Application for Exemption Under the Special Authority for Certain Unmanned Systems, 49 U.S.C. §44807

Acronyms

AGL - Above Ground Level

AO – Area of Operations

COA – Certificate of Authorization

MP – Mission Planner

NAS - National Airspace System

PIC - Pilot in Command

UA - Unmanned Aircraft

VLOS - Visual Line of Sight

VO - Visual Observer

VTOL – Vertical Takeoff and Landing

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Regulations we are seeking exemption from:

14 CFR PART	SUMMARY OF REGULATION
21, Subpart H	Certification procedures for products and parts, Airworthiness Certificates
43	Maintenance, Preventive Maintenance, Rebuilding, and Alteration
45, Subpart C	Nationality and Registration Marks
61, Subpart A	Certification: Pilots, Flight Instructors, and Ground Instructors
68	Requirements for Operating Certain Small Aircraft Without a Medical Certificate
91.9	Civil aircraft flight manual, marking, and placard requirements
91.21	Portable electronic devices
91.103(b)	Preflight action
91.105	Flight crewmembers at stations
91.107	Use of safety belts, shoulder harnesses, and child restraint systems
91.109	Flight instruction
91.119	Minimum safe altitudes
91.121	Altimeter settings
91.127(a)	Operating on or in the vicinity of an airport in Class E airspace
91.151	Fuel requirements for flights in VFR conditions
91.159	VFR cruising altitude or flight level
91.203(a(1))	Civil aircraft: Certifications required
91.207	Emergency locator transmitters
91.209	Aircraft lights
91.213	Inoperative instruments and equipment
91.215	ATC transponder and altitude reporting equipment and use
91.221	Traffic alert and collision avoidance system equipment and use
91.225(f)(g)	Automatic Dependent Surveillance-Broadcast (ADS-B Out equipment and use

91.307	Parachutes and parachuting
91.311	Towing: Other than under § 91.309
91.313	Restricted category civil aircraft: Operating limitations
91.319	Aircraft having experimental certificates: Operating limitations
91.403(b)	General
91.405	Maintenance required
91.407	Operation after maintenance, preventive maintenance, rebuilding, or alteration
91.409	Inspections
91.417	Maintenance records

Introduction

SparkCognition is seeking an exemption under the Special Authority for Certain Unmanned Systems, 49 U.S.C. §44807, to operate its over 55lb Grasshopper and Saphira 1.5 UAs for civil commercial purposes. Three versions of these vehicles are currently operated under a Special Airworthiness Certificate for Research and Development, which has allowed the new design concepts to be tested, different use cases explored, and the opportunity to integrate software, whose goal is to improve the aviation industry.

The inspiration behind these platforms is to provide a range of vehicles that can demonstrate SparkCognition's AI software capabilities and extend research technology to end user applications. These softwares are highly advanced, and their primary goals are to ensure safety and facilitate low risk operations. To actuate these software capabilities, unique payloads have been developed for each vehicle to demonstrate solutions to real world problems and show how AI software can enable a safer, more effective, and more efficient airspace.

Essentially, the Grasshopper and Saphira UAs are platforms that enable the development of these types of software more efficiently. The use of UAs in the modern era is not a question of if, but when. Thus, beginning to make these advancements earlier, using a risk based approach with these UAs, will help ensure globally safer operations when they are implemented on a wide scale in the future.

As will be detailed in this document, safety will be the ultimate priority in the development work concerning these UAs. Our team includes pilots and engineers who have specialized in UA technology and have conducted hundreds of hours of unmanned flight under both the Exception for Recreational Flyers and under Part 107. Safe flights are in everyone's best interest and our team always follows strict procedures to minimize risk, mitigate hazards, and conduct safe operations.

The specific regulations we are seeking exemption from are 14 CFR Part 21 - Subpart H, Part 43, Part 45 - Subpart C, Part 61 - Subpart A, Part 68, Part 91.9, 91.21, 91.103(b), 91.105, 91.107, 91.109, 91.119, 91.121, 91.127(a), 91.151, 91.159, 91.203(a(1)), 91.207, 91.209, 91.213, 91.215, 91.221, 91.225(f)(g), 91.307, 91.311, 91.313, 91.319, 91.403(b), 91.405, 91.407, 91.409, and 91.417. We seek full relief from these regulations in order to operate our UAs for commercial purposes within the United States.

1. Petitioners should describe how the proposed UAS operation will be safely conducted to minimize risk to the NAS or to persons and property on the ground. Specifically, petitioners should describe the design and operational characteristics for the type(s) of UAS they intend to operate, e.g. aircraft performance and performance limitations,

operating procedures, and aircraft loading information in as much detail as possible. This could be provided in the petition or in an Aircraft Flight Manual or similar document.

