Nightingale Security
Operations Manual

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Acronyms

AC - Alternating Current

ABC extinguisher - all purpose

AGL - Above ground level

BC extinguisher - rated for liquids and electrical equipment

Blackbird - Nightingale Security Drone

CB - Comms Box

CB 2.0 - Comms Box 2.0

CFR - Code of Federal Regulations

DC - Direct Current

DE - Deployment Engineer
EC - Emergency Controls
ELZ - Emergency Landing Zone
ESC - Electronic Speed Controller
FAA - Federal Aviation Administration
GPS - Global Positioning System
GTZ - Ground Traffic Zone
IPP - Intelligent Path Planning
IR - Infrared
ISR - Intelligence, Surveillance, Reconnaissance
IT - Information Technology
LED - Light Emitting Diode
LOS - Line of Sight
mAh - Milliamp Hour
MM - Mission Manager
MRU - Maintenance, Repair, Upgrade
NFZ - No Fly Zone
NOTAM - Notice to Airman
NS - Nightingale Security
OTA - over the air
PIC - Pilot in Command
PL - Precision Landing
POE - Power over ethernet
POI - Point of Interest
PSU - Power Supply Unit
PT - precision Takeoff
RA - Relay App
RGB - Red, Green, Blue
RPM - Rotations per minute
RSSI - Received Signal Strength Indicator
RTB - Return to Base
RTL - Return to Land
RX - Receiver
SIGMET - Significant Meteorological Information
sUAV - small Unmanned Aerial Vehicle
sUAS - small Unmanned Aerial System
TAF - Terminal Aerodrome Forecast

UPS - Uninterruptible power supply
VLOS - Visual Line of Sight
VO - Visual Observer
VPN - Virtual Private Network

Introduction

Nightingale Security's (NS) robotic aerial system is a cutting edge Intelligence, Surveillance, and Reconnaissance (ISR) platform that allows you to protect your most valuable assets 24/7 from a unique aerial vantage point. The system consists of a small Unmanned Aerial Vehicle (sUAV), base station, communications infrastructure, weather station and proprietary software.

The system is designed with a focus on safety and reliability, while providing the user actionable data in real time. This manual is meant to provide the information necessary for operational proficiency. It is a requirement for any operator to read this manual and familiarize themselves with the product.

Before operation, a Pilot in Command (PIC) must:

- ☑ Have a valid **Part 107** certification and working knowledge of federal, state, and local laws governing small Unmanned Aerial System (sUAS) operations
- ☑ Have read this document and understand operational limits of the NS robotic aerial system
- ☑ Pass a basic knowledge exam demonstrating the operators comprehension of Nightingale's best practices (administered electronically following deployment training)

System Components | Hardware

The Nightingale Security Robotic Aerial system consists of **hardware** and **software** components that are designed and engineered in the United States.

The **hardware** components will be installed at your location by Nightingale engineers and include:

- *Blackbird* - quadrotor vehicle
- *Base Station* - landing pad and enclosure for sUAV
- *Communications Infrastructure* - comms box, antennae, etc
- *Weather Station* - weather vane and water collection system

The **software** components are preloaded onto the hardware or accessible via web or iOS application, and include:

- *Mission Manager*
- *Relay App*

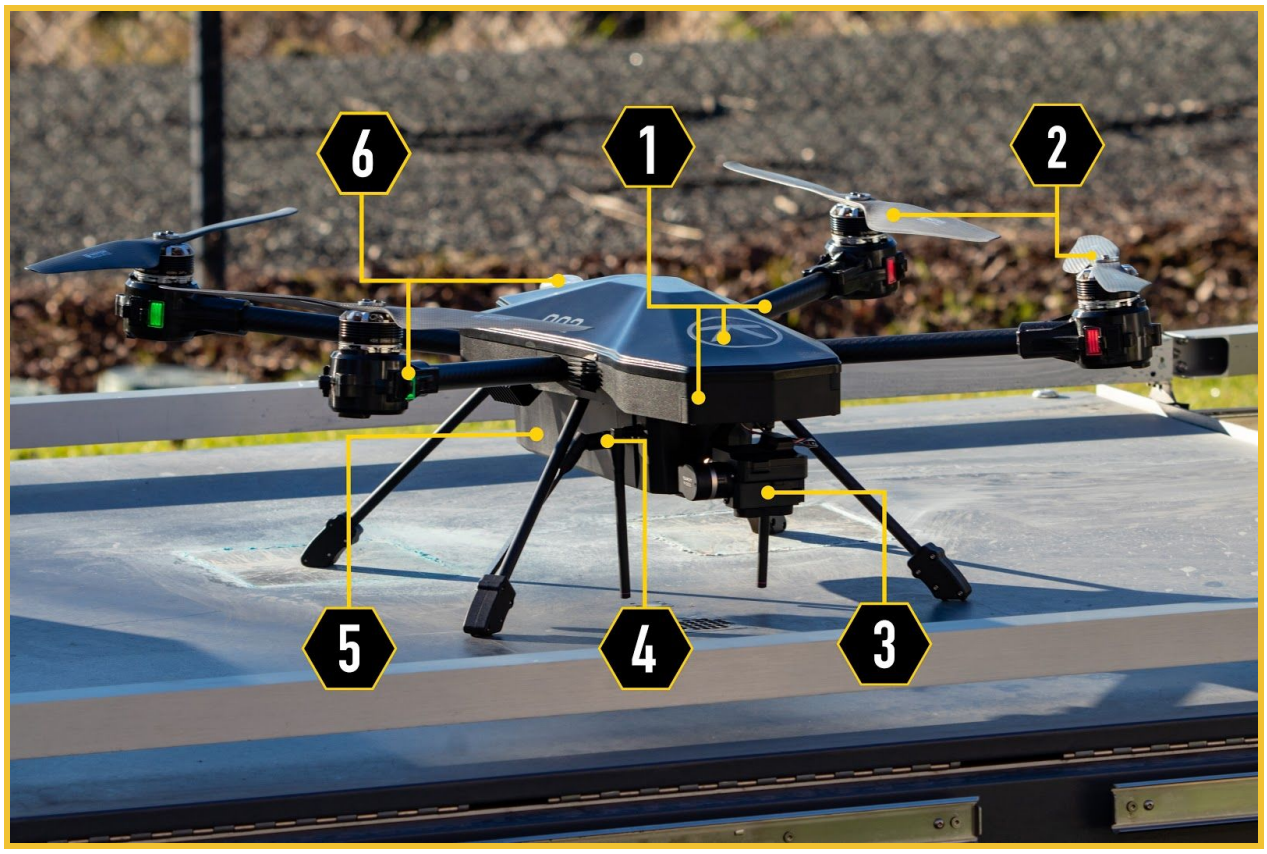
- *Proprietary on-board intelligence* required for the sUAV to execute autonomous flight, precision landing, object detection and artificial intelligence tools, and more

Software components will be regularly updated over the air (OTA) (feature updates, bug patches, etc.) during mutually agreed upon windows, so as not to interrupt operations. If mutually agreed upon times are not set, then Nightingale will contact the customer with the following information before proceeding with the update

1. Information about the type of software update occuring
2. Proposed timeline or urgency of recommended software update
3. Estimated system down time from software update
4. Permission and agreed upon timeframe with customer to push software update
5. Follow up with customer on success of update and return to normal operations once update is completed and verified.

The Blackbird

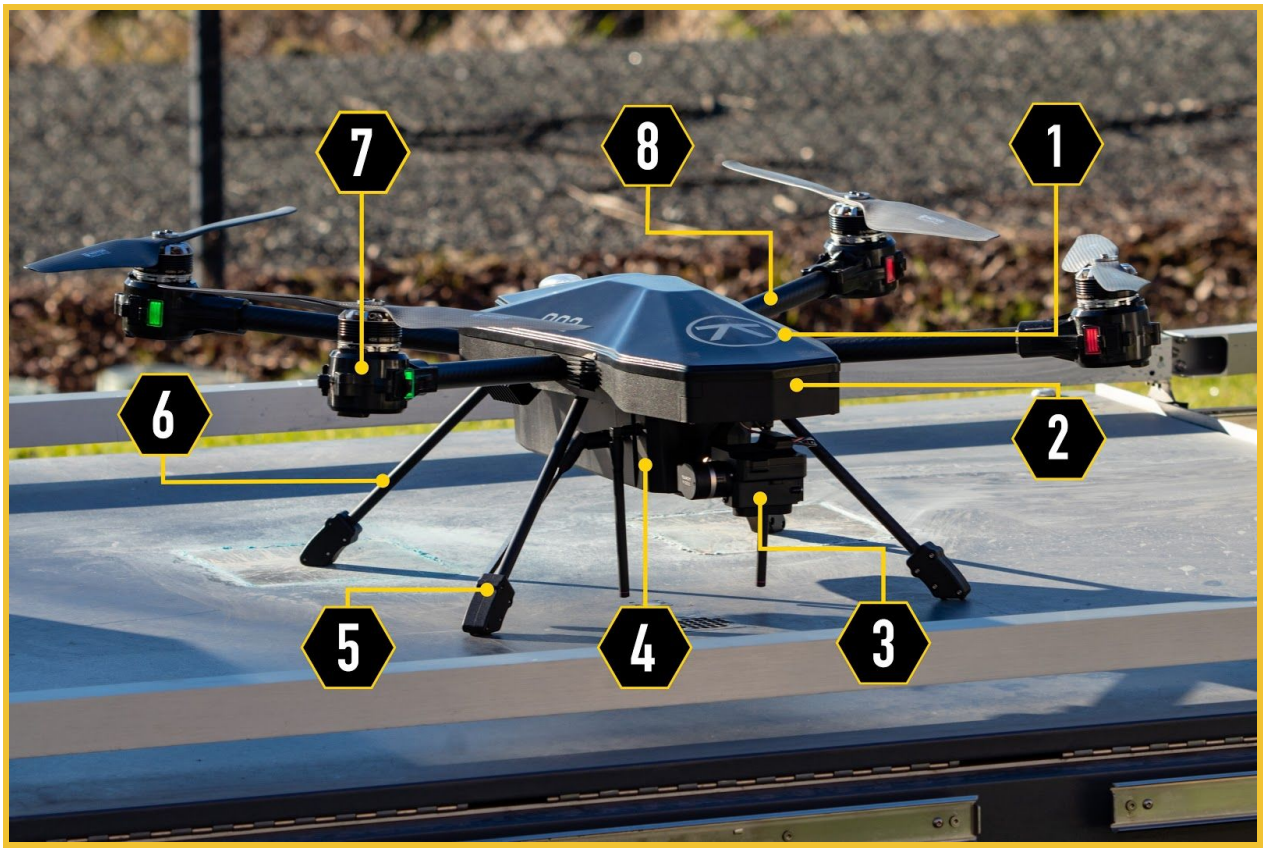
The Blackbird is a quadrotor aircraft composed of several major subsystems:



1	**Airframe**
2	**Propulsion**
3	**Sensors**
4	**Communications**
5	**Power**
6	**Lighting**

Airframe

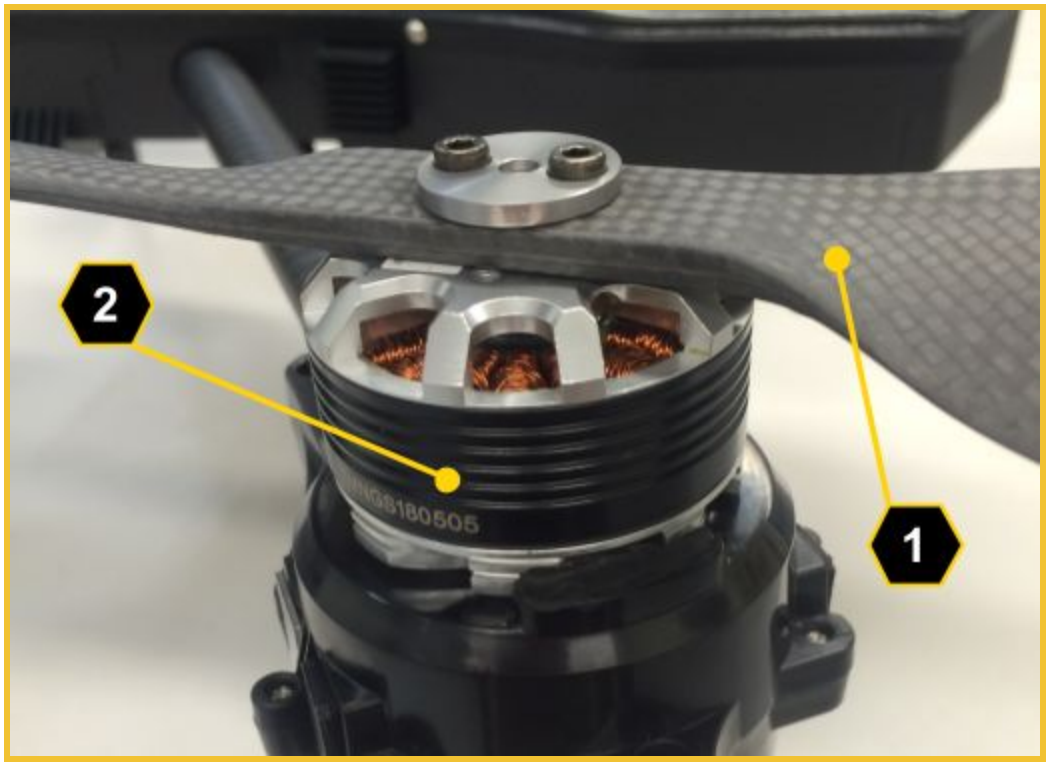
The Blackbird structure consists of an airframe containing vital components necessary for flight and acts as a mounting platform for other subsystems. The airframe is made from polycarbonate injection molded perimeter frame, carbon fiber top and bottom plates, and weatherproof lid. Carbon fiber tubes are mounted to the frame and make up the arms and legs. For specific airframe specifications see amendment.



Airframe		
1	Lid	Housings
2	Fuselage	
3	Gimbal Sensor Housing	
4	Data-link Housing	
5	Foot	Landing Gear
6	Leg	
7	**Motor Mount**	**Mounts**
8	**Arm**	

Propulsion

Propulsion is composed of four brushless DC motors mounted on the end of each of the four arms. Motor wires are routed inside the arms and connect to an Electronic Speed Controller (ESC) which provides the current to spin the motor. Removable 18 inch diameter carbon fiber w/ balsa core propellers are attached to the top of each motor bell which generate lift necessary for flight.



Propulsion		
1	Propeller	Exterior Components

2	Motor	

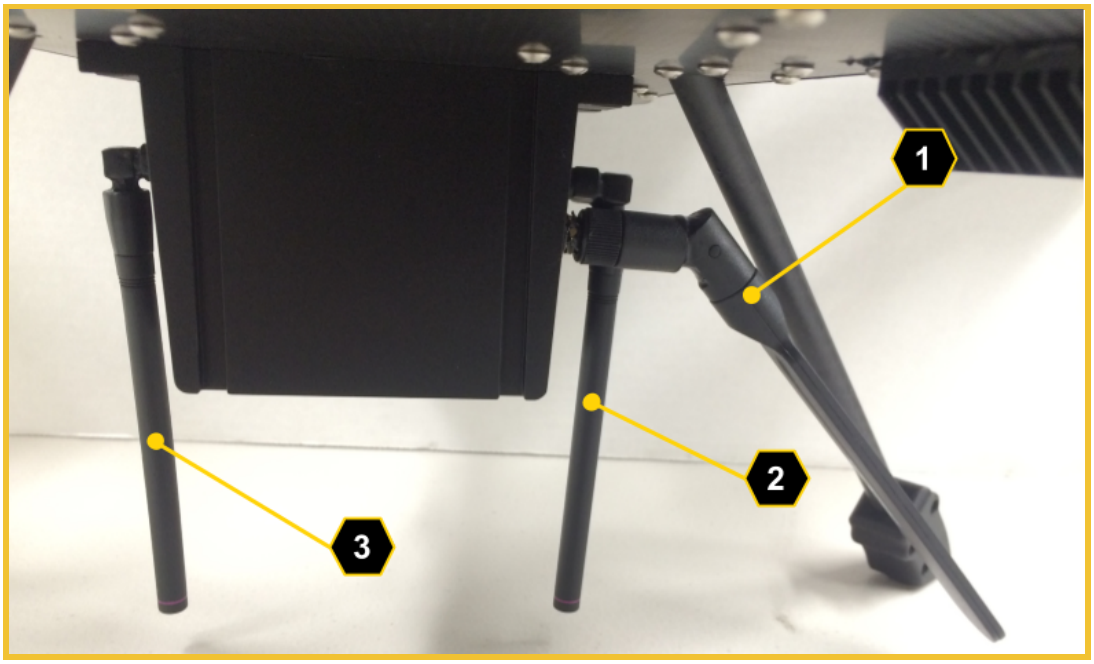
Power

The power system includes a 16,000 mAh Lithium Polymer battery mounted to the underside of the drone. Charging pins located on the underside of both rear feet make contact with the base station charging pads. A battery management system monitors the voltage and current draw during flight and charging.

Power		
1	Power Switch	Exterior Components
2	Battery	
3	Charging Pins	

Communication

The Blackbird communicates with the base station during all phases of flight using a 2.4 GHz wireless communication link for command and control features and video streams. LTE wireless communication is also utilized as a backup when needed.

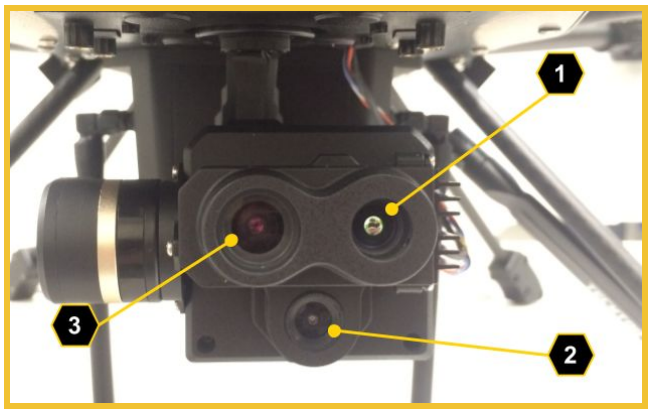


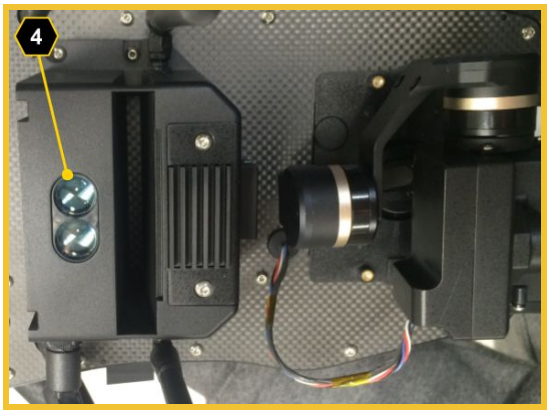
Exterior Communications		
1	LTE Antenna	LTE Communication
2	Data-link Antenna 1	Local Communication
3	Data-link Antenna 2	

Sensors

A gimbal mounted sensor package incorporates an RGB, thermal and IR camera. The RGB and thermal sensor provide real time actionable data while the IR sensor aids in precision landings onto the base station. The gimbal allows the sensor package to tilt while stabilizing video streams.

Additional sensors are used by the flight controller. The LIDAR sensor determines the altitude above ground while a barometer provides a backup for the same purpose. A Global Positioning System (GPS) compass is used to find the location of the Blackbird.

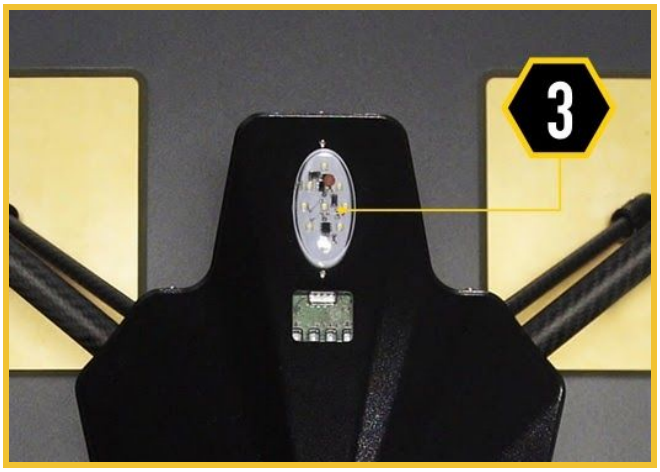




Optics		
1	FLIR Boson 320	Thermal Camera
2	IR-LOCK Sensor	IR Sensor
3	Sony IMX274LQC	RGB Camera
4	Lightware LW20/C Lidar	Rangefinder

Lighting

A strobe light is fixed to the top airshell and functions as anti-collision lighting as per FAA regulations for night flights. Light emitting diodes (LED) are placed on the motor mounts to aid in determining the direction of the Blackbird, red on the left side and green on the right side.



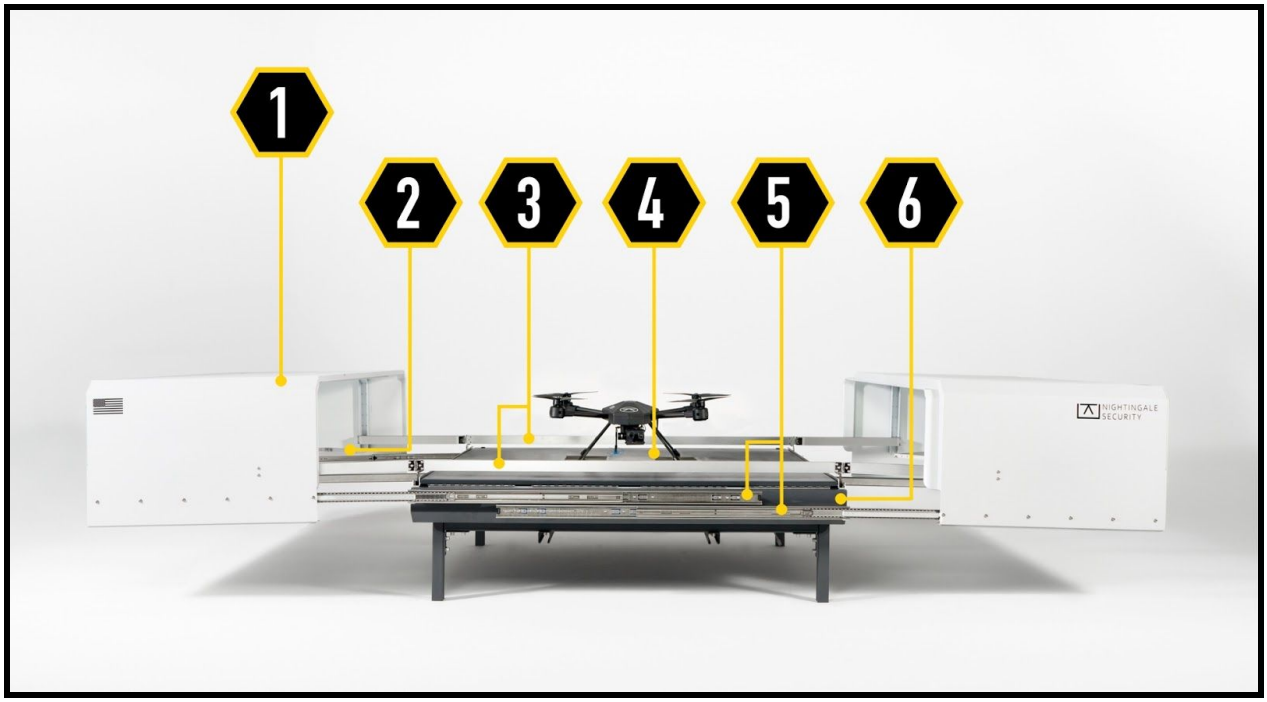
1	Green Navigation Lights (Right side)	Located on the sides of each motor mount

2	Red Navigation Lights (Left side)	
3	Strobe Light	Located on the lids tail end

Base Station

The base station houses the Blackbird and essential equipment for operation. The base station and all of the subsystems run off standard US 120v. All internal electronics are plugged into a single powerstrip which feeds into the UPS shelved underneath the base. All components are 240v capable with request, the UPS will need to be bypassed. Essential equipment located in the base station includes:

- Housing
    - Doors
    - Centering devices
    - Door rails
    - Landing pad
- Motors
- Charger
- Base computer
- Base Server
- UPS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NIGHTINGALE SECURITY


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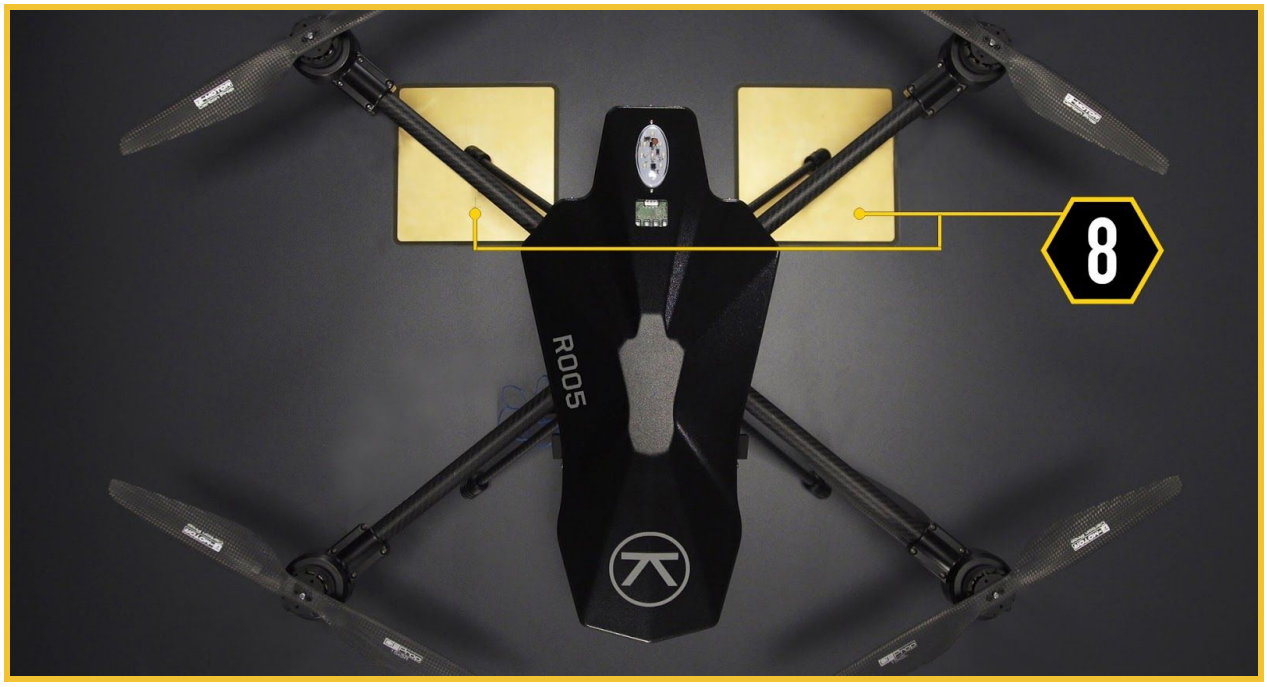
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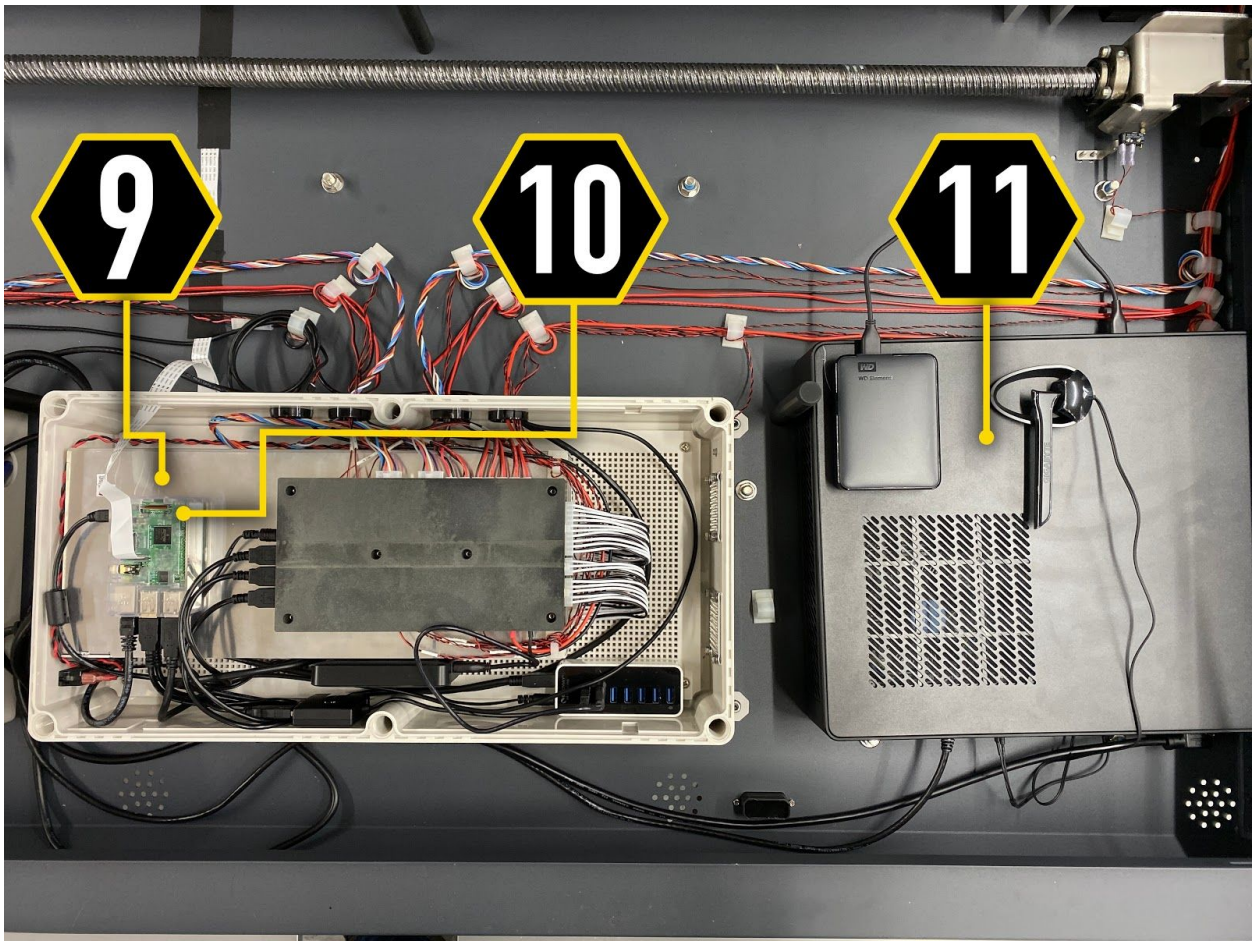
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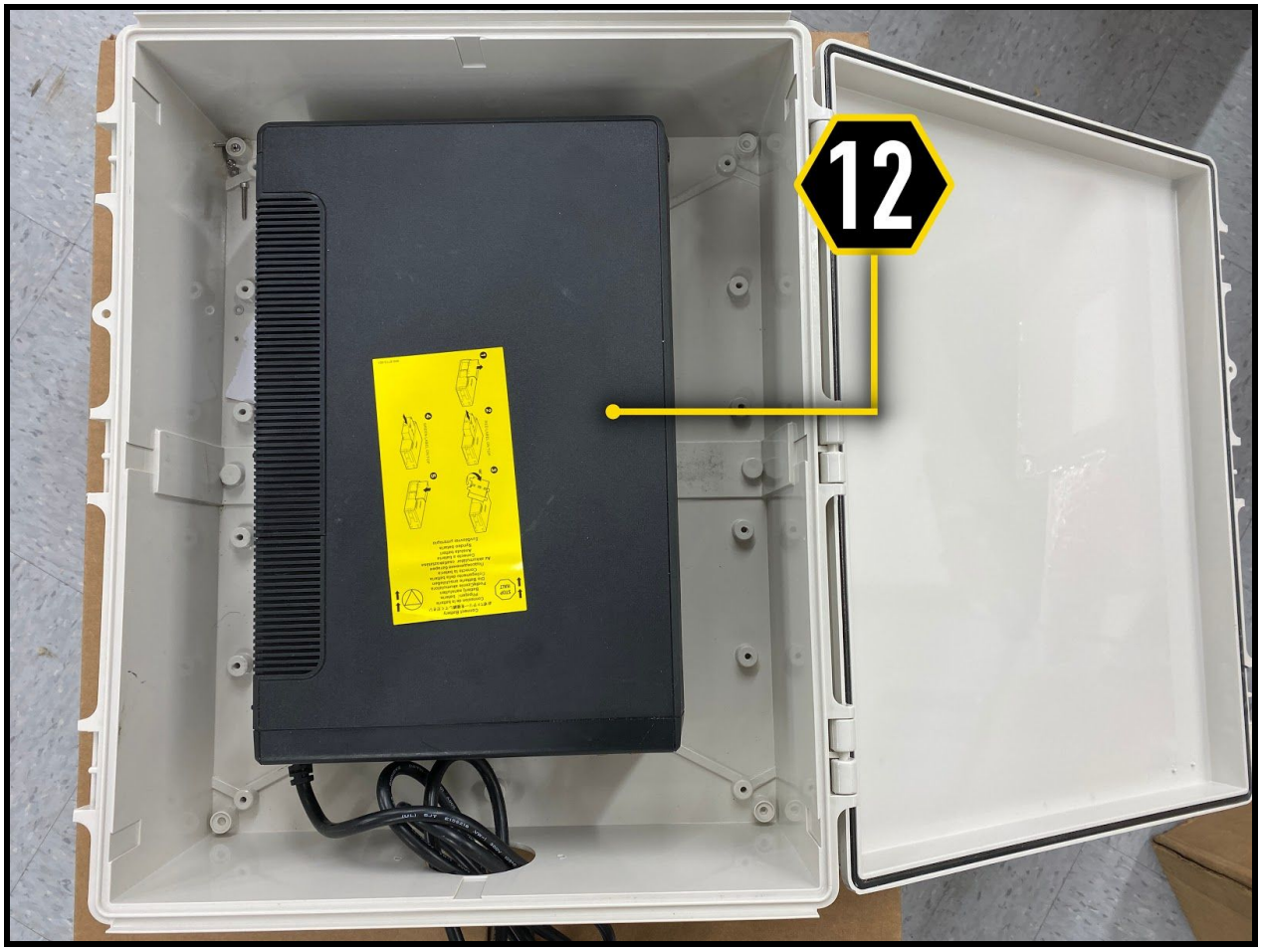


Diagram of hardware components that make up the base station:

No.	Item	Category
1	Base Doors	Mechanical
2	X-axis centering Bars	
3	Y-Axis Centering Bars	
4	Landing Surface	
5	Door Rails	

6	Bottom Enclosure	
7	IR Beacon	Electrical
8	Contact Charging Pad	
9	Internal Charger	
10	Base computer	
11	Base server	
12	UPS Box (APC Back-UPS Pro 1500VA Battery Back-Up System)	

Housing

- The base enclosure protects the Blackbird from natural elements through the use of automatic doors which double as centering devices. While not being operated the drone sits idle enclosed by the base doors transferring videos to server, sending updates and charging until a launch command is sent. Once a launch command is sent, the base doors will automatically open while the Blackbird prepares its flight route. After takeoff, the Blackbird will proceed on its mission, sending a request to close the base doors. During landing, the Blackbird will send a request to open the base doors, post landing the base doors will shut.

