Stalker User Guide

Prepared by

for the

Alaska Center for Unmanned Aerial Systems Integration

December 13, 2015

Contents

1 Theory of Operation

The Stalker system is a fixed wing UAS capable of extended missions when compared to its multi-rotor counterparts. During the course of the semester, the student in the EE656 class at UAF began work on getting it running. New integration boards were developed for future integration. Batteries have been purchased and all communication systems to control and monitor the UAS have been delivered. With the addition of the payload rails it is capable of carrying loads up to 2 kg. Payloads will be mounted on plates using velcro or screws and the plates will slide onto the rails to allow for adjustment of the center of gravity. The Stalker system is designed to be flexible in the payloads and flight times that it can achieve.

While extensive progress has been made on the Stalker, there is still much work to be done. Final placement of components so it is flyable must be done. This includes printing/buying the connectors for items suchs as the Lightbridge, integration board and battery. The payload rails have been designed but have not yet been positioned inside the Stalker. This document serve as an introduction of how to set up the Stalker and take care of it. Many references to external data sheets are provided as most of the parts have been purchased. This is currently a working document and will be finished in the coming months when the Stalker is fully built.

2 Pre-Flight/Post-Flight Plan

2.1 Pre-Flight

1. Make sure you are five miles or further from any airports.
2. Set the UAS on level ground.
3. Inspect the UAS.
   (a) Make sure props are tight.
   (b) Visually check wires and connections.
   (c) Visually check craft for damage.
   (d) Log starting battery voltages and percentage of charge.
4. Turn on camera.
5. Set camera to desired mode - check for SD card.
6. Make sure any people in the area are at least 15 feet away and aware that you are turning it on.
7. Turn on Controller.
8. Plug in Battery.
   (a) Check voltage meter.
9. Flip the onboard arming switch.
10. Setup Mission Via Mission Planner.
    (a) Upload preferred imagery into Mission Planner.
    (b) Create Waypoints for your UAS to travel.
11. Announce to everyone that you are getting ready to arm the UAS.
12. Check all equipment signals.
13. Launch the Stalker in one of three ways:
    (a) Using the Bungee Launcher
    (b) Throwing the Stalker by hand
    (c) Holding the Stalker out of roof of a truck
14. Perform Mission
15. Land in open area, clear of people.

2.2 Post-Flight

1. Disarm UAS with controller.
2. Disarm UAS on the UAS itself.
3. Disconnect battery.
4. Turn off controller.
5. Inspect UAS for damage or loose connections.
   (a) Feel motors and speed controllers for heat.
   (b) Inspect battery and battery connectors for signs of external wear or excessive.
6. Make a list of issues that need to be fixed before the next flight.
7. Log ending battery voltages and percentage of charge.

3 Assembly Instructions

3.1 Propulsion

The propulsion system of the Stalker consists of the Turnigy GliderDrive SK3 Competition Series 3858 motor and associated propellers. This section details how to install the motor into the body of the Stalker.

Motor Installation

The first step in attaching the propellers is to ensure that all necessary components are present. These include 3 screws, 3 propeller blades, and the motor at the front of the Stalker.

Insert the propeller to the motor such that the screw hole lines up for the propeller and the mount. The writing on the propeller should be legible while facing the front of the Stalker. Insert the screw and tighten until lightly torqued as seen in Figure 1.

Figure 1: Attach the propeller using screwdriver and screw while being careful not to over tighten.

Connect the servos and ESC signal to the main output pins of the Pixhawk as seen in the Figure 2. Power the servos by connecting 5 VDC to the power and ground of any unused Pixhawk output pin.

The signal and power connections leading to the tail are laid out at as seen in Figure 3.

Pin	1	2	3	4	5
Output	Aileron (Left)	Elevator	ESC	Rudder	Aileron (Right)

Figure 2: Servo motor pin-out for the Stalker

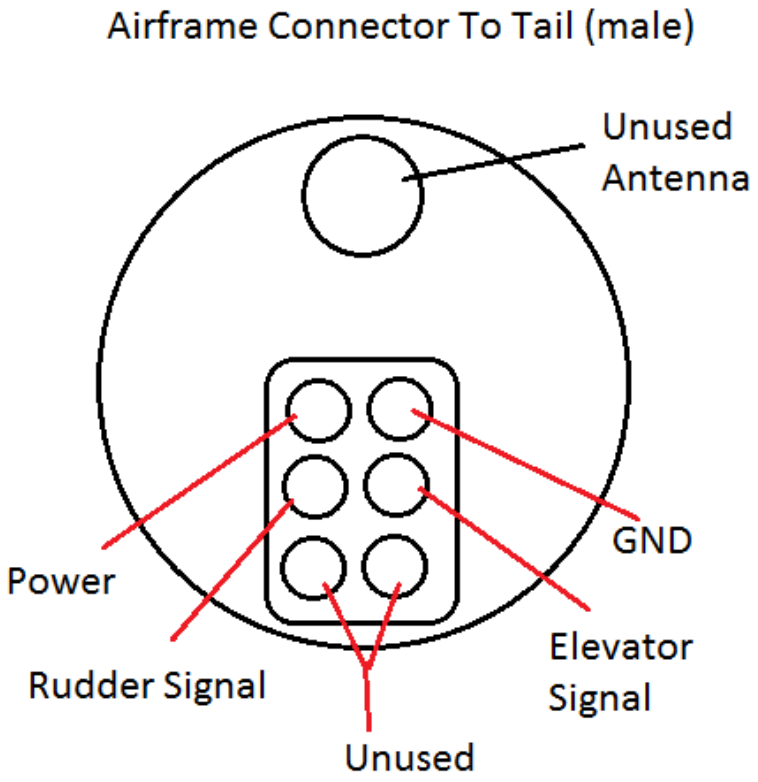

Figure 3: Connector diagram for the tail

Attach the tail to rear of the Stalker body so the connector ports on tail and rear fuselage align. After the tail is in place, shift (do not rotate) the circular locking mechanism to the locked position as seen in Figure 4.

