land the aircraft while remaining within safe battery margins.

## GCS failsafe
A 'GCS failsafe' will activate if the aircraft has not received any data from the GCS within the last 20 seconds. The GCS failsafe will cause the aircraft to enter the rally flight mode, thereby moving the aircraft closer for better radio signal.

## RC Failsafe
Loss of the safety pilot's (RC) link will activate the RC failsafe if the aircraft was in any flight mode other than manual. The failsafe timer can be configured in Swift GCS settings. RC failsafe will cause the aircraft to enter the rally flight mode. If the safety pilot is under manual control and RC link is lost, the failsafe action will cause the aircraft to immediately circle in place until the 20 second window has expired - at which point it will transition to rally.

# Section 2: Performance and System Limitations

| General | |
|---|---|
| **Wingspan** | 2.3 m |
| **Propulsion** | Electric |
| **Empty Weight** | 2.0 kg |
| **Battery Weight** | 1.0 kg |
| **Max Payload** | 0.7 kg |
| **Maximum Gross Takeoff Weight** | 3.7 kg |
| **Center of Gravity Limits** | -6.0 to -9.5 cm (center wing leading edge datum) |
| Performance | |
| **Cruise Speed** | 16 m/s |
| **Never Exceed Speed ($V_{NE}$)** | 22 m/s |
| **Stall Speed** | 9 m/s |
| **Endurance** | Up to 180 min (with Sony a6000 payload) |
| **Range** | Line-of-sight (LOS) |
| Takeoff | |
| **Takeoff Method** | Hand launch |
| **Auto Takeoff Climb Angle** | 15 degrees |
| **Distance to clear 18 meter obstacle** | 60 m (with 5 m/s headwind) |
| **Distance to clear 50 meter obstacle** | 150 m (with 5 m/s headwind) |
| Landing | |
| **Landing Method** | Deep-stall |
| Electrical | |
| **Fully Charged Battery** | 25.2 volts (4.2v per cell) |
| **Low Battery Voltage** | 16.2 volts (2.7v per cell) |
| **ESC Cutoff Voltage** | 15.0 volts (3.0v per cell) |
| **Battery Charge Limit** | 5 Amps |
| **Battery Discharge Limit** | 3C burst |
| **Safety Pilot (RC) Frequency** | 2.4 GHz |
| **Telemetry Frequency** | 915 MHz |
| Environmental | |
| **Wind Limitation** | 12.8 m/s (25 knots) |
| **Precipitation** | None |

## Prohibited Maneuvers:

- Launch or landing with any tailwind
- Flight into known icing conditions
- Flight into visible moisture
- Flight beyond safety pilot’s visual line-of-sight (LOS)
- Flight beyond telemetry link

# Section 3: Getting Started

This section explains how to install the required software and the recommended configuration.

## Swift GCS

The current version of Swift GCS and this manual can be found at: https://srp.aero/getting-started-lynx-m

Swift GCS will notify you when a new version is released if you are connected to the internet on startup.

## Install Swift GCS

You will be asked for a license key during installation. Each Lynx system includes one license key which may be activated two times. Without a key, the GCS will run in free mode which only supports uploading 15 waypoints.

## Updating the Autopilot Firmware

Due to the large number of changes that can happen with an autopilot firmware update, it is recommended to wait for a new release to be tested first by SRP. Any required changes in parameters will be noted with the parameter updates as well as any expected behavior changes. You will be automatically notified by the GCS when you should update firmware on the autopilot.

# Section 4: Mission Planning

## Survey

To create a mapping mission, a survey grid will need to be created in Swift GCS. Select the Survey button from the Mission tab to add one. You will be prompted to load a KML (or KMZ) file or to draw a new area by placing polygon points on the map. Polygons that you create in Swift GCS can be saved for future use. The survey grid makes all calculations based off the camera you selected during the preflight. Adjusting the flight altitude will allow you to change the ground sampling distance (GSD), or simply put, the imagery resolution.

Reaching the start of a survey will cause the camera to begin taking photos. The camera will continue to take photos until the last waypoint in the survey is reached. If you need to land before a survey is complete, the camera will continue taking photos until on the ground. This is fine, but those photos may need to be deleted before processing.

Settings for the survey mission can be modified by expanding the survey item in the list of waypoints.

### Altitude

Altitude should be set based on the resolution requirements for your mission. It is critical to also account for safety factors such as surrounding terrain, air traffic, and local regulations. Flying higher will always increase your ground coverage vs. time but at the expense of reduced resolution.

### Heading

Adjusting the heading control the direction of the flight legs. Flight legs should be perpendicular to the prevailing wind (crosswind). This will cause the aircraft to crab inflight but will result in a consistent ground speed from one flight leg to the next. A headwind/downwind scenario will cause the aircraft to have a slow ground speed one direction, and a high ground speed in the other direction. A high ground speed may cause motion blur in the imagery. Additionally, if the ground speed is high enough, the camera will be unable to take photos quickly enough which will result in missing photos.

You will be able to choose what side of the polygon the aircraft starts at with the Swap Start button. When possible, choose the starting position that will cause the aircraft to turn upwind. The result will be tighter turns between flight legs.

### Overlap and Sidelap

Adjusting the overlap and sidelap percentages will control the number of photos that contribute to your mosaic for a given spot on the ground. Overlap controls the distance between photos along a flight leg. Sidelap controls the distance between photos from one leg to the next. The default numbers are 75% overlap and 70% sidelap. The starting numbers should be kept if you are uncertain of the settings, or if you are flying over hilly or forested areas. In areas of flat terrain, it is possible to safely lower these numbers. Doing so will allow you to cover more ground and reduce the amount of data to process. Never reduce the percentages below the minimum required for your imagery processing software.

### Lead In and Overshoot

Lead in and overshoot are utilized to make sure that the aircraft is turning around outside the area of interest being mapped. The default values of 110 meters lead in and 150 meters overshoot are suitable for Lynx in most cases.

### Statistics

Survey statistics will display information about your survey and polygon. The field of view (FOV) is the cameras footprint at the survey mission altitude. The photo estimation is the number of photos you can expect the camera to take during the survey; that number should be below what the camera's SD card can store. Lines is the number of flight legs. Distance is linear distance of each flight leg, excluding turns. Time is the estimated duration to complete the survey. Note that the time estimate is based on a zero wind situation. High winds increase the time required to complete a mission because the aircraft's ground speed is reduced overall. Area is the polygon's area in square kilometers.

## Rally Points

Rally points are used to control where the aircraft will go given if the following happens:

- If the mission is completed, or
- If mode rally is commanded, or
- If the aircraft loses link with the GCS long enough to trigger the failsafe.

The aircraft will proceed to the nearest rally point within 5 km.

Rally points should be placed at safe locations that will be close enough to you to regain link in the event of a failsafe.

## Guided Points

The guided flight mode is essential a 'fly here' mode. Guided allows the operator to specify a location and altitude to loiter at. Guided is the operator's primary way of moving Lynx dynamically. It is used for setting up landing patterns, interrupting a mission, or to avoid other traffic.

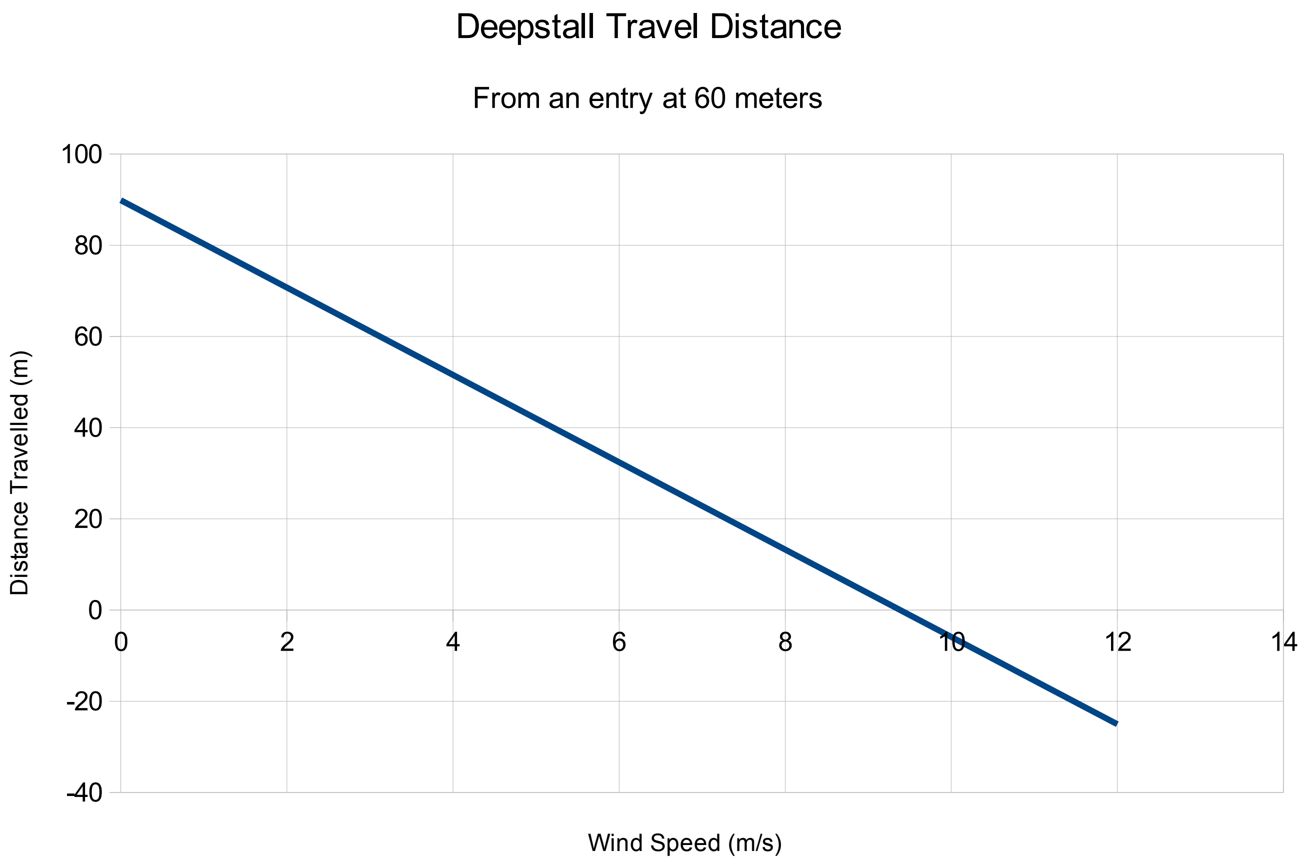
To enter guided, select the Guided button from the right hand side of the map and then tap the point on the map where you wish to fly. The GCS will then prompt you to confirm the altitude and the desired loiter direction.