NOTE: The FAA will consider all information and data submitted by the petitioner that describes the UAS developmental and operational history. This could include statistical data or other documentation for the specific design and performance characteristics of the UAS, including the operational history and operational failure modes, obtained through previous Research & Development (R&D) and/or flight test activities, e.g. operations conducted under a COA, with a civil airworthiness certificate, or under other authorized operating conditions.

These airframes have been developed over the past two years under a Special Airworthiness Certificate for Research and Development. This has allowed our team to do things like validate the designs, determine operational limitations, test failure modes, validate and invalidate supplier provided specifications, integrate specialized payloads, and troubleshoot electrical interferences with sensitive electronics. Overall, this has allowed us to arrive at processes and designs that allow for safe operation of our UA in the NAS.

Design and operational characteristics for each aircraft are included in Appendix 1 and 3 and SparkCognition Large UA Operating Standards are included in Appendix 5. Prior to each flight, the PIC will check for NOTAMs in the area, check weather conditions, and submit a sUAS NOTAM. Once at the flight location, the PIC will conduct a preflight assessment of the vehicle and the AO, will brief the flight crew on the mission, and will conduct the mission. After the flight, the PIC will debrief the flight crew and conduct a postflight assessment of the vehicle. More information on these procedures can be found in Appendix 1 and 3.

2. Petitioners should describe any procedures they would implement, such as pre-flight inspections, maintenance, and repair, to ensure that the UAS is in a condition for safe flight. This could be provided in the petition, an Aircraft Flight Manual, a Maintenance and Inspection Manual, or similar document. 6 Rev. 9/25/2014

NOTE: The Aircraft Flight Manual and Maintenance and Inspection Manual may be separate documents or combined in a single document.

The pre-flight inspections for each vehicle can be found in Appendix 1 and 3 and the Maintenance and Inspection Manual can be found in Appendix 2 and 4. The preflight procedure is required for each flight and will be performed by the PIC with assistance from the VO. The aircraft logbook contains remarks about any major changes to the aircraft, and should be reviewed by the flight crew during the preflight.

3. The petitioner should describe the Radio Frequency (RF) spectrum used for control of the UAS and associated equipment that is part of the UAS (i.e., sensors, cameras, etc.), and whether it complies with Federal Communications Commission (FCC) or other appropriate government oversight agency requirements.

NOTE: Petitioners should be able to provide the FCC approval letter or show compliance with FCC requirements upon request. Regarding the Unmanned Aircraft PIC

The telemetry radio used in all three aircraft operates on the frequency range of 902-928MHz and is designed to be compliant with FCC 15.247 and AS4268:2012.

The remote controller used for all three aircraft operates in the frequency range of 2.408-2.4775GHz. The FCC ID is XYFX7QDS and more information can be found here: https://apps.fcc.gov/tcb/GetTcb731Report.do?applicationId=yLo%2BpKSYC9XsZghT0HRiMg%3D%3D&fcc_id=XYFX7QDS

Any payloads that contain electronic devices that operate on the Radio Frequency spectrum, such as a WiFi, bluetooth, or video streaming device, will contain a FCC certification mark to ensure that the electromagnetic interference from the device is under limits approved by the FCC. FCC compliance for current and future electronic payload devices can be provided upon request.

4. Petitioners should describe the qualifications required of any PIC(s) who will be directly responsible for the operation of the UAS, including information such as: the level of airman certificate held; any applicable training related to the operation; and any minimum hours of flight experience required by the PIC(s), both total flight time and the time with the particular UAS. If the operation would use visual observers, petitioners should describe their roles and qualifications.

The PIC is required to hold a 14 CFR § 107 pilot certificate and must be familiar with conducting operations with large UA. Typically, pilots become familiar through initially serving as a VO. At a minimum, all PIC(s) will have 10 hours of experience with the specific UA prior to conducting any operations. If the PIC does not meet the minimum hour requirements to operate the UA, then they must be accompanied by a pilot who meets these requirements or a lead engineer.

A VO is required to assist the PIC during each flight to recognize any non-participating aircraft, to maintain situational awareness around the AO, avoid any distractions to the PIC, and serve as a ground station operator or sensor operator as necessary. The VO will be designated by the PIC during the pre-flight brief and must also hold a 14 CFR § 107 certification. At all times during the flight, the PIC and VO will maintain audible communication to ensure a safe and successful operation.

5. Petitioners should describe the medical standards and certification of the PIC(s) directly responsible for the operation of the UAS.

Both the PIC and VO must be in a physical and mental condition to safely operate a UA. It is the responsibility of each to not operate an UA, or serve as a VO, 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 UA.

In addition, the PIC and VO must comply with 14 CFR § 107.27 - Alcohol or drugs. More information on PIC and VO standards can be found in Appendix 5 - SparkCognition Large UA Operating Standards.

Regarding the Operation of the Unmanned Aircraft

6. Petitioners should fully describe their intended UAS operation(s). Petitioners should describe how the proposed operation(s) would not adversely affect safety, or how they would provide a level of safety at least equivalent to that provided by the rule from which exemption is sought. Petitioners should address any plans to implement clearly defined operational borders and procedures to ensure public safety, which includes persons and property both in the air and on the ground. This can be described in the petition, in an Operations Manual, or similar document.