Figure 4: Connection between the tail and the airframe

Connect the elevator to the tail as shown in Figure 5.

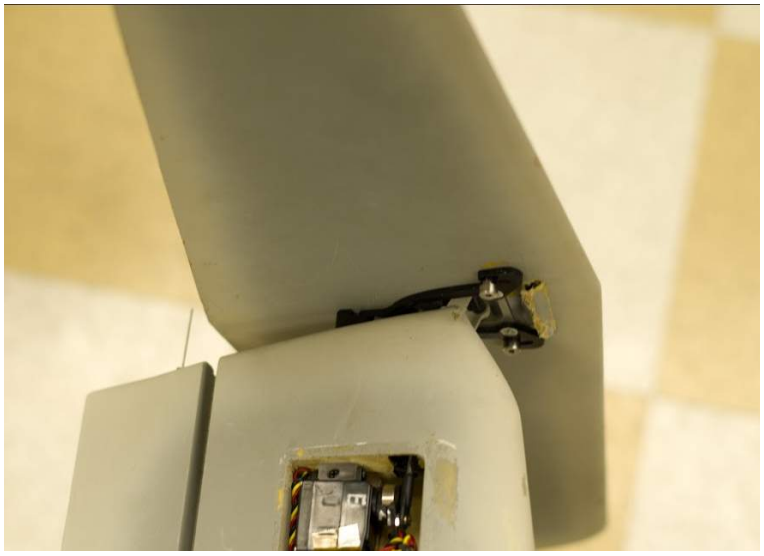
Figure 5: Elevator connection to the tail

To connect the wings to the Stalker it is important that the correct wings (Left and Right) are attached to the appropriate side of the middle piece. There are multiple pins that are wired to provide control of aileron servos. The layout of these pins on each wing piece can be seen in Figure 6.
In addition to circuitry there are structural components that need to be lined up appropriately. These spars can be seen in Figure 7.

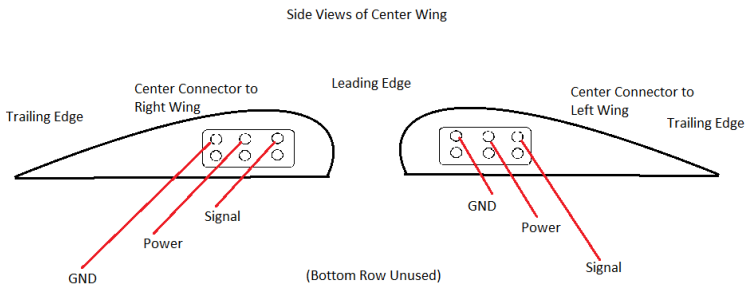

Figure 6: Wing attachments as seen from the Stalker frame. The right wing carries signal closest to the front of the aircraft while the left wing has ground pin in that position. The lower row of pins are currently not being used.

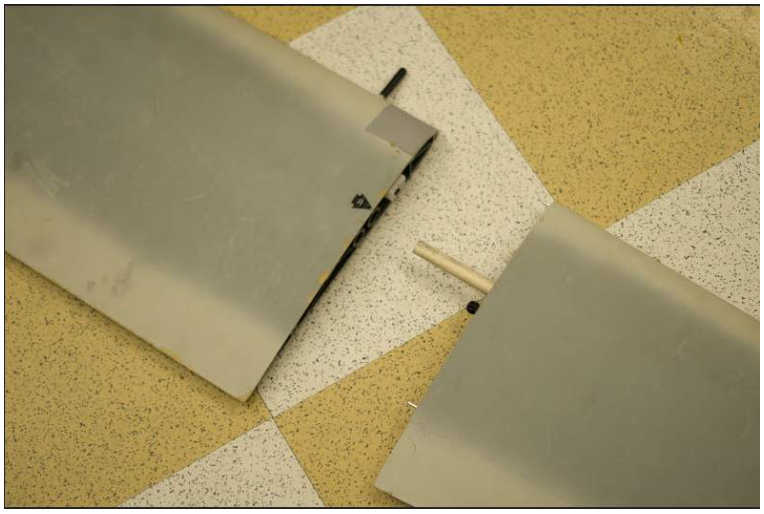

Figure 7: The spars must be inserted into the wings to ensure sturdiness.

Once the wings are appropriately connected to the middle segment, the entire wing span needs to be connected to the airframe. There are pins that need to be connected as well. The layout of these pins is seen in Figure 8.

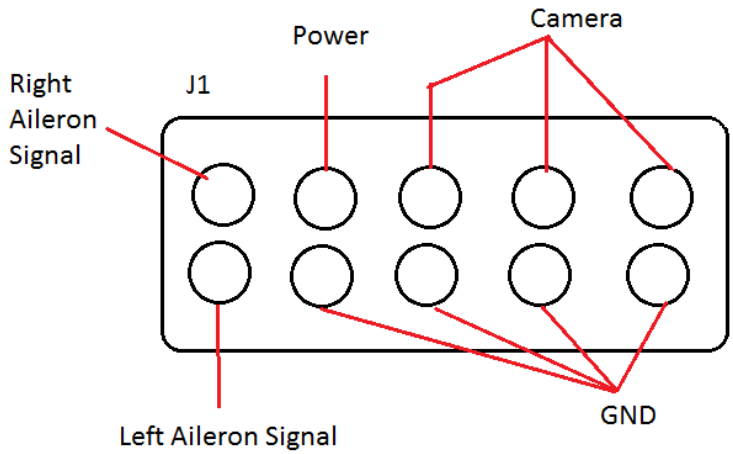

Figure 8: Pin-out for the middle section of the wing. Four of the five pins on the bottom row are tied to ground

While attaching the wing pieces to the airframe the pins shown above need to line up. Additionally, there are structural components that need to connect appropriately. These are seen in Figures 9 and 10.

Figure 9: Center wing piece as seen from below. The front wing section is oriented towards the bottom of the picture.