To change the guided spot simply drag the guided icon on the map. The altitude can be adjusted by tapping guided again and adjusting the altitude or direction and then select the Update button.

# Section 5: Deep-Stall Landing

## What is a Deep-Stall?

A deep-stall landing is a controlled, near vertical descent to the ground in which the wing is completely stalled and creates drag instead of lift. The angle at which the aircraft descends will vary based on the winds. A wind speed of around 9 m/s will result in a nearly vertical descent. Less wind will shallow the descent, higher winds will cause the aircraft to actually travel backwards from a ground perspective. Zero wind will still result in a relatively steep 40 degree landing.



# Landing Options

A deep-stall can be performed automatically or manually. In an automated deep-stall, the operator chooses where the aircraft should land on the map in Swift GCS. In flight, the aircraft will fly the entire approach and landing using the aircraft's wind estimation to pick an optimal path.

With a manual deep-stall, the safety pilot needs to determine the wind direction and then choose when and where to begin the landing. Once initiated, the safety pilot steers the aircraft during the descent.

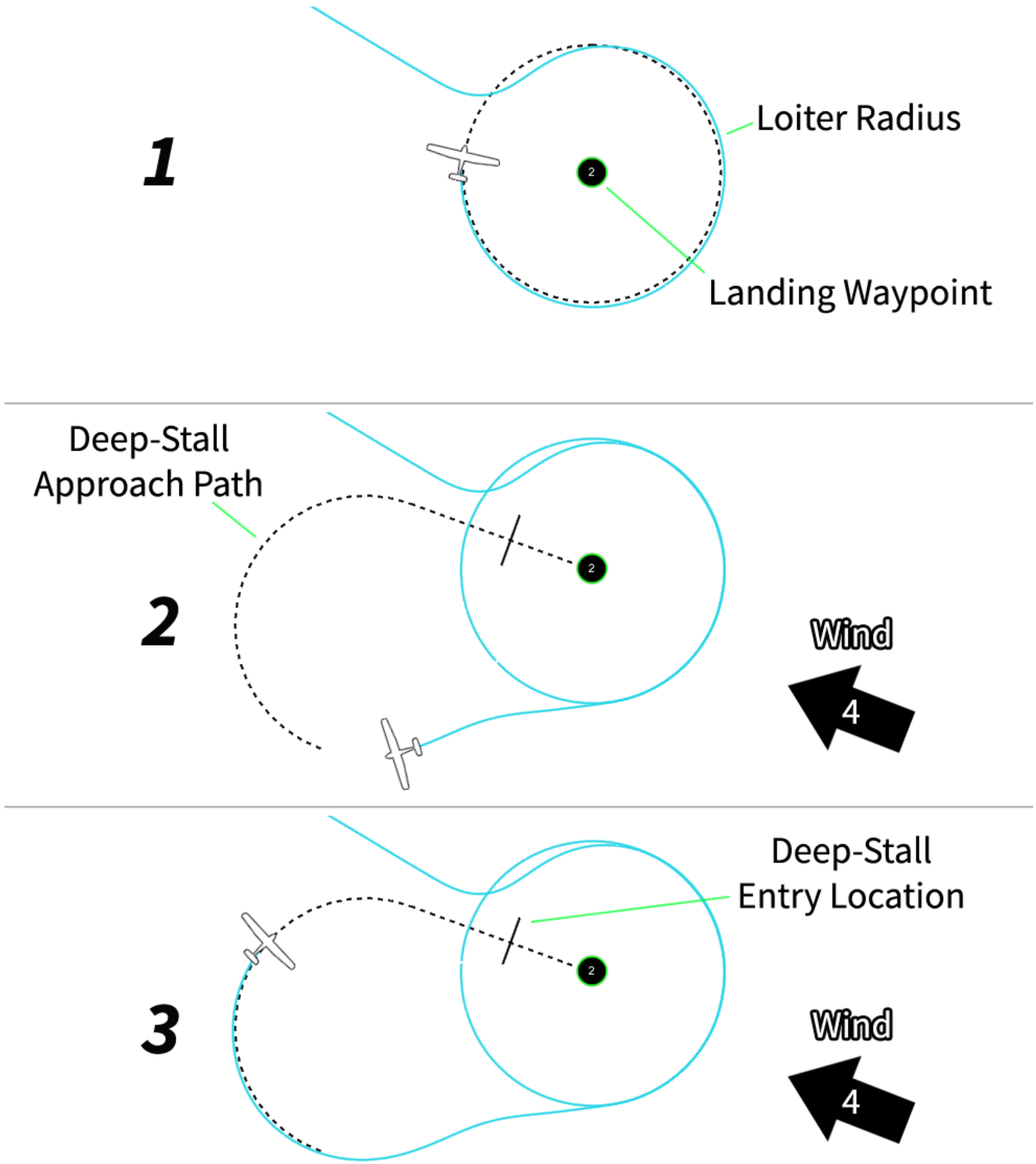
## Auto Deep-Stall

For an auto deep-stall, the user chooses the landing location in Swift GCS. It is recommend to physically check your landing spot before takeoff to ensure you are not accidentally landing on hidden obstacles, and to verify that the location is actually where you want it. As such, there are two helpful ways to do this in Swift GCS: use the Moving Base feature to verify location, or use the aircraft location after it is powered on.

Lynx will automatically begin the landing sequence at the end of a mission or when commanded. The auto deep-stall begins with the aircraft flying to the landing waypoint to loiter **(Item 1)**. The loiter allows the aircraft to estimate the winds at the landing location. The loiter altitude, or entry altitude, is typically 60 meters AGL but can be changed depending on obstacles or terrain. In general, a higher entry altitude reduces landing accuracy.

Lynx will circle the landing spot at least once and then choose its approach path. The approach path will attempt to land directly into the wind based on the aircraft's wind estimation. As such the aircraft will exit the loiter with a tailwind and then circle back around to the landing spot facing into the wind **(Item 2)**. The approach path is displayed in the GCS once picked.

The aircraft flies the approach path and continues to update its estimate of when to begin the deep-stall to hit the landing spot. This is indicated by a line that crosses the approach path **(Item 3)**.


1
Loiter Radius
Landing Waypoint
Deep-Stall
Approach Path
2
Wind
4
Deep-Stall
Entry Location
3
Wind
4

## Manual Deep-Stall

A manual deep-stall is when the safety pilot is in control and decides when and where the aircraft will deep-stall.

An auto deep-stall will always pick the wind approach path, but manually the user must plan the path to be into the wind. This can be done with waypoints or using guided mode to dynamically move the aircraft. A manual deep-stall approach is typically done from 60-90 meters AGL. Always consider surrounding obstacles. Typically, a higher entry altitude will be more difficult to judge for landing spot accuracy, but it will give you more time to react or abort.

Activating the deep-stall switch on the handheld transmitter will do the following:

- Override the autopilot regardless of what the previous flight mode was allowing the safety pilot to steer
- Disable motor output (although the propeller may continue to windmill from air flow)
- Deflect the stabilator upward to approximately 45 degrees causing the aircraft to initially pitch up and then settle

While a deep-stall landing is quite stable by itself, the safety pilot will need to maintain the desired direction by steering with the right stick (rudder) on the handheld transmitter. The safety pilot is steering to maintain a flight path into the wind and to aim at the desired landing area. The rudder is the only flight surface that can be moved during a deep-stall.