Motors

- The motors that control the base doors are housed inside the base under the landing pad. The motors are an essential piece of equipment because a malfunction will cause an emergency status. The encoders in the motors are quite sensitive, they determine if the base doors are open or closed. Uneven distribution on the doors will cause the base to go into an unknown state, it is important to place the base on a level surface to prevent undesired states.

Charger

- During normal operation, the base station will charge the Blackbird through copper plated contact pads. The pads are coated with conductive material, it is important to clean pads weekly to ensure sufficient contact between the plating and the drone feet. The charger will initiate automatically once the base computer receives confirmation that the Blackbird is safely on the landing pad and feet are positioned onto the pads. The

charger status will toggle between on and off to protect the integrity of the Blackbirds battery and extend its life cycle. When checking battery volts before flight, the percentage will vary between 90% to 100% due to the safety toggling of the base charger.

Base computer

- The base computer is responsible for communication between the Blackbird and the base station. The internal computer tracks and responds to requests regarding charger information, weather and base doors. The base computer also acts as a relay for transferring videos from Blackbird to the local server.

Base server

- The base server is home to *Mission Manager* and downloaded HD videos. Located in the base, the server handles all commands sent from a device being sent to the Blackbird. All visible system information is passed through the server at some point in order to reach the end user.

UPS

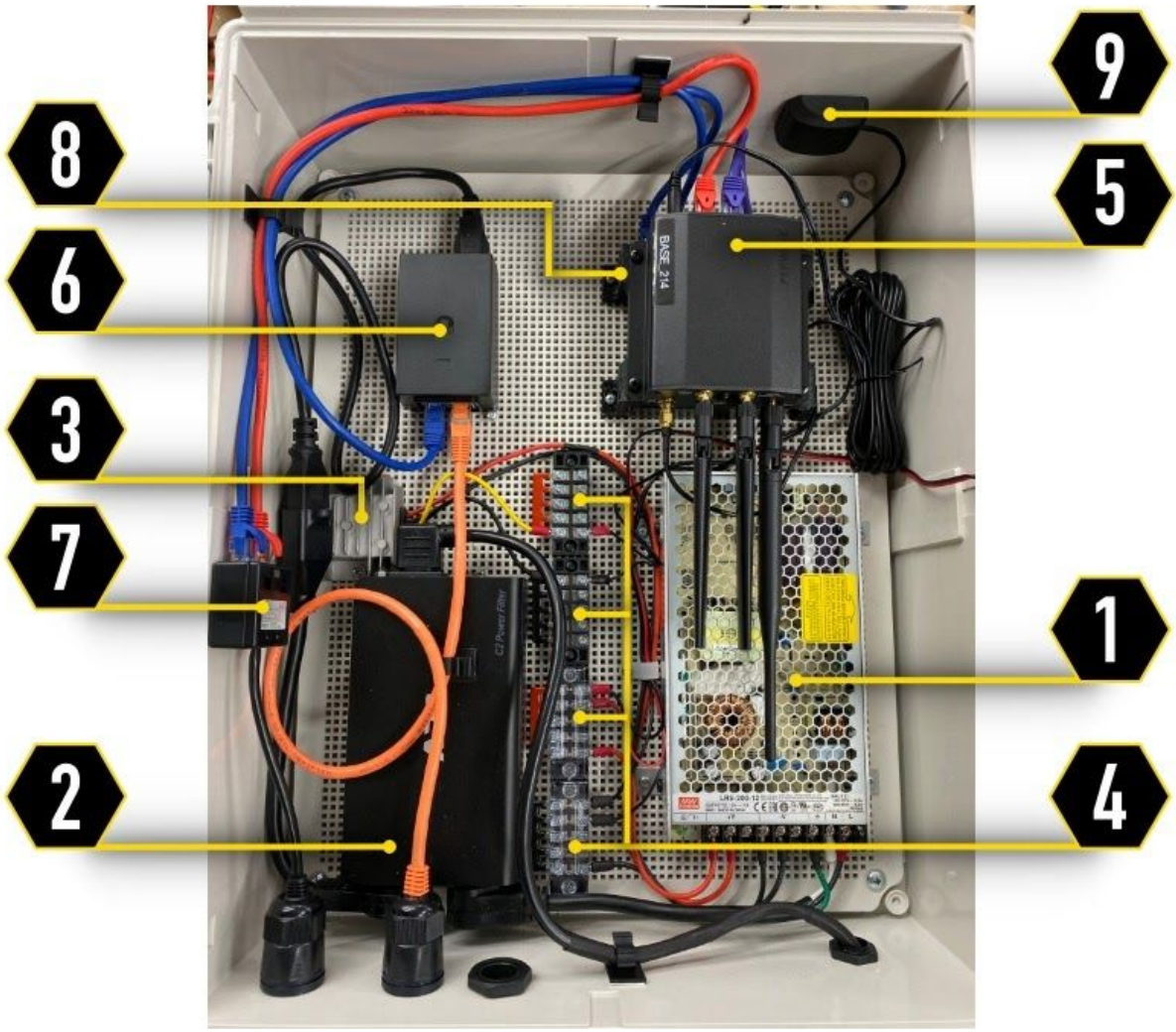
- The APC Back-UPS Pro 1500VA Battery Back-Up System -- uninterruptible power supply is a subcomponent of the base that power is routed through. The purpose of the UPS is to mask interrupted power coming from an outside source and protect the system from power surges. In the event the site loses power, the UPS will provide backup battery for 13* minutes to allow any in-flight Blackbirds to safely return to base.

Note: If the operator experiences sounds coming from the UPS box, contact support@nightingalesecurity.com.

* Test was conducted with max amp draw (Blackbird charging at max speed and all systems on)

Communications Box (Comms Box)

The *Communications Box* is an essential part of the Nightingale system that connects the base and Blackbird to each other and to the world. It is the communications hub for traffic transferring from air to ground. Like the base station the comms box requires 120v input with the ability for 240v upon request. The 240v version does not include the APC power filter. The components of the *Comms Box* include: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1	LRS-200-12 Power Supply	Power
2	APC AV C Type Power Filter	
3	DC 12V to DC 5V Buck	
4	5 Position Terminal Block (x4)	
5	Peplink BR1 (Pepwave)	Communications Infrastructure
6	48v POE injector	
7	RJ45 Splitter	
8	Data-link pDDL2450-ENC	
9	Pepwave GPS module	
10	Pulse 8dbi high gain	
11	High gain l-comm 15dBi antenna	

APC AV C Type Power Filter

- Power runs from the base UPS Box to the *Comms Box* through liquid tight conduit and meets this Power Filter.

LRS-200-12 Power Supply

- Power from the Power Filter runs into the LRS-200-12 Power Supply (PSU). The PSU converts AC power to DC, and distributes it to the downstep and the terminal blocks throughout the *Comms Box*.

DC 12V to DC 5V Buck

- The PSU bracket runs DC power directly to a grey 12V to 5V downstep Buck. The Buck downsteps power from 12V to 5V, and runs the 5V power to the two 5 Position Terminal Blocks labeled +5V/-5V.

5 Position Terminal Block (x4)

- All components in the *Comms Box* receive power from each of the 5 Position Terminal Blocks labeled either +12V/-12V or +5V/-5V. The 5V Terminal Blocks power the Wilson Signal 4G Amplifier. The 12V Terminal Blocks power the Data-link, the Wifi Signal Booster, the Pepwave, and the fan.

48v POE Injector

- Powers the CB 2.0 via an ethernet cable. Has a max distance of 300 feet. Runs off of the APC power filter.

LComm Antenna 15dBi

- The L-comm Antenna (x2) are mounted on an antenna mast that is secured to a pole above the communications box, the antennas directly connect to the CB2.0. It receives and transmits 2.4 signals to and from the Blackbird.

Pulse Antenna 8dBi

- The Pulse Antenna 8dBi (x2) are mounted on an antenna mast that is secured to a pole above the communications box, the antennas directly connect to the CB2.0. It receives and transmits 2.4ghz signals to and from the Blackbird.

Peplink MAX BR1 (Pepwave)

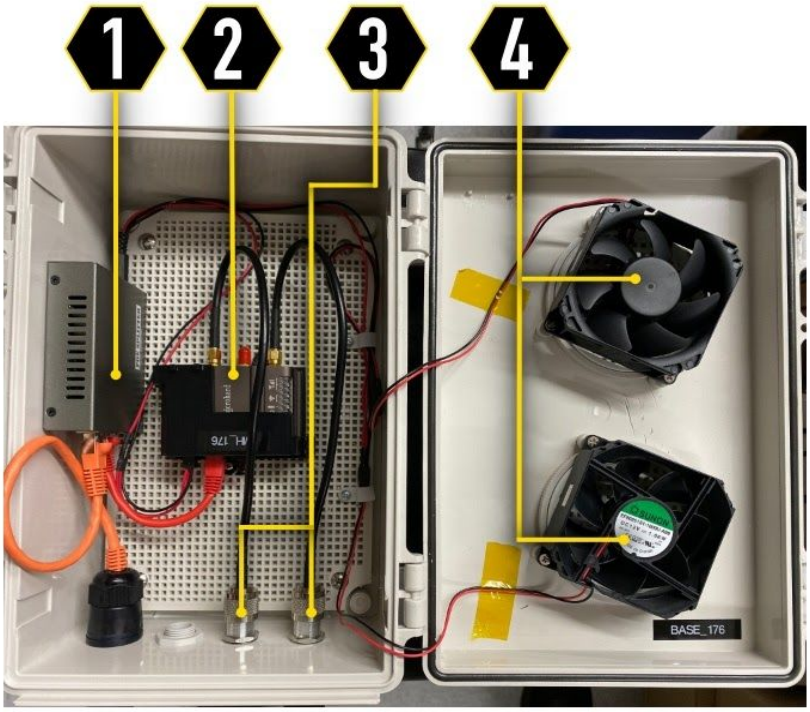
- The Pepwave hosts the local network on which the Data-link, base components, and world can communicate.

Ethernet Coupler and RJ45 Splitter

- The Ethernet Coupler is mounted to the bottom of the *Comms Box* in front of the Hawking Antenna Surge protector. Ethernet runs from the *Base Station* through this coupler and the RJ45 Splitter, from which two ethernet cables transfer data to the Pepwave.

Communications Box 2.0 (CB2.0)

The CB2.0 houses the Data-link unit and a switch powered by ethernet which is kept cool by two electric fans.



No.	Item
1	Switch
2	Data-link
3	Lightning Arrestors
4	Cooling Fans

Microhard pDDL2450-ENC (Data-link)

- The Data-link is connected to: the l-comm Antenna through the Wifi Signal Booster and a lightning surge protector; the externally mounted 8dBi Lcomm Antenna through a lightning surge protector; the TBS Crossfire Nano RX through an SBUS to serial module; the Pepwave via ethernet; and is powered by the blue Data-link power connector. Most of the system communications run through the Data-link.

Weather Station

The weather station is an integrated part of the Nightingale system and provides real-time, localized weather data for the sUAV's operational area. The weather station provides the PIC and Nightingale with data about the current flight conditions to determine if the environment is conducive to flight operations. Weather limitations are displayed to the PIC in the mission control software. These limitations can be found in the Operations | Envelope and limitations section. The weather station consists of is a multiple component system that includes:

- Sensor Suite
- Uplink Module
- Display console

Sensor suite

- The sensor suite is a combination of sensors that gather all weather data including wind, precipitation, and temperature. The sensor suite is mounted on the base enclosure fence post or nearby. The sensor suite is powered using a solar panel with a backup lithium battery. The most important sensor is the anemometer. The anemometer determines wind direction and speed hyper-locally.

Uplink module

- The uplink module is the wireless data transmitter mounted on the sensor suite. It is transmitted at 915 MHz to the display unit located in the base.

Display console

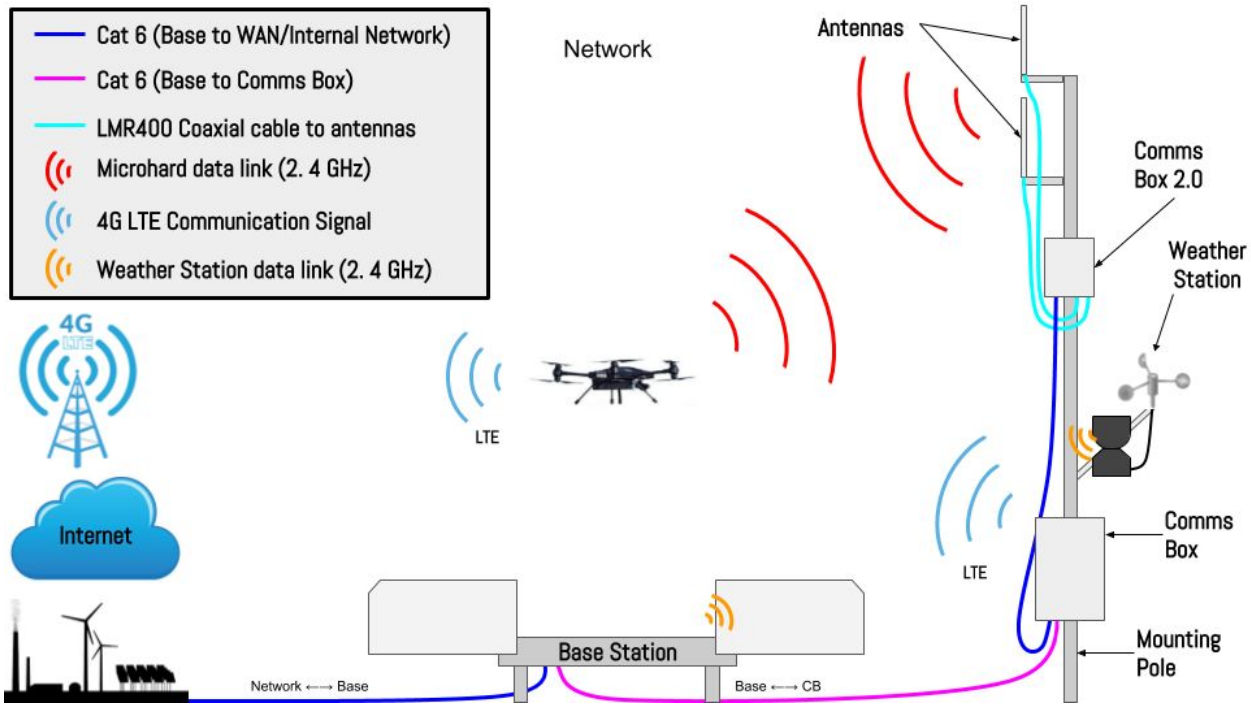
- The display console is located inside the base where the base computer, charger and server reside. The display console takes the weather information transmitted from the sensor suite and uploads it to the base computer where the information is integrated with the software. The information from the display console can be seen on the MM page or Relay app to aid the PIC in making flight decisions based on local weather. The console also relays the necessary information for the Nightingale system to automatically override launches based on Blackbird and FAA weather limitations.

No.	Item
1	Anemometer
2	Display Console

3	Integrated Sensor Suite
4	Uplink Module w/ Solar Panels

Network

The Nightingale Security system network is configured in various ways, depending on the security requirements of the customer and the infrastructure available. The safest and most ideal configuration connects to the customers existing network infrastructure to provide reliable internet connection for consistent uptime. That configuration is discussed below, with a diagram for reference.



- The **Base Station** is connected to the facility's **local network**. It is highly recommended that the base station is connected to the sites local network with access to the internet. (**blue**) There is an option for the base station to acquire network connection through the comms box supplied by LTE. however, due to data restrictions this is highly inadvisable.

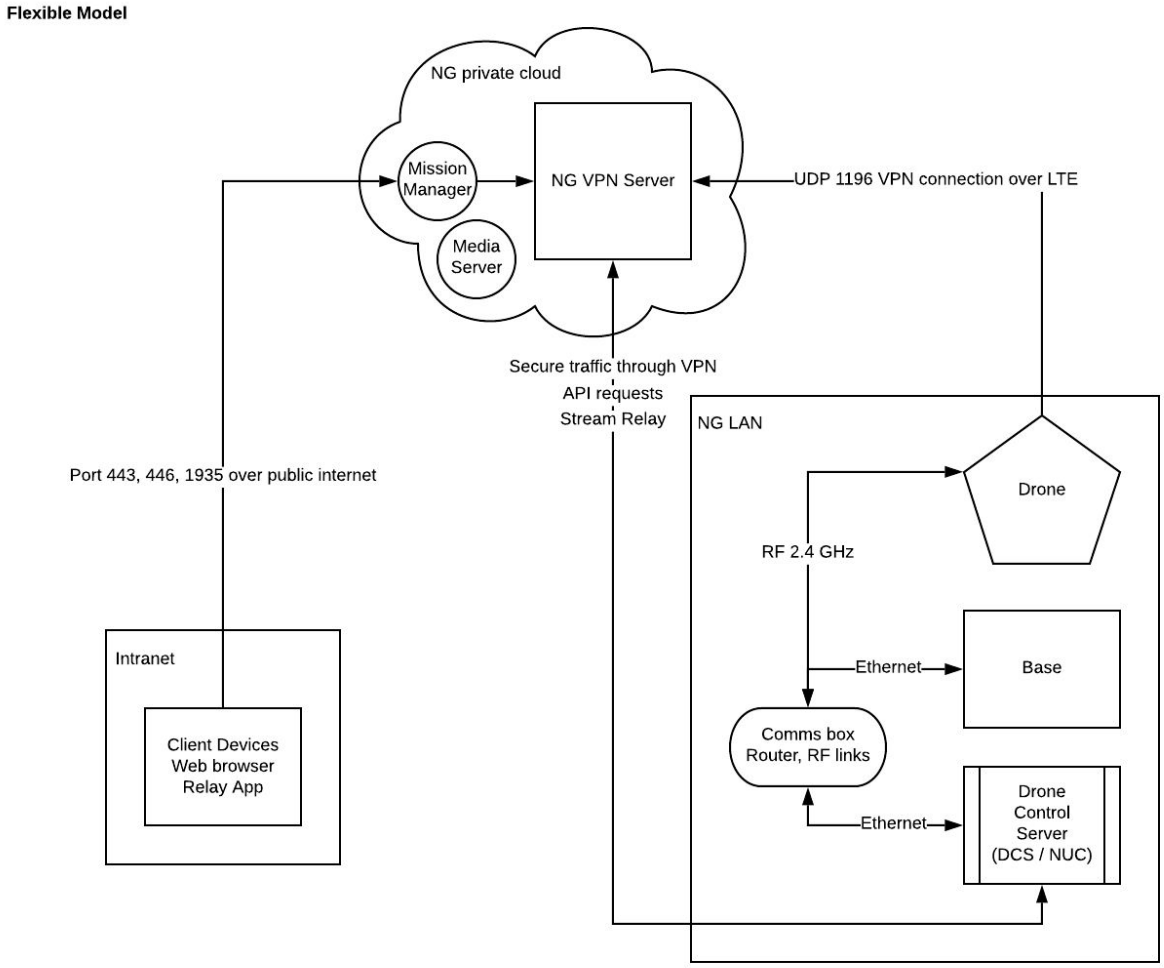
- Processes on the Base Station computer can communicate to the rest of the system via the link from the Base Station to the **Communication Box** (**purple**).
- There is a router inside the comms box behaves as a hub for network activity. All devices in the Nightingale System are linked to the router, including the **data-link**.
- The data-link is inside the **Comms Box 2.0**. It is powered by a cat6 ethernet cable carrying power over ethernet (POE) from the comms box (**blue**).
- The **antennas** are connected to the data-link by LMR400 coaxial cables. These cables are typically 25' in length (light blue).
- Commands propagated from the Base Station computer to the **Blackbird** are cast through the antennas, and received by a data-link module onboard the Blackbird (**red**).
- The data-link link, illustrated in **red**, is the primary stream link to the Blackbird. It is a 2.4 GHz link, with a range as great as 2.3km. In can also be used as a back-up link for Command and control, if LTE were to fail, the system will automatically try to re-establish connection of the local data-link.
- LTE connection (blue) exists on two components, the Blackbird and the Comms Box. This allows for commands from anywhere that has internet access and can be received by the comms box, which in turn is received by the Blackbird. LTE is the primary link for all command and control inputs; if the LTE fails, the system will automatically fall back to the **local data-link**.
- There is a wireless link (orange) between the **weather station** and the Base Station so that live and local weather data can be viewed by the pilots.

Note: data-link signal degradation scales with the length of the LMR400 cables. For this reason, it is ideal to configure the infrastructure in a way that the Comms Box 2.0 is very close to the antennas.

Network Architecture

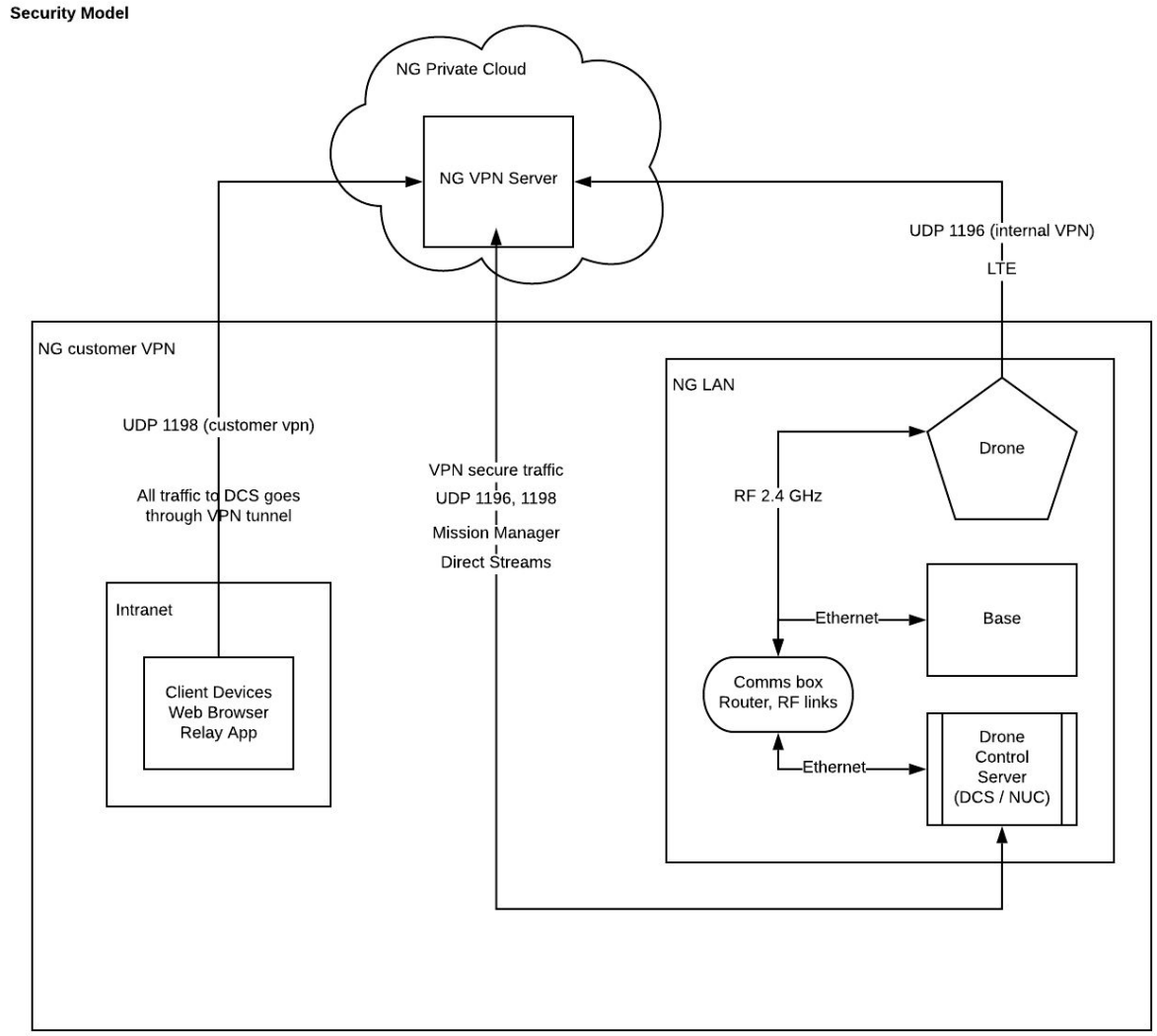
The Nightingale network can be constructed in various ways depending on the need for accessibility versus security. The networking model heavily depends on IT requirements and use case requirements. The three major network options are shown below:

Flexible model



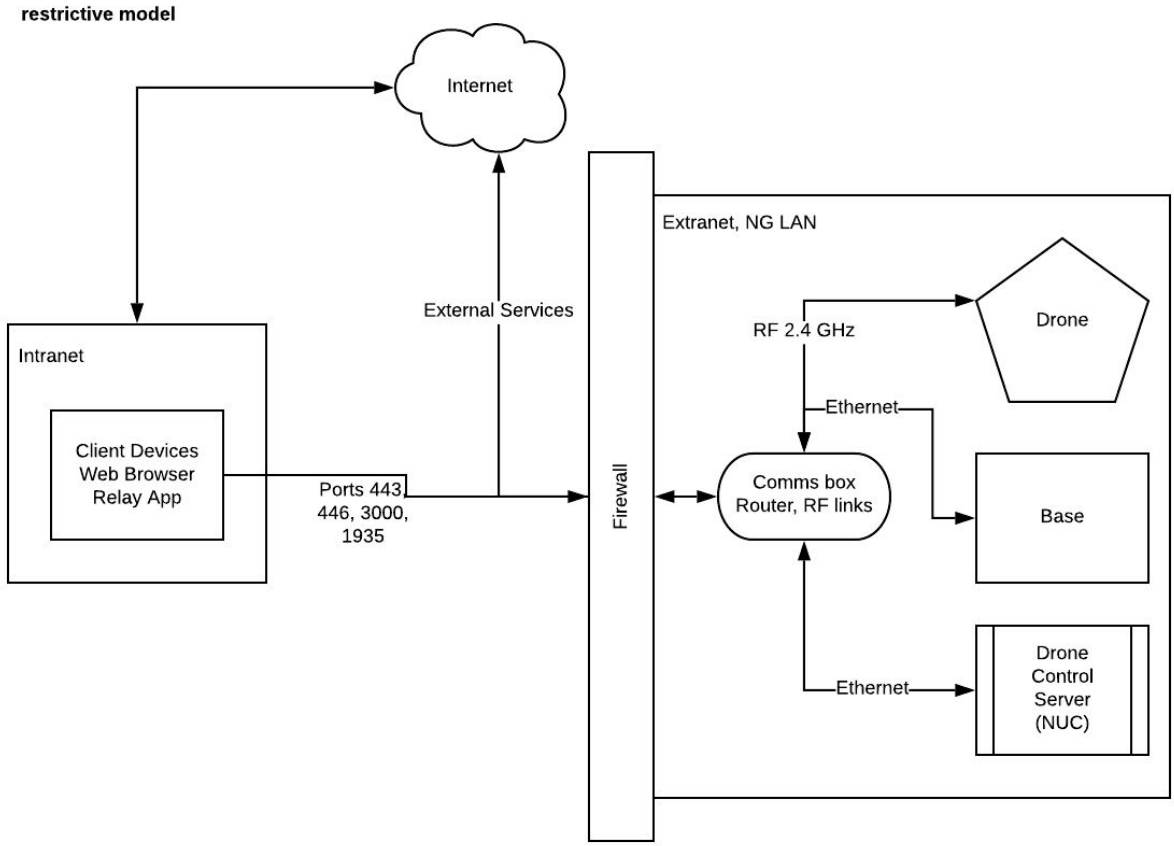
- The flexible model uses publicly accessible web server as a gateway to the drone control server physically located at the customers facility. All traffic is secured through HTTPS and is proxied down to the NG Base server (DCS) using a VPN tunnel. This allows users to access their drone management software from anywhere in the world without using a VPN client. Streams are securely transmitted through HTTPS and with token hash authentication. This configuration is ideal for both ease of access and convenience. It secure, but accessible to the public.

Security model



- The security model makes use of VPN client and server architecture which allows the user to control their drone and view streams securely from anywhere in the world. Clients will be provided VPN keys to get their devices connected onto the network. After establishing a connection to the VPN, users will be able to control the drone through using Mission Manager web software or the Relay App on iOS. Server access will only be accessible to connected VPN clients and is invisible to the public internet.

Restrictive model



- The restrictive model is a local network setup. This is to isolate the server from the outside world and all communications obey the client's network configuration. An isolated extranet can be created with a firewall to restrict users and traffic from accessing the Nightingale drone control server. The system can still be accessed from the public internet if desired by using port forwarding.