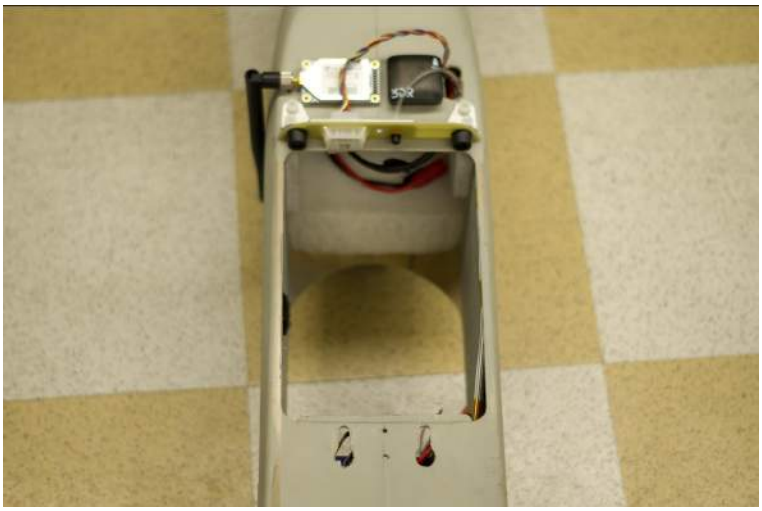

Figure 10: Stalker frame as seen from above.

The portion of the Stalker wingspan shown in Figure 9 snaps onto the portion shown in Figure 10. The locking knobs and the pins all need to line up for the Stalker system to be properly assembled.

3.2 Payload

The payload system of the Stalker consists of a payload bay with rails to support a wide array of payloads. In addition to this, some payloads will be supported directly that are anticipated to be commonly used, such as the Lightbridge video system. This section outlines how to install payloads into the standard payload bay as well as providing the locations for any specifically supported payloads.

Payload Bay

Mount the payload in question to the payload plate using either velcro or screw holes that are available on the plate. It is anticipated that velcro may be the only choice for some payloads as it is impossible to provide mounting holes for every payload.

Once the payload is attached to the plate, slide the plate onto the rails and secure with the screws provided. Figure 11 shows an example of the payload rails that will be installed in the Stalker. When installing heavier payloads, it will be important to check that the center of gravity is not changed significantly. The payload mounting system can adjust this by sliding the plate along the rail and tightening it to a different slot. This way payloads with a different weight can be supported with out a major redesign. The center of gravity can be checked by hanging the Stalker from the ceiling using the points on the wings as a mounting position.

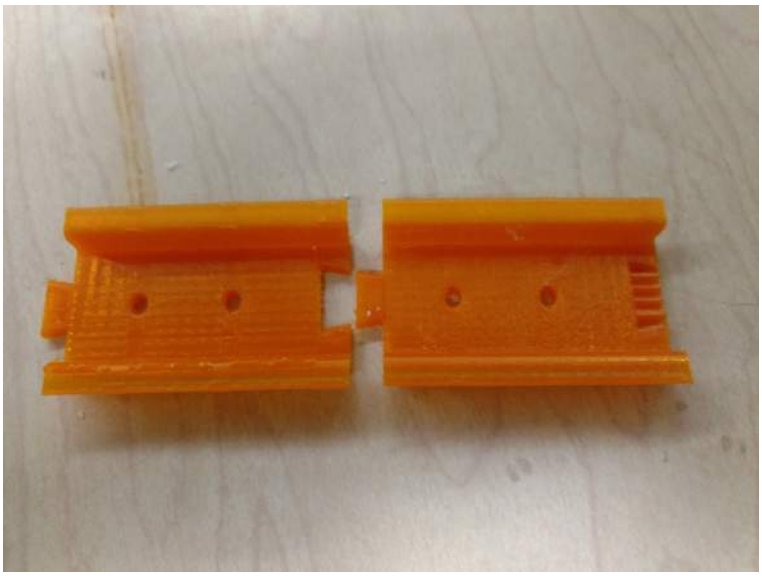

Figure 11: Example payload rails outside of the Stalker. Holes will be used to adjust position of payload for center of gravity balancing.

3.3 Power

The power system consists of high capacity Lithium-Polymer batteries. This section outlines how to install these batteries into the Stalker and where they will be placed.

Battery Installation

Insert Turnigy Multistar High Capacity 6S 20Ah Lipo battery pack into insulation container (make sure to have charge and temperature sensors connected). Fit insulation container with batteries into stalker frame. Figure 12 shows the location of the battery towards the front of the Stalker along with the connections to be made to connect the battery. When connection the battery, be sure to attach quickly. If a small section of the connectors are touching (not completely connected) the connectors can be damaged.
Connect ground (Black connector) followed by the red connector to power on.

Figure 12: Battery position in Stalker while not in case. When in the case, the battery will screw/latch down to ensure it is secured.

The battery connections have reverse voltage protection to protect systems from damage due to improper battery connection. The batteries are also equipped with keyed connectors to ensure proper battery connections.

3.4 Communcations

The communications subsystem consists of the Lightbridge, PixHawk and DX8 Manual Controller. This section outlines how to install each subsystem and what each system is connected to as well as what kind of connection is used.

Lightbridge Installation

The air system portion of the Lightbridge will be located in the body of the Stalker, attached to the upper corner and connected to the video camera. It will get its power from the integration board at four to six Lithium-Polymer cells of voltage level. Refer to the Lightbridge data sheet for more information.

Figure 13: Foam block to illustrate where Lightbridge will go when it gets in.

The antennas will be mounted on the sides of the Stalker, to facilitate the communications to the ground station. There will be connections on the side for mounting. Due to not getting the Lightbridge in, this has not been pictured but will be added in the future.

The HDMI or the AV connection on the Lightbridge will be connected to the camera. Only one of these connections may be connected during any one mission depending on what camera is being used.

Air system power is provided to the Lightbridge via the provided power cable.

The DBUS cable is the connection between the flight controller and the Lightbridge. This connection is not used on the Stalker but future designs may make use of the ability to control the Stalker through the Lightbridge.

Each of these connections can be found in the user manual for the Lightbridge and should be referred to for more information.