# Deep-Stall Abort

Both auto and manual deep-stall landings may be aborted during the approach or after the aircraft has stalled. The most common reason for aborting would be a manual landing whereby the safety pilot misjudged an entry and will thus overshoot or undershoot the landing area. Aborting below 30 meters may result in aircraft damage because the initial pitch down causes a loss of altitude.

An auto deep-stall abort commanded with the GCS will cause the aircraft to climb straight out until it reaches the entry altitude, at which point it will restart the landing sequence.

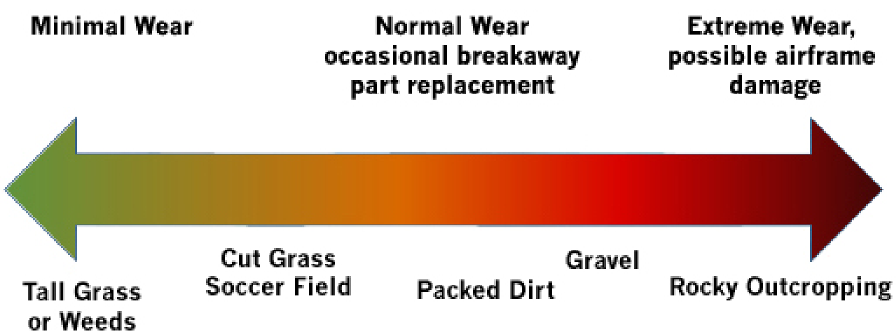
A manual deep-stall abort is done by disengaging the deep-stall switch on the handheld transmitter. Aborting will cause the aircraft to resume the flight mode it was in before starting the landing. For example, a deep-stall from guided will return to guided if the deep-stall was aborted. If the aircraft was in manual before the deep-stall, the abort will require a manual recovery and the safety pilot to resume flying the aircraft in manual.

# Selecting a Landing Spot

Auto deep-stall has an expected accuracy of being within 30 meters of the target location, with an average error of 17 meters. Almost all errors are along the final approach path, rather than side to side errors. This will improve over time as improved autopilot code is released to better manage this. An experienced pilot can do a manual deep-stall with an accuracy of 10 meters or better.

Lynx is an extremely rugged aircraft designed to handle repeated deep-stall impacts. However, deep-stall landings will fatigue the airframe like any landing.

The area selected for landing should seek to minimize risk to the airframe. Refer to the graphic below.




# Auto Deep-Stall Checklist

1. Landing Site - Select

   Select a suitable landing site by adding a land waypoint within Swift GCS.

2. Mission - Upload

   Ensure that the mission with the land waypoint has been uploaded.

3. Landing - Start

   From the Land menu, select “Start landing sequence” to begin the auto deep-stall approach.

# Manual Deep-Stall Checklist

1. Weather/Winds - Verify

   Check the wind direction and speed.

2. Landing Site - Select

   Choose a suitable site for landing. Ensure that the site and the approach path are clear of obstacles and personnel.

   Note: Experience will dictate how much space is ultimately required. Obstacles and wind are major factors in determining required space.

3. Altitude - Greater than 30 meters AGL
4. Heading - Into Wind
5. Throttle - Idle (safety pilot)

    Reduce throttle to idle on the handheld transmitter.

> Note: Throttle is programmed to automatically turn off during deep-stall, however, it is prudent to also manually reduce the throttle as an additional safety precaution.

6. Deep Stall - Engage (safety pilot)
7. Heading Into Wind - Maintain (safety pilot)

    Ensure the aircraft's heading remains into the wind by steering with the rudder.

8. Aircraft - Disarm

    Once the aircraft is on the ground, disarm by pressing the disarm button on the preflight tab in Swift GCS.

> Caution: If a loss of link is encountered on the ground while the aircraft is still armed it may attempt to spin the motor

9. Throttle Safety Key - Insert

    Reinsert the throttle safety key.

> Caution: Without the throttle safety key the motor can still be inadvertently spun under manual control.

10. Takeoff Button – Press

    Press and hold the takeoff button until it begins to flash.

## Deep-Stall Abort Checklist – Manual

1. Altitude - Greater than 30 meters AGL (safety pilot)

2. Deep-Stall - Disengage (safety pilot)

# Section 6: Post Flight

## Powering Off Checklist

1. Safety Key - Insert
2. Aircraft - Disarm
3. Takeoff Button – Press

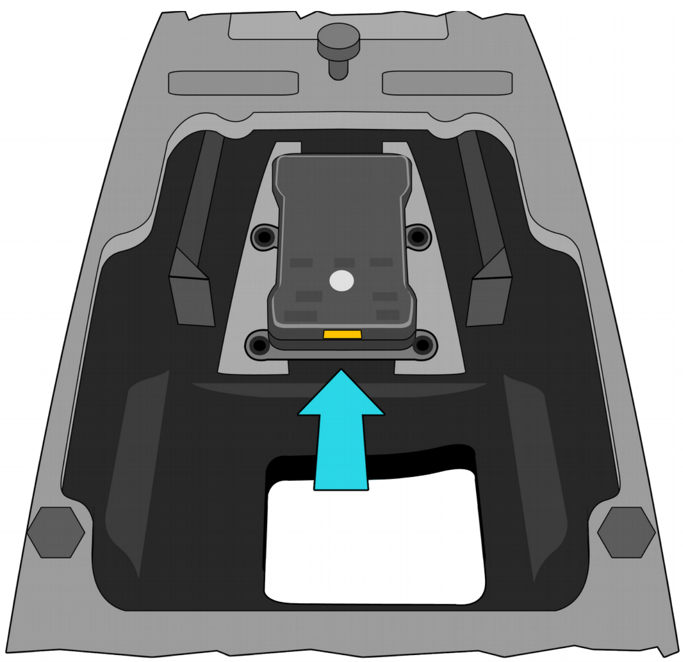
    Press and hold until the light begins flashing.

4. Battery - Disconnect

## Photo Tagging

The autopilot has a removable micro SD card that stores flight logs. The flight log is needed to geo-tag photos.

Start by removing the camera from the payload bay. Next remove the foam camera block. With this removed, the autopilot's micro SD card is accessible. The micro SD card is flush with front of the autopilot in a spring loaded housing. You will need to first push in with your fingernail to pop the card out.



Next, insert the card into your GCS computer. Open Swift GCS. Select the Geo-Tag tab. Select the location of the autopilot log, the folder containing the photos from the flight, the synchronization photo, and where you would like the tags to be saved. Once all the required fields have been selected, select Tag photos to begin geo-referencing. Once the process is complete, you will be shown a variety of statistics about the tags and imagery collected.

# Section 7: Emergency Procedures

The following section details the likely best course of action to take in the event of some emergencies. Not all emergencies can be planned for, and the situation will always dictate the best course of action. You, as the operator, must think quickly during an emergency to make the right decision(s). Your first priority in an emergency is to protect human life - both that of your crew, and that of the public. Your second priority is to minimize damage to equipment and property.

## Low Flight Battery

Lynx should be landed as soon as possible if battery voltage has dropped to 16.2 volts or below.

> Caution: The ESC will momentarily cut power to the motor whenever cell voltage drops below 15.0V to protect the battery. Use of full throttle at voltages lower than 16.2 volts total, such as in a go-around or wave-off, may result in a temporary loss of power due to voltage sag triggering the ESC cutoff.

## Handheld Transmitter Low Battery

The transmitter will signal that its battery is low with an on-screen warning. This is a critical emergency, and the aircraft must be landed as soon as possible. Avoid this by either charging the transmitter fully before the flight or connecting the charger in-flight

## Motor Failure Checklist

1. Mode - Manual (safety pilot)
2. Throttle - Reduce (safety pilot)

   Immediately reduce the throttle to zero. If the battery is temporarily depleted because of voltage sag, it may regain a small amount of voltage while gliding. As a result, there may be a small amount of power available during the final approach.

3. Safe Heading - Establish (safety pilot)
4. Recovery Site - Select
5. Deep-Stall - Engage (safety pilot)

| |
|---|
| Note: All crewmembers should assist in securing the aircraft. If there are bystanders, attempt to keep them away from the aircraft. Insert the throttle safety key as soon as possible. If possible, disconnect the flight battery. |
| Warning: If a Li-ion battery is punctured or ruptured, use extreme caution in handling. Exposed Lithium may catch fire without external sources of ignition. Keep away from flammable materials. |

# Uncontrolled Flight Checklist

1. Mode - Manual (safety pilot)
2. Controllability - Assess (safety pilot)

Quickly determine how the aircraft responds to manual inputs.

If the aircraft is uncontrollable:

3. Deep-Stall – Engage (safety pilot)

If controllable:

3. Land – As soon as practical (safety pilot)

If the aircraft is controllable when in manual, but not under autopilot control, there may be a problem with the autopilot or one of its sensors.

# GPS Failure Checklist

If the GPS fails, the aircraft will continue to try to navigate using “dead reckoning.” This is an estimation of position based on angular velocities and lateral accelerations. Dead reckoning is highly inaccurate and will become exponentially erroneous over time. Do not rely on it to continue the mission or to navigate home.