    - **Important note: Choosing the restrictive model will alter standard flight operations, please see notes under RTL in SOPs section and Communication loss in the EMERGENCY PROCEDURES section.**

    - **Restrictive model only allows for one method of communication to the Blackbird safety and emergency backup protocols will be affected.**

System Components | Software

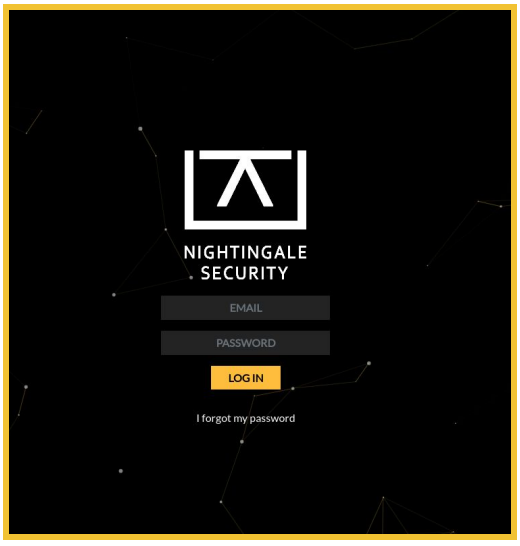
Mission Manager

Mission Manager is Nightingale's proprietary web application from which all workstation-based operations are conducted.

In Mission manager users are able to not only able to manipulate flight of a Blackbird on pre-defined missions but create missions and operational areas as well.

Getting Started

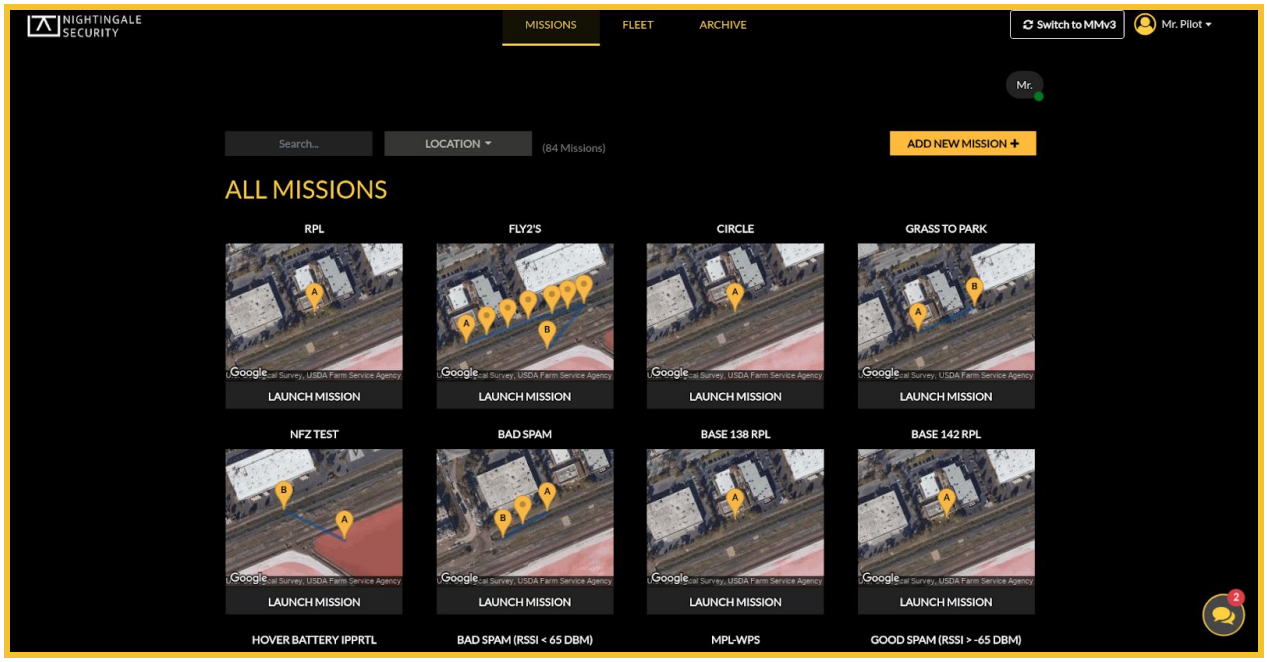
- Login - Nightingale staff will provide all administrators, pilots, and support staff a set of login credentials based on their qualifications. Login credentials consist of an email address and password. The image below shows the login screen where the credentials are entered.
    - Passwords:
        - Must contain 10 or more characters
        - Contain a capital character
        - Contain a special character
        - Contain a numeric character



Credential Levels

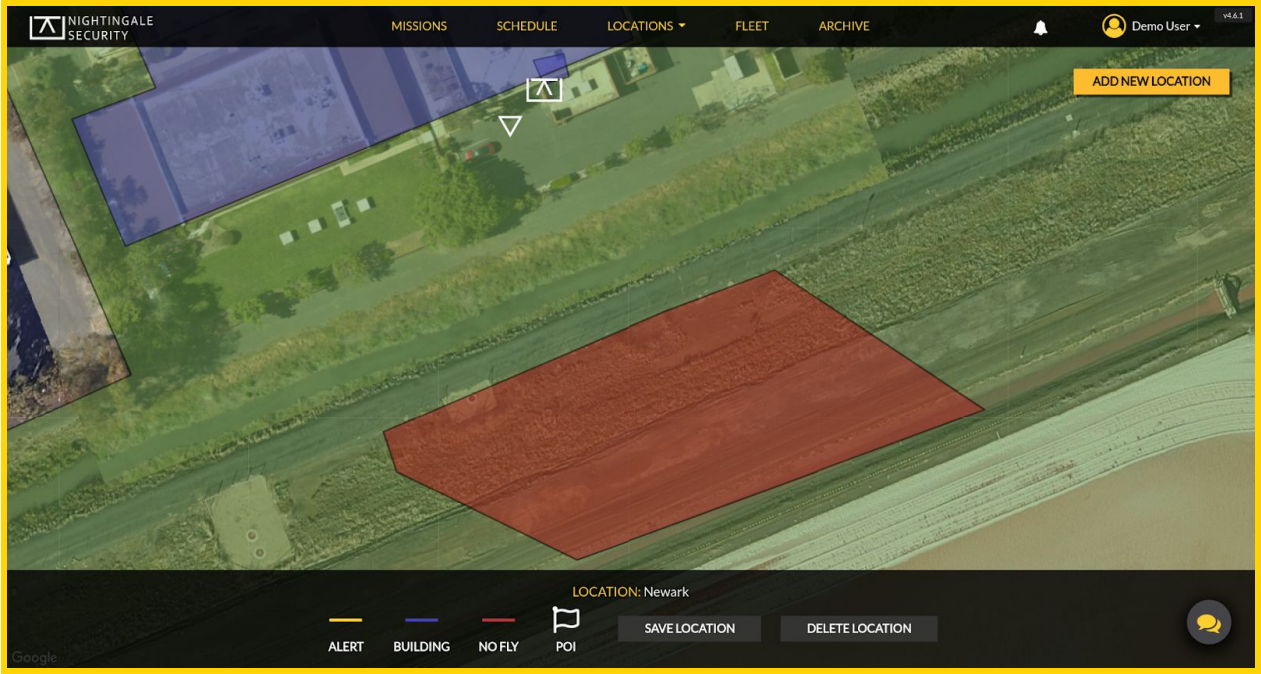
- *Admin* - coming soon
- *Captain* - can create and execute missions, edit locations, and has full access to drone controls
- *Pilot* - can create and execute missions, with full access to drone controls
- *Wingman* - can watch streams and view archive pages

- After login, the Mission Manager will direct to a page like this:



Geofence

A Geofence is the operational area of the system as defined by specific GPS coordinates based on the site evaluation done by a Nightingale Deployment Engineer (DE). The Blackbird will only operate in the defined geofence space. Operations outside the approved area are strictly prohibited and will be flagged as system failures automatically by the software system.



The **geofence** is represented by transparent green shading on the map. The geofence represents boundary of operations, and the Blackbird will not accept commands that require it to leave this boundary.

If a waypoint or route is determined by the system is to be outside of the geofence or inside a NFZ, the route will be rejected and the Blackbird will abort any launch sequences.

Note: While on-site during installation a DE can work with the operators to include in the geofence site specific requirements and use cases.

All flight hazards will be identified and mapped out by a DE prior to operation of the system. It is the PIC's responsibility to verify the accuracy of the location by visually inspecting the area of operation and adding any new obstacles to the geofence via the appropriate tool and with the approval of a Nightingale employee.

Geofence parameters

Note: A detailed cut sheet of the site airspace will be provided in a site assessment document. The document include specifics of site airspace and climate.

Before flights can be conducted, the surrounding airspace will be evaluated by a DE. After assessing the site, the DE will define the geofence for approved operations, including defining buildings and No Fly Zones

- Edits to the **Geofence boundary** is required to be approved by a Nightingale Deployment engineer. If the operator decides there are new use cases or site expansion, they are to reach out to Nightingale with proposed extension and it will be reviewed for safety.

- Edits to a **Building** are possible. If a building had new construction to add floors or towers, an edit might be necessary. If the pilot feels an altitude change to get closer is safe, or to raise altitude for safety, they can do so in location editing.

- Adding a **Building** feature (blue shape) allows the Blackbird to still operate in that location but calculates the height of the obstacle and reroutes over specified altitude by 10 meters. Define the size to be larger than the obstacle and include the height (in meters), ensuring proper clearance above the top of the obstacle. The Intelligent Path Planning (IPP) software will recognize this assigned obstacle height and autonomously fly the 10m buffer altitude above the obstacle to ensure no impact is possible.

    - Example: A crane is on site temporarily. It will not be on site long enough to justify new mapping, but it is in the proximity of a few critical patrol missions. Simply outline the area on the map where the crane is located, set the proper clearance height, and now you can be sure that the Blackbird will properly avoid the temporary obstacle.

- Add a **No Fly Zone** (red shape) to prevent any operations in a desired area. The Blackbird cannot enter the No Fly Zone (NFZ), and will use Intelligent Path Planning (IPP) to find its way around any NFZ's to the next waypoint.

    - Example: As laid out in the Part 107 training, flights over non-participating parties are **not** allowed. This means that missions should avoid areas known to have heavy pedestrian traffic. It is up to the operator to decide that a walkway to the main entrance of the building, outdoor eating areas, the main street to access parking lots, etc. are best to be listed as No Fly Zones (NFZ's) to ensure compliance.

- Add a Point of Interest (flag) at any location which requires special attention. This marker will be visible on the Mission View page during operations and can be referenced and interacted with in-flight.

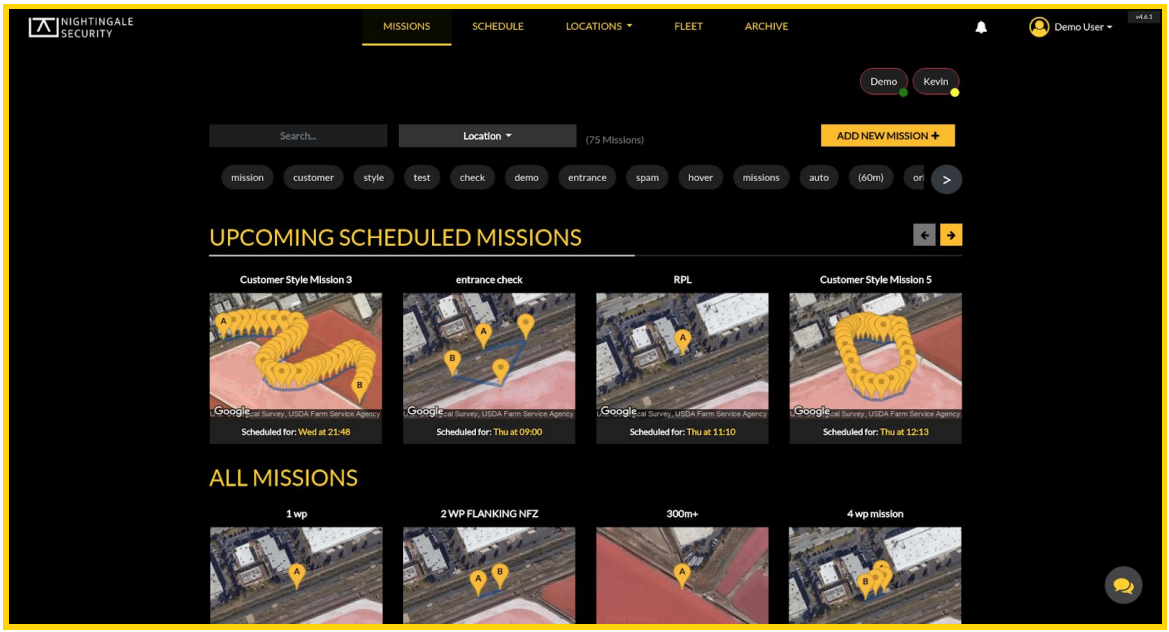
    - Example: If during a scheduled fenceline patrol, there is an area which requires frequent inspection, it can be marked with a Point of interest. The Point of Interest can then be used during subsequent fenceline patrols as a reference for Set Gaze commands.

- Add an Alert (yellow zone) over areas in which detection alerts are desired. If the Blackbird detects anything in this zone, an alert will be sent to the Mission Manager.
    - Example: Vehicles are prohibited in Lot A after 0100hrs and before 0500hrs. Place an Alert zone around Lot A, and any detections of vehicles in Lot A will be sent as an alert to the Mission Manager.

NOTE: Alert zone is functional on Mission Manager, though detection is still in development phase.

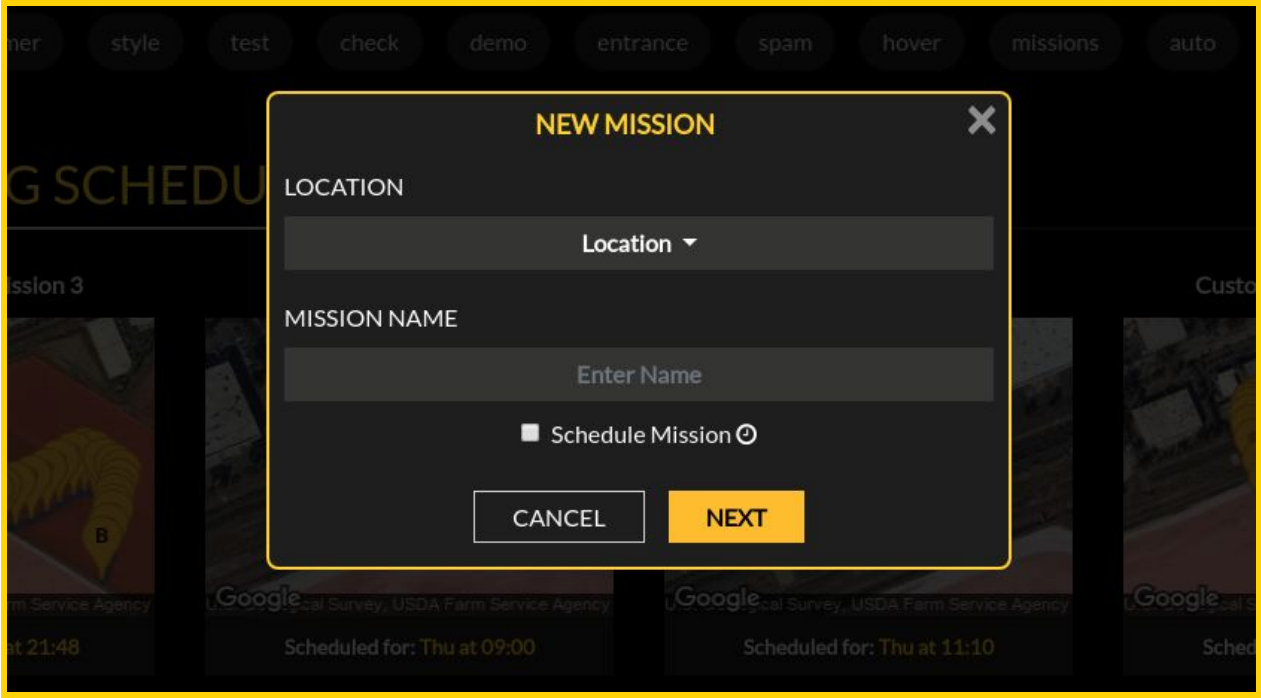
Mission Setup

- Create Missions
    - Once a *Location* is defined, users with the appropriate user permissions can define *Mission* profiles. To do this, click the *ADD NEW MISSION +* button and follow the instructions here. Below is a written explanation.



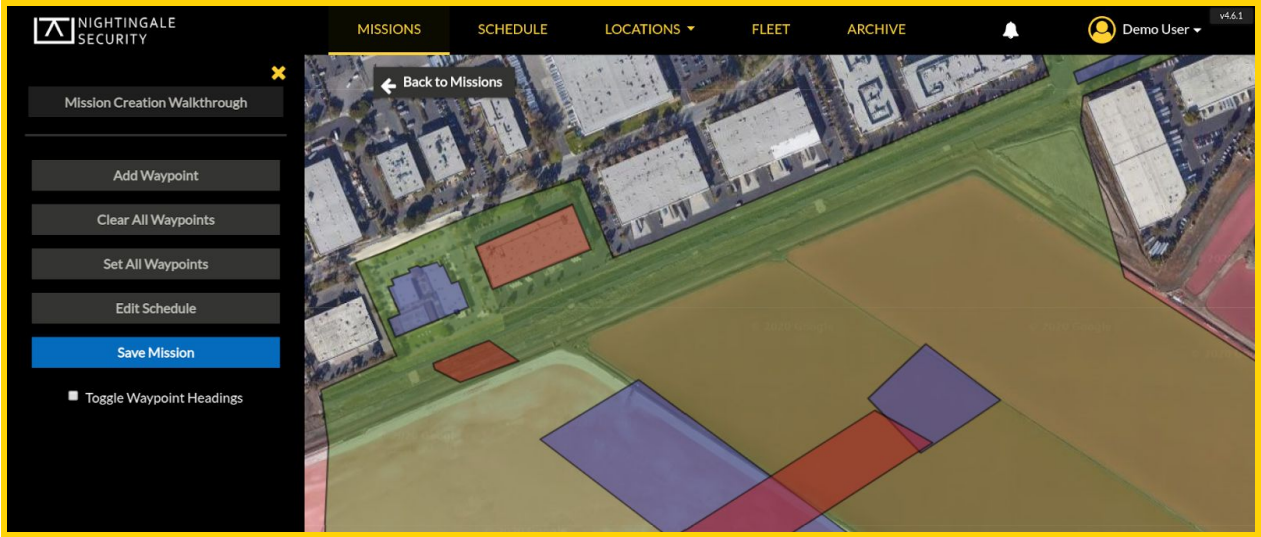
A new window will come up asking for the following:

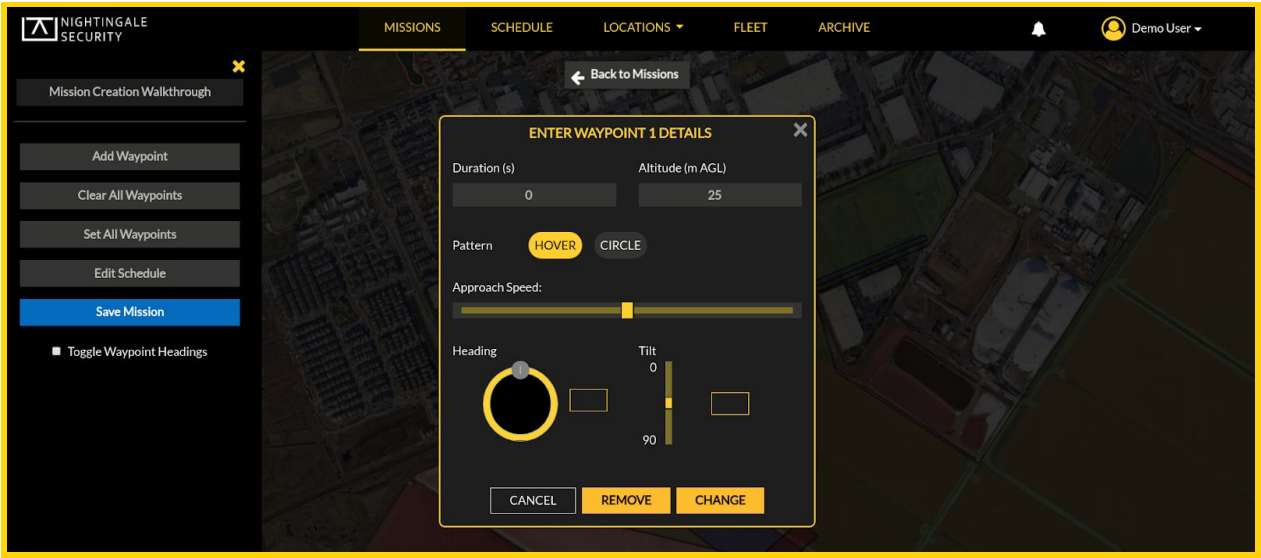
- Location - Select operational area
- Mission name - Enter name
- Selection - Option to make this mission scheduled



- Click NEXT when done

Creating mission parameters:





- Click on Add Waypoint and position the mouse cursor within the geofence boundary where the Blackbird will fly to and click on that position. Waypoint will be placed, to alter parameters click on the waypoint.
    - Fill in modify/fill in parameters:
        - Duration - In seconds, the amount of time the Blackbird will hover at that point. Blackbird commence duration once at waypoint and not before.
        - Altitude - In meters, how high the Blackbird will be at that waypoint and from that waypoint to the next if unchanged. If altitude between waypoints are different, the Blackbird will ascend or descend en-route to achieve desired altitude.

            - Note for obstacle altitudes: If waypoint is placed in an obstacle the Blackbird will fly to a minimum of 10m above set height of that obstacle. If the Blackbird is not at the altitude required for that

waypoint the flight computer will place a new waypoint on the edge of the obstacle zone to assure the Blackbird can ascend to correct height before proceeding into the zone.

- Heading - Magnetic North headings based on a 360 degree radial defining the direction the Blackbird camera will face. Blackbird will change heading once at waypoint and not before.
- Tilt - Degrees from 0 to 90 the angle the camera will point. 90 is looking straight down, 0 is look straight ahead. Blackbird wil tilt once at waypoint and not before.
- Pattern - Hover/Circle: The option to choose whether the Blackbird will hover and look at fixed locations or choose circle and it will rotate around a point for defined amount of time. Blackbird will commence pattern once at waypoint and not before.
- Approach Speed - select speed of the Blackbird going to this waypoint in units defined under user settings, max speed is 15.6 m/s. If approach speed is not defined, it will automatically set to the default (10 m/s)

- Once done with setting waypoint click the "Change" button and continue creating mission
- To add additional waypoints, continue to click within the geofence and update waypoint parameters accordingly.
- Hover over waypoint with cursor to see the waypoints set parameters
- To set a parameter to all existing waypoint click on the *set all waypoints* tab and fill in the requested information after navigating to the desired parameter within the dropdown menu.
  - Clicking "ok" will set the newly inputted value to the field. To return to the mission tools list click "save mission".
- To remove a single waypoint, click on the waypoint and hit the "Remove" button.
- To restart and remove all waypoints select the *Clear all waypoints* button

Note: Adhere to CFR Part 107 regulations during mission creation. Ensure that waypoint locations and the paths in between waypoints are safe. Reminder of regulation:

- § 107.39 Operation over human beings.

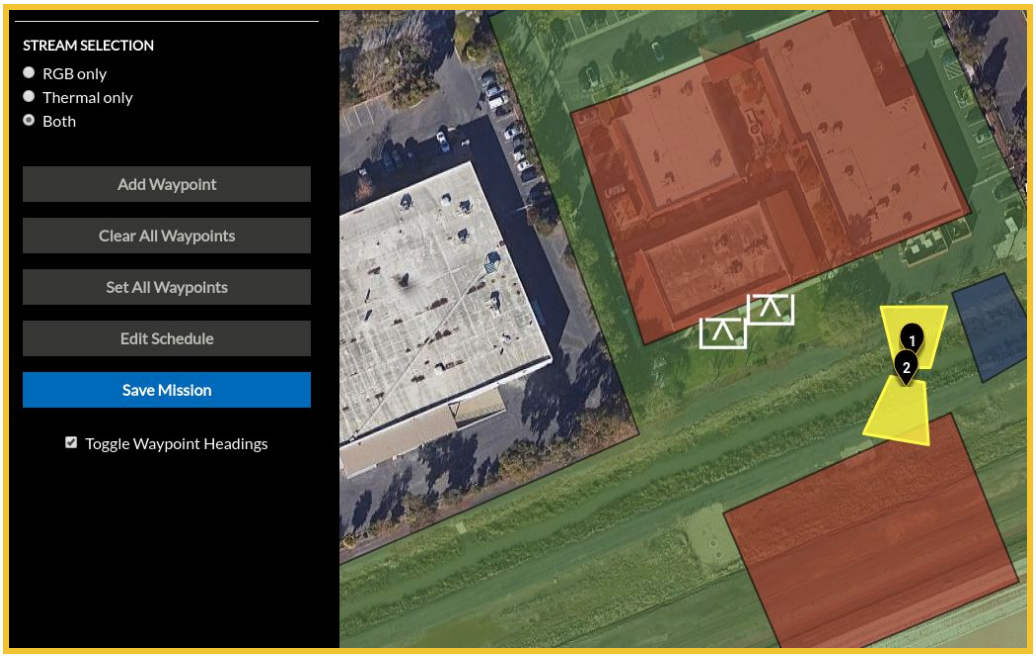
No person may operate a small unmanned aircraft over a human being unless that human being is:

(a) Directly participating in the operation of the small unmanned aircraft; or

(b) Located under a covered structure or inside a stationary vehicle that can provide reasonable protection from a falling small unmanned aircraft.

Useful tools

- Toggle waypoint heading box
    - Checking this box will allow the user to visually see on the map which way the Blackbird will be heading at that set waypoint.
    - Example of toggle on below of waypoint 1 facing (360) and waypoint 2 facing (190):



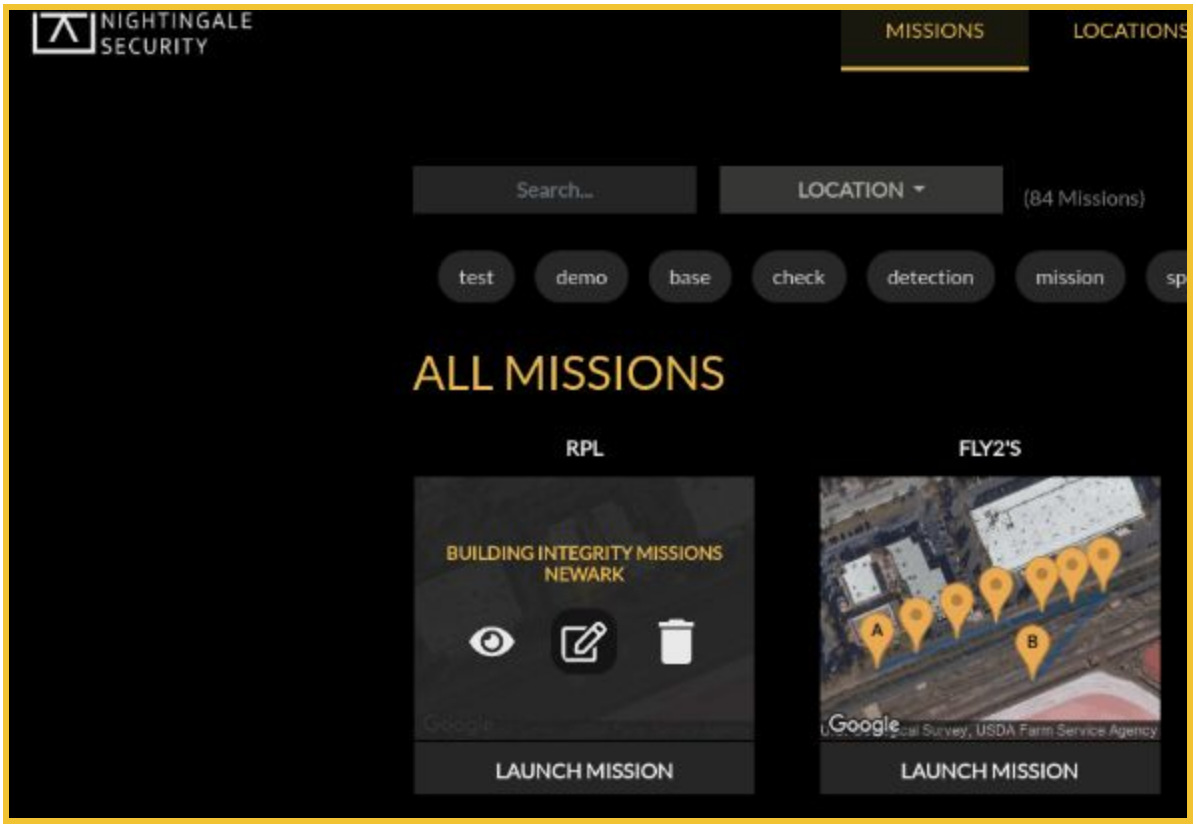
- The user also has the ability to edit mission name before saving or edit the schedule by clicking in their respective fields.

Mission selection

Pre-mission options

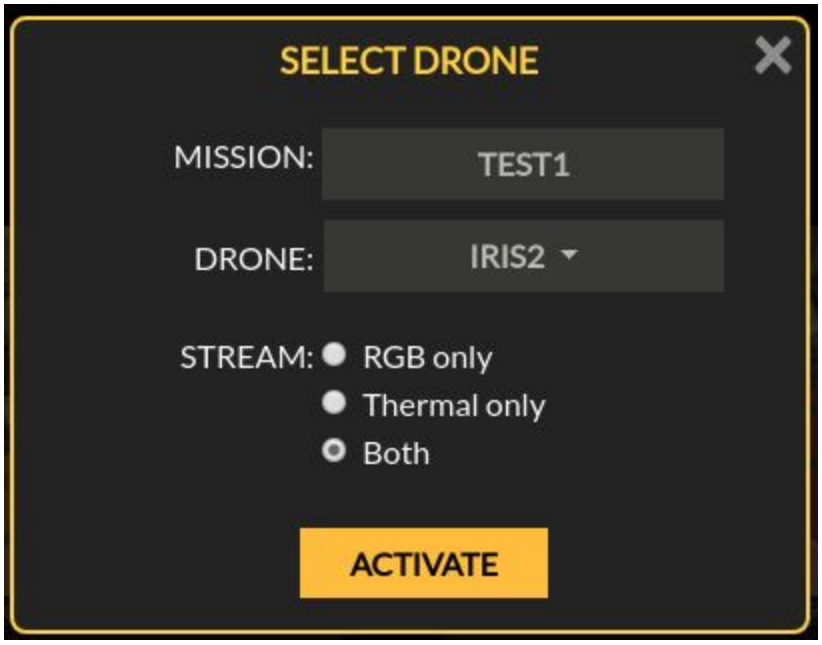
- Edit - Once a mission has been saved, it can later be edited. To edit missions, click the edit button (pen and paper) that appears when the cursor is hovering over the desired mission.

- Delete - To delete a mission, click the delete button (trashcan) just to the right of the edit button.
- View - To view an existing mission click the view button (eye) just to the left of the edit button.

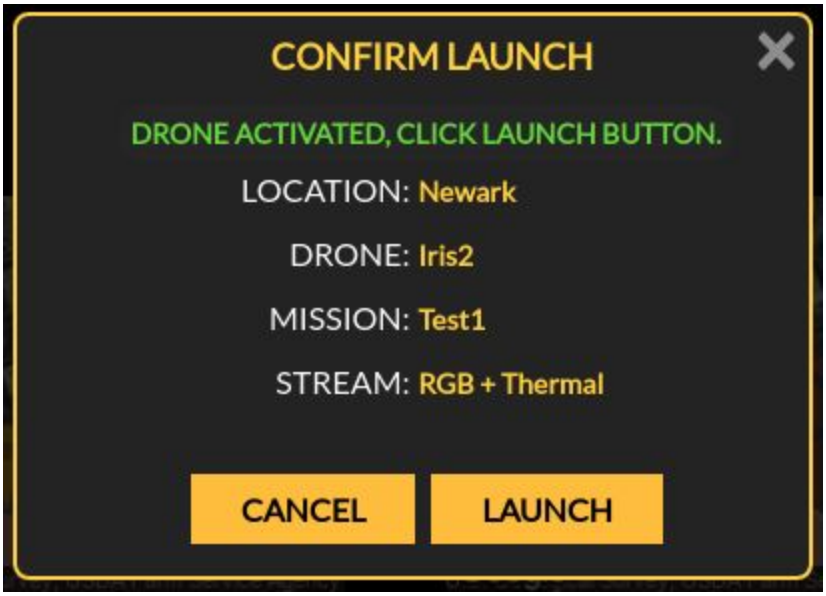


Selecting mission

- Selection of *launch mission* will bring up a dashboard of pre-mission options
- *Mission* name will be identified
- *Drone* will be selected through a dropdown menu
- *Stream* selection can be used to view single streams or both depending on user preference for mission goals.
    - Note: Quality of stream increases if only one stream is selected.