XBee XTend Installion

The XBee XTend will be installed near the integration board. The antenna for the XBee will extend out the side or bottom of the Stalker ideally for better communications with the ground station.

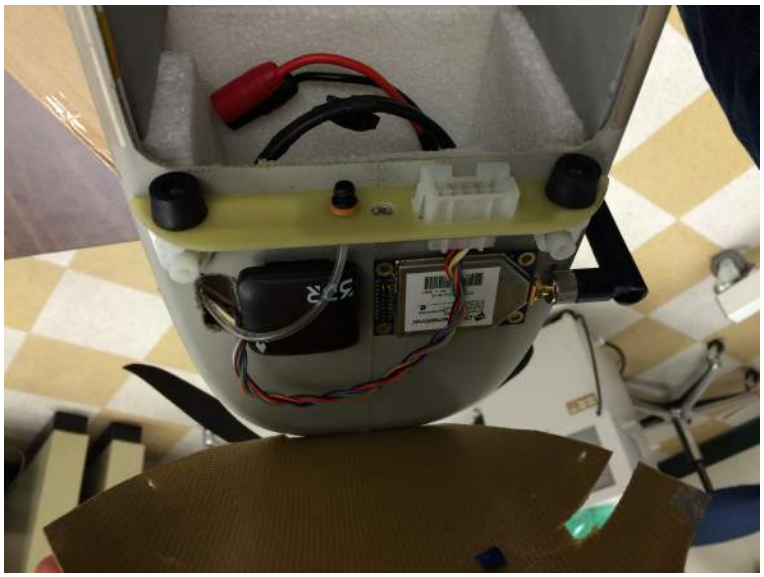

Figure 14: Location of the XBee XTend and antenna.

Manual Controller Installation

The manual controller will not need any assembly as it is a package that is self-contained. It should be turned on and connected after initial setup and synchronization. It should not require any additional assembly. The AR8000 receiver should be placed away from the XBee XTend to minimize any Radio interference. On the Stalker it will be placed in the small section above the integration board as seen in Figure 15.

Figure 15: The AR8000 receive is located under the hood on the Stalker to protect it from the elements.

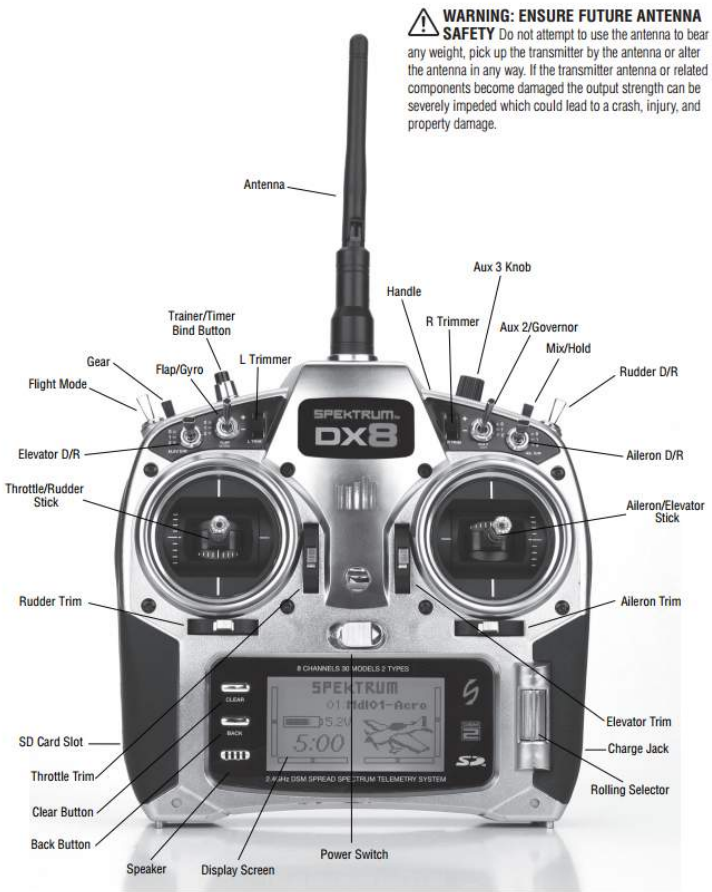

Figure 16: an example of what the DX8 controller looks like and some of the controls on it.

3.5 Ground Station/Autopilot

The ground station needs to be set up when out on a mission. This section consists of how to set up the ground station and prepare the laptop for communication with the Stalker.

Laptop Setup

To set up the ground station, a few programs need to be starts. First Mission Planner needs to be started and connected to the XBee XTend by clicking on the connect button in the upper right of Figure 17.

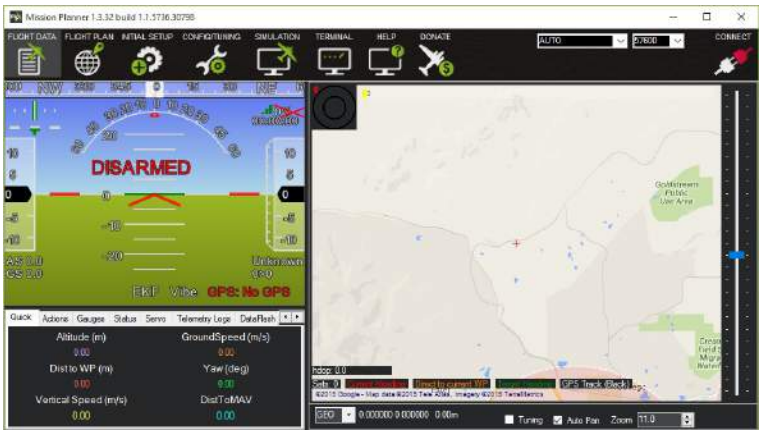

Figure 17: Mission Planner screen shot with the options that are available on screen.

The Lightbridge ground station will also be connected. It needs to be connected to a monitor and have connectivity to the air system. Follow the instructions that are present in the Lightbridge manual for more information.