1. Mode - Manual (safety pilot)
2. Land - As soon as practical (safety pilot)

# GCS Crash Inflight

If the GCS crashes (software or computer) while the aircraft is in the air, the aircraft will continue to fly its mission until the telemetry failsafe activates. The operator, however, will have no situational awareness or ability to send the aircraft commands. For this reason, the GCS must be restarted and link must be regained. After the flight, please submit the GCS log report to support@srp.aero for diagnosing.

1. GCS - Restart
2. Telemetry Link - Connect
3. Waypoints – Download

Utilize the download button on the mission tab to download waypoints from the aircraft. Attempting to download a mission, especially a large one, is best attempted with the aircraft nearby for better link.

# Section 8: Troubleshooting

Please contact support@srp.aero for any issues encountered with Lynx or Swift GCS.

## Downloading Autopilot Logs

If for any reason you need assistance with reviewing a problem encountered with a flight, preflight, or configuration, there are two logs that you will typically be asked to provide. The first is the autopilot log, and the second is the GCS log.

To download the autopilot log, simply remove the SD card from the autopilot, open it on any computer to find the APM/LOGS folder. This folder will contain the log files from the autopilot. Typically, the log you would be looking for is the most recent log file, which will be the highest number. If not you can try looking at the size and date created to determine which one you need. Copy the .bin file from the micro SD card and send to support@srp.aero. Do not forget to reinsert the micro SD card back into the autopilot.

## Swift GCS Logs

To find the GCS logs, look inside the folder where the GCS was installed and select the logs folder. Find the appropriate date/time for the log file and send the .tlog and .log files. (If you are unsure you can send all the files that have the same name).

## Compass Calibration

A compass calibration may be required if the compass checklist step is failing, or the aircraft is refuses to arm due to a compass error.

Before starting a compass calibration, make sure that the payload is installed in the aircraft, and that the aircraft is not located near a magnetic source (large metal objects, vehicles, magnets, high power transmission lines). To start, go to the Settings tab in Swift GCS and expand the Compass menu. Select Start Calibration to begin the calibration process. The GCS will now show a progress bar next to each enabled compass.

Rotate the aircraft about each axis. As you do so the progress bar will slowly move until complete. The process typically takes less than a minute. If the aircraft observes a magnetic anomaly, or gets inconsistent data during the calibration, the calibration will automatically restart. Once a valid calibration has been obtained, the aircraft will need to be restarted before proceeding. The GCS will show a prompt that allows you to restart the aircraft without having to disconnect the battery. Set the aircraft on the ground before restarting.

## Accelerometer Calibration

An accelerometer calibration may be required if the aircraft is refusing to arm due to an accelerometer error.

To start, go to the Settings tab in Swift GCS and expand the Accelerometer Calibration menu, then select Start Accelerometer Calibration. The GCS will walk you through all the required steps. After the calibration is complete the aircraft must be restarted.

# Failing the ‘Deepstall - Test’ in Swift GCS

If you fail the deep-stall test step during the preflight, you will need to power cycle the aircraft and redo the preflight.

# Exhausted Camera Battery Inflight

While the flight battery can typically power the aircraft inflight for three hours, the Sony camera is still dependent upon its own internal battery. If the camera is off after landing, chances are that the camera shut off at some point during the mission. The biggest concern here will be determining when the camera shut off and how much imagery you may be missing. Do this by geo-tagging the imagery to have them appear on the map to determine at what point during the mission the camera turned off.

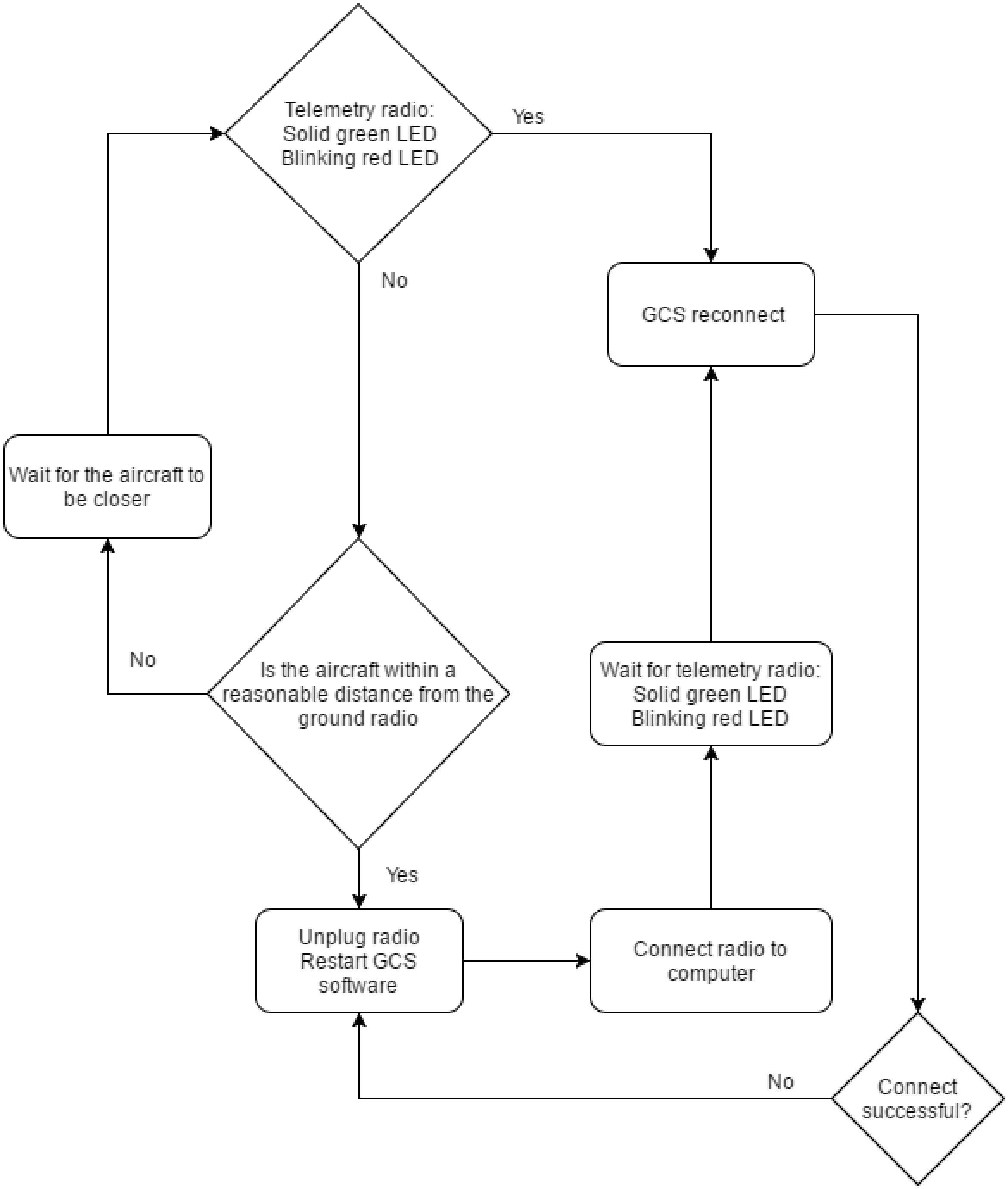
To reduce the chances of exhausting the camera battery inflight:

- Use a fully charged battery before each flight
- Reduce the camera’s screen brightness
- Reduce the survey overlap percentage is possible
- Limit flights to a shorter time
- Use high quality batteries or Sony brand
- Replace old batteries

# Telemetry Connection Problems

If unable to make the initial telemetry connection to the aircraft, or if radio issues are encountered in flight, the following flow chart should be consulted.

AFM 4-1


Telemetry radio:
Solid green LED
Blinking red LED
Yes
No
GCS reconnect
Wait for the aircraft to be closer
No
Is the aircraft within a reasonable distance from the ground radio
Wait for telemetry radio:
Solid green LED
Blinking red LED
Yes
Unplug radio
Restart GCS software
Connect radio to computer
No
Connect successful?

# Section 9: Scheduled Maintenance

## Servo Replacement

As a precaution against servo failure inflight, it is required to replace both the rudder and stabilator servo every 30 hours of flight time. This is a preliminary hour interval until discrepancies between the servo manufacturer's data sheet and claims can be resolved.

Please contact support@srp.aero for more information regarding maintenance, to place an order for replacement servos, or help with the replacement process in general.

See Repair Instructions: Replacement of a Servo for more tips.

# Section 10: Repair Instructions

This section describes the procedures for operator level repairs.