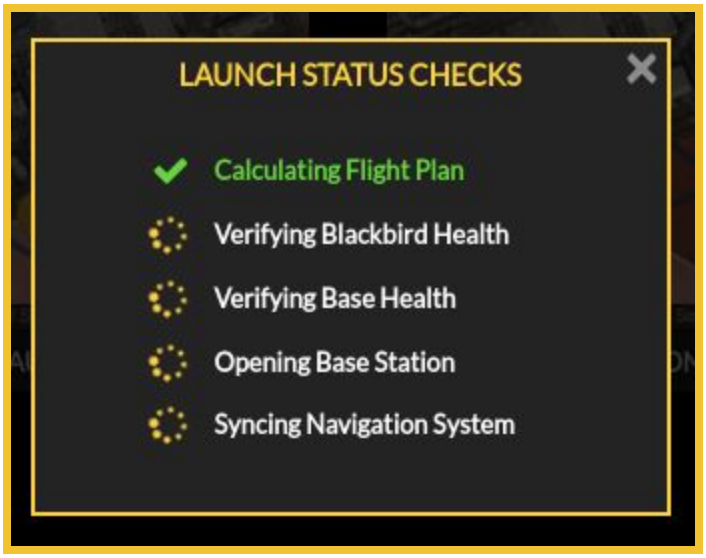
- Activate will open a new window with a mission summary based on choices selected on the *Select Drone* window.

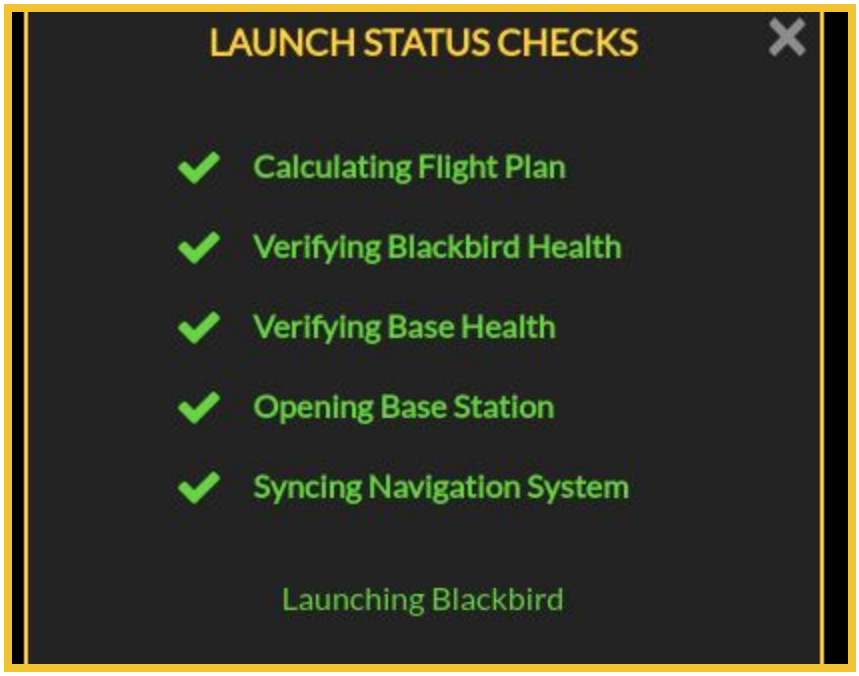


- Cancel to go back

Launch initiates startup sequence, the Blackbird will perform internal diagnostics and verify its mission ready.

- **Calculating Flight Plan**
    - Blackbird will perform its IPP (Intellectual path planning). This step writes all relevant mission information to the on board flight computer.
        - Note: The larger (distance and or number of points) the mission the longer this step may take.
- **Verifying Blackbird health**
    - An internal safety check linking command and control.
- **Verifying base Health**
    - Link is established between Blackbird and base station confirming support systems are online.
- **Opening base station**
    - Commands sent from Blackbird to base to open doors. Confirmation is received via status update over network and no from visual appearance.
- **Syncing Navigation System**
    - Operational status of navigational sensors cross referenced for consistency.





Once all Launch Status Checks are verified the user is brought to the mission view page and the Blackbird is launched.

- Execute Missions (iOS)
    - Passively watch a pre-planned mission or get into the action and perform ad hoc maneuvers including:
        - Hover
        - Fly-To
        - Return to Base (RTB)
        - Emergency Land (ELZ)
        - Pan/Tilt Camera
        - Dodge
            - This feature is top be used in cases of possible incursions. If a low flying GA aircraft is in the airspace, the dodge feature will command the Blackbird to descend to minimum safe altitude defined in geofence. To resume, simply press resume.

- Perform administrative tasks - like monitoring their fleet (iOS) or setting user permissions

Note: While creating missions, safety requirements must be taken into consideration and are detailed in the *Mission Planning* section of this document.

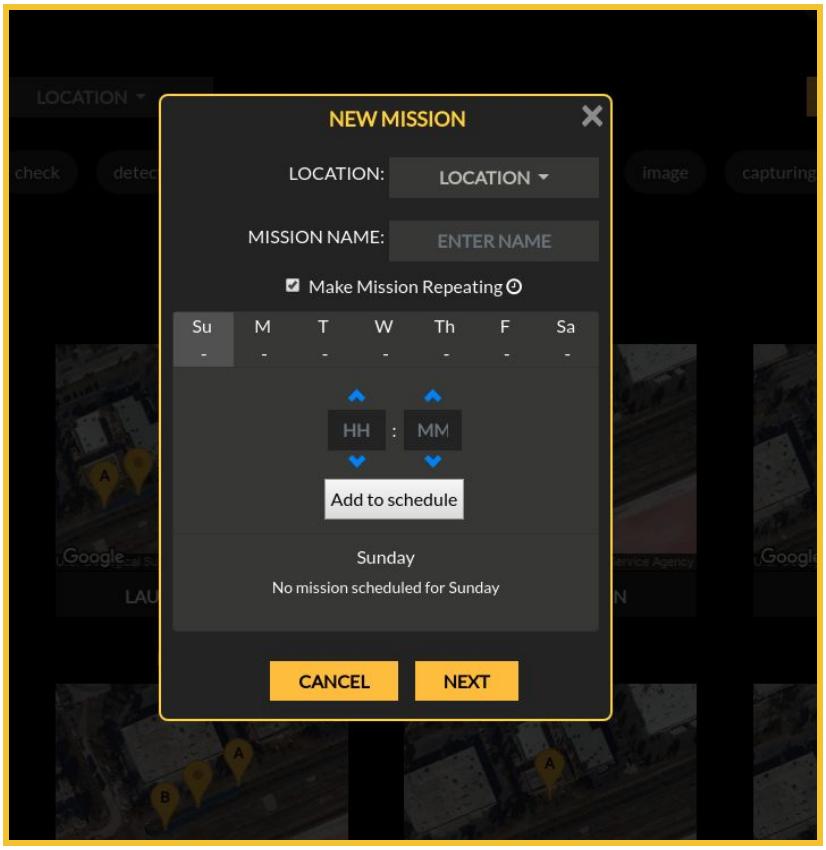
Mission Scheduling

Mission manager gives the operator the ability to schedule defined missions using three different tools.

Make mission repeating

- During the mission creation flow, the option to “Make Mission Repeating” is an option after choosing the Location and Mission name.

- Selecting Make Mission Repeating will bring up an extended window to schedule missions:

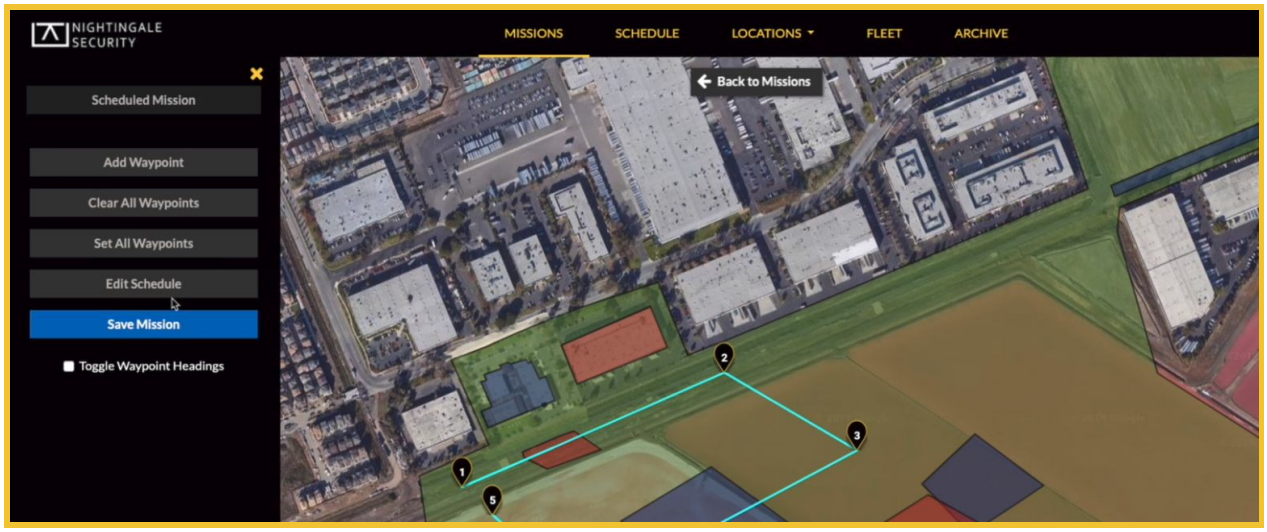


- Using the 24 hour clock input the designated time slot for the mission.
    - Select day desired for the mission
    - Click “add to schedule”
        - Time slots will be saved and days can be changed to add the same time across multiple days quickly.
- Once parameters are set clicking the “Next” button will bring you to the mission creation page.

Mission scheduling during creation

As part of the tools available during mission creation, scheduling missions will allow the user to develop mission parameters and then apply the use case to specific times of the day.

- Click “edit schedule”



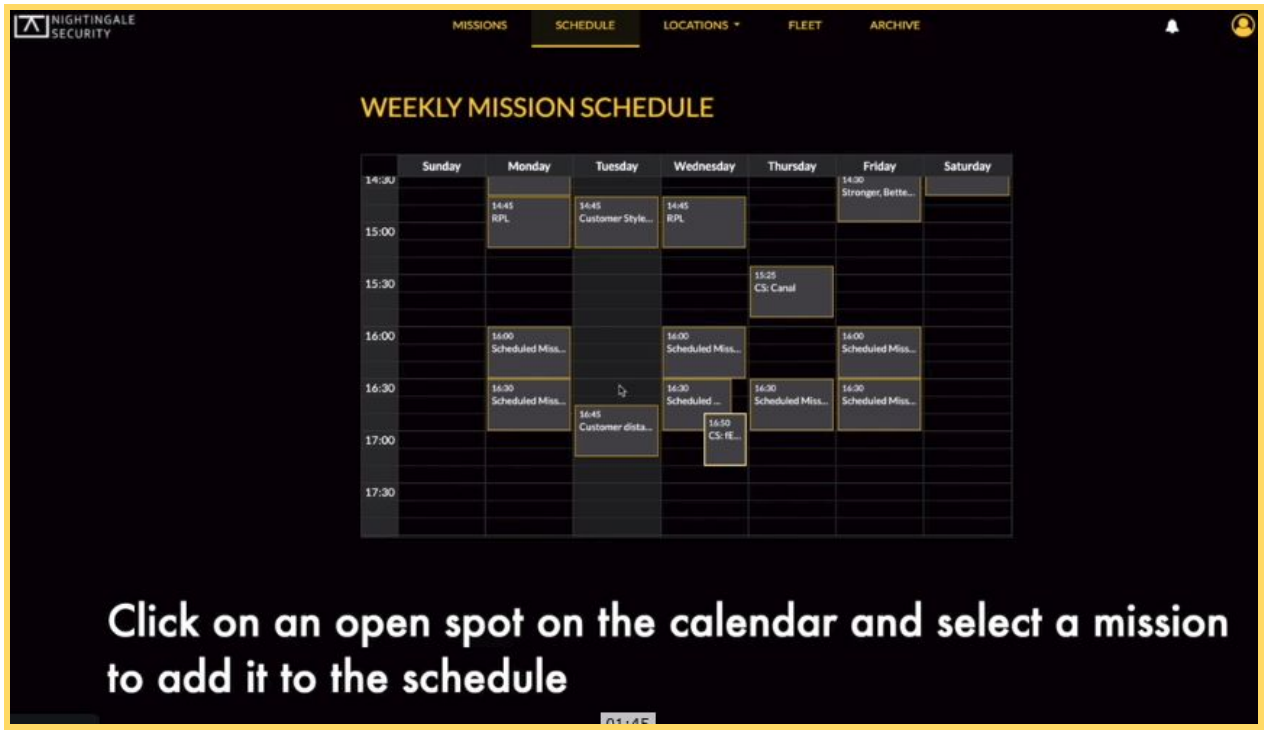
- Edit schedule will open a sub menu to set the time slots for the mission

- Using the 24 hour clock input the designated time slot for the mission.
    - Select day desired for the mission
    - Click “add to schedule”
        - Time slots will be saved and days can be changed to add the same time across multiple days quickly.
- Click “save mission” when complete and the schedule will be written.
    - User will be returned to the initial mission configuration list.

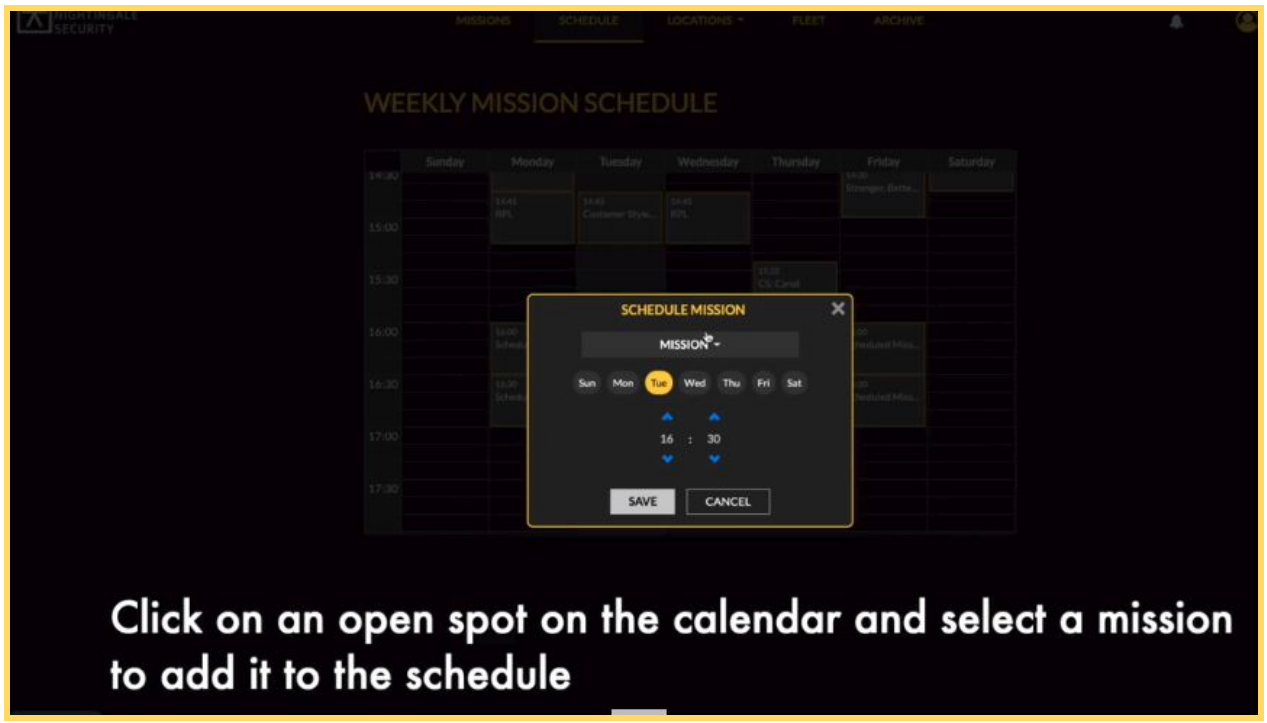
Scheduling with the calendar

Using the tabs bar on the top of the screen, users can click “Schedule” to bring up a weekly view of scheduled missions. If no missions appear here, the user can also create time slots for missions.

- Click “Schedule”

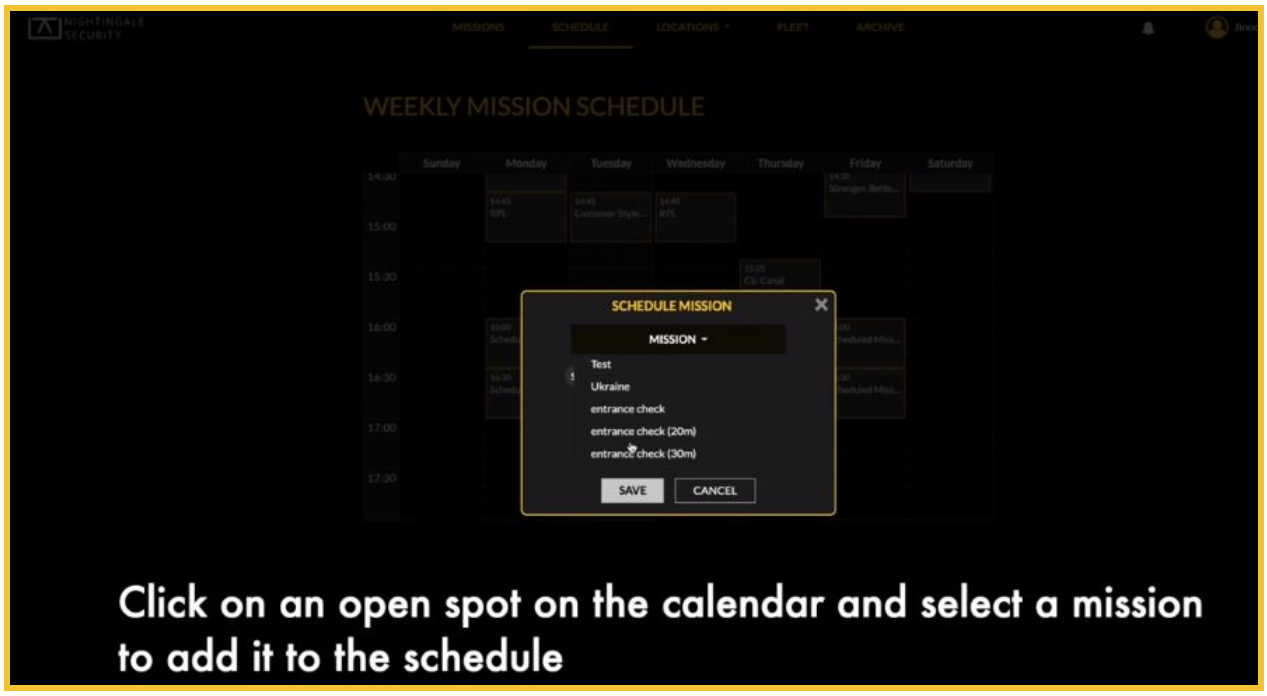


- If an user wants to create a new time slot any blank block will initiate a prompt.



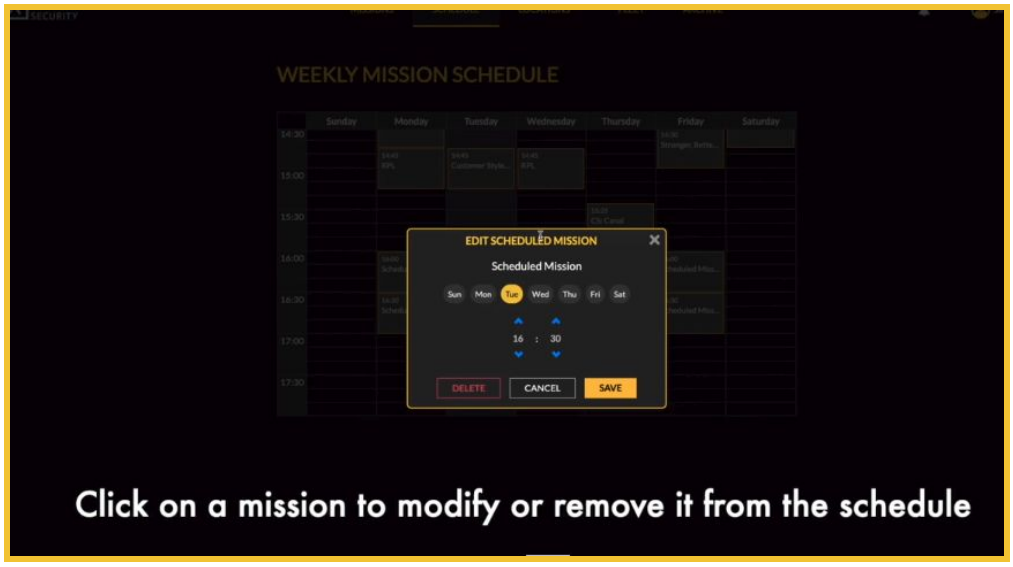
- Using the 24 hour clock input the designated time slot for the mission.
    - Select day desired for the mission
    - Click “add to schedule”

- Using the mission dropdown bar, choose the mission for the designated time slot

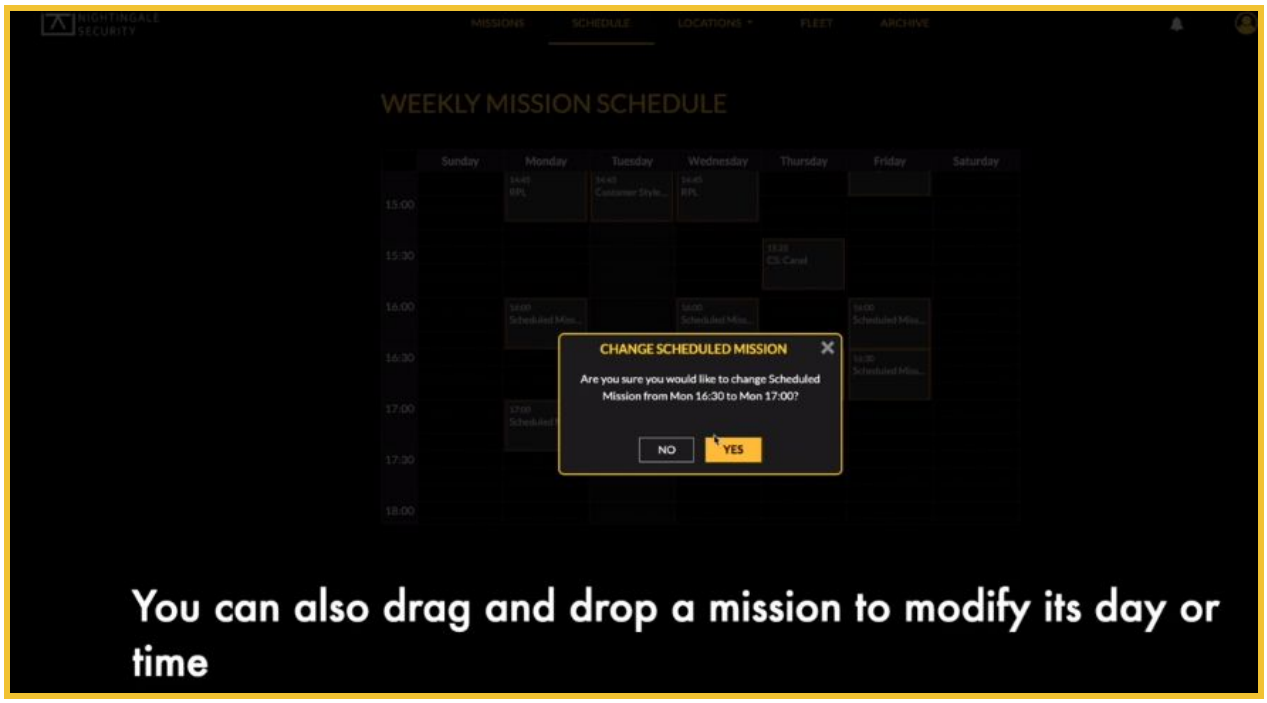


- Click “save mission” when complete and the schedule will be written.

At any point the user can click on a existing schedule block to modify it



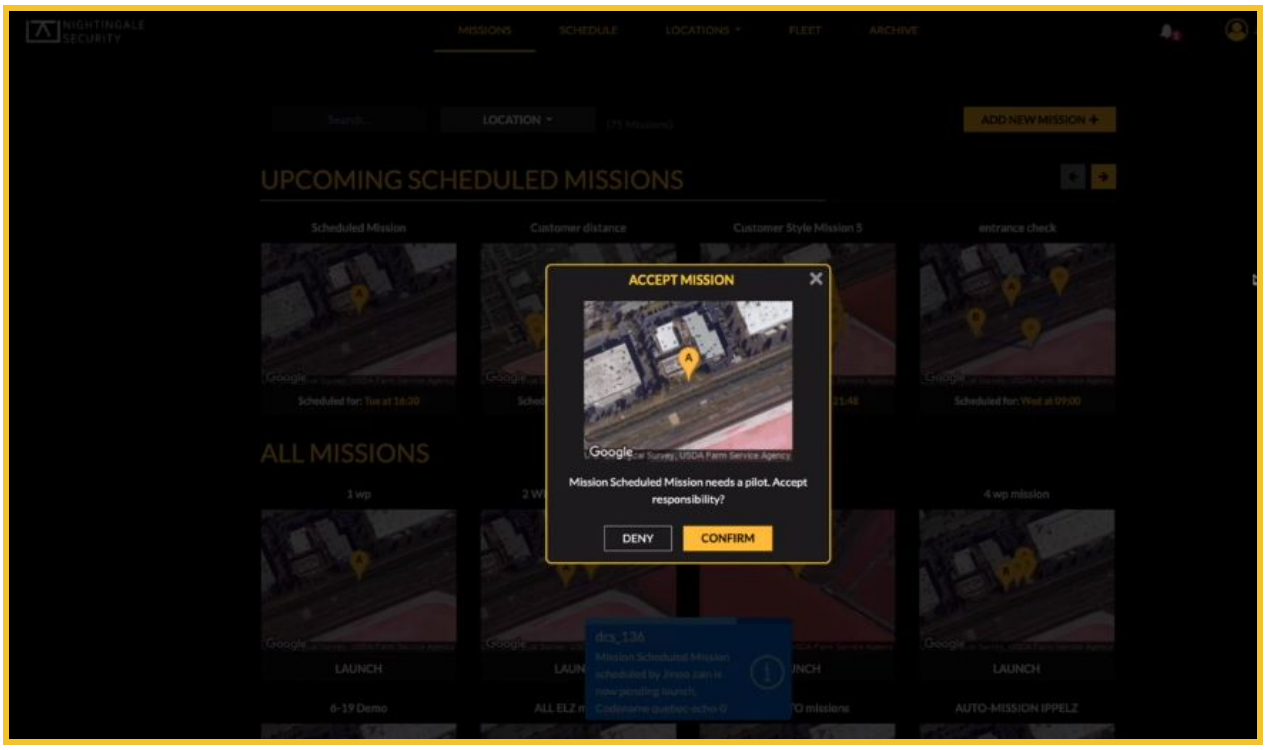
If a mission needs to be moved to a different time slot, the user can simply drag and drop the block into a new space



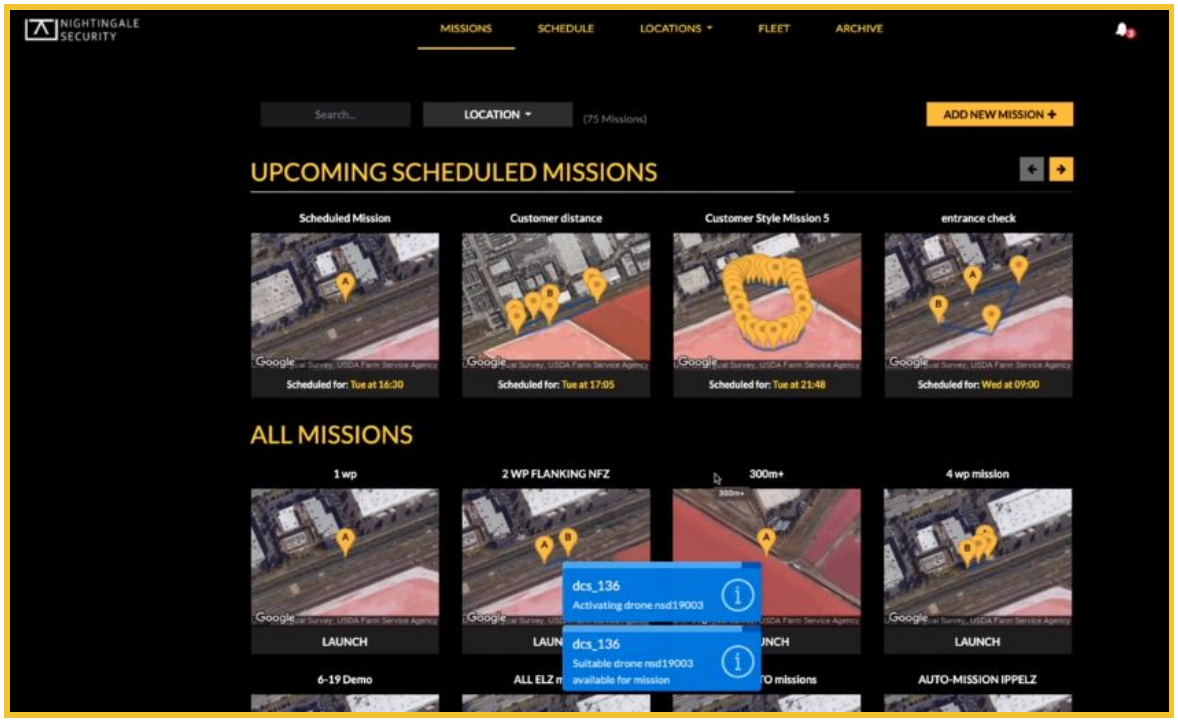
Launching a scheduled mission

When a scheduled mission is ready to launch a prompt asking for a pilot will appear, in order for a successful launch it will need to be accepted.