4 Disassembly

4.1 Propulsion

The propulsion system should not be removed under normal circumstances, but in the event that it malfunctions and needs to be replaced, instructions are provided in this section on how to remove. In general, the removal process will be the reverse of the installation process, and the figures in the assembly section will still hold true.

Motor Removal

To un-install the Turnigy GliderDrive SK3 Competition Series 3858 motor on the Stalker, the front section of the Stalker frame must be emptied of all other components. See appropriate sections for each subsystem for information on properly un-installing and reinstalling systems in the front half of the Stalker.

Once the other systems and components have been removed from the front of the UAS, remove the screws mounting the motor to the UAS.

You will need to reach inside the Stalker to remove the motor. Keep track of the other subsystems and components. It is not recommended that they are reinstalled until the motor has been reinstalled.

4.2 Payload

The disassembly of the payload is simply the reverse of the assembly. This section will briefly cover how to remove the payload plate from the Stalker rails. Individual payloads will not be covered due to the wide range of payloads that would have to be accounted for.

Payload Removal Procedure

Remove wing sections from the fuselage to access the payload bay. Unscrew/unlatch the payload plate from the payload rails using the appropriate screwdriver. It is the same process as assembling the payload section except in reverse. Therefore the assembly section can be referred to in order to see the figures that are relevant to the Stalker.

4.3 Power

Proper removal of the battery system of the Stalker is important to prevent any damage to wires or connectors. This section outlines the necessary procedure to remove the batteries without causing harm to the rest of the system.

Battery Removal

Disconnect the red connector then black connector to power off. Refer to the assembly section for power to see what the connectors look like.

Remove insulation container from Stalker frame. This is currently not implemented on the Stalker but will be in future versions of this User's Guide.

To remove the battery from the insulation container, unscrew the screws located on the bottom of the case, remove the cover and pull the battery out.

4.4 Communications

Lightbridge Removal

The first step in removing the light bridge will be to remove the power source, then remove all other connections into the Lightbridge. Refer to the Lightbridge user guide for details. Since the Lightbridge will be screwed into the side of the Stalker, you must remove the screws to release the light bridge to get the Lightbridge out.

Antennas are removable from the frame of the Stalker but do not strictly need to be removed, since the weights of the antennas are negligible for flights where they are not being used.

The Lightbridge system in general should not be removed unless absolutely necessary for the mission. It provides a visual when piloting or on autopilot that will reaffirm that the Stalker is oriented how it is supposed to be and gives vision of obstructions nearby.

XBee XTend Removal

The XBee XTend can be removed by simply pulling it out of the sockets that hold it in place. Ensure that the power is off before doing so to prevent damage to the component. This should not be removed except to update the firmware.

Manual controller Removal

The DX8 does not have any disassembly, as it is a stand alone package.

The AR8000, the receiver for the DX8, can be removed by taking off the back overhang of the Stalker. Ensure the power is off before removing it from the Stalker. There is no real reason to remove it however, as it will be present on every mission in case the Autopilot fails. As with all of the disassembly sections, the same pictures that are associated with the assembly section.

4.5 Ground Station/Autopilot

The ground station must be put away after the mission. The Lightbridge, laptop, external monitor and antennas should be packed into the Pelican case that they were designed to fit into.

Ground Station Disassembly

Properly close all applications that are open on the laptop. Shut down the computer and disconnect all peripherals. Lightbridge and accompanying monitors should be powered down as well, since they will work in conjunction with the laptop to provide maximum connectivity. Once everything is powered down it should be placed back into the storage containers. An example mock up of the storage container is shown in Figure 18, it shows how there will be a number of cut outs for all the components of the ground station. Figure 19 shows what will be contained inside of the case.

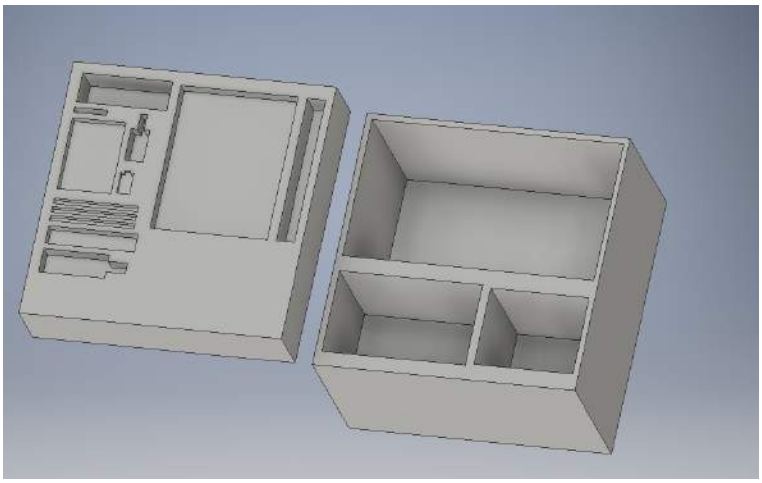

Figure 18: CAD image of what the ground station case looks like.

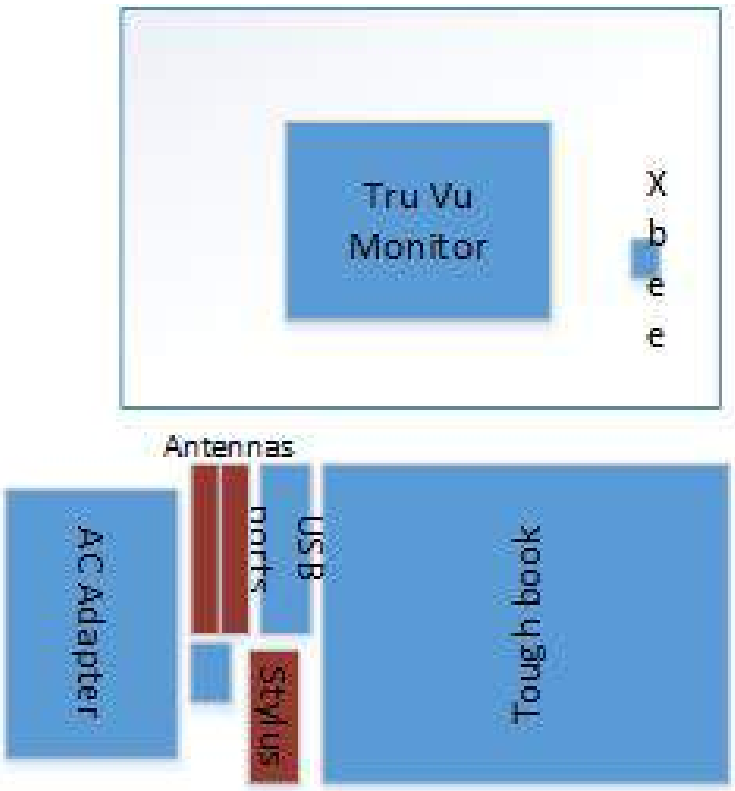

Figure 19: Contents of the ground station case and roughly where they will be located.