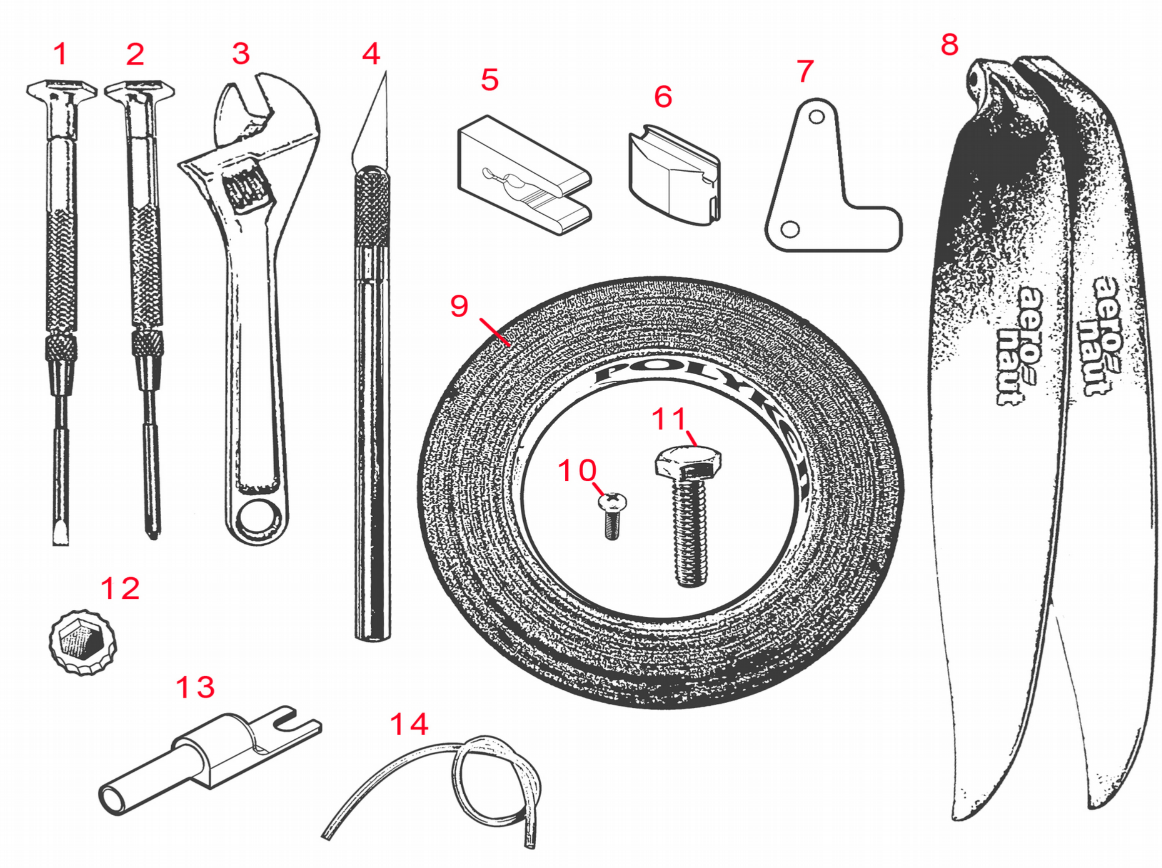
- Replacement of a propeller
- Replacement of a broken wing bolt
- Replacement of a tail clip
- Replacement of the motor (advanced)
- Replacement of a servo
- Replacement of a skid pad
- Repairing wing delamination

For any questions, concerns, or advice regarding repairs, please contact support@srp.aero.

## List of Common Replacement Hardware

| Item | Hardware Specs |
|---|---|
| Wing Bolt | Nylon 1/4" -20 x 1/2” hex cap screw |
| Motor Bulkhead Screw | Nylon 6-32 x 3/8” Philips pan head screw |
| Servo Retaining Screw | Nylon 6-32 x 3/8” Philips pan head screw |
| Throttle Key Retaining Screw | Nylon 6-32 x 3/8” slotted flat head screw |
| Tail/Wing Clip Screw | Steel 4-40 x 1/2” Philips pan head screw |
| Servo Linkage Screw | Steel 4-40 x 1/2” Philips pan head screw |
| Servo Linkage Retaining Nut | Steel 4-40 nylon-insert hex locknut |

# Tools and Spare Parts Layout




| | Item | Description |
|---|---|---|
| **1** | Flathead Screwdriver | Miniature screwdriver |
| **2** | Phillips Screwdriver | Miniature screwdriver |
| **3** | Crescent Wrench | Adjustable wrench |
| **4** | X-Acto Blade | Precision knife with swappable blade |
| **5** | Tail/Wing Clip | Used to attach the stabilator and outboard wings |
| **6** | Pitot Tube Clip | Used to attach the pitot tube to the top of the rudder |
| **7** | Stabilator Arm | Connects to the elevator servo and actuates the stabilator |
| **8** | Folding Propellers | 15x10 Aero-Naut CAM folding propellers |
| **9** | Repair Tape | Gaffers tape |
| **10** | Motor Bulkhead Screw | Mounts the motor bulkhead to the fuselage |
| **11** | Wing Bolt | Attaches the center wing to the fuselage |
| **12** | Wing Bolt Socket | Used to adjust wing bolts |
| **13** | Wing Bolt Spacer and Pitot Tube Cover | Used to space wing bolts and to cover the pitot tube during the airspeed calibration preflight step |
| **14** | Pitot Tubing | Spare flexible pitot tubing |

# Replacing a Propeller

If the propeller is broken, cracked, or chipped, it must be replaced. If you are unsure of the condition of a propeller, perform a quick throttle check. A damaged propeller can cause harmful vibrations to the airframe and will make a buffeting sound during the full throttle check.

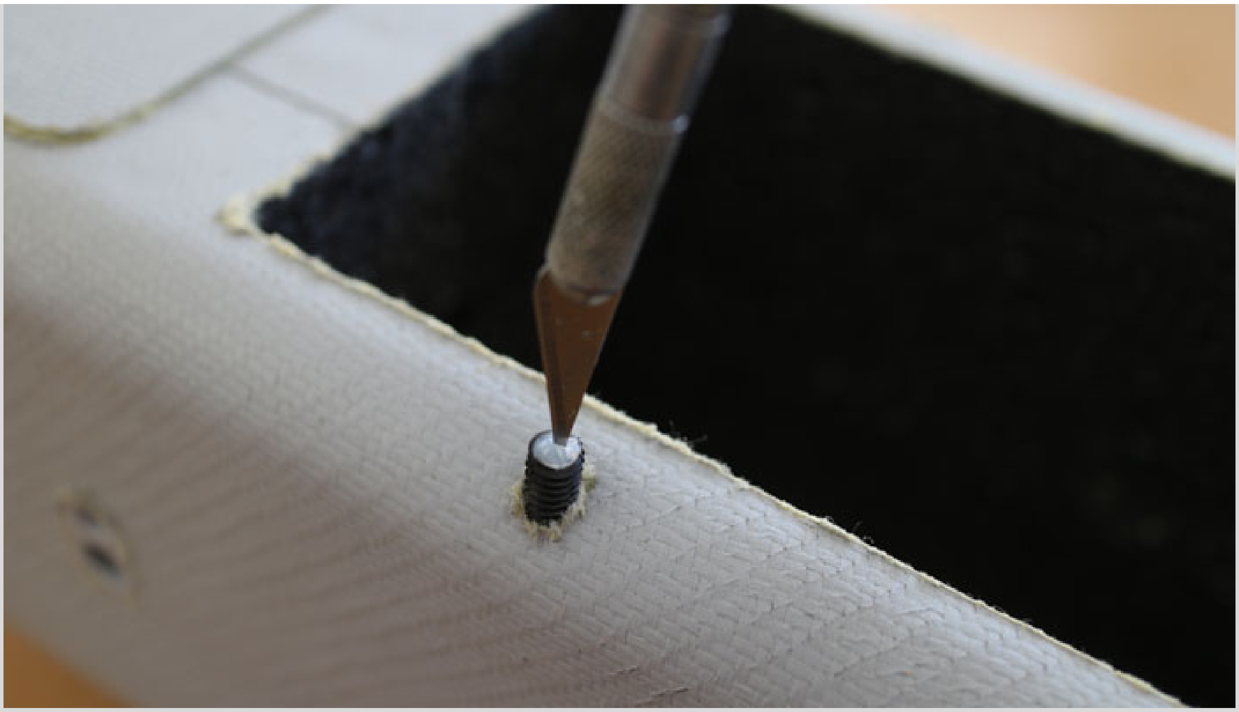
It is possible that one propeller blade will break, and the other will remain intact. Replace only the broken side. Make certain that the two propeller blades are identical. Raised lettering near the center of the propeller indicates the diameter and pitch (i.e. 15 x 10).

To replace a propeller blade, use the crescent wrench and flathead screwdriver to remove the nut and screw attached to the propeller yoke. Place the new propeller blade root into the yoke, ensuring that the printed lettering on the propeller is facing forward. Insert the screw and thread the lock nut into place and re-tighten. Tighten until the propeller has enough friction to remain in place when extended.

*Remove a propeller using the crescent wrench and flathead screwdriver.*

# Replacing a Broken Wing Bolt

It is possible for one or more wing bolts to break upon landing. This is normal and prevents damage to the fuselage and wings. To replace a broken bolt, attempt to use pliers to twist off the broken shaft. If the bolt is completely recessed, insert the tip of an X-Acto blade into the plastic bolt and twist counter-clockwise to remove. It may be necessary to tap the backside of the knife to bury it deeper into the bolt.