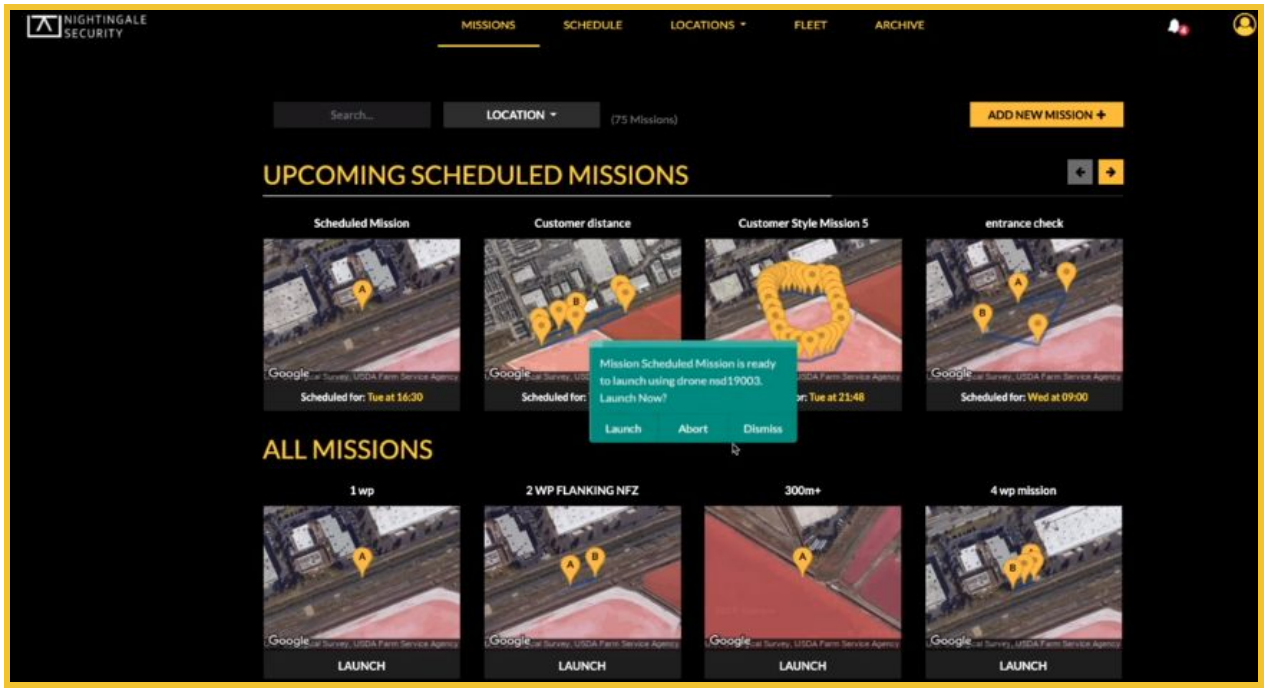
- FAA regulation requires a pilot to accept responsibility for any mission. Without accepting responsibility the mission will automatically be cancelled. See **Regulations** section for more information on FAA requirements.



- If accepted, the system will look for an available Blackbird.



- Once a Blackbird is found, the option to Launch will be prompted.



- Once accepted the Blackbird will begin its launch sequence.

Denying a scheduled mission

There are two ways to deny a scheduled mission;

- If no pilots or Blackbirds are available, the launch will automatically be aborted.

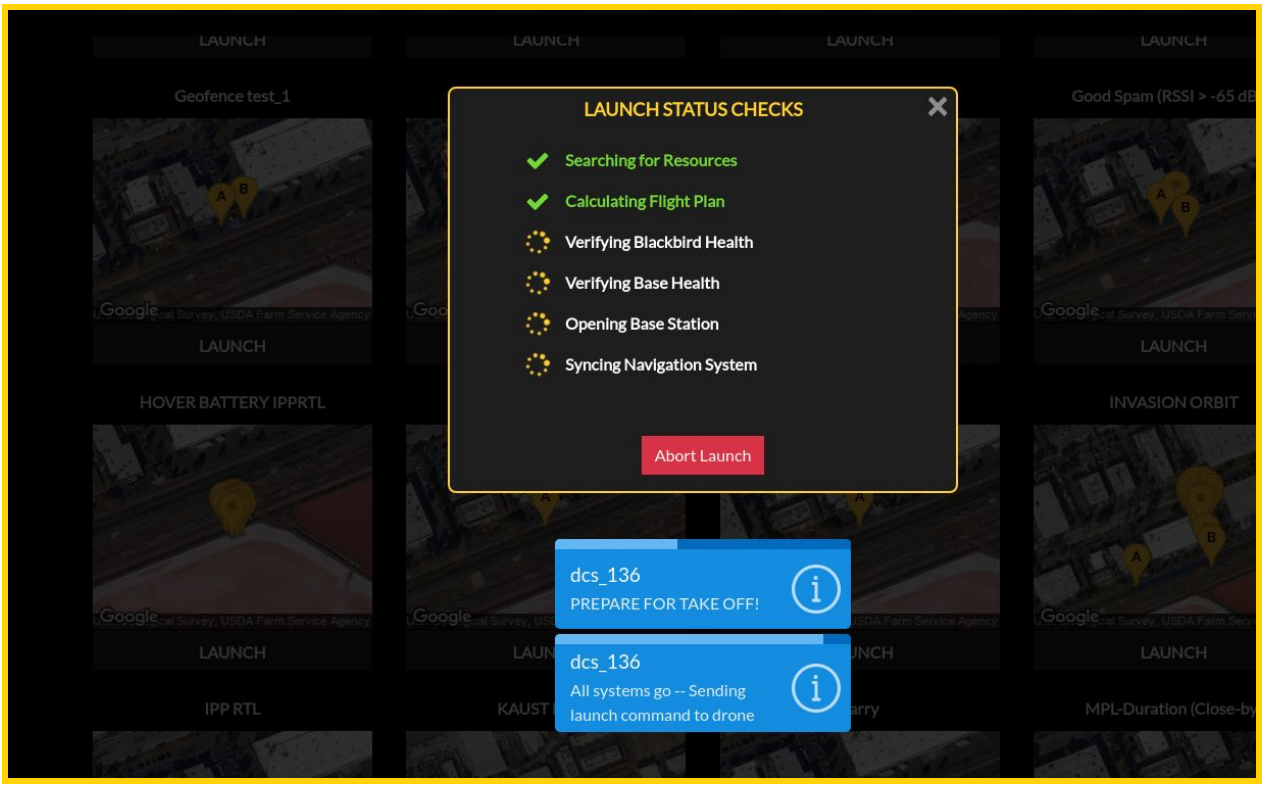
- When the prompt appears, the user can press DENY (if no other pilot accepts)
    - In 2 minutes the launch sequence will timeout and an information message showing the mission has been aborted will appear.
        - These messages include the name of the mission and who denied it.

Flight Operations

When a Mission has successfully queued, the user can either let the mission carry out autonomously, or step in and manipulate the Blackbird's flight patterns, camera settings, and stream settings. The mechanics of these manipulations are outlined in detail below.

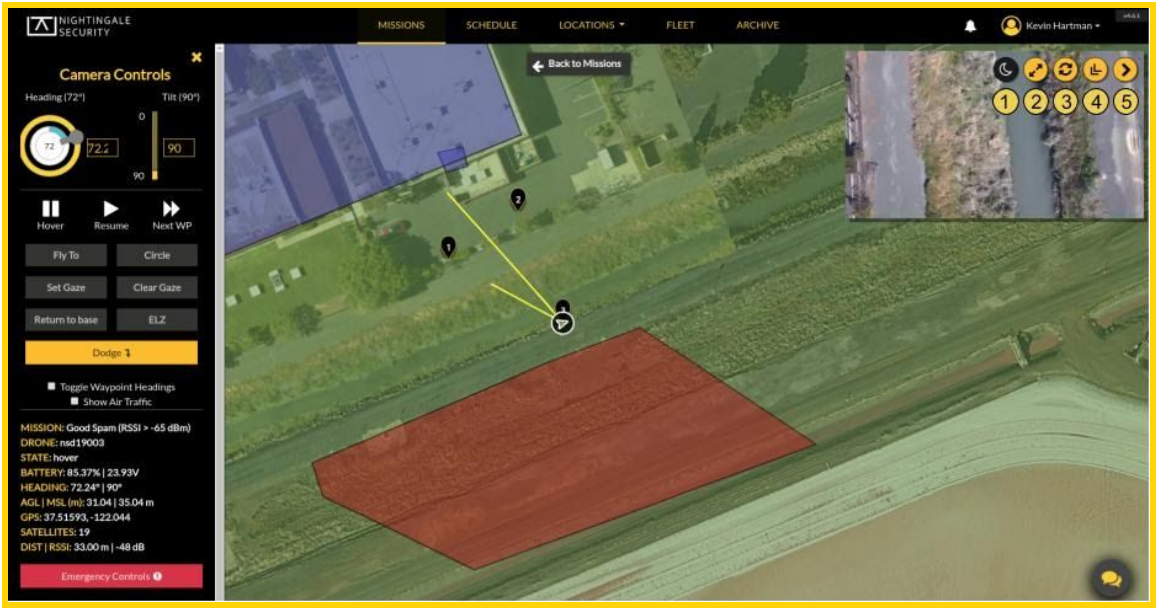
Preflight Controls

When a mission has enqueue, the Blackbird will begin a series of system checks to ensure that operations are safe to begin. These *Launch Status Checks* are displayed after the *Launch* command is sent; see the image below.



At any point during the *Launch Status Checks*, any user can abort the launch with the *Abort Launch* button. When the checks have completed, the Blackbird will launch and Mission Manager will redirect the the Mission View.

In-flight Controls

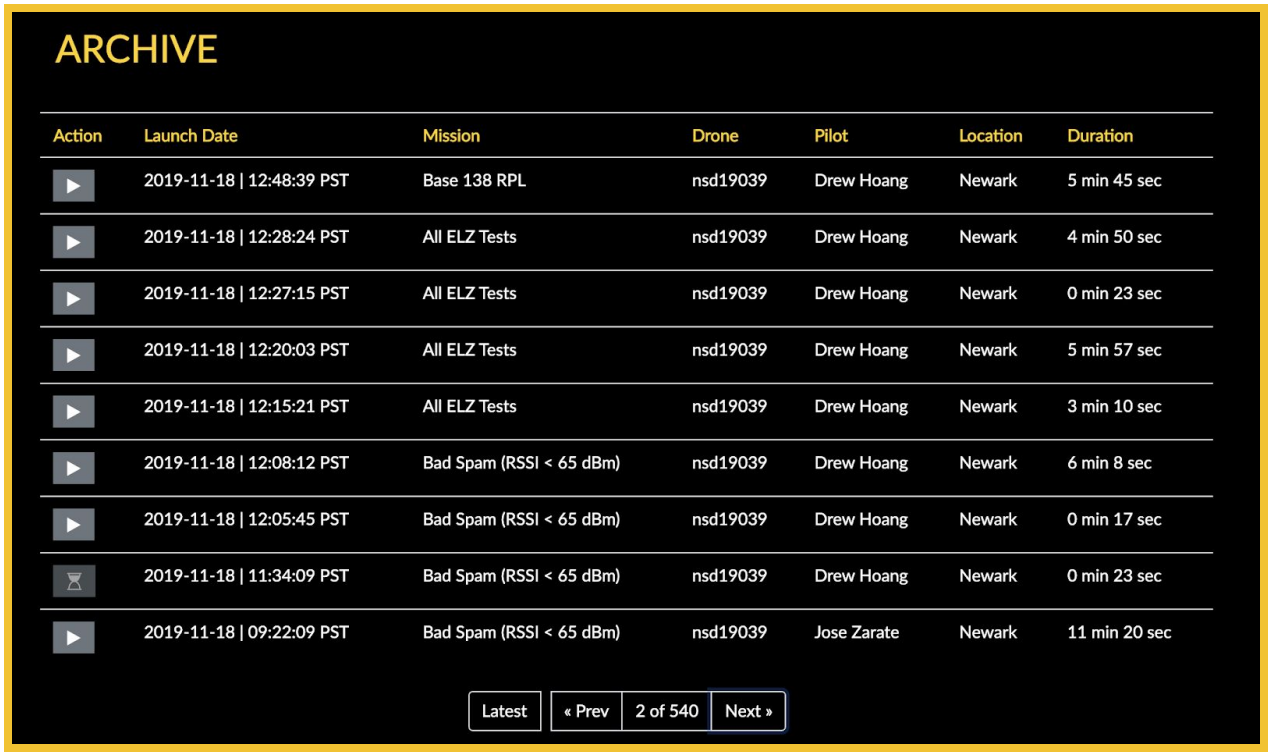


- Camera Controls
    - Heading - can be changed by grabbing and dragging the grey ball in the outer slide wheel. The inner slide wheel represents the Blackbird's current heading, and will always catch up to the position of the outer slide wheel. Heading can be adjusted precisely with the text box.
    - Tilt - can be adjusted with the slider bar and adjacent text box. Angles between 0 degrees (directly forward) and 90 degrees (directly downward) are allowed.
- Flight Controls
    - Hover - will command the Blackbird to hover in place until further notice.
    - Fly To - can be commanded with the button on the left hand bar or with a right click on the map. A Fly To will command the Blackbird to approach a waypoint with a designated altitude.
    - Resume - will interrupt a user-commanded Return and any Fly To or Circle
    - Circle - will command the Blackbird to hover in place and rotate clockwise until further notice.
    - Set Gaze - will command the Blackbird to adjust the camera settings to continuously survey a ground location selected on the map. This operation can be commanded with a right click, but also by clicking Set Gaze then clicking the ground target of the gaze.
    - Clear Gaze - will abort any active Set Gaze command and the Blackbird will maintain its current camera settings until otherwise commanded by waypoints or the user.
    - Return to Base - will command the Blackbird to return to the base and land.
    - Next WP - will command the Blackbird to either skip the duration of a hover at a Mission waypoint when in a live mission or proceed past a Ground Traffic Zone during a return state
    - ELZ - will command the Blackbird to abort a mission and proceed to the Emergency Landing Zone.
    - Dodge - will command the Blackbird to rapidly reduce altitude to the predefined safe minimum. This command is intended for use when a non-participating aircraft or flying animal encroaches on the airspace.
    - Emergency Controls - emergency controls are designed as a last resort tool for manual control of the Blackbird in an emergency situation.
- Stream Controls (by labeled number)
    1. Toggle thermal camera view and rgb camera view
    2. Toggle map view to the small player, and vice versa
    3. Refresh the stream player
    4. Expand the small window to a slightly larger size
    5. Hide the small player

Mission Review

- Video Archive
    - Video archives is where the mission videos can be watched and downloaded. Once a mission has been completed, the RGB and thermal videos are automatically

stored on the base station server. Click on the *Archive* tab to access the Video Archive page as shown below. There are two windows showing the RGB and Thermal video of the most recent mission flown.

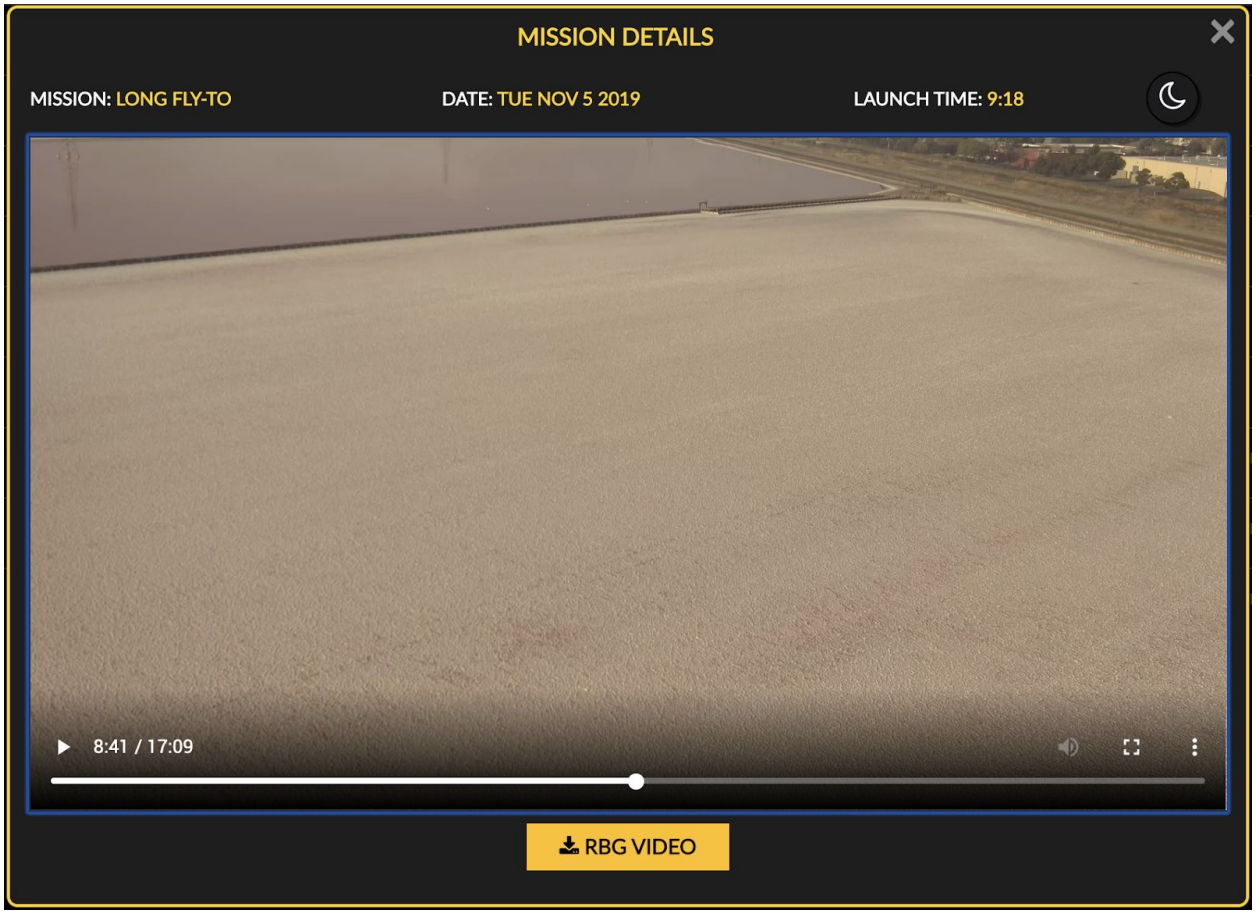


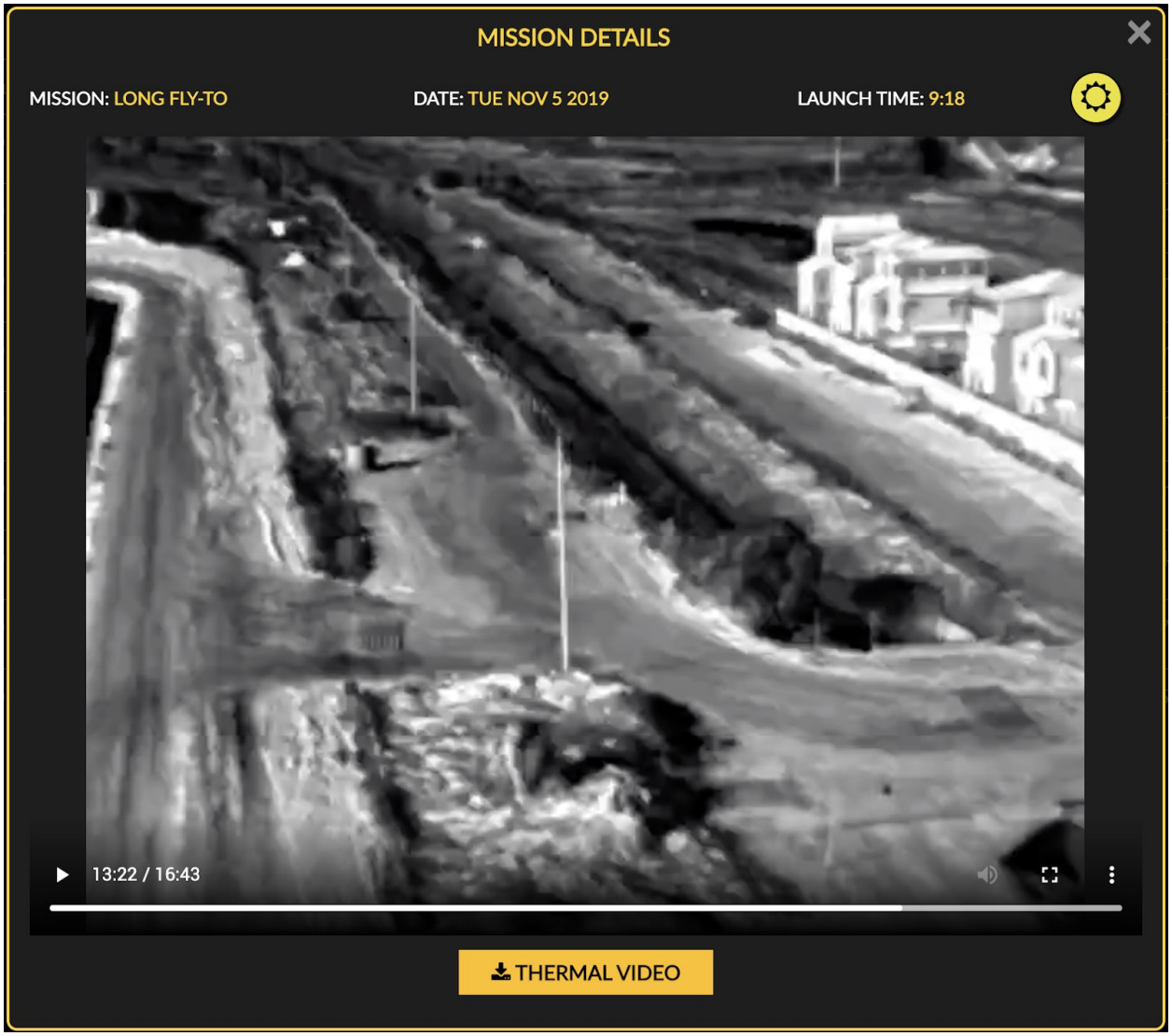
- Navigating Video Archive
    - Each mission flown will be listed with parameters including:
        - Launch Date
        - Mission Flown
        - Blackbird Number
        - Pilot (Launched By)
        - Location
        - Duration (min)

    Missions can be ordered numerically and alphabetically by clicking the up or down arrow on the right side of each parameter. Once the desired mission has been located, click on the play button under the *Actions* column on the left to view the selected video.

- Downloading Videos
    - To download the video, locate and press the yellow button at the bottom center of the video player. Clicking on this button will save the video to the storage of the

device used to access Mission Manager. Clicking on the half crescent moon or sun buttons in the top right will toggle between thermal and RGB video.





NOTE: In the above section, clicking on each underlined link will direct the user to a video that further explains how to use Nightingale's command and control software. Clicking the (iOS) link will provide instructions on how to use that task in the Relay App, while tasks without the (iOS) next to them means that functionality is only available on the web application Mission Manager.

Relay App

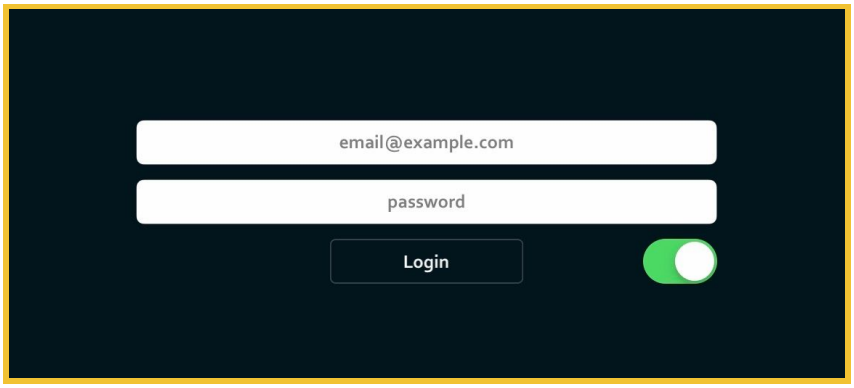
Relay App is the mobile (iOS) application from which remote operations are conducted. With the same login credentials provided for Mission Manager, users login and control the system, quick launch missions, and if credentials allow draw out autonomous flight paths. Relay App work flow is generally as follows:

Connect VPN

- Nightingale staff will provide all Relay App users with a VPN key via email for accessing the system through iOS. To use this VPN key, the iOS application *OpenVPN* is required. After this application is installed, opening the VPN key in the email will load it to OpenVPN. The VPN can then be connected and data transfer statistics will begin to post.

Login

- Nightingale staff will provide all administrators, PICs, and support staff a set of login credentials based on their qualifications. Login credentials consist of an email address and password. The image below shows the login screen where the credentials are entered. Once login credentials are granted, be sure to set a memorable password. This is the same email and password used in Mission Manager.



Dashboard

- After logging into the Relay App, the *Dashboard* will display (see below). Here, high level *Blackbird* and *Base* information is displayed, and users can select particular bases and Blackbirds for control and low-level monitoring. Tapping the refresh button will update the dashboard to display the most current system information, and tapping the gear opens the settings menu where thermal video and map type can be toggled.

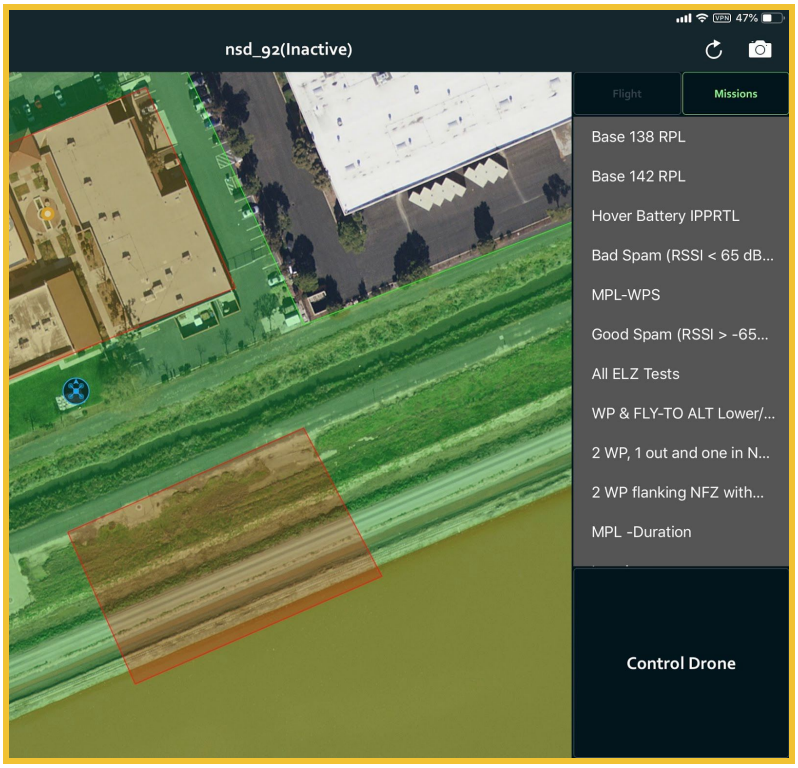
- Blackbirds
  - Green *Blackbirds* are currently flying or are preparing for takeoff (e.g. 19007)
  - Yellow *Blackbirds* are active, meaning they are ready for flight. (e.g. 19008)
  - Grey *Blackbirds* are inactive and on their respective base charging (e.g. 19009)
  - Red *Blackbirds* are currently offline

- Bases
    - *Bases* will display as either open or closed on the dashboard. Here, base_142 is open and base_138 is closed.
    - When a base is offline or in an unknown state, it will appear as a red base (e.g. base_174). When this is the case the base should be investigated for disconnected wires, power loss, or a stuck door; and it is advised to contact Nightingale support.

Create or Select a mission

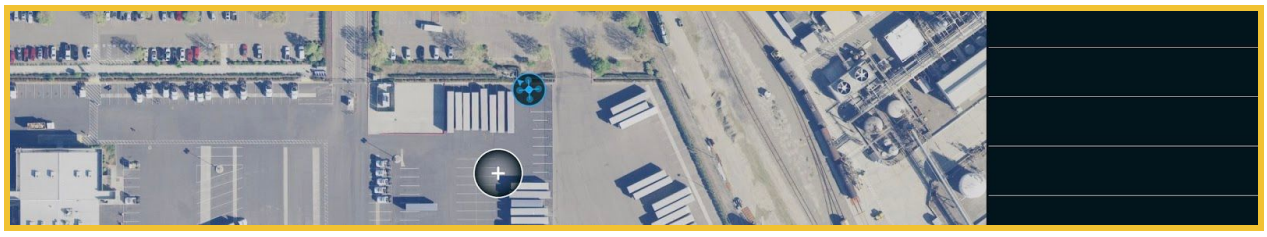
Mission Menu

- Tapping on a *Blackbird* from the *Dashboard* opens a birds-eye view of that *Blackbird* and its surroundings as they have been defined on the base system's local server (below, left). From this menu, existing missions are previewed and the selected *Blackbird* is controlled.

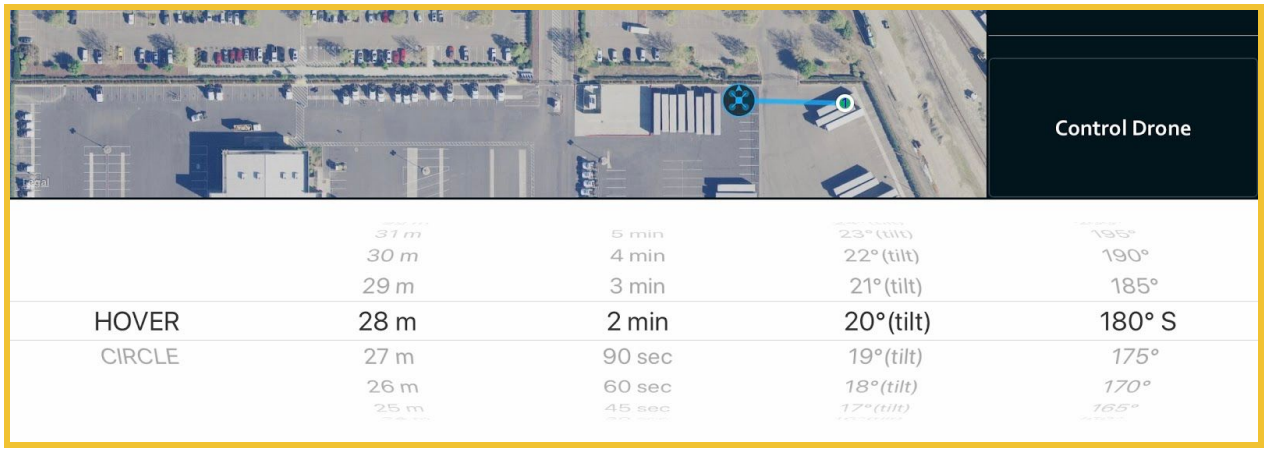


Creating a Mission

- From the *Blackbird Menu*, tap *Flight* and *+ Add Waypoints*. From here, a lens with a plus sign will appear on the map, marking the location a waypoint will be dropped (see below). This lens with crosshairs can be moved with iOS drag.



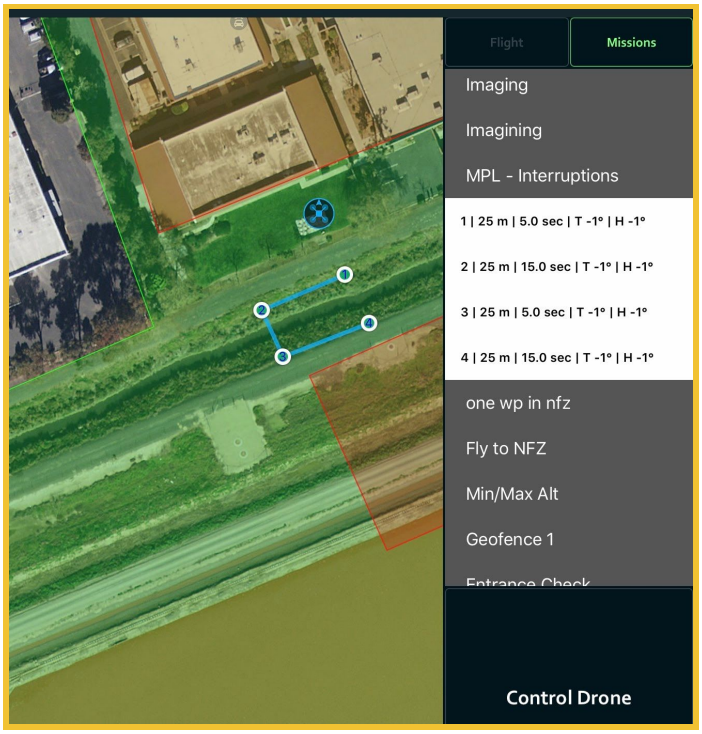
- To add a waypoint, tap the crosshairs. To cancel waypoint creation, tap anywhere on the map. Use the scroll wheels (below) to set waypoint details, and tap anywhere on the screen to finalize waypoint creation.