The autopilot will never be removed unless it needs to be updated using the ground station laptop through mission planner. Currently it is attached using velcro and is removable by simply pulling it off after removing all the cables.

5 Use instructions

5.1 Propulsion

Use of the propulsion system will be through monitoring the motor usage characteristics at the ground station. This section will also cover the expected operation characteristics of the propulsion system.

Expected Characteristics and Monitoring

The Stalker motor is currently set up to run on either a 4-cell or 6-cell lithium-polymer battery. Figure 20 shows the expected characteristics of the motor based on how much current it is consuming. In mission planner you will be able to monitor the current and determine whether the motor is operating along the proper curve. If it is found to be operating off the curve, it should be examined for any anomalies and systems should be checked to ensure nothing is broken or malfunctioning.

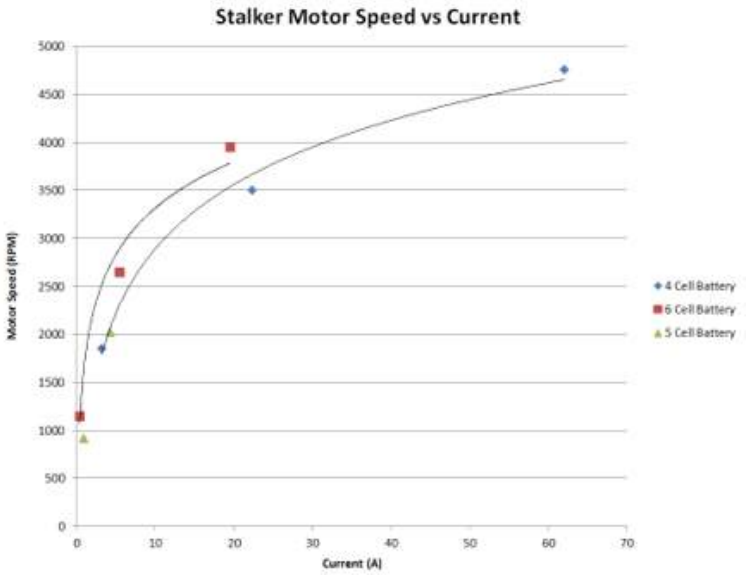

Figure 20: RPM vs current of the Stalker motor.

5.2 Payload

Payload is not a system that is used. For instructions on how to attach the payload plate to the payload rails, see the assembly section.

Payload Bay

How to use the payload will vary from payload to payload. Check the payloads user manual for instructions on use.

5.3 Power

The power system is not specifically used. This section discusses what to expect from the batteries. Future iterations of this section will contain the testing results for the battery and how the voltage varies as the

Battery Use

The batteries have not yet been tested for how the voltage varies as the current as drawn. This is to be added when the batteries are tested and logged extensively. In general, the voltage of the battery will tend to drop when in use. The more current that is drawn, the more the voltage will drop.

5.4 Communications

The communications systems have a large amount of usage information specific to each system. As such, it is recommended to read the data sheets for each system in addition to the summaries present in this document. Data sheets can be found in the digital archive that has been given to Professor Hatfield at UAF.

Using Lightbridge

The Lightbridge user guide should be referred to in order to see all details, but a brief outline is presented here. Power on the air system first, then the ground system. The video link indicator will turn solid green then change to flashing green when the ground and air systems are communicating normally.

Connect the ground system to an HDMI monitor to display the image, alternatively, the Lightbridge app can be used to display the image.

Occasionally the firmware of the Lightbridge should be updated. This is done by connecting a PC to the ground system using a Micro-USB cable. Click on the upgrade icon to check for upgrades and install them if the system requires it. (Refer to Lightbridge User manual in archive.)

Operating the Lightbridge is essentially keeping radio contact with the Stalker. In this section, the maximum distance of the Stalker system is outlined. The limitation of the system will be presented to ensure that the user knows what to expect from the system when in flight.

Using XBee XTend

The XBee XTend is interfaced with using various programs on the computer and is connected to the PixHawk on the Stalker to transmit telemetry data back to the ground station.

To test the XBee XTend before flight, connect one to the computer and set the other to loop back. Make sure that the XBee's have the proper addresses for source and destination in XCTU. Figure 21 shows the latest version of XCTU used to program the XBee radios. It shows the important settings to get the radios communicating with each other.

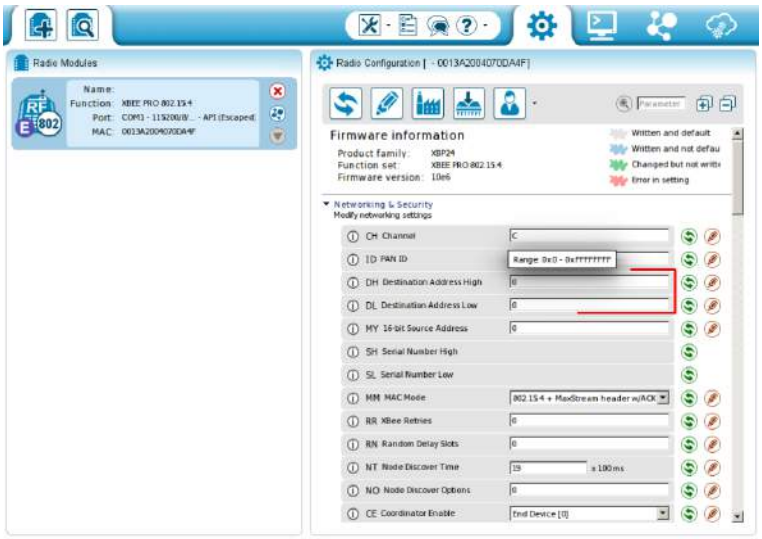

Figure 21: Settings on the XBee as seen in XCTU that are used to ensure connectivity.