*An X-Acto blade removes a broken wing bolt.*

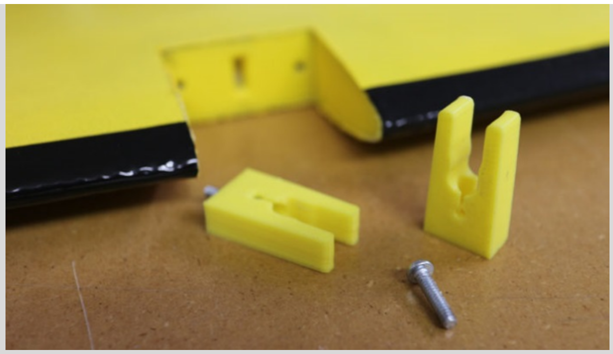
If the bolt remains difficult to remove, drill a small hole into the center of the broken shaft and tap an X-Acto blade into the hole. The drilled hole will provide extra leverage for the blade.

***Left:*** *Broken wing bolt removed. The bolt will typically shear at the base of the hex cap.* ***Right:*** *Wing bolt spacer.*

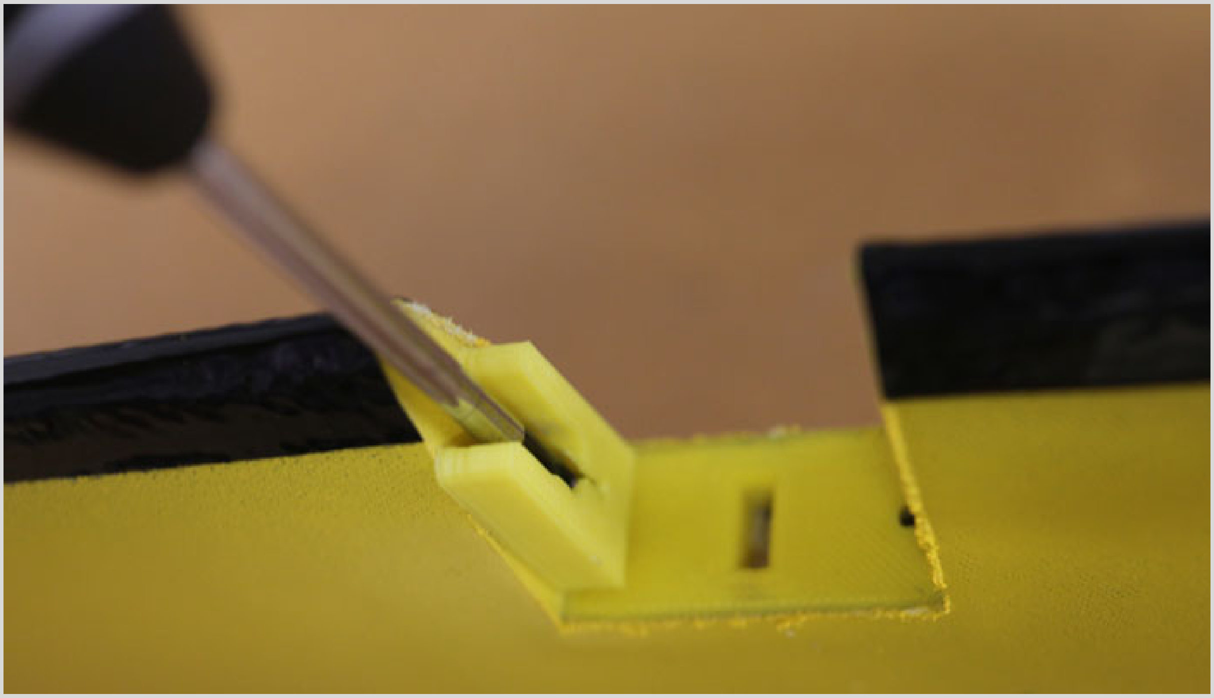
Insert the new wing bolt and turn clockwise. Use the wing bolt spacer and socket (if difficult to hand turn). Tighten down the new wing bolt until it touches the spacer. The spacer should leave roughly the correct gap for the center wing to slide on.

## Replacing a Tail/Wing Clip

If any tail or wing clips become cracked or broken, they must be replaced. To remove the broken tail clip, use the Phillips screwdriver to remove the screw inside the clip. Insert the screw into the replacement tail clip and reinstall with the Philips screwdriver.



***Left:*** *A cracked tail clip with screw removed.* ***Right:*** *Two clips ready to be installed.*

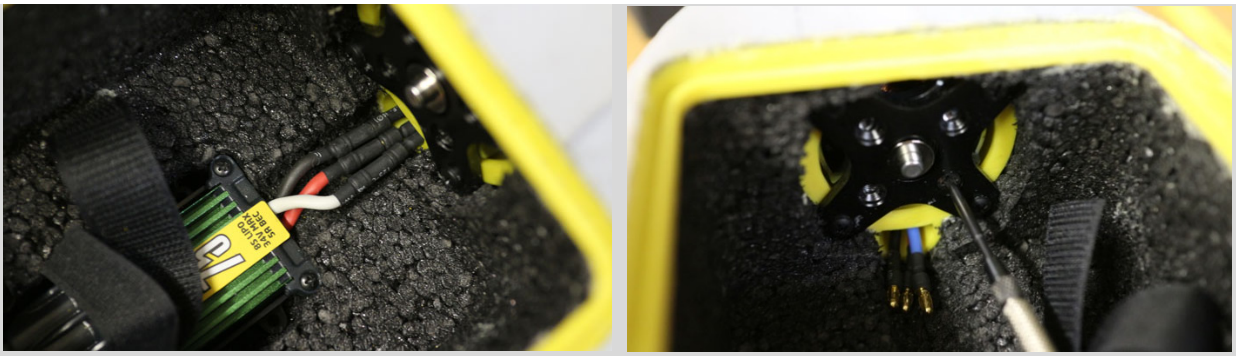


*A spare tail clip is installed with a Philips screwdriver.*

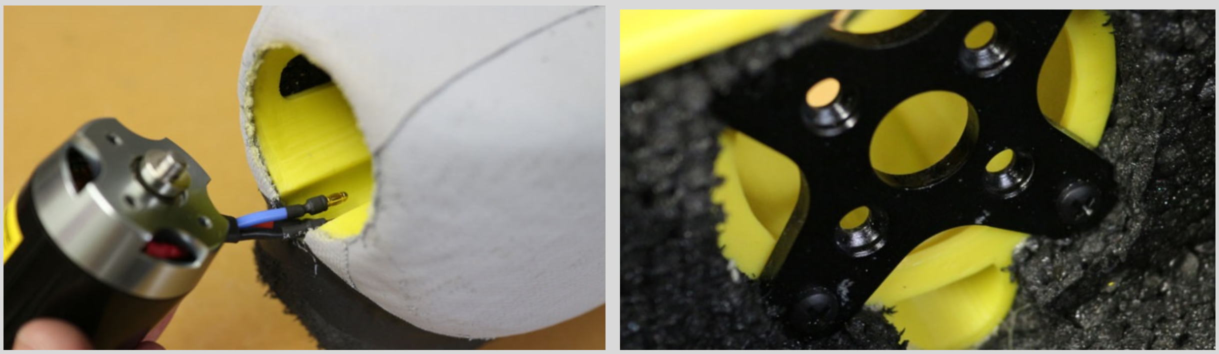
# Replacing the Motor

If the motor does not spin freely, has a bent shaft, or makes a loud whining noise, it must be replaced.

First open the battery bay and remove the battery. Disconnect the three ESC wires connected to the motor. Remove the four metal counter-sunk screws holding the motor in place using a Philips screwdriver. Slide the motor forward and out.

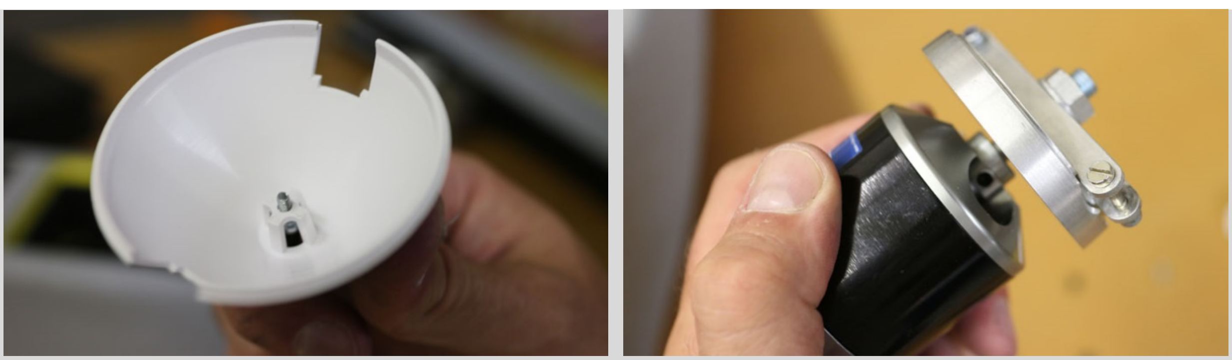


***Left:*** *Looking into the battery bay. The ESC and motor connect with three wires.* ***Right:*** *Four counter-sunk screws fasten the motor to the bulkhead.*



***Left:*** *With the screws removed, the motor will slide out the front.* ***Right:*** *The bulkhead attaches to the motor mount with four nylon screws.*

Remove the plastic spinner with a screwdriver. Remove the propeller nut using the crescent wrench. With the nut removed, grasp the motor and twist the hub off. Never attempt to pry the hub off by leveraging a screwdriver between the fuselage and propeller hub.