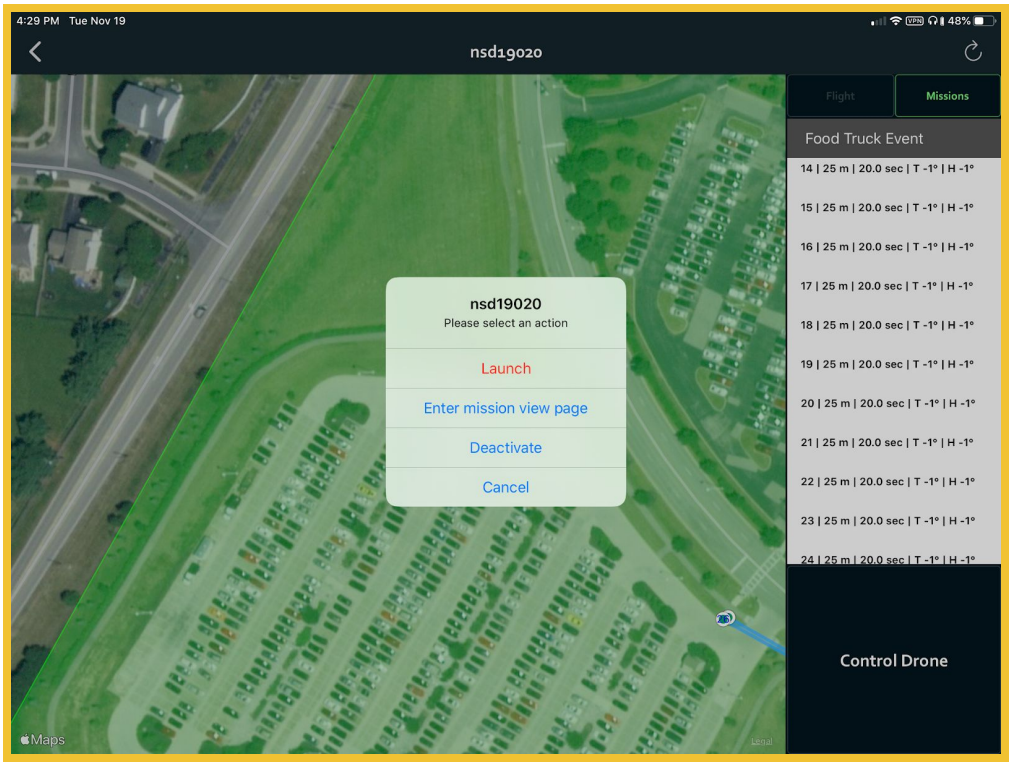


- Once all waypoints have been placed and confirmed as safe (see below), *Save Waypoints*, give it a name, and *Save Mission*. Waypoints can be deleted at any point during mission creation by swiping left on a specific waypoint.

Selecting a mission

- The missions tab will list both newly saved missions that have been created in the Relay app and missions created from Mission Manager. These missions cannot be edited from the application.





Checking Blackbird health

- To view and monitor the sUAS health postings at any time, navigate to *Control Drone* and *Enter Mission View Page*. The Blackbird postings are listed underneath the stream (below).

Note: Before every flight, assess the health of the system. If the status values do not fall within the metrics defined in the SOPs | System Envelope and limitations section of this document, do not fly.

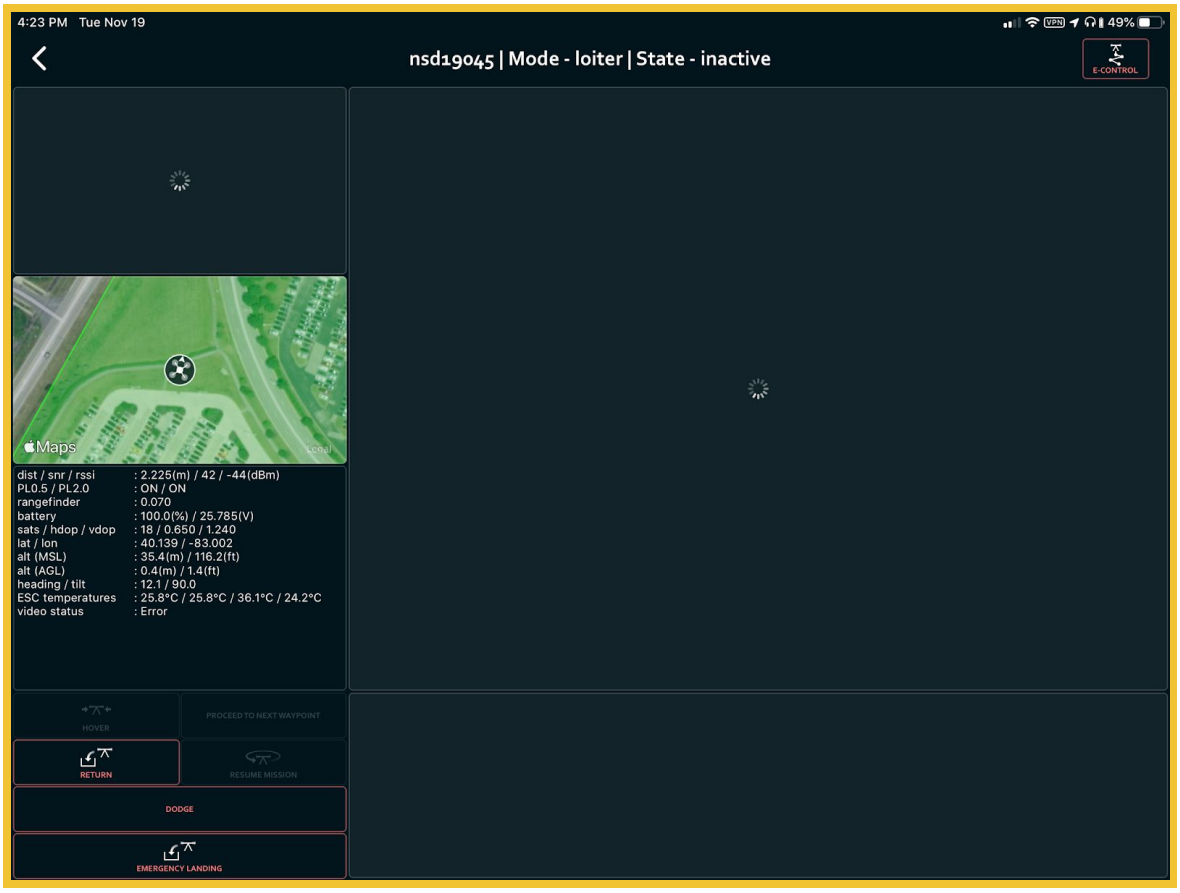
Mission View Page

Pre-flight and In-flight monitoring of the selected *Blackbird* is achieved from the *Mission View Page* (see below). There is some extra information displayed on the Relay app that is not displayed in Mission Manager:

- PL0.5/PL2.0
    - Shows if Blackbird has beacon acquired for tracking during landing.

- Hdop/Vdop

    - Positioning accuracy of the GPS (Do not need to monitor)
- ESC temperatures
    - Temperature of motor controllers (Do not need to monitor)
- Video status
    - Shows if video streams are working.



Flying a Mission

- To fly a mission, first tap on *Control Blackbird* then tap *Activate*. Now one of the *Missions* can be selected from the *Missions* dropdown and a preview of the flight path is displayed. After determining that the flight path is safe according the FAA regulations and Nightingale safety requirements, *Control Blackbird*, *Launch*, and confirm.

- Command Panel

- In flight control is the same as in *Mission Manager*, the Blackbird can be hovered, returned, resumed, emergency landed, flown to individual waypoints, and dodge.

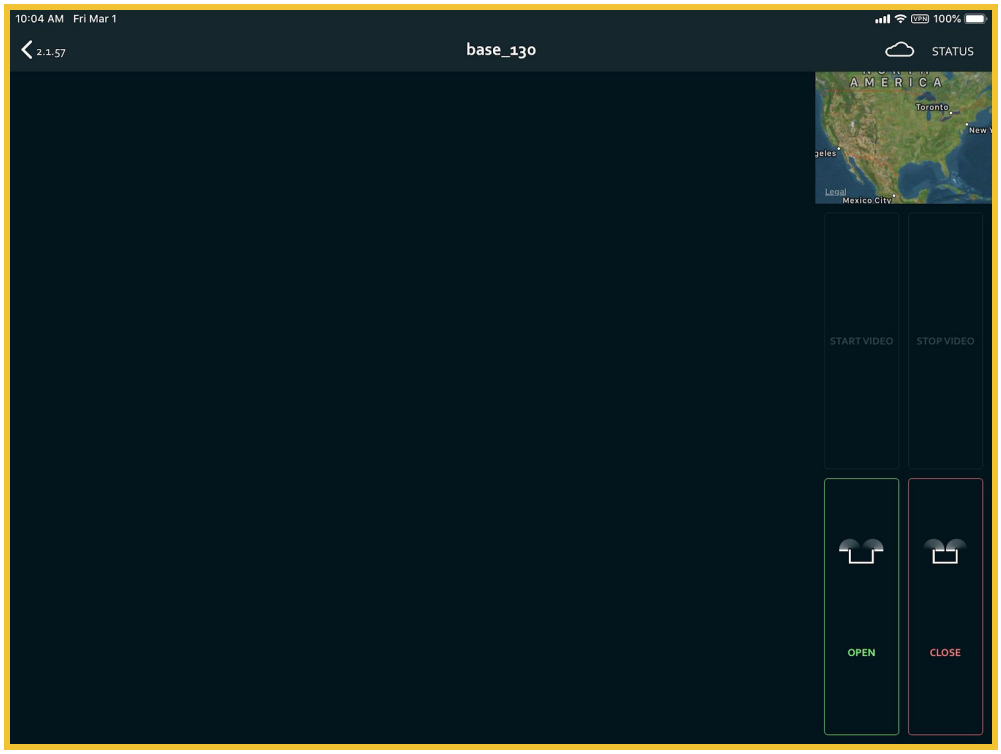
- Camera Control
  - In *Relay App*, cycle between the video feeds and a birds eye view by dragging the desired window to the largest viewing area. When a video stream occupies the largest viewing area, *Blackbird* yaw and camera tilt are controlled with horizontal and vertical swipe, respectively.

- Emergency controls
  - Found in the upper right hand corner, the emergency control button will open the panel when pressed. See Emergency procedures section for information on using emergency controls.

Support

Base Menu

- The base menu (below) provides a means of controlling the base, monitoring its status, and viewing the live weather station feed. To reach the *Base Menu* tap the base icon that displays the desired base number featured on the *Dashboard*.



Base Control

- Use the OPEN and CLOSE buttons to open and close the base when it is safe to do so. Always be sure that the base's surroundings are clear before opening and that there are no internal obstructions before closing.

- Status monitor
    - Tapping *Status* opens a yellow screen with the following information:
        - the *Blackbird*'s elz and respective base's location in terms of latitude and longitude
        - The *Base* state, name, heading, and override boolean
        - The weather data posted by the *Weather Station*

All this information is useful to support tickets being filed to Nightingale staff if any issues arise with the base.

Weather Information

- Checking local weather is a key part of preparing to operate a sUAS and assessing risk. The small cloud in the top right corner of the *Base Menu* displays a panel with the most recent weather data collected by the *Weather Station*. Tap anywhere off of this panel to dispel it.

Pre-flight

NOTE: *When operating the Nightingale Security Robotic Aerial Security System, operators are required to follow Federal Aviation Administration (FAA) regulations as outlined in CFR Part 107 and the expressed best practices of this handbook at all times.* ***Safety should always come first****.*

This section will deal with the following:

- Explaining the roles and responsibilities of the **Pilot in Command (PIC)** and **Visual Observer (VO)**
- Defining software tools required for maintaining the operational area

- Outlining necessary steps for a pre-flight inspection and proper maintenance logs
- Defining the Operational Envelope of the system

Pilot in Command (PIC) Responsibilities

The PIC is the person in charge of the sUAS operation. They must have a valid Part 107 certificate and have passed a Nightingale Security training exam. Responsibilities associated with the PIC include but not limited to:

- The remote PIC is directly responsible for, and is the final authority as to, the operation of the sUAS. 14 CFR 107.19(b)

- A remote PIC **MUST** be designated before the flight. 14 CFR 107.19(a)

- The remote PIC must ensure that the sUAS will pose no undue hazard to other people, other aircraft, or property in the event of a loss of control. 14 CFR 107.19(c)

- **IT IS REQUIRED** that the PIC has constant and consistent access to primary flight controls for the full duration of the flight ***Any transfer of controls to a non-certified (Part 107) operator is not permitted by Nightingale Security.*** 14 CFR 107.12 (a)(2)

- The remote PIC must familiarize themselves with their operational area. They should have an understanding of both fixed and temporary obstacles, traffic patterns (pedestrians, vehicles, general aviation), and weather patterns. The PIC should avoid flights over people and moving cars, as it violates 14 CFR 107.39 and currently Nightingale does not have a waiver for this regulation. All ground control links need to be verified operational before flights and sufficient power is available for mission. 14 CFR 107.49 (a)(b)(c)(d)(e)

- If leveraging a **Visual Observer (VO)** to extend line of sight, the PIC should coordinate the placement of the VO ahead of time and establish the communication pathway and protocols necessary to ensure consistent communication. 14 CFR 107.33 (a)(b)(c)

- The remote PIC must make available to the FAA, upon request, the sUAS for inspection or testing, and any associated documents/records required to be kept under the rule. *Inspection, Testing, and Demonstration of Compliance* linked here for specific requirements 14 CFR 107.7

    - **If you are contacted by the FAA to fulfill this requirement please reach out to Nightingale for support and guidance.**

- The remote PIC must report to the FAA within 10 days of any operation that results in serious injury, loss of consciousness, or property damage of at least $500. Nightingale Security MUST also be notified of any operations that result in damages. The remote PIC

is responsible for filing a report with the FAA within 10 days of any operations resulting in the following:

- File report at https://faasUAVzone.faa.gov/#/.
  - If not already created, the PIC will need to create an account
  - Once account is created, follow the prompts for filing an Incident Report
  - Once filed, please save a copy of the report for your records and provide a copy of the report to Nightingale Security
    - 14 CFR 107.9

- The remote PIC must conduct a preflight inspection, to include specific aircraft and control station systems checks, to ensure the sUAS is in a condition for safe operation. An outline of said checks follows in 14 CFR 107.49

  - Note: Nightingale recommended Pre-flight inspection with FAA 107.49 compliance located in Operations | Pre-flight and Maintenance logs section.

Visual Observer (VO) Responsibilities

A VO does not need to have a part 107 certificate but is required to have the situational knowledge required to relay adequate and useful information to the PIC.

- VO's should be trained to assist the PIC in identifying and avoiding routes; over people, through prohibited flight paths and in the way of manned aircraft. The PIC should include information regarding:

  - The operational capabilities of the system.
  - Operational flight area including but not limited to; NFZ's, buildings, obstacles, high traffic areas, dynamic airspace conditions.
  - How and where to strategically position themselves (VO) to maintain line of sight (LOS) of the system.
  - Establish a loss of communication protocol specific to flight operations.
  - Instruction for the VO on how and when to notify the PIC to stop or return the sUAV upon an airspace incursion from a non participating aircraft.

- VO's are required to identify flight hazards and direct the PIC to take action necessary to avoid intrusions:

  - Ground hazards: include but are not limited to; people, cars, trees, construction equipment, powerlines, cranes.
  - Airborne hazards: include but are not limited to; debris, low-flying aircraft, weather.

- VO's are required to position themselves throughout the operation of the flight to maintain Visual Line of Sight (VLOS) of the aircraft. Should the sUAS break with the VOs VLOS they are recommended to immediately try and reestablish VLOS while requesting the PIC to stop (Hover) the sUAS. If LOS cannot be obtained return the sUAS to base.

- If at any point, weather deteriorates to a state where operations are no longer deemed safe, the VO is recommended to request the PIC return the sUAS to base.

Important:

- Contacting PIC for hazards should be done with uninterrupted two-way communication using concise instructions to mediate risk.

Preflight

The Blackbird preflight is a two part safety check of the system before each flight. It is required by FAA regulations to do a pre-check before all flights and must be done by the PIC. Pre-checks are designed to be thorough to prevent emergency situations and increase the operational longevity of the sUAS. The following sections contain the Nightingale recommended preflight check.

- External
- Internal
- Weather
- Airspace

External check

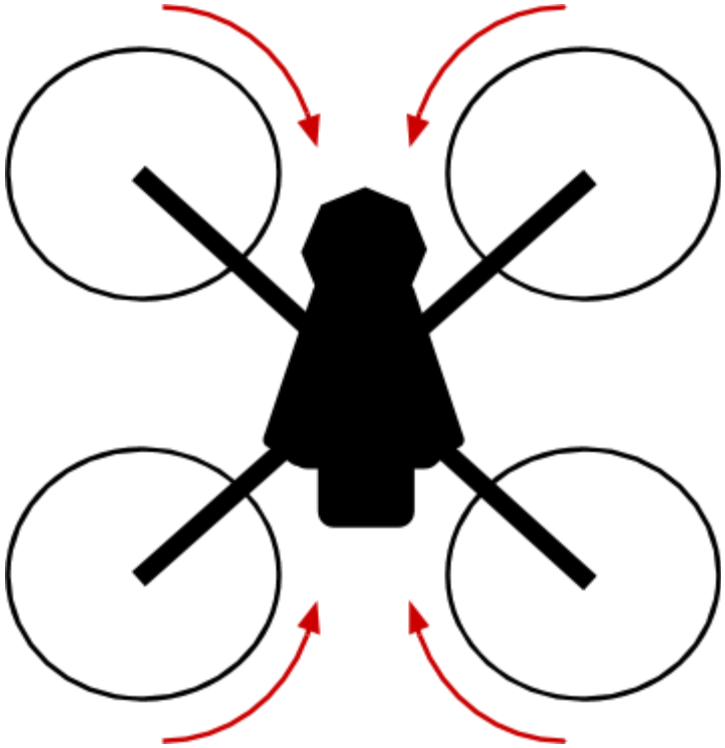
Before every flight operation, it is mandatory to conduct an external check of the sUAS, making notes of and if necessary amendments to any atypical system characteristics. Below is a comprehensive walkthrough of the best practices for a pre-flight check on the Nightingale Security Blackbird.

Propulsion

Props

- Check the propellers' leading edges, trailing edges, and surfaces for cracks or chips, anything which could affect the structural integrity or aerodynamic characteristics of the propellers. Propellers should not be flimsy nor give when checking rigidity. They should be firmly mounted to the motor bells with two H-2.5 machine screws and a spacer should be present between propellers and motor mounts. The propellers should be right-side up and oriented to spin in the direction depicted below. If the propellers are loose, report the

problem to Nightingale, and tighten the screws with middle finger, index, and thumb only. DO NOT OVER-TORQUE.



Motor Bells

- Use two fingers to grab base of props near motor bell and pull up while holding the motor mount down. Should feel no vertical give or any free range of motion. Spin motor to check for any bad bearings, should not hear or feel any grinding or catching when rotating. While rotating motor check plane between side walls and motor mount, and be sure there is no wobble "wobble".

Airframe

Motor Mounts

- The motor mounts need to be secured to the arms and have no rotational give. Check the mounts for cracks and any disturbances which contrast to manufactured process including chips or fissures. Specifically looking at the screw drive holes, modular joints or other high stress areas for new or developing cracks. Any gaping or warped components specifically looking at modular joints with of high stress areas (motor mount).

Arms

- The arms need to be secure to the fuselage. There must be no displacement in twist, push or pull where each arm meets the fuselage. A small amount of force will be enough to verify this.

Feet

- As with the motor mounts and the arms, there must be no twisting displacement or push/pull displacement where the foot meets the leg. Each foot is secured to each leg with four machine screws. The rear feet have pogo pins for charging inside them, exposed at the bottom of the foot. They must depress easily. If a drone is ever not charging, checking these pins for cleanliness or debris is a good first step.

Legs

- As with the arms, the legs need to be secure to the fuselage. There must be no displacement in twist, push or pull where each leg meets the fuselage. Applying a small amount of force will be enough to verify this.

Fuselage

- Check the perimeter of the fuselage for cracks and/or splits.

Cracks

- Any disturbances with contrast to manufactured process including chips or fissures. Specifically looking at screw drive holes, modular joints or other high stress areas.

Fatigue points

- Any gaping or warped components specifically looking at modular joints and high stress areas (legs and arms)

Screws

- Fastened all the way in and all drive holes have a screw in them. Components in which they are fastened to are secure. Tightening screws carefully involves turning with thumb, index, and middle fingers; DO NOT OVER-TORQUE.

Pogo pins

- Able to compress fully and decompress back out. Not obstructed by feet and both able to make contact with charging pads (fully compressed).

Gimbal

Arms

- Move gimbal on all axis to look for catching or grinding of gimbal motor arms, not tangled in gimbal wire. Ensure the gimbal arms are not limp. Look for any fatigue or cracks near joints.

Optics

- Housing free from cracks or stresses specifically on modular joints. Lenses are clear, clean and fastened securely. All heat sinks on and secure.

Wire

- Wires not tangled, pinched, cut, bent or fatigued.

Antennae

LTE

- Connection is secure, can give slight torque on connection. Locked in 45 degree position. Antennae casing free from cracks.

Local wifi links

- Connection is secure, can give slight torque on connection without it rotating. Antennas are pointed down and connections are blackened without wear.

Top

Lid

- Fastened securely on top. All screws in place with no loose objects underneath lid near components.

Strobe

- Showing no lit LEDs. Check for fatiguing or cracks on strobe casing.

Power

Battery

- All screws in place in proper drive holes, fastened, lights on capacity indicators.

Power switch

- Secured to the airframe. Power on is **switch right**.

Telemetry Checks

Human required checks: Checks to be done by the PIC

Battery

- Voltage minimum of 22.1v to ensure enough battery is available to launch.

Ground control Connectivity

- RSSI
    - Signal quality is an automatic check, though in order to satisfy FAA regulations the PIC must confirm “Ground control station” connectivity by using the RSSI values as a metric. See **SOPs** for the operational safety thresholds.
    - Confirmation of changing telemetry on the fleet page also indicates ground control connectivity.

After Launch commanded is selected, the mission has commenced and the preflight is complete. The system will do a final Launch Status Check before taking off, for details on these checks see the **SOPs** section of the operations manual.

Support Systems check

While doing a Blackbird pre-flight it is recommended the PIC also checks necessary support system equipment to ensure mission safety. These recommendations include checking cables for damage, flight area is clear of debris, and the nest is able to open and close freely. Any progressive degradation of wires or components should be noted and made aware to Nightingale.

Nightingale depends on the observation of on-site personal to diagnose conditions caused by environmental factors. Changes, if any, in equipment can be small during daily operations. Storms, although, could cause both noticeable changes in physical properties of the system as well as communication capabilities. Operations in post-storm conditions warrant a more diligent support systems check, pooling or leaking of water should be noted. Cut and damaged cables are reason for grounding the system until repairs are made.

Weather check

- Review hyper local data from installed weather stations as well as data available from local forecasts to understand the current and potential future weather conditions that could impact operation. Including but not limited to:

    - Ambient temperature
    - Wind

    - Precipitation
    - Visibility
    - Extreme weather conditions

- 14 CFR 107.51 Operating limitations for small unmanned aircraft
    - (c) The minimum flight visibility, as observed from the location of the control station must be no less than 3 statute miles. For purposes of this section, flight visibility means the average slant distance from the control station at which prominent unlighted objects may be seen and identified by day and prominent lighted objects may be seen and identified by night.
    - (d) The minimum distance of the small unmanned aircraft from clouds must be no less than:
        - (1) 500 feet below the cloud; and
        - (2) 2,000 feet horizontally from the cloud

Useful aviation weather tools can be found at: https://aviationweather.gov

- Metars are useful for current local weather
    - Ask a Nightingale Deployment engineer for nearest airport
- TAFs are useful for forecasted local weather
    - Use same airport as Metars
- SIGMETS are useful for determining if convective weather (Thunderstorms/Tornadoes etc.) is expected in a local to regional area.

Weather Information pertaining to a specific flight can be reviewed on FAA approved flight service websites links include:

- https://www.1800wxbrief.com/Website/#!/
- https://www.duats.com/
- Call 1-800-WX-BRIEF

Weather should be cross checked with available government sources such as https://www.aviationweather.gov/

For specific Nightingale system weather restrictions see the **System envelope and Limitations** section.

Airspace Check

NOTAMs (NOtice To AirMan)

The purpose of a NOTAM is to advise local pilots of the sUAS operation. A NOTAM is filed on behalf of the customer by Nightingale before flight operations commence. NOTAM's are filed

24-48 hours before the operation and can be granted for up to 6 months. Information in the NOTAM consists of, but not limited to, the following:

- GPS coordinates of intended operation of sUAS
- Operational hours of sUAS
- Radius of operation from given GPS coordinates
- Maximum altitude of sUAS flight envelope
- Estimated frequency of operations
- Contact information to personnel at operational location

NOTAMs are time critical notices identifying changes in aeronautical charts or publications that relate to safe and legal operation of aircraft.

NOTAMs pertaining to your specific flight will be identified when completing a thorough brief of the previously linked weather sources.

For individual NOTAM information linked sites include:

- https://notams.aim.faa.gov/notamSearch/nsapp.html#/
- https://pilotweb.nas.faa.gov/PilotWeb/

TFRs (Temporary flight restrictions)

TFRs restrict specific aircraft from operating in a defined section of airspace.

TFRs are often found coupled with the NOTAM section of a flight briefing.

Individual TFR information outside of a standard flight briefing can be found by contacting a Flight Service Station (FSS) or at the linked website: http://tfr.faa.gov

When using the Relay application please do a Airspace and operational area check on the map.

Airspace and operational area checks:

- Green Geofence is displayed
- All obstacles, buildings, Points of interest, and NFZs appear on the map.
- The Blackbird icon is displayed on the mission map and is close to base icon

- This image demonstrates a valid icon proximity

Standard Operating Procedure

The Nightingale system is designed to operate with as much autonomy as possible. All missions are preprogrammed and have the ability to implement commands that alter the original flight plan. Regulations require a human to be in the loop, but when it comes to operating the system the PIC is simply monitoring system health for situational awareness. This section is intended for describing how to monitor the system and what normal operation looks like. For a refresher on commands and flying a mission reference the Software | Mission manager section.

User checks have been completed:

- Mission waypoint parameter; durations, altitudes and location are verified. Waypoints and flight paths follow FAA and Nightingale safety requirements.
- No new obstacles in Geofence.
- Local FAA airspace restrictions and manned aircraft traffic patterns.
    - Airspace restrictions found in NOtice To AirMans (NOTAMs)
        - For further information regarding NOTAMs see **Regulation | Airspace** section in the document.
    - Traffic patterns observed in daily operations on site
    - Awareness of emergency services

Once a mission is selected and pre-flight checks are complete, the operator will initiate start-up sequence with the “Activate” command. Once the Blackbird is activated it will run through autonomous system checks to verify it is mission ready, if the systems result in a failure the launch will be aborted. The system has 2 minutes to complete internal tasks, outside of 2 minutes the launch will be aborted.

States

Internal diagnostics are verified and the Blackbird will begin a pre-takeoff sequence indicated by the STATE field. State fields are important indications of normal operation, the following is a list of state fields and their expected behavior;

- Inactive
    - Blackbird is sitting on base, conserving power and waiting for a command.
- Idle
    - Blackbird is online and ready to be launched.
- Pre Takeoff
    - Blackbird is going through its pre-flight checklist, preparing for takeoff.
- Takeoff
    - Blackbird is climbing to mission transition altitude of 20m above base.
- Altitude ready
    - Blackbird has reached mission altitude and undergoes final flight checks.
- Approach
    - Blackbird is en-route to a waypoint.
- Pattern
    - Circle command.
- Hover
    - Hovering in place, also described as loiter mode.
- Return
    - Blackbird is done with mission and returning home or an RTL has been triggered.
- Pre_land
    - Blackbird is above base looking for beacon and confirming communication to the base.

- Land
    - Blackbird has acquire beacon and established comms with base. It will now start its descent to landing.
- ELZ
    - An emergency event has been triggered and the Blackbird will now proceed to an ELZ.

Note:

- ELZ or RTL can be issued in any state.
- A user command ELZ or RTL can be cancelled with a hover or fly-to.
- An auto ELZ or RTL cannot be cancelled.
- Takeoff, RTL, ELZ and land are all protected states in which no commands are accepted unless fall under the operations listed above.

Once in pre-takeoff the nest doors will open and the anti-collision light will be flashing.

Launch

Always announce a launch to all involved parties of the sUAS operation. Consistent and reliable communication with a Visual Observer is required under CFR **§107.33** and by the Nightingale safety requirements. The following is the sequence after Launch is commanded.

Launch Status Checks:

- During launch status check, if for any reason the pilot feels uncomfortable with the flight or an unforecasted issue arises. The launch can be aborted with the Abort Launch button.
    - Searching for resources
        - The system is verifying that the Blackbird selected is not in a mission, activated and not grounded in addition check there is a pilot assigned.
    - Calculating flight plan
        - The IPP logic is creating the mission, setting waypoints, planning the route and calculating battery.
    - Verifying Blackbird Health
        - Sub-system checks; Navigation health, payload health, communications, battery and propulsion.
    - Verifying Base Health
        - Communication with the base is established and telemetry is being transferred.
    - Opening Base Station
        - Base is confirmed open by the flight computer.
    - Syncing Navigation system
        - GPS is being converged, altitude is converged between multiple sensors, and navigation sub-systems are cross referenced.

Launch sequence:

- Launch Blackbird from either the *Relay App* or *Mission Manager.*
    - Launch Status Checks
- The Blackbird will enter a pre_takeoff state and streams will start.
- Base doors will open automatically.
- Shortly after the base doors open, the Blackbird will takeoff.

Takeoff sequence:

- The blackbird will have a stable ascent using Precision Takeoff, PT is a function that tracks the IR beacon up to altitude.
- Once 20 meters above the base is reached, the Blackbird will initiate a home capture and transition from takeoff to altitude ready. During this switch it is expected to observe the Blackbird bounce and sway as the system calibrates GPS positioning in air.
- Once calibrated and a coordinate for base location is captured, the Blackbird will proceed will programmed mission.

Inflight

Once inflight make every effort to keep the Blackbird within you or your Visual Observers line of sight to look out for hazards within the airspace it's also required under CFR **§ 107.33** and by nightingales safety requirements there.

The PIC is responsible for monitoring vital telemetry data during the flight.

- Monitor both RGB and FLIR streams
- Monitor mission critical information (RSSI, GPS, Battery)
- Monitor flight area for hazards in accordance with any VOs
- Scan mission critical information (RSSI, GPS, Battery)
- Monitor landing location for any obstructions

NOTE: A detailed list of operational thresholds can be found in the "Operational Limitations" section below. For more detail please refer to that section

Line of sight

- Carefully monitor the Blackbird and do your best to predict hazards along your flight plan
- Maintain steady and reliable communication with your Visual Observer or PIC (if VO)
- Avoid operating over people and moving cars.

Note: It can be expected to see up to a 12 second lag observing commands through the stream. It is also expected for a command to be observed LOS in under 5 seconds.

Landing

Once the Blackbird is on approach for landing it will hover over the base, rotate to the correct heading for landing, and tracking must be established before descending for final touchdown.

Once at the base

- The state of the Blackbird will enter an approach_home state when it has completed its mission or reaches its minimum battery capacity.
- After correct heading is established the Blackbird will look for the IR beacon on the base.

- It is expected to roll aggressively to the center of the base once tracking of the beacon is established.
    - If the beacon cannot be captured, the Blackbird will descend from a height of 40 meters to a predetermined safe altitude, in an attempt to search for the beacon.
    - It will attempt this search 3 times before proceeding to ELZ.
- The rails and centering rods will position the Blackbird on the charging pads if not already making contact as it closes.
- Using *Mission Manager* or *Relay app* check to see that the Blackbird is charging, the battery levels should show a continuous increase in percentage.

System Envelope and limitations

In addition to FAA limitations on weather minimums, Nightingale has established a set of limitations for the system. There are the pre-flight requirements as described in **Operations | Preflight** section as well as in-flight limitations to safely operate the Blackbird.

During the deployment process, a Nightingale DE will work closely with the operators to determine optimal altitude, distance and speed of the Blackbird.