Alternatively, if the XBee is connected to the PixHawk, the other radio can be connected to the computer and Mission Planner started. If they are connected properly, you will be receiving data from the PixHawk and be able to see it in Mission Planner

If no data is received, follow these steps to obtain a connection:

1: Check Source and Destination address in MCU software, each radio should have the source address of the others destination and vice versa.

2: Ensure the ID/Network is the same, they cannot communicate if they are on different networks.

3: Connect one XBee for Loopback and verify connectivity.

Using Controller

Using the DX8 to control the Stalker is described here. All the controls available will be listed with a pointer to the actual controller to show where the control is. Figure 22 shows each of the controls on the DX8 controller.

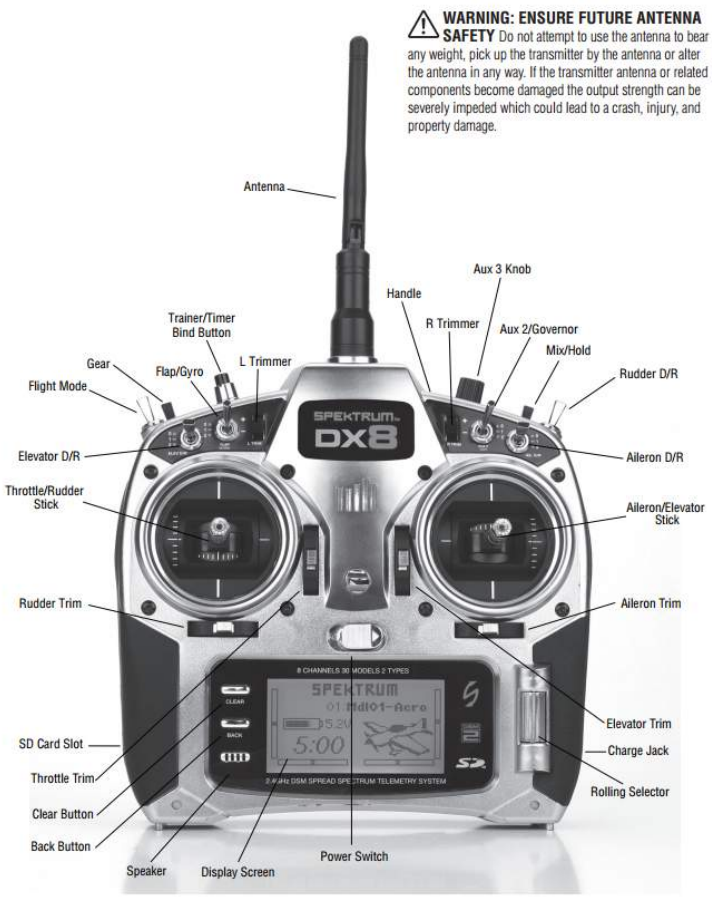

Figure 22: an example of what the DX8 controller looks like and some of the controls on it.

5.5 Ground Station/Autopilot

The ground station use is primarily on how to use mission planner. This section will specify how to use this program and any other tools that will fall to ground station that is not already covered in another system. For example, Lightbridge will be covered in the communication section.

Laptop Use

Mission planner is the software that is used for getting back telemetry data from the Stalker as well as program the autopilot with the waypoints that will be traveled to on the mission. Instead of filling this document with how to use mission planner a link to the Mission planner website is provided. From there, links to the other settings and features can be found and used for learning purposes.

http://planner.ardupilot.com/wiki/mission-planner-overview/

6 Maintenance Instructions

6.1 Propulsion

The propulsion system will need to be maintained. To this end, it will consist of inspection procedures and what should be done if certain symptoms are discovered. The motor and propeller will each have a maintenance procedure list here.

Propeller Inspection

Check propeller leading edge(s) for damage; run a fingertip over each leading edge to feel for chips, bends and cracks. If any damage has been done to the propellers, remove and replace the propellers as described in the disassembly and assembly sections.

Motor Check

Check power connectors at the base of motor mount, inside the nose of the body. Check exposed ESC/power wires inside fuselage for damage/wear. Check the motor characteristics that is presented in the propulsion use section. If there is significant drift in characteristics such as motor speed is lower than expected, consider removing and replacing the motor.

6.2 Payload

The payload system must be maintained like every other system. In this section, methods of checking the payload bay for damage will be covered. It will outline what to look for to determine whether the mounting plates or rails are damaged and the way/s to fix or replace them.

Payload Bay

The rails on the inside of the Stalker should be smooth and allow the payload plate to slide smoothly when not fastened down to it. If some of the mounting holes are not usable in the sense that the plate cannot be fastened to it, it is possible to print off new pieces to replace them. The plate should not move when it is installed in the Stalker. If it is loose, try to identify the problem, new plates can also be printed to accommodate the varying payloads which may help in Stability of certain payloads.

6.3 Power

This section outlines how to deal with the batteries on the Stalker. It covers battery logs, how they function and how to visually inspect them, how to dispose of them and how to properly charge them.

Battery Functionality

Lithium-ion batteries require routine maintenance in order to maximize lifespan. Note that the typical lifespan of a battery is around 300 to 500 charge cycles if the battery is fully discharged

during use. The lifespan of the battery is dependent on the depth of discharge experienced during routine use [1].