***Left:*** *plastic spinner removed.* ***Right:*** *Motor removed with propeller hub still attached.*

Insert the replacement motor in from the nose, ensuring that the three motor wires are facing down and along the trough of the motor mount. The wires should enter the battery compartment. Attach the motor to the bulkhead with the four metal counter-sunk screws. Apply blue thread locker before inserting each screw into the motor.

Connect the motor and ESC wires.

Slide the propeller hub onto the motor shaft. Leave an appropriate gap to ensure the hub spins freely without rubbing the fuselage. Tighten the propeller nut using the crescent wrench. A loose prop nut will cause the propeller to launch forward when full throttle is applied. Reattach the spinner.

***Left:*** *Spinner and propeller hub disassembled.* ***Right:*** *The prop nut fastens the hub to the motor.*

Turn on the handheld transmitter and aircraft. Remove the throttle key and test the throttle. Ensure no rubbing occurs between the propeller hub and the fuselage. Ensure the propeller spins clockwise when viewed from behind. Swapping any two motor/ESC wires will reverse the direction of the motor.

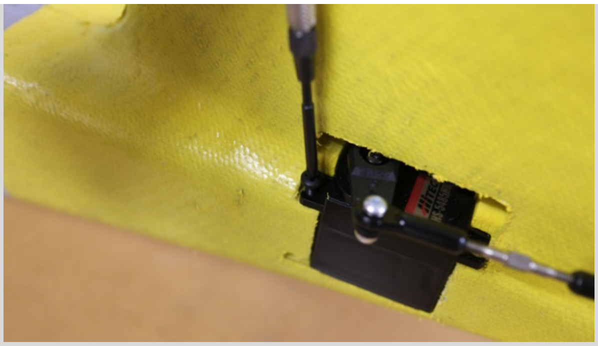
# Replacing a Servo

If a servo is immobile, has stripped or partially stripped gears, makes a clicking noise, or cannot hold its position properly, it must be replaced. The same procedure is used for either servo.

Disconnect the control rod using a Philips screwdriver and crescent wrench. Do not twist the control rod as this will affect the aircraft's trim. Next, remove the two nylon screws holding the servo in place. Grasp the servo arm and slide the servo out from its tray. Pull the servo out until the connector becomes accessible

Disconnect the bad servo and replace with a new one. Only use pre-calibrated servos from SRP. **Off the shelf replacements will not have the appropriate connector, nor will they have the correct servo trim and travel required by the autopilot.**

Re-connect the servo and slide it back into the tray. Fasten the servo down with the original two phillips screws. Re-connect the control rod the same way that it was removed.



***Left:*** *Remove the two nylon retaining screws.* ***Right:*** *Servo removed from its tray.*

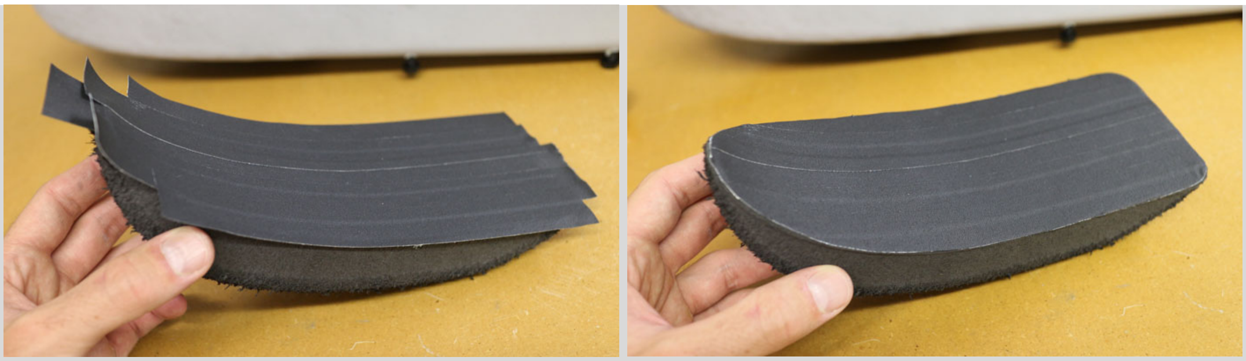
# Replacing a Skid Pad

Normal wear (cuts, abrasion, dents) of the skid pads can be patched with gaffer's tape.

If a skid pad has large pieces of foam missing, or is missing entirely, it is necessary to replace it.

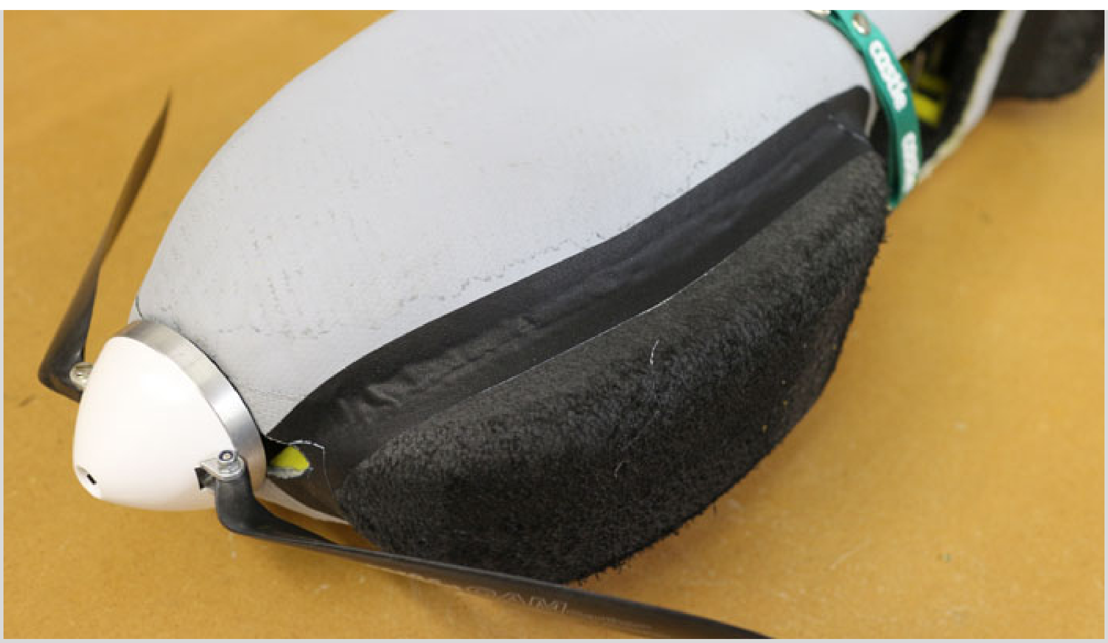
To replace a skid pad, first remove what remains of the old one. Remove the gaffer's tape around the edge, if present. Forcibly pull the skid pad material off as thoroughly and cleanly as possible. Use a flathead screwdriver or rounded-tip knife to scrape away any remaining foam, tape, or glue. Paint may be scraped but the Kevlar skin will remain resilient as long as it is not cut.

Adhere gaffer's tape to the flat side of the skid pad. Use the tape to bend the pad such that it matches the curvature of the fuselage. Trim any excess tape.



***Left:*** *Gaffer's tape applied to the flat side of a replacement skid pad. Note how the tape holds a bend in the pad.* ***Right:*** *Skid pad with trimmed Gaffer's tape.*

Attach the replacement skid pad using a hot glue gun. Apply hot glue around the perimeter of the skid pad and attach it to the aircraft making sure it conforms to the fuselage. Apply pressure to the pad until the glue has cooled. Finally, add gaffer's tape around the edges of the skid pad.

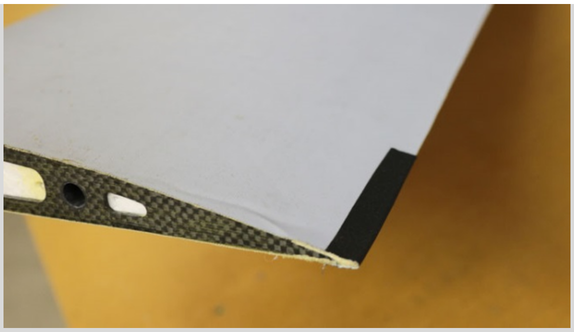
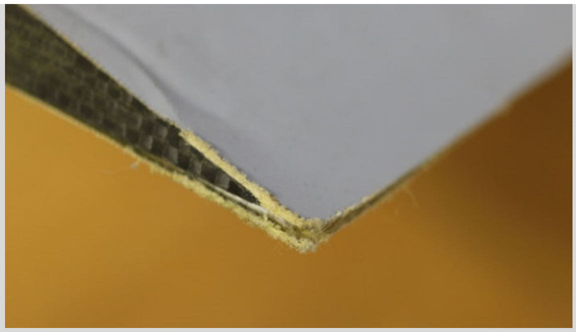


*Skid pad attached and seamed with gaffer's tape.*

# Repairing Wing Delamination

If the Kevlar skin on the wings or stabilator begins to lift or delaminate from the underlying foam, it should be repaired. Delamination typically occurs near a wing's rib and at the corners of the trailing edge.