- Distance - Max operational area is defined by the Geofence. Standard distance is a 2.3 km radius from communications mast.
    - Longest expected trip is 6 miles total

- Altitude - Hardcoded into the flight parameters, only a Nightingale employee can alter the altitude limitation. Standard altitude operations are between 30 - 70 meters agl (above base).
- Speed - Hardcoded maximum is 15 m/s into the flight characteristics, speed can be altered before flight during mission creation. The speed entered at a waypoint is speed FROM that waypoint with the option between 3 m/s and 15 m/s. Standard speed is 12 m/s if left untouched.

The following table displays important thresholds for both weather conditions and system functionality based on Nightingale product testing. This is to be used in accordance with predefined FAA regulations on sUAS operating limitations:

Metric	Fly	No-Fly
Wind Speeds	0-25 mph	25+ mph
Winds speeds inflight	0-45 mph	45+ mph

Temperature	5-122 ℉**	<5 ℉; >122 ℉
Battery Voltage	25.8v (100%)	<22.1v (15%)
Number of Satellites	7+	<7
RSSI	> -85 dBm	< -85 dBm

Included in Nightingale weather limitations are reminders of important system health limitations. System health information can be viewed in the mission launch page or on the fleet monitor. Localized base weather information can be viewed on both Mission manager and the Relay app, helpful for determining wind speed.

**NOTE: Temperature limitations are subject to change as Nightingale deems necessary, advances in cooling and heating systems are continuing to be researched and developed. Benchmark limitations shows system is operational up to 122 ℉ (50 °C) while in the base.

Precipitation limitations

No-Fly perception events include:

- +RA (Heavy Rain)
- +SN/SN (Heavy and Moderate Snow)
- GR (Hail)
- FG (Fog)

If uncertain about the severity of weather, use aviation weather sources and the local airport will have more detailed information.

In addition to precipitation events, Thunderstorms and Icing conditions are in direct violation of operational safety limitations. Local weather sources have more information on both conditions.

In the event of unforecasted weather it is the PICs responsibility to manually return the Blackbird, if base area is deemed unsafe, utilize the ELZ command if necessary.

The ability to distinguish atmospheric condition intensity can be found utilizing the tools provided in the **Weathe**r subsection in the **Operations | Pre-flight** section.

The restrictions provided by the FAA and Nightingale are issued with safety for operators and non-participating bodies in mind. If at any time the conditions are within prescribed limitations the PIC has the authority ground operation if safety is a concern.

Certain weather phenomena do not ground the system but the PIC is required to be aware of how adverse weather conditions affect subsystem components.

- Lidar - Used for takeoff and landing, a lidar sends a light pulse and measures return time to determine distance. Accuracy of Lidar is greatly affected by rain and snow due to reflective light properties. Operations in clouds or heavy precipitation is prohibited.
- GPS - Receiving signals from a satellite at wavelengths that are interfered with by dense storm clouds. Satellite count is expected to decrease during times of cloudy atmospheric conditions. Time of day also affects the number of satellites in available to lock on. Important to note Blackbirds that have been sitting in the base with doors closed for extended periods of time (multiple days) will have trouble with satellite acquisition.
- Signal - Received signal strength quality can be susceptible during times of dense perception (snow). Signal can also be affected during periods of high traffic, specifically on LTE towers. Examples; rush hour and large events.

Note: In the event an unforeseen weather event occurs in-flight, promptly return the system using the RTL command and halt further operation until even has passed.

Autonomous System Checks

The Nightingale system will perform autonomous checks during its internal preflight diagnostic and in-flight. Autonomous checks are intended to warn the operator of encroaching limitations and override operations in the event of limitations being exceeded. Nightingale system checks are designed to keep the human in the loop of Blackbird health and overall autonomous operations. If operators ignore warnings, measures will be taken automatically to ensure the safety of operation. Pre-flight system checks are described in the **Operations | Pre-flight** section of this document.

Recommended Operator action:

- Motor temperatures
- Battery temperatures
- Communications (secondary)

Note: Failure to comply with recommended actions in a warning message will result in the automatic override of the Blackbird.

Automatic overrides will transition the system into a return state. Return states are the RTL and ELZ modes, the following is a list of standard automated overrides and associated message.

Note: All triggers will be accompanied by two messages; a specific message identifying the failure and a generic message informing the pilot of the safety measures being taken.

Note: ELZ falls under emergency procedure protocol and is not a Standard Operating procedure, please refer to the Emergency Procedures section in the operations manual.

Generic messages:

- Automatic override: Launch aborted
- Automatic override: RTL
- FAILURE: System health checks
- FAILURE: Takeoff failed
- FAILURE: Flight controller
- FAILURE: Flight computer

Pre-flight check specific messages

Launch aborted

- WARNING: Memory full - Recommended action: Contact Nightingale support
    - If the flight computer detects the memory is full, it is unable to write the mission and aborts launch of out safety.
- FAILURE: Satellite minimum not met - Recommended action: Leave base open, re-launch when minimum is met.
    - The flight computer does a system health check, number of satellites is important in determining positioning accuracy. A healthy GPS is critical in flight operations, if the minimum of 11 is not met, the Blackbird will abort launch. It is recommended that the pilot leaves the base open and monitors count in the fleet page. Often satellite count will improve dramatically after a few minutes with the doors open.
- FAILURE: GPS horizontal positioning outside limitations - Recommended action: Leave base open, re-launch when minimum Satellite count is met.
    - Similar to the GPS satellite count, horizontal position is checked before flight, a maximum error of 30 meters is determined to be safe enough to launch. The recommended action is the same as satellite count, often coupled together, leaving the doors open for a few minutes often improves quality of positioning. Since horizontal positioning is directly affected by satellite count, it is recommended to observe improvement through the fleet page count.

- FAILURE: Gimbal - Recommend action: Contact Nightingale security
    - The flight computer detects a gimbal failure, the Blackbird will not have the ability to track during landing.
- FAILURE: Rangefinder
    - The flight computer detects a failure on the range finder component, with a failed rangefinder the Blackbird will not be able to land safely on the base.
- FAILURE: Compass calibration failed - Recommended action: Contact Nightingale support
    - The flight computer checks against a variance limit, if exceeded it is determined the Blackbird isn't healthy enough to fly and will require recalibration.
- FAILURE: Base unresponsive
    - If the base cannot communicate to the Blackbird that it is open.
- Failure: Mission planning - Recommended action: Contact Nightingale support
    - The IPP software goes through a list of eight checks, any of these check could result in the inability to successfully plan a mission. If a mission fails to plan, please contact Nightingale support and do not attempt a re-launch until the software has been verified.
- Failure: Magnetic interference - Recommended action: Contact Nightingale support
    - GPS and compass rely heavily on magnetometers for sense of direction, if a magnetic disturbance is detected before flight the launch will be aborted and it is required a Nightingale support ticket is filed.
- Failure: GPS module - Recommended action: Contact Nightingale support
    - Unlike the Satellite count and health checks previously described, a GPS module failure indicates a complete loss of GPS telemetry, for safety it is required that there are no launch attempts until signed off by Nightingale.
- Failure: Takeoff time limit exceeded - Recommended action: Contact Nightingale support

    - Two minutes is allotted for the Blackbird to take off from the time of sending the launch command. If pre-checks cannot be completed in this time, please contact Nightingale support. Missed launch windows are encompass a wide range of possible complications, though often accompanied by the root cause.

- FAILURE: Motor startup not in-sync - Recommended action: Retry launch, if problem persists contact Nightingale support.

    - Motor current draw is detected during startup sequence. If current sensors detects below minimum draw, the launch will be aborted. Often this will trigger when a Blackbird had just flown a mission, please attempt a re-launch, if problem persists Nightingale support can identify if further action is required.

In air specific messages

RTL

- **End of mission**

    - Last way point has been reached and hover time has passed, the Blackbird will return home.

        - Only an INFO associated message confirming the command was sent will appear, Blackbirdthen will proceed as planned. The Geofence will switch to return state map.

          Note: Under the restrictive model network, loss of the local 2.4 ghz connection will trigger an auto RTL.

- WARNING: Battery low

    - The Blackbird will return to the base station we in detects battery is running low and reach the home waypoint with 20% reserves left.

- FAILURE: High operating temperature - limit exceeded

    - If the sensors detect that temperatures exceed or drop below defined range. Detected components include; speed controllers, flight computer and flight controller.

- FAILURE: Motor stress limitation exceeded - Recommended action: Contact Nightingale

    - If the motors are detected to be over stressed or out of sync

- FAILURE: Power system disruption - Recommended action: Contact Nightingale support

    - If a glitch in the power management system the Blackbird will RTL for safety and should remain grounded.

-
- WARNING: Memory full - Recommended action: Contact Nightingale support

    - Memory is detected to be close to full, for safety an RTL is issue to prevent the flight computer from crashing.

- FAILURE: Power does not meet mission requirements - Recommended action: Contact Nightingale support.

    - This battery check is done during the takeoff state which is why it has a different message. If the battery check pre takeoff passes but see an unusual drop on takeoff, the system will RTL. A failure of this type should be conveyed to Nightingale as it is a precursor to a damaged battery.

- FAILURE: Battery critically low

    - A Battery critical low indicates that the intelligent path planning logic missed the primary trigger to return Blackbird home due to low battery. This message will occur when the low battery is caught by the flight computers backup system check.

INFO messages

Information messages are designed to indicate successful autonomous operations. These messages keep the pilot in the loop of system performance, allowing the user to understand the actions being taken.

- INFO: Landing successful

    - Information indicating the Blackbird has successfully landed.

- INFO: IPP relocation successful
    - Information message indicating the blackbird has successfully navigated out of a NFZ (typically seen with GPS drift or dual map protocol.
- INFO: Base open
    - Information message indicating the base has successfully opened.
- WARNING: Retrying takeoff
    - Warning message indicating an autonomous relaund attempt is being sequenced, message is only seen after the Motor startup not in sync failure. 3 attempts will be made.

Additional messages

- FAILURE: Battery sensor - Recommended action: Contact Nightingale support
    - A battery sensor failure indicates the cell readings inside they battery may be unreliable. This will not cause an RTL or ELZ but an MRU of the battery is likely required, the IPP estimations will also be inaccurate and reduced flight time is likely.
- WARNING: Low WIFI connectivity
    - A warning message indication the local wifi connection is degrading and may soon lose connection, during times of low connectivity, stream quality will be affected. It is at the pilots discretion to continue mission with the risk of losing the secondary communications link.

Auto-land emergencies

In the event of a critical instrument failure, the following sensors will trigger an immediate descent to land no matter where the Blackbird is:

- Complete compass failure
- Complete GPS failure

Emergency Procedures

The system is designed with safety and reliability in mind, in case of unforeseen failures emergency protocol has been put in place to properly navigate adverse situations. Keeping the system failures from compounding is paramount, keeping people away from harm is the most important rule when dealing with an emergency situation. The following are instructions on the protocol for system failures that can cause emergencies and how to use Emergency Flight Controls.

In emergency situations please ensure you contact emergency services and follow onsite required protocol first to ensure containment and proper emergency response.

Automated Emergencies

The emergency notification system is constructed in the same way as the Standard operating notification system. The Emergency will display a generic message accompanied by a more specific message identifying the cause of the ELZ.

Generic Message:

- Automatic override: ELZ

Emergency messages:

ELZ

- User command ELZ

    - A user commanded ELZ has no specific message or generic message, once issued the Blackbird will proceed to the nearest ELZ with a INFO confirmation message displayed.

- FAILURE: Abnormal motor vibration detected
    - The flight controller detects unusually high vibrations, often caused by a failing motor.
- FAILURE: Rangefinder
    - The flight computer detects a failure on the range finder component, with a failed rangefinder the Blackbird will not be able to land safely on the base.
- FAILURE: Base unresponsive
    - If the base cannot communicate to the Blackbird that it is open.
- FAILURE: Gimbal - Recommend action: Contact Nightingale security
    - The flight computer detects a gimbal failure, the Blackbird will not have the ability to track during landing.
- FAILURE: Communications lost
    - Complete communications loss of both LTE and wifi, the flight computer will attempt to reconnect for 30 seconds. If unsuccessful, an ELZ is triggered.

        Note: Under the restrictive model network, loss of the local 2.4 ghz connection will trigger an auto RTL.
- FAILURE: Beacon Lock (In-flight and in base)
    - If the beacon on the base is undetected by the Blackbirds sensor, it will attempt to acquire 3 times
- FAILURE: Battery fail-safe enabled

    - If both the path planning logic and the flight computers backup check miss identifying a low battery, the flight controller will detect low volts and ELZ the Blackbird immediately. This circumstance would occur in the unlikely scenario the flight computer crashes, freezes or get powered off.

- FAILURE: Wind limitations exceeded

    - Winds are detected from the base station every 20 seconds. If a reading exceeds the value of 45 mph in-flight the Blackbird will ELZ, if in LAND mode a reading exceeds 25 mph the Blackbird will ELZ.

- FAILURE: Mission planning relocation - Recommended action: Contact Nightingale support

    - In the unlikely scenario the Blackbird finds itself inside a NFZ or outside the geofence and cannot plan a path back in an error in relocation will appear. Under the circumstance follow the emergency deviations checklist.

While the system is in an emergency landing logic state, the beacon tracking with the IR camera will still be active. This means that if the base station is open and the ELZ is close in proximity to the base station, the Blackbird will try and track the beacon down to landing. Ways to avoid this include;

1. Place the ELZ a minimum distance of 30m horizontally from the base station.
2. If the Blackbird begins tracking the beacon in an emergency state and the base can be closed, close the base.
3. If the base station cannot be closed, cover the beacon.

The logic of the system will place the tracking of the beacon over the command inputs of the pilot in the described situation.

Emergencies that require manual intervention

The first step in effectively gaining control in an emergency situation is being able to identify what

failure is causing the problem. Be careful to pay attention to the various types of failures that can occur as they may call for a slightly different protocol. The situations described in this section require manual intervention. A failure has occurred that Co-pilot cannot assist in fixing.

Situations:

- **Deviations -** Any route the Blackbird may take that has not been previously planned or commanded, deviations tend to occur within the FLIGHT COMPUTER.
    - Flight route does not follow planned mission route, a fly-to does not route to commanded destination.
    - Flight takes Blackbird outside defined Geofence zone and does not replan back into zone.
    - A flight into a NFZ, does not plan itself back out.
- **Commands -** Any time a state command is sent and the Blackbird ignores call. Command emergencies are likely forecasts of NETWORK complications, with occasional FLIGHT COMPUTER logic errors.
    - **Hover** command sent but Blackbird continues mission
    - **RTL** command sent but Blackbird does initiate return
    - **ELZ** command sent but Blackbird does not initiate ELZ
- **Abnormal flight behavior -** the FLIGHT CONTROLLER displays difficulty in sustaining flight.
    - Blackbird exhibits excessive pitching or rolling, flight appears to be unstable
- **ELZ -** Landing zone is unsafe, EXTERNAL FACTORS are a likely cause of of an unsafe landing zone but be aware of possible GPS complications.
    - Obstacle in landing path
    - GPS inaccuracies take Blackbird outside allocated landing zone

Manual emergency procedure

Deviations - A deviation is identified, the flight computer is the likely failure. Follow the provided steps to troubleshoot and safely land the system.

- Step 1 - Issue RTL

        - First issue a change of state command, the idea is to try and break the flight computer out of its current logic loop, under normal operations a RTL will change current flight state to a return state.
            - Note: If time permits check signal quality
                - If good, and no change is observed then proceed to step 2
                - If bad, command may take time to been received (If time is critical proceed to step 2 for immediate action)
                - No signal, ELZ will be triggered
    - Step 2 - Initiate Show Emergency controls
        - Note: Flight computer is bypassed (Geofence/NFZ/Obstacles are ignored) when in this mode.
    - Step 3 - Issue STOP
        - Note: Blackbird should hover in place and camera is pointed down
    - Step 4 - Issue FIX ELZ
        - Note: Writes path directly to specified ELZ location in software
    - Step 5 - Issue EXECUTE ELZ
        - Note: Climbs to emergency altitude then proceeds to defined ELZ location
    - Step 5 - Kill motors
        - Follow prompts to initiate a kill motor command once Blackbird is on the **ground**

- **Commands -** Any time a command is sent, the system should receive and implement the action within a few seconds depending on latency. If a command is sent and is being ignored, this could be an indication of degrading network quality. Please verify signal strength before proceeding in emergency protocol. If signal strength is good but the system is still unresponsive, a flight computer issue is likely occurring,

        - **Note: If system readouts "freeze" try refreshing, then if state remains unchanged and no connection error pops up proceed with emergency protocol.**

    - Step 1 - Issue RTL
        - First issue a change of state command, the idea is to try and break the flight computer out of its current logic loop, under normal operations a RTL will

change current flight state to a return state.

- Note: If time permits check signal quality
  - If good, and no change is observed then proceed to step 2
  - If bad, command may take time to been received (If time is critical proceed to step 2 for immediate action)
  - No signal, ELZ will be triggered

- Step 2 - Initiate Show Emergency controls
  - Note: Flight computer is bypassed (Geofence/NFZ/Obstacles are ignored) when in this mode
- Step 3 - Issue STOP
  - Note: Blackbird should hover in place and camera is pointed down
- Step 4 - Issue FIX ELZ
  - Note: Writes path directly to specified ELZ location in software
- Step 5 - Issue EXECUTE ELZ
  - Note: Climbs to emergency altitude then proceeds to defined ELZ location
- Step 5 - Kill motors
  - Follow prompts to initiate a kill motor command once Blackbird is on the **ground**

- **Abnormal Behavior** - Abnormal behavior is described as excessive pitch or roll of the Blackbird on its flight axis. This behavior will appear to the observer that the stability of the system is unsafe and outside normal operations. Position hold is greatly affected in this condition and would be a key symptom in identifying a flight controller emergency.

  - Observation of uncontrolled pitching or rolling of Blackbird
  - Under the observation of erratic flight controls PIC is recommended to land Blackbird immediately.
- Step 1 - Initiate Show Emergency controls
  - Note: Flight computer is bypassed (Geofence/NFZ/Obstacles are ignored) when in this mode
- Step 3 - Issue STOP
  - Note: Blackbird should hover in place and camera is pointed down

    - Step 4 - Issue Nudge
        - Note: The objective is to Nudge Blackbird away from obstacles to safe landing zone. Use Ascend/Descend if necessary when around tall obstacles. (Reminder: NFZ/Obstacles disabled)
    - Step 5 - Land slow
        - Note: Once a landing zone is determined to be safe. Initiate land slow.
    - Step 5 - Kill motors
        - Follow prompts to initiate a kill motor command once Blackbird is on the ground

- **ELZ -** During ELZs of any type (manual or automatic) there is a change the landing zone is not clear. If the Blackbird appears it could be landing on an obstacle, manual intervention is required to move the system into a safe landing position.

    - Step 1 - Initiate Show Emergency controls
        - Note: Flight computer is bypassed (Geofence/NFZ/Obstacles are ignored) when in this mode
    - Step 3 - Issue STOP
        - Note: Blackbird should hover in place and camera is pointed down
    - Step 4 - Issue Nudge
        - Note: Nudge in the direction away from the obstacle (will need to issue multiple commands)
    - Step 5 - Issue Land Slow
        - Note: Blackbird descends at 1 m/s
    - Step 5 - Kill motors
        - Follow prompts to initiate a kill motor command once Blackbird is on the ground

- **Note: If at any point Emergency Controls (EC) are initiated, PIC can still defer to STOP to regain situational awareness.**

- **Note: Anytime EC are activated, theBlackbird is grounded in the software and you must reach out to Nightingale support to continue operations.**

Emergency Flight Controls

NOTE: Mission Manager and the Relay App have identical functionality for the Emergency Flight Controls - the instructions below will work for both systems.

Emergency controls need communication connection to be utilized

Overview

The purpose of this section is to familiarize the operator on how to use the Emergency Flight Control features of the Nightingale Blackbird system. These commands are for emergency operations only, and should only be used when the previously described situations occur.

It is important to note again, that when emergency controls are utilized, the geofence and IPP logic is not being used. The Blackbird will not avoid obstacles on its own and these controls must be used with caution.

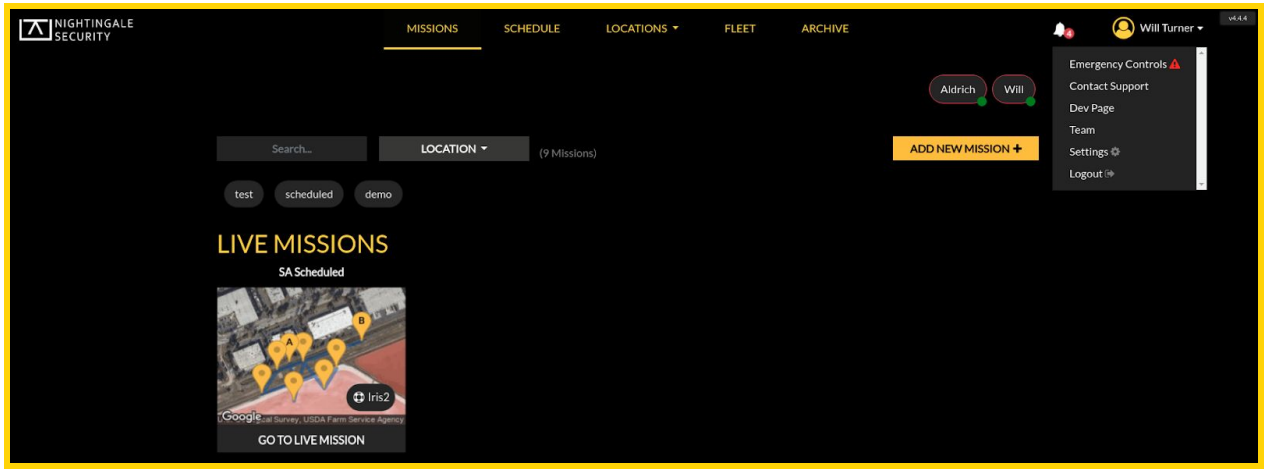
Emergency flight controls bypass the flight computer and directly manipulate the flight controller.

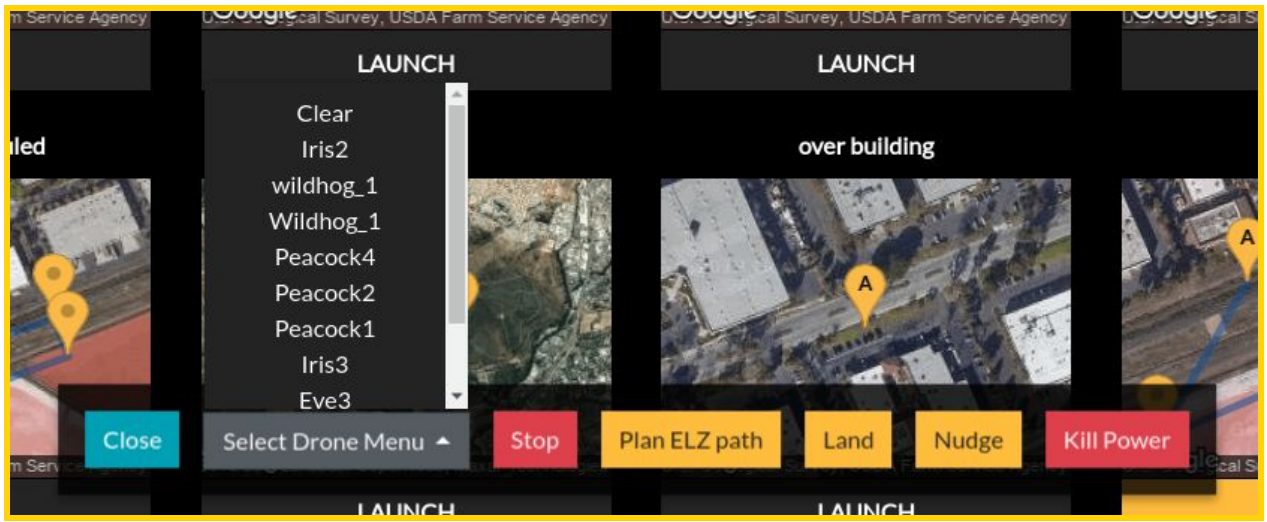
Accessing Emergency Controls

There are two locations a PIC can access emergency controls

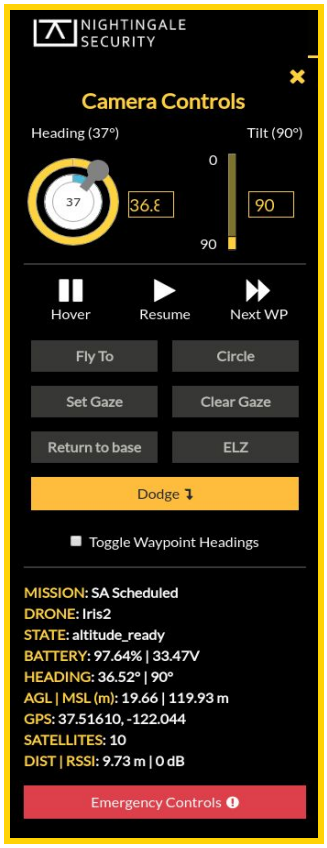
- In the top right corner of the Mission Manager there is a panel with the user's login name and a dropdown menu. The EC (Emergency Controls) panel can be accessed by clicking the

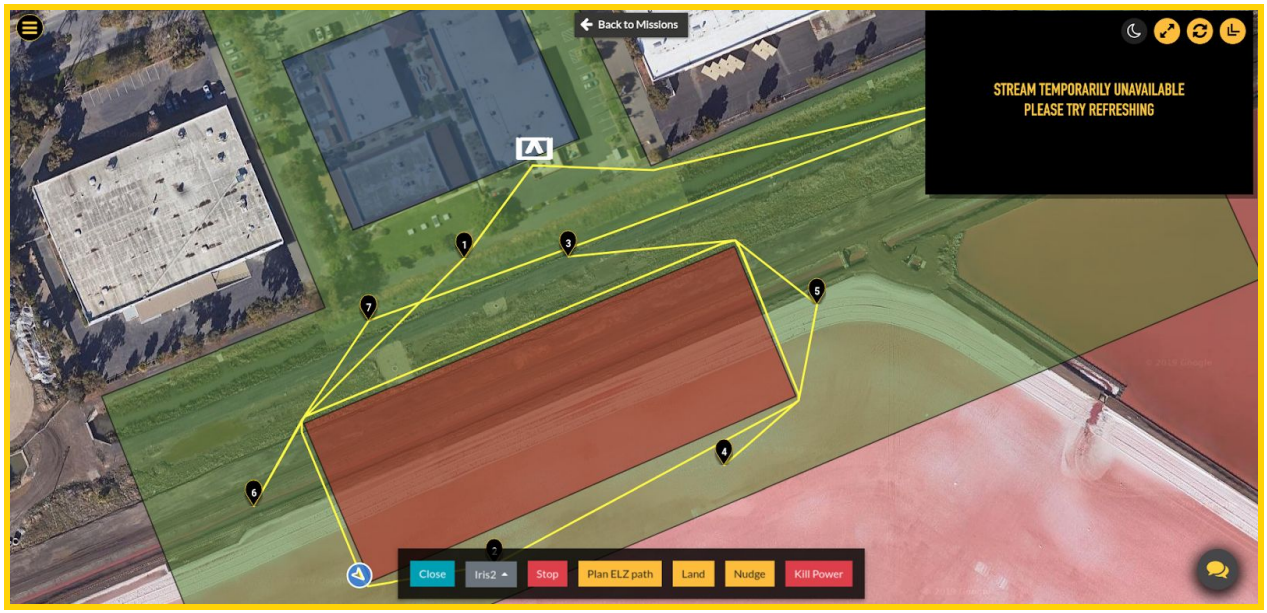
user name and selecting Emergency Controls⚠. This will open the below panel at the bottom of the screen.





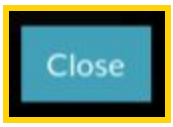
- In the mission view page, the panel on the left of the screen will display all available user commands. At the bottom of this panel, there is the Emergency controls button displayed in red. To activate the emergency controls bar, simply press the red button and the bar will appear.





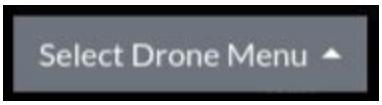
Using Emergency Controls

Close Button



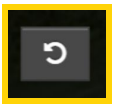
- The “Close” button closes the Emergency Controls panel.

Select Drone Menu



- For operations involving more than one drone, it is necessary to first select the drone of which emergency control is needed unless emergency controls is accessed on the mission page.

Return Button



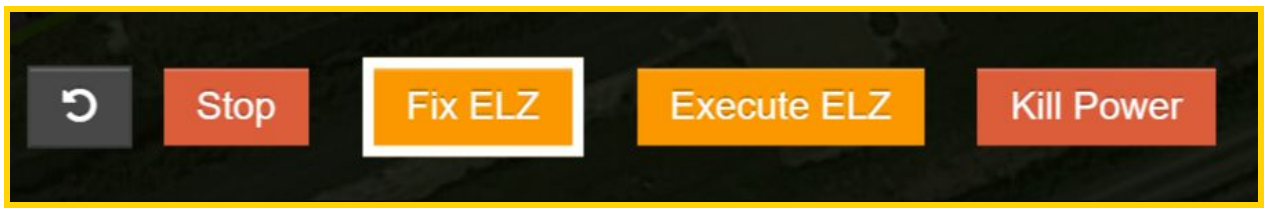
- Brings the Emergency Controls panel back to previous options.

STOP

- Kills the Blackbirds current mission and tells the flight controller to hover in place. The camera will then point straight down. Once the **STOP** command is executed, the Blackbird can no longer resume its original mission, but is ready to take a new Emergency Command.

Plan ELZ path

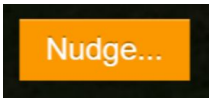
- The button will take the user to a subset menu while simultaneously overwrites the previous ELZ mission creating a new one from the Blackbirds current location to the ELZ location. This feature will fly a direct path from its current location to the ELZ location, without any IPP data.

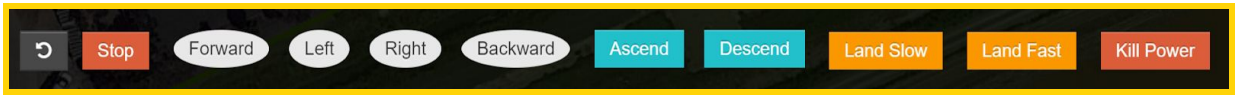


- **Fix ELZ**: This feature rewrites a direct path to the ELZ location from Blackbirds current location. (*This feature bypasses IPP and will take a direct line of flight to ELZ location, disregarding all NFZ's and Obstacles)*

- **Execute ELZ**: Once the **Fix ELZ** button is executed, the user can hit the **Execute ELZ** button to command the Blackbird to fly the newly defined ELZ location.

NUDGE



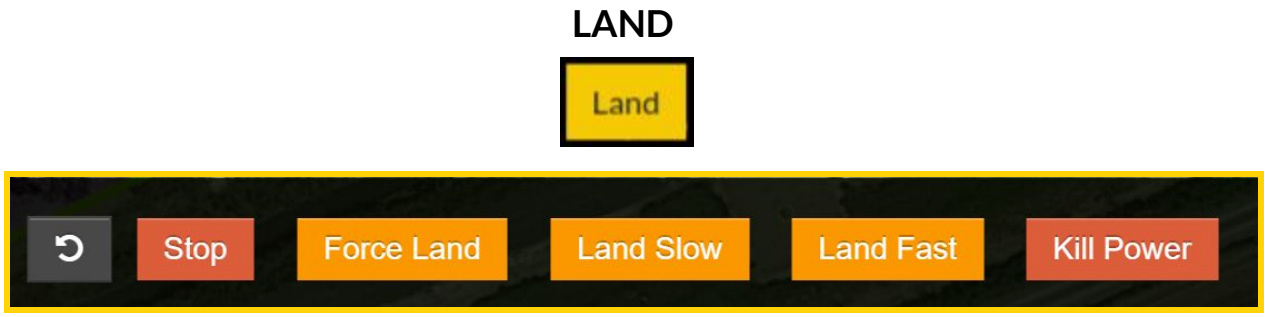


NOTE: On the Relay App, the user does not need to press the "NUDGE" button to access related buttons - they are already displayed.