In an effort to extend battery life, the following measures can be taken to extend battery life. Note that the following are not always ideal for the missions required by the system. First, the number of cycles of a batterys life increases if the battery is not fully discharged during use. A battery is also stressed when held at a higher temperature and a high cell voltage during storage. If the charge of the battery is lowered from 4.2 Volts per cell, then the number of cycles will also increase. For each 0.1 Volt per cell lower, the number of cycles approximately doubles. It is clear from this that the lowering of the peak charge voltage will ultimately limit the capacity. However, by bringing the cell voltage again to 4.2 Volts per cell, the battery will resume its normal capacity.

Battery Storage and Disposal

When placing batteries into storage for long periods of time the battery should be at 30-50 % capacity. The battery should be kept at the charge and be checked on at least every 6 months. The battery ideally should be stored separately from the rest of the components and at temperatures 5-20 C [2].

The battery should be carefully handled. Follow proper battery disposal methods that can be found for your region. A battery that is damaged or punctured should not be used and any fluid released should be carefully handled. Do not allow the battery to reach temperatures above 60 C.

Battery Logs

After charging a new battery, it is important to note the run time of the system to develop a basis to compare with future runs. If the battery appears to be running for a shorter period of time (on the order of 80% of the original flight time) or the battery requires a much longer period of time to charge, then a replacement battery should be considered. As with all batteries, it is important to follow the charging procedures given by the battery for optimal battery life.

P

6.4 Communications

Much of the maintenance in communications is preventative and ensuring that everything looks operable. This section lists what to look for before flight to give the greatest chance of success.

Lightbridge Maintenance

Connections must be checked before takeoff to ensure nothing will come loose. This includes the video, power and antenna connections. This is done to prevent any loss of signal or components from hitting anything and causing damage to the Stalker or the environment. Cables must also be examined to ensure they do not fail midflight.

The Lightbridge can be tested by placing one meter from the ground station and verifying there is a solid connection. This should be done to make sure that there is proper connection

Antennas should be checked for stable attachment to the Stalker frame so they do not fall off.

In addition to verifying that all physical connections are stable, the software of the Lightbridge should be updated regularly to provide optimal performance. This is covered in the user manual for Lightbridge and should be referred to if more detail is desired. A firmware update should be checked for about once a month to see if it needs updating.

XBee Maintenance

The maintenance for the XBee is minimal. If the preflight checklist is followed each mission, it will verify that the XBee is functioning properly. If the radios are no longer working, set them up use XCTU and run a loop-back test after ensuring the addresses are set correctly. If you find that there is no connection, make sure that each radio is turning on and replace if is non-functional.

Manual Controller Maintenance

Ensure that the antennas are working and you have connectivity to the Stalker before takeoff. The controller needs minimal maintenance and will require changing the batteries/ charging the batteries before use.

6.5 Ground Station/Autopilot

The ground station must be maintained just like every other system. This section will describe how to keep the ground station running quickly and smoothly and maintain any hardware associated with it.

Laptop Maintenance

Ensure that all updates are installed on the laptop before running a mission. It is possible that it auto-updates while on the mission otherwise. Mission Planner should be updated to the latest version to make use of all features and the most stable build.

Hardware Maintenance

Ensure that all connections are tight. Make sure hardware shows no signs of damage. The monitor should be checked for damage when not working correctly. The cables to the monitor should be verified to have no visible defects.
All antennas should be connected properly and securely. Loose connections could cause damage to the components due to undesired reflections.

7 Parts List

7.1 Propulsion

Item: Aeronaut CAMCarbon, 43 x 28 cm Propeller
Description: Carbon Propellers for the Stalker.
Price: $13.80 each

Item: Stalker Motor
Description: Motor for the Stalker.
Price: No suitable replacement has been found yet.

7.2 Payload

Item: Payload Bay
Description: The Payload bay will be designed by UAF students. It will allow a plethora of payloads to be attached and held securely to the Stalker. The idea is to have a standardized attachment for maximum flexibility when choosing different payloads for missions.
Price: The cost of the filament used or printing costs from higher quality print place.

7.3 Power

Item: Turnigy Multistar 16-20 Ah batteries.
Description: Best batteries found on a budget that will provide the current required. Price: $119.86

Item: Connectors
Description: Connectors will be required for every subsystem that uses power, these will generally come with each subsystem that is purchased.
Price: $1.00 - $3.00

7.4 Communications

Item: Lightbridge Video Link
Description: Lightbridge is a high definition video system that connects to the camera and transmits it to the ground station. It also has the ability to act as the remote control system if that option is taken advantage of.
Price: $999.

Item: PixHawk Kit
Description: The PixHawk is an Autopilot system for Autonomous Vehicles. It is a PPM-input autopilot that is usable with many different receivers. It is capable of controlling various aspect of flight including motor control and programmable waypoints. It will serve as the main brains of the Stalker and will be connected to GPS so its location is always known. The kit comes with GPS module, PPM encoder, airspeed sensor and various other attachments that would prove useful in

different circumstances.
Price: $539.00.

Item: XBee XTEND
Description: The XBee XTEND is a 900 MHz radio frequency module used to transmit the data from the Stalker to the ground station to enable the monitoring of telemetry.
Price: $179.00

Item: XBee Dipole Antennas
Description: These antennas are used to convert the electrical signal and propagate it through free space. This will transmit the telemetry data to the receiver at the ground station to be monitored.
Price: $9.00

Item: XBee USB Adapters
Description: The USB adapters are used to connect the XBee at the ground station to the computer. This will allow mission planner to interpret and display the data for human reading.
Price: $24.00

Item: DX8 Manual Controller and AR8000 Receiver
Description: Used to control the servos and motor on the Stalker.
Price: $429.99

7.5 Ground Station/Autopilot

Item: Panasonic Toughbook 54
Description: The toughbook is used for increased resistance to the elements. It runs Mission Planner and other programs to run the mission and communicate with each of the subsystems. It is also used to set up the communication units on board the Stalker.
Price: $1300 -$2000

Item: Pelican Case
This item is used to store the Stalker and ground station while it is in transit. During operations it will also house the laptop, displays and receiver/transmitters for the mission.
Price: $1000+

References