When in the field, use gaffer's tape to pinch down the Kevlar skin until a repair can be performed.

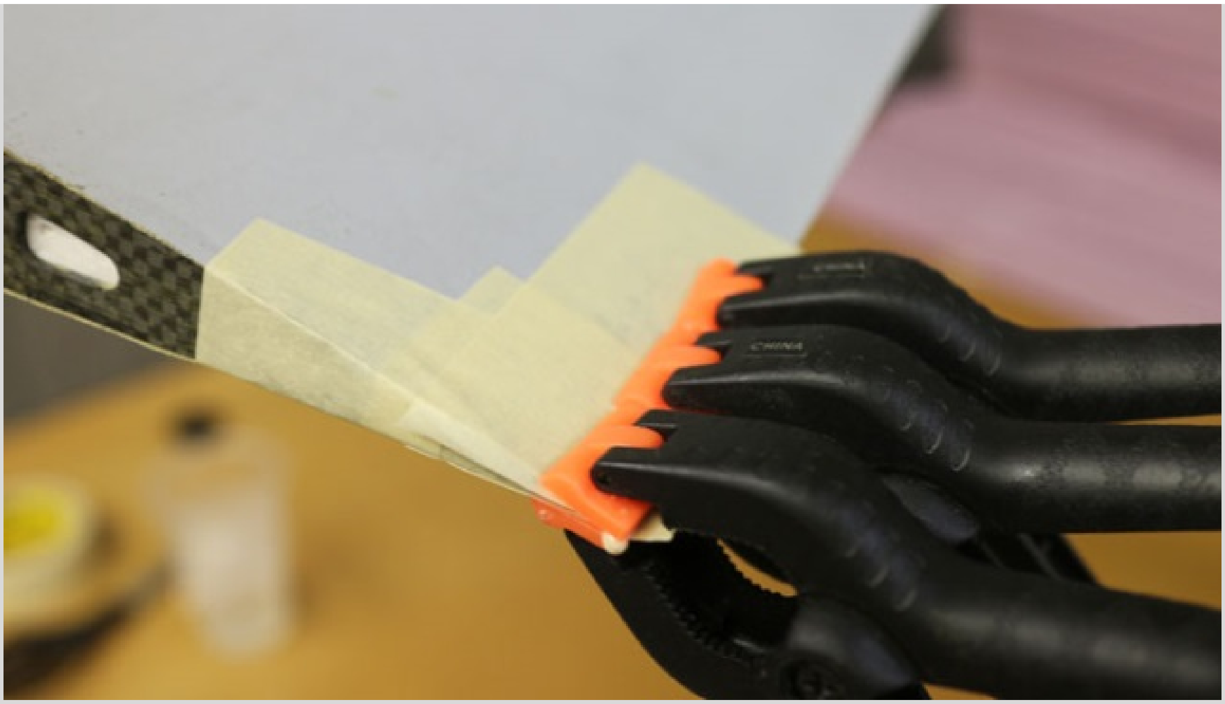



***Left:*** *Gaffer's tape around the trailing edge.* ***Right:*** *Gaffer's tape removed showing delamination.*

To repair the wing, pull back the lifted Kevlar skin and apply a **foam safe** glue (i.e. polyurethane, Gorilla Glue in the USA) to the exposed foam. Smear the glue with a paper towel or cotton swab until a light film evenly covers the foam.


***Left:*** *Kevlar skin pulled back exposing wing foam.* ***Right:*** *Gorilla Glue being applied beneath the Kevlar.*

Apply gaffer's tape or masking tape to the glued area. The tape is used to clamp down the lifting skin and to minimize the amount of glue that may seep between the Kevlar weave (important for glues that expand). Additional clamps or weight may be used for stronger adhesion.



*The wing is taped and clamped until dry.*

Once dry, remove the tape and peel away or sand any remaining glue.

# Appendix I

## ESC Beep Codes

ESC beeps notify status and/or errors of the propulsion system. The ESC code table is reproduced from page two of the Castle Edge Manual (P/N: 095-0176-00 revised 03/2013).

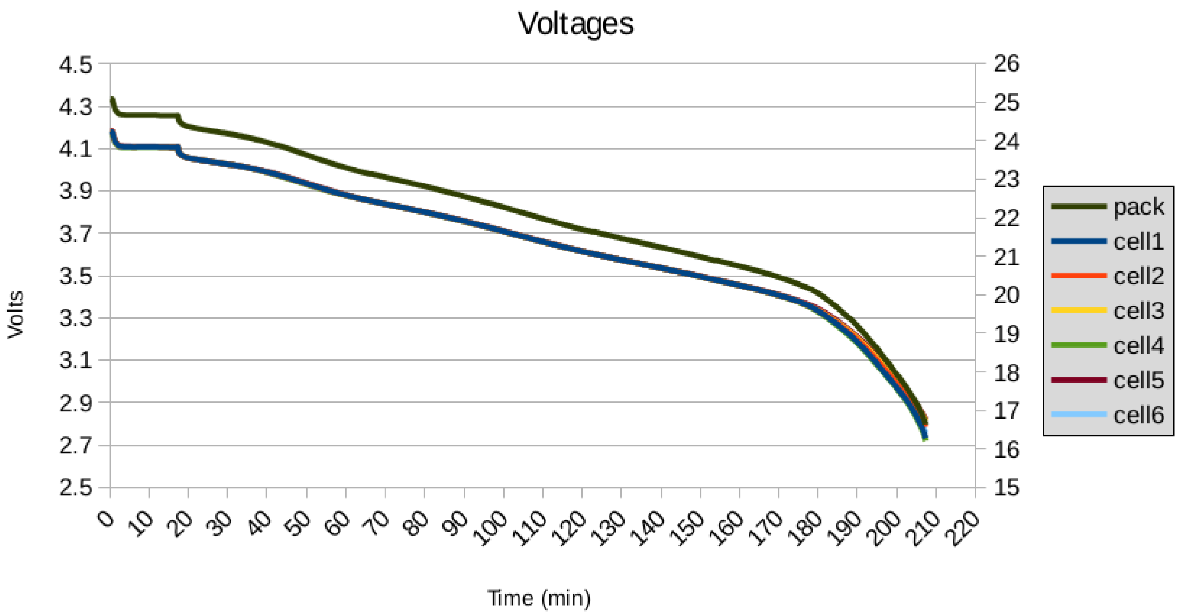
As of 2017, inserting the throttle safety key will cause to motor to emit a disarm tone.

(*) Repents a short beep (–) represents a long beep

| Tone | Meaning | Description |
|---|---|---|
| "Castle Power" tune with beeps corresponding to number of cells | Power up notice | ESC plays Castle signature tone and beeps out the number of cells attached to controller. Note: when Auto-LiPo detection is disabled by the user, ESC will not beep the number of cells. ESC will not run motor until it receives an arming signal from the radio via the throttle lead |
| Arming Tone | ESC ready to run motor | ESC plays the Castle arming tune once it receives a signal from the receiver. Controller is ready to run the motor at this point. |
| * | Powered ESC notice | ESC beeps motor every 10 seconds to remind user that power is connected to the ESC. This notice may be disabled in Castle Link. |
| *- | Low Voltage Cutoff | Main battery voltage dropped below the cutoff value. The default is Auto-LiPo which sets the cutoff value based on the detected cell count. Other settings may be entered in Castle Link |
| *-* | Over Temperature | ESC reached an overtemp condition. Occurs when operated under too high a load or operated without proper cooling airflow |
| *-- | Excessive Load | ESC detected very high current spikes. Causes may include damaged wiring leading to, or inside, the motor, or the use of too large a motor for the controller.<br><br>Remove power from the controller and check for shorts. If none are found, verify the controller can handle the motor's current load. As a safety feature, if multiple Excessive Load errors are detected, beeping will be disabled. |
| ** | Start Fail | ESC was unable to start motor |
| **- | Radio Glitch | ESC detected unusual signals or loss of signal on throttle wire. |
| *** | Motor Anomaly | ESC detected a sudden interruption of the motor's rotation. |
| -* | Over-Current | ESC detected operating currents that exceed the cutoff value. |
| -** | AUX Wire Glitch | ESC detected unusual signals or loss of signal on the AUX line. |

# Appendix II

## Battery Cell Discharge Curve



# Appendix III

## Pixhawk 1 Main LED Codes

| Pixhawk LED | Status |
|---|---|
| Flashing Red & Blue | Initializing |
| Double Flashing Yellow | Error. System refuses to arm |
| Flashing Blue | Disarmed, searching for GPS. |
| Flashing Green | Disarmed, GPS lock acquired. Ready to arm |
| Rapid Flashing Green | Disarmed, DGPS lock acquired. Ready to arm |
| Solid Blue | Armed without GPS lock. Do not fly |
| Solid Green | Armed with GPS lock. Ready to fly |
| Solid Red | Failed to boot or read the microSD card |
| Flashing Yellow | RC failsafe or battery failsafe activated |
| Flashing Yellow & Blue | GPS glitch or GPS failsafe activated |