The **NUDGE** command is used to incrementally change the position of the Blackbird. Each command sends an input with a duration of (1) second in the direction commanded. This feature is to be used when making an emergency landing off of the base station. These commands should be executed by the operator to move the Blackbird to a safe location for the emergency landing.

- **Forward**: moves the Blackbird forward
- **Backward**: moves the Blackbird backward
- **Left**: moves the Blackbird left
- **Right**: moves the Blackbird right

- **Ascend**: increases altitude
- **Descend**: decreases altitude



NOTE: On the Relay App, the user does not need to press the "LAND" button to access the related buttons (FORCE LAND, LAND FAST, LAND SLOW) are already displayed.

The **LAND** button will open up functionalities for commanding the Blackbird to land in its current location. At any point, the operator can issue a **STOP** command to kill the landing sequence and enter a hover. This can be used with the **NUDGE** commands to precisely land where intended.

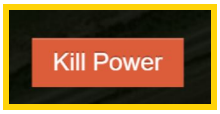
- **Force Land**: A gradual descent of roughly 1 m/s commands Blackbird to change into a LAND state. *Under **Force Land** the nudge controls are inactive.* Landing is not guaranteed to shut off motors - if needed use **Kill Power** command to disarm.

- **Slow Land**: tells the Blackbird to land at a slow rate (~1m/s)

- **Fast Land**: tells the Blackbird to land at a fast rate (~2m/s)

*NOTE: The operator MUST issue a **KILL POWER** command to stop the motors. The Blackbird will not stop the motors automatically after landing using the Emergency Controls, it must be done by the operator using the **KILL POWER** button.The KILL POWER commands must be executed by typing in the word "confirm" and hitting enter. The second step of manually typing "confirm" is required to stop the motors*

KILL POWER

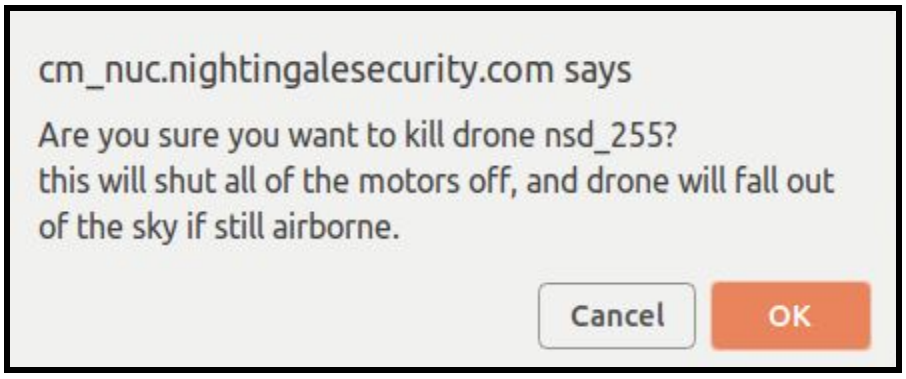


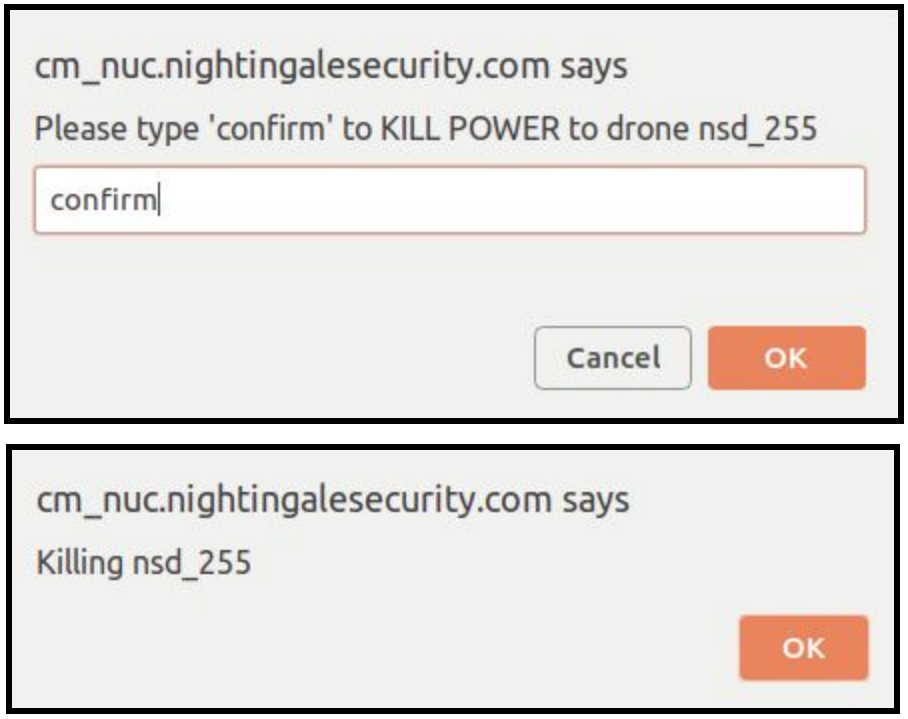
The **Kill Power** command sends a signal to stop all motors. This command is intended to be used after an emergency landing conducted off of the base station to stop all motors. After landing using the Emergency Flight Controls, the Blackbird motors will continue to spin in a reduced RPM until user commands **Kill Power**.

- Controlled crash - **if the Blackbird is flying, it will fall out of the sky.** It is the responsibility of the PIC to determine if a controlled crash is the most necessary and reasonable course of action. In such an event, Nightingale will need a complete report of the incident detailing why the PIC felt taking an extreme course of action was justified.

Once the **KILL POWER** button is pressed, the user will need to type the word "confirm" in the window to accept the command and execute motor stop for all.

- **KILL POWER** dialogs on mission manager:





PIC Responsibility:

It is the responsibility of the PIC controlling the Blackbird to use the Emergency Control features in a safe manner. These controls are only to be used as a backup to primary flight controls, and all commands must be executed with safety as the primary objective.

NOTE: Once the STOP feature is activated, the Blackbird will not be able to resume its current mission or be issued any FLY-TO commands. The only controls once STOP is activated are to ELZ or land via the Emergency Control buttons.

During an Emergency Controlled landing, the PIC should make sure that the intended landing location is free and clear of any personnel, moving traffic, debris, obstacles, tall grass, and that the ground is level. Since the motors continue to spin once the Blackbird makes its emergency landing, there is the possibility the Blackbird could flip trying to level itself if the emergency landing location is not flat. Once the Blackbird has landed and the PIC has confirmed via the streams and visual observation of the Blackbird, the Kill Motors command may be executed.

Post Emergency Landing Procedure:

After executing an off-base landing using the Emergency Control features, you will need to contact Nightingale Security support at support@nightingalesecurity.com to report the off-base landing. Only NS can reset the Blackbird's software to allow for the continuation of missions. Please provide a brief explanation for the reason of the manual Emergency Control feature flight. The following steps should be adhered to:

1. Recover Blackbird from emergency landing location.
2. Conduct post-landing inspection of the following items before returning Blackbird to base.
    a. Propellers - Inspect for any damage to propellers.
    b. Legs - Inspect legs for any looseness or play that seems abnormal.
    c. Gimbal - Inspect Blackbird gimbal to make sure no damage to sensors occurred during landing.
    d. Arms - Inspect Blackbird arms to motors to see if there is any looseness or play.
    e. Overall - Inspect overall Blackbird system for nothing abnormal.
3. Return Blackbird to its base station.
    a. Open command may need to be executed from app or Mission Manager.
4. Place Blackbird on base station.
5. Close base station.
6. Contact Nightingale Security support line. Provide as much detail as possible on all events that transpired.

Reminder: Nightingale will have to remotely reboot the Blackbird for operations to continue.

Blackbird Crash

During Takeoff or Landing

Should the Blackbird crash immediately after take off or right before touching down for landing, the PIC should immediately notify Nightingale of this event via the support@nightingalesecurity.com alias.

Please incorporate the text "**URGENT - Blackbird Crash during takeoff / landing"** in the subject line.

As a rule, there should be no persons or property located within the wind fence during take off and landing to prevent injury in these types of situations. If no wind fence is installed then a 20'x20' area around the base should remain clear of persons and property for the duration of take off and landing.

In Flight Crash

Follow on site requirements for reporting injury to persons or damage to property.

In the event that a person is injured the primary focus should be on getting them the medical help they need. After ensuring the person is properly cared for, the PIC should contact Nightingale via phone or support@nightingalesecurity.com. We will promptly make contact with you and help guide you through the resolution process.

If the crash event incurs bodily damage or property damage in excess of $500 an incident report must be filed with the FAA by the Pilot In Command. Nightingale will provide steps on how to do so if such an event occurs. Please reach out to Nightingale Security should this event arise.

Post crash recovery:

1. In the event of a LiPo fire, please extinguish immediately following standard procedures of the emergency governing body on location and LiPo fire recommendations below.
2. In the event of a damaged battery, and battery fluids are visible, do not power on. Remove from Blackbird in safe manner as recommended by emergency services and dispose of in a compliant manner
3. In the event the crash results in no harm of the battery bay nor fire, please return to the base. Contact nightingale with next steps.
    a. Likely Nightingale will ask the Blackbird to be turned on in order to download flight logs.
    b. Once logs are downloaded for failure analysis the system may be powered off, please contact Nightingale for next steps to repair damaged Blackbird.
4. In the event the system causes bodily harm and or destruction to critical infrastructure. It is advised to contact proper local authorities, as the recovery of the system and or attention of shall be the last priority.

In the event the Blackbird crash site location is unknown due to loss of situational awareness, the last known GPS coordinates can be taken from the Mission Manager flight page. These coordinates will give the most up to date geo-coordinates of the system.

In all circumstances, it is required to contact Nightingale immediately, as many emergency cases are highly situational and it may be warranted to assess in live time.

United states:

If the crash event incurs bodily damage or property damage in excess of $500 an incident report must be filed with the FAA by the Pilot In Command. Nightingale will provide steps on how to do so if such an event occurs. Please reach out to Nightingale Security should this event arise.

LiPo Fire

In the event of a fire, contact the proper emergency response services per your location's standard protocol. If you have access to an ABC or BC extinguisher and you are able to safely approach the fire and discharge the canister, then do so.

Support

In the event support is needed regarding use of our software or hardware, it is encouraged to reach out for have any questions on the system, operations, and regulation questions.

Simply reach out at support@nightingalesecurity.com and a resolution will be communicated promptly. Please be sure to include:

- PIC's name
- Severity of Problem
- Topic of Issue -software, hardware, feature request, etc
- Share a brief summary of what you are experiencing
- Any pictures, screenshots, or other visual documentation necessary or available

Based off the content and severity of the support tickets we will either channel you to some useful resources or reach out to help you troubleshoot your problem live.

In emergency situations please ensure you contact emergency services and follow onsite required protocol first to ensure containment and proper emergency response. You can find out more on how to handle emergencies in the next section.

Incident Reporting

Periodically you will need to reach out to Nightingale for support regarding use of our software or hardware. We always encourage you to reach out if we can be of assistance, have any questions on the system or operations, or legal or regulation questions.

We have made this process easy - simply reach out to us at support@nightingalesecurity.com and we will reach out with a resolution promptly. Please be sure to include:

- PIC's name
- Severity of Problem
- Topic of Issue -software, hardware, feature request, etc
- Share a brief summary of what you are experiencing
- Any pictures, screenshots, or other visual documentation necessary or available

Based off the content and severity of your support tickets we will either channel you to some useful resources or reach out to help you troubleshoot your problem live.

In emergency situations please ensure you contact emergency services and follow onsite required protocol first to ensure containment and proper emergency response. You can find out more on how to handle emergencies in the next section.

Preventative Maintenance

General Information

Batteries

The Blackbird's battery is rated for anywhere between 160 and 200 cycles. A cycle is draining the battery's voltage from 26V, its maximum, to 21.7V its safe minimum. For the Blackbird, this number of cycles translates to between 80 hours and 100 hours of flight time. In order to best predict when a Blackbird is ready for a battery swap, it is recommended to keep track of flight hours in a maintenance log.

Motor mounts

Motor mounts should be checked for cracks or fatigue points whenever a pre-flight inspection is performed. Thorough testing shows that for the Blackbird, the recommended frequency of pre-flight inspection is once-per-day if flights are being performed every day.

Charging pogo pins

There are spring-loaded pins inside the Blackbird's rear landing gear. These make contact with the charging plates on the base and allow the Blackbird to charge. Whenever the Blackbird makes a ground landing anywhere but the base, it is possible that some debris make get lodged in the cavity which houses the pins. It is recommended to clear this area of dirt after a ground landing and before replacing the Blackbird on the base.

Pre-flight inspection

Pre-flight inspections are a very important part of sUAV operation. Before flight operations begin it is highly recommended to do a pre-flight inspection of all the hardware, and any flight telemetry available. For details on doing a Pre-flight inspection of the Nightingale Security sUAS, see **Pre-Flight**.

Optics

There are either four or five optical sensors on the Blackbird, depending on the model, one beacon on the base. For the best image and the most reliable telemetry it is necessary to keep the glass clean. For recommended frequency of cleaning optical sensors, see **Scheduled Maintenance**.

Scheduled Maintenance

The Scheduled Maintenance section provides recommended routines to ensure the safety of equipment. Various environmental conditions will determine the frequency of preventative maintenance checks. Some components are more susceptible to wear, please pay close attention to how conditions affect the maintenance routines.

Preflight Checks	
Propellers: free of chips, cracks, or fray	Legs: not loose at the joint to airframe
Motors: spin without grinding and not loose	Gimbal: pointing down; not limp on any axis
Motor mounts: free of cracks and no wiggle	Gimbal case: no cracks or fatigue
Arms: not loose at the joint to airframe	Lid: secured to airframe by five screws
Battery: Secure to airframe	Airframe: not cracks or fatigue points
Power switch: not loose; at right position	Exposed cables: no tears or damage
Charging pads: clean and no burn marks	Base beacon: clear of dust/obstructive debris

Check Every Week
Are gimbal sensors (x3) and LIDAR/OPTIFLOW lenses clean? Clean if necessary.
Are pogo pins on rear landing gear clean and free of debris?

Are motors rotating freely? No grinding or irregular friction?

Check Every Month
Base landing beacon is free of debris or residue. Clean if necessary.
Weather station rain catcher is free of debris and anemometer rotates freely. Clean if necessary.
Weather station solar panels are free of dust and dirt. Clean if necessary.
Base doors open freely and smoothly. No grinding. Clean if necessary.
Blackbird battery charges to 100%
Base fans are free of dirt or buildup. Clean if necessary.

Special Operating Conditions

In certain operational conditions, namely the following, the Nightingale Security sUAS will require additional maintenance than the above. When operating in these conditions for extended periods of time (3+ months), it is necessary for keeping a healthy system to perform these maintenance checks at the documented frequency. If any of the following conditions are met for even a short period of time, it is still recommended to consider the maintenance practices described in each section.

Cold Weather Operations	
As needed	Removing snow and ice from the base
Temperatures (< -15 °C)	Powering off the Blackbird and bringing it indoors

Prior to snow-fall events	Power on ground heating pads (if applicable)
Automated (< 15 °C < 25 °C)	Base heater on and base fans off
Automated (< 10 °C < 15 °C)	Blackbird battery heater on (if applicable)

Hot Weather Operations

Hot Weather Operations	
Tempatures (>37°c)	Too hot to fly
Automated (>25°c)	Base fans turn on
Automated (Internally regulated)	Blackbird fans turn on

Desert environment

Sandy/Dusty Operations	
Weekly	Check base fans for dust. Clean as needed.
Weekly	Clean LIDAR and gimbal-mounted optics
Monthly or as needed	Clean and grease base rails
Weekly or as needed	Clear beacon of debris and dust
During pre-flight inspections or as needed	Check motor bells for sand or grinding
Monthly	Check UPS box for dirt/dust

Maintenance tools

Included with all Nightingale Security systems is a kit of tools that are useful for performing regular maintenance on the system.

Maintenance Kit Contents	
Level (x1)`	Use this to monitor base level
Snow brush (x1)	For clearing snow off of the base after storms
Ice scraper (x1)	Use to clear ice if the base will not open
Air can (x1)	For clearing beacon and lenses of debris
Cleaning wipes (x62)	General purpose, base landing pads, drone
Safety glasses (x1)	Safety first.
Super lube bottle (x1)	Lubing base rails, typically done by NG Sec
Rubber gloves (x24)	General purpose; use while lubing the base
Lens wipes (x24)	Use these to clean the camera lenses
Heating pad end caps (x4)	If heating pads are installed, these are spare parts

WARNING - FOR SCHEDULED FLIGHTS PLEASE COMMUNICATE WITH NIGHTINGALE BEFORE ANY MAINTENANCE TASKS

MRU

The Maintenance Repair and Upgrade (MRU) program offers comprehensive care for the Nightingale system. An MRU includes tracking maintenance requirements for aging components, repair damaged or out-dated systems and upgrade existing systems.

While the system is deployed, Nightingale will continuously monitor the health of the Blackbird and nest from data collected during operation. This information allows Nightingale to monitor components of the system remotely and determine the most efficient interval of replacing and upgrading hardware. Life cycle depends on individual flight time of a Blackbird, allotted time will be determined on a case by case basis once enough data is collected on location specific flight operations.

Before components exceed life expectancy, Nightingale will notify the customer that the Blackbird is ready to be "MRU'd". Nightingale will send a new Blackbird to the customer and replace the previous system on site. The customer is responsible for sending the old Blackbird back to Nightingale to undergo routine maintenance.

Software upgrades will be pushed to systems as determined by Nightingale Security. Operators will be notified of planned software updates to the system in advance. In the event there are new features, Nightingale will provide training material on how to interface with new versions.

Shipping the old Blackbird

A supplemental document will be provided on the packaging/receiving of a replacement unit. Below is a high level overview on the order of operations for shipping/receiving a new or old unit.

a. Turn the 3-position toggle switch all the way to the left to turn off the Blackbird
b. Take the Blackbird off base and place it on a flat surface
c. Place foam between the gimbal housing the bottom of the Blackbird to limit gimbal movement
d. Place the Blackbird back into shipping box and tape the box closed
e. Ship the box with the Blackbird back to Nightingale

Receiving the new Blackbird

a. Remove the new Blackbird from its shipping box
b. Remove the gimbal packaging to let the gimbal move freely in all directions
c. Place the new Blackbird on the base

d. Turn the 3-position toggle switch all the way to the right to turn the Blackbird on
    i. Do not place Blackbird on charging pads during bootup, please offset so legs do not rest on pads.
e. The Blackbird will beep as it powers on and begins its boot up process.
f. Allow a couple minutes for the Blackbird to boot up and connect to the network to pair with the base
g. Contact Nightingale Security at support@nightingalesecurity.com to confirm that the Blackbird is online and functioning properly
h. Upon approval, launch the predefined 'MRU Test' mission

Drained Battery

If the Blackbird battery drains to the point that the internal hardware can no longer be powered, the pilot will no longer be able to control it and the base will no longer be able to charge it. In this case, the pilot must remove the drone from the base if it is on the base and flip the power switch to the middle position. Leave the drone indoors off the base until the dead battery can be replaced with a new one.

CLEANING INSTRUCTION

1. With provided app or web interface, open the nest with the OPEN command
2. Identify the sUAV and landing surface
3. Remove Blackbird from the base and place on a flat and safe area
4. Use a wet wipe to clean the landing surface (focus on charging pads)
5. Clean the surface and remove foreign objects (leaves, small rocks, etc)
6. Put the Blackbird back to the landing surface
7. Make sure the sUAV is facing the correct direction (i.e. camera over the beacon and rear legs on the charging pad)

Regulations

Throughout the Operations Manual, regulations have been referenced as the individual circumstances arouse. Regulations is a dedicated section to quickly and directly refer to pertinent part 107 rules at any point during operation of the Nightingale system. To avoid confusion, it is no mistake these regulations have been stated multiple times throughout this document. It is recommended that any certified part 107 PICs stay up to date on the changing landscape of Unmanned System Regulations.

Regulations | PIC 107 (14 C.F.R 107)

A complete list of the 14 CFR Regulations can be found at the link here.

Important Thresholds

- **Speed -** Maximum ground speed of 100 mph (87 knots)
- **Altitude -** Maximum altitude of 400 feet above ground level (AGL)
    - 400 feet above the tallest obstacle if within 400 feet of obstacle.
- **Visibility -** Minimum weather visibility of 3 miles from control station

Additional Restricted Operations

- No operations from a moving aircraft.
- No operations from a moving vehicle unless the operation is over a sparsely populated area.
- No careless or reckless operations.
- A person may not operate a small unmanned aircraft if he or she knows or has reason to know of any physical or mental condition that would interfere with the safe operation of a small sUAS.

Regulations | Waivers

Nightingale has acquired waivers to part 107 regulations. These waivers include multiple UAVs and night operations.

Nightingale's waivers can only be used during Nightingale sanctioned operations. To extend these waivers to PICs operating the system, a Pilot's Agreement must exist between the operators and Nightingale. This agreement is made through a contract or agreement bounded by a signature of the "Pilot's Pledge". Agreeing to the practices stated in the document will extend operational control to site operators. Comprehension of procedures for safe, reliable, and compliant operations is required by Nightingale to perform a full system handover. Nightingale staff will review in detail with the operators at the point of deployment and provide a written examination to ensure pilot competency.

Night operations waiver

Section waived: 14 CFR § 107.29 - Daylight operation

Waiver Number: 107W-2016-00213B

Additional Training Requirements:

Visual Illusions

Per Nightingale's waiver requirement regarding education of visual illusions caused by nighttime operations:

- " Prior to conducting operations that are the subject of this Waiver, the Responsible Person listed on the Waiver must ensure the remote PIC and VO are trained, as described in the Waiver application, to recognize and overcome visual illusions caused by darkness, and understand physiological conditions which may degrade night vision. This training must be documented and must be presented for inspection upon request from the Administrator or an authorized representative"

Warning: Diet and general physical health have an impact on how well a person can see in the dark. Deficiencies in vitamins A and C have been shown to reduce night acuity. Other factors, such as carbon monoxide poisoning, smoking, alcohol, and certain drugs can greatly decrease night vision. Lack of oxygen can also decrease night vision as the eye requires more oxygen per weight than any other part of the body.

Examples of Visual Deficiencies that can be exasperated during nighttime operations, as per Chapter 13 of Helicopter Flying Handbook

- **Night Myopia**
  - At night, blue wavelengths of light prevail in the visible portion of the spectrum. Therefore, slightly nearsighted (myopic) individuals viewing blue-green light at night may experience blurred vision. Even pilots with perfect vision find that image sharpness decreases as pupil diameter increases. For individuals with mild refractive errors, these factors combine to make vision unacceptably blurred unless they wear corrective glasses.
  - **Dark Focus** When light levels decrease, the focusing mechanism of the eye may move toward a resting position and make the eye more myopic.
  - These factors become important when pilots rely on terrain features during unaided night flights. Practicing good light discipline is very important and helps pilots to retain their night adaptation.
  - Keeping the surrounding lighting dim allows the pilot to better identify outside Details

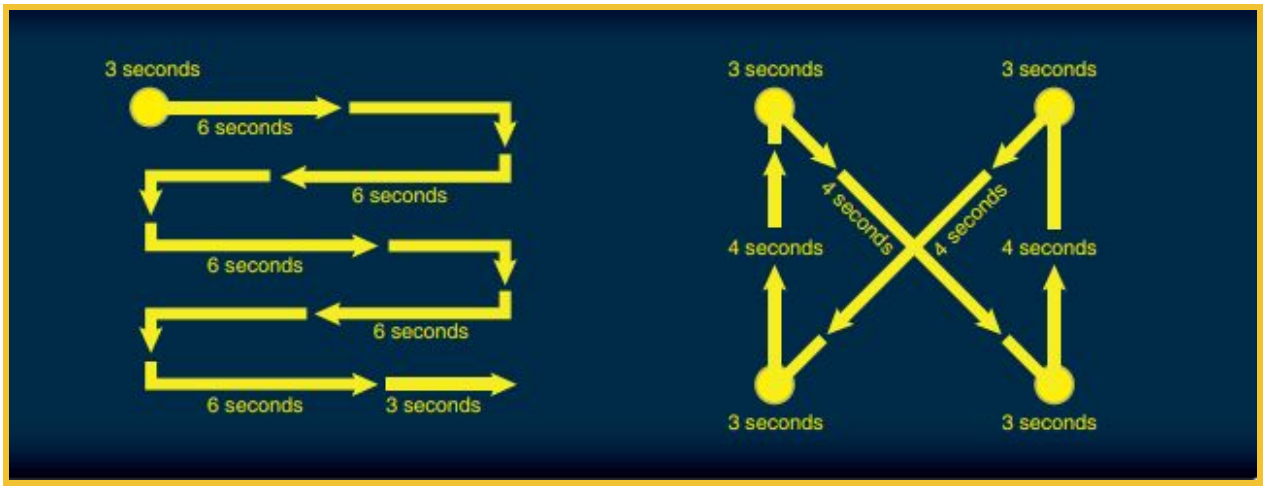
- **Hyperopia**
  - Hyperopia is also caused by an error in refraction. In a hyperopic state, when a pilot views a near image, the actual focal point of the eye is behind the retinal plane (wall), causing blurred vision. Objects that are nearby are not seen clearly; only more distant objects are in focus. This problem is referred to as farsightedness.

  - =
- **Astigmatism**
  - The unequal curvature of the cornea causes an inability to focus on different meridians simultaneously
  - Ex: Power line pole will be in focus but power lines out of focus
- **Presbyopia**
  - Farsightedness caused by loss of elasticity of the lens of the eye, occurring typically in middle and old age.

Tools to help counter the illusions possible during nighttime operations

- **Dark Acclimation:** Get acclimated to the dark before the first mission, do not go directly from a well lit area into the dark without providing 20-30 minutes of acclimation

- **Scanning:** Scan left to right using peripheral vision at night (Rods become more receptive at night and cones cause blind spot in the center of vision). Use off center viewing at roughly 10 degree increments slowly and do not stare.



- **Obstruction Detection:** Surfaces with poor reflective surfaces are difficult to detect, best to look for support structures to identify objects such as wires or small tree limbs

- **Aircraft Lighting:** Per 91.209 - During the period from sunset to sunrise aircrafts must operate with its position lights active. Position lights indicate aircraft direction of movement *(While facing same direction of aircraft)*
  - **GREEN** lights on right side of aircraft
  - **RED** lights found on the left side of the aircraft
  - lights found on the tail of the aircraft

Assessment of Premises for Obstacles

Per Nightingale's waiver requirement regarding sufficient illumination or proper daylight site assessments:

- " The remote PIC and VO must ensure the area of operation is sufficiently illuminated to allow both the remote PIC and VO to identify people or obstacles on the ground, **OR** the remote PIC and VO must conduct a daytime site assessment prior to conducting operations that are the subject of this Waiver, noting any hazards or obstructions"

Nightingale staff will execute a thorough site assessment with the operators team before handing over operations . We will define location using the following tools:

- **Geofence** - our team will next help create a geofence to limit operations to areas that are approved for flight and clear of major obstacles
- **No Fly Zones / Obstacles** - Where operations will face a high likelihood of temporary obstacles and either prohibit operations via a "No Fly Zone" or increase the altitude to a safe clearance via an "Obstacle"

Proper Lighting

Per Nightingale's waiver requirement regarding sufficient aircraft lighting:

- " The sUA must be equipped with lighted anti-collision lighting visible from a distance of no less than 3 statute miles. The remote PIC may reduce the intensity of the anti-collision lighting if he or she determines that, because of operating conditions, it would be in the interest of safety to do so."

Nightingale's sUAV will have the proper lighting already installed and operational.

Height Restrictions

Per Nightingale's waiver requirement regarding permitted altitude:

- " In addition to the requirements of § 107.51(b), the sUA must not fly higher than 200 feet above any structure's immediate uppermost limit"

Nightingale's software will limit the maximum altitude allowable to adhere to this requirement. The pilot should still be aware of this requirement and take corrective action should he/she notices a deviation.

Multiple sUAVs

Section waived: 14 CFR §107.35
Waiver Number: 107W-2016-00213B

Single Pilot Requirements:

Identifying Obstacles and Structures
Per Nightingale's waiver requirement regarding identifying obstacles and structures:

- "Prior to conducting operations under this Waiver, the remote PIC has a means to identify the boundaries of any structure so as to avoid collision with, or damage to property;"

Nightingale staff will execute a thorough site assessment with the operators before handing operations over. We will define location using the following tools:

- **Geofence** - Create a geofence to limit operations to areas that are approved for flight and clear of major obstacles
- **No Fly Zones / Obstacles** - Where operations will face a high likelihood of temporary obstacles and either prohibit operations via a "No Fly Zone" or increase the altitude to a safe clearance via an "Obstacle"

PIC <> VO Communication
Per Nightingale's waiver requirement regarding communications between PIC and VO:

- "Communication between the remote PIC and VO must allow for the remote PIC to light the sUA and/or ground the sUA with sufficient time to yield right-of-way in accordance with §107.37."

The blackbird is illuminated with an anti-collision light and red and green position lights. The VO must communicate to the PIC how to yield to or give right-of-way to any encroaching non participating aircraft based on Blackbird orientation from the position lights.

As part of the deployment and training by Nightingale staff require a flight test to demonstrate comprehension of what to and how to communicate incursions through mock missions. Competency will be tested in the following fields:

- An encroaching aircraft
- Non participating and unplanned ground traffic
- In-flight emergencies
    - Communications loss
    - Situational awareness loss

- Erroneous sensor readings

Containing Failures

Per Nightingale's waiver requirement regarding containing failures:

- "The remote PIC must ensure that an individual system failure does not interfere with the operation of other sUA or cause incidents, accidents, or loss of control involving other aircraft in the swarm;"

Each sUA independently calculates it's route, has an independent base to return to in the event of an emergency, and will be given a dedicated ELZ, such that any event compromising one of the sUA will not impact the ability of others to perform their mission or return to base safely.

Pre Flight Validation of Obstacle Avoidance Systems

Per Nightingale's waiver requirement regarding pre flight validation of obstacle avoidance systems:

- " Prior to conducting operations under this Waiver, the remote PIC must ensure that the geofence system, onboard obstacle avoidance system, associated flight control systems, and sensors, as described in the Waiver application, operate properly;"

Nightingale staff will demonstrate how these systems can be validated in person. Intelligent path planning (IPP) will manifest itself as a yellow dotted line in the pre-flight user interface and show a path clear of No-Fly zones and within the bounds of the geofence. If during preflight IPP does not calculate or the pilot notices the path violates the integrity of a known obstacle area they should abort the flight and contact Nightingale at support@nightingalesecurity.com before continuing operations in that vicinity.

Maximum Weight

Per Nightingale's waiver requirements regarding the operation of multiple sUA's:

- " The weight of the sUA flown under this Waiver must not exceed 10 lbs and the ground speed of the sUA must not exceed 45 miles per hour."

The Nightingale Blackbird currently outweighs this 10 pound limit and is in the process of requesting an amendment from the FAA. Until approved, and all customers and operators will receive the amended waiver once received, all operations are limited for one system per pilot.

PILOT'S PLEDGE

I, _____ , hereby pledge to follow the best practices laid out by Nightingale Security in this Training Manual.

I am a part 107 certified pilot and will perform all needed actions to maintain my status as such. Should, at any point or for any reason, I lose my status of Part 107 certified I will promptly notify Nightingale Security and cease operations until my certification is properly reinstated.

I understand that while I work for / at the direction of ,
, Nightingale has operational control on all aspects of UAS (sUAV) operations and I should follow their best practices for safe operations.

I further pledge to do proper due diligence to maintain the integrity of my operational airspace, performing the proper pre-flight checks, maintaining the locations of temporary obstacles, and abiding by FAA regulations at all times.

I understand that it is my responsibility to coordinate operations that place safety above all else, and that I have the power and responsibility to intervene in missions when confronted by mechanical issues, inclement weather, encroaching aircraft, or any other event that introduces undue risk to operations.

I understand that I can reach Nightingale via support@nightignalesecurity.com or via (510) 754-5990

As such I sign this pledge as confirmation of my knowledge and acceptance of the above.

Signature of Nightingale Employee Witness: _____

Signature of Pilot in Command: _____

FAA Pilot Certificate Number: _____

Date of Acknowledgment: _____