NOTE: The FAA will closely examine the proposed operation(s) with respect to safety of flight, NAS safety considerations, and the safety of the non-participating persons and property during the operational period and within the operational area.

Our operations are focused on providing a bridge between software and hardware in industry. Not only is it in our best interest, but it is a first principle of ours to put safety first in every operation that we conduct. By following the procedures outlined in the Appendices, having full spectrum experience in the unmanned aviation industry, and by following the guidelines presented by the FAA and community organizations, safety is a core concept in every operation we conduct.

Before each flight, the PIC will outline the AO and the emergency procedures in the case that the UA breaches the AO, or in the case of any other emergency. If gound level of the AO is not viewable from where the PIC is operating, then the PIC and VO are required to survey the area before flying. At any time during the flight, any member of the flight crew has the authority to call off the flight. This should be communicated to the PIC immediately and emergency procedures should be followed.

7. Petitioners should specify the proposed maximum operating speed and altitude, and describe minimum flight visibility and distance from clouds for their intended operation(s). Petitioners should describe potential hazards and safety mitigations associated with these proposed conditions. These issues can be addressed in the petition, an Operations Manual, or similar document.

All flights will be conducted less than 100 mph, less than 400ft AGL, with more than 3 statute miles of visibility, and more than 500ft below and 2000ft horizontally from clouds. The PIC is responsible for verifying weather conditions prior to each flight and should discuss any possibility of changing weather conditions and inclement procedures with the flight crew.

Potential hazards under these conditions include impacts with wildlife, fast-moving, low flying aircraft such as crop dusters, paramotors, and helicopters, and the influence of wind, especially in gusty conditions or around large structures. To mitigate this, the PIC and VO should familiarize themselves with the AO prior to each flight and discuss any potential hazards and mitigations that may be necessary for the specific operation. The PIC has the final authority to begin each flight and should conservatively make the decision to operate given knowledge of the AO and environmental conditions. As mentioned previously, any member of the flight crew may call off the flight if they deem it necessary.

8. Petitioners should describe the characteristics of the area of intended operation(s) and the associated potential hazards, in accordance with the statutory mandate under Section 333 7 Rev. 9/25/2014 regarding proximity to populated areas. These issues can be addressed in the petition, an Operations Manual, or similar document.

Each AO will be carefully reviewed by the flight crew prior to each flight and any associated potential hazards will be mitigated to a reasonable level of safety. Furthermore, the flight crew will discuss how they will ensure that the intended operations will not operate over any non-participating persons on the ground, especially when operating within or near populated areas. More information on safety and risk mitigation is provided in Appendix 5.

9. Petitioners should describe if they intend to operate in the proximity of any airports, in accordance with the statutory mandate under Section 333 regarding proximity to airports.

All flights will be conducted outside of any towered airspace. All other nearby, non towered, airports will be notified on a case-by-case basis of the operation as determined by the PIC necessary to increase safety. The PIC will make this decision based on local NOTAMs, publicly available airport operational statistics (such as airnav.com), proximity to the airport, and the operation being conducted.

10. The UAS must be operated within visual line-of-sight (VLOS), in accordance with the statutory mandate under Section 333(b)(1). Petitioners should describe how they intend to comply with this mandate.

At all times during a flight, the UA will be operated within unaided VLOS of the PIC and/or VO(s). If at any time the aircraft will be operated outside of the VLOS of the PIC, the PIC and VO(s) will survey the AO and discuss how to conduct the operation with the highest level of safety. If the PIC and a VO(s) are not physically located at the same location, then they will have two-way audible communication. There will always be one VO located with the PIC.

11. Petitioners should describe any procedures they would implement for conducting a preflight safety risk assessment to determine that the UAS is in a condition for safe flight (14 CFR § 91.7(b)) and that the planned operation can be completed safely. These

procedures can be addressed in the petition, an Aircraft Flight Manual, Operations Manual, or similar document.

Before each flight, the PIC is required to conduct a preflight assessment of the UA and required operating systems. The preflight procedure for the Grasshopper UAs can be found in Appendix 1 and the preflight procedure for the Saphira 1.5 UA can be found in Appendix 3. In addition, the aircraft are maintained as outlined in Appendix 2 and Appendix 4.

12. If petitioners intend to conduct operations which have existing requirements to notify Flight Standards District Offices (FSDOs) prior to operations – such as motion picture and television filming, or pipeline and powerline patrol – petitioners should describe their intended coordination in this regard for their proposed operation(s).

We will not be conducting any operations that have existing requirements to notify FSDOs.

13. The FAA intends to require entities who obtain an exemption under this process to also obtain a Certificate of Waiver or Authorization (COA) from the FAA Air Traffic Organization prior to conducting operation(s) in the NAS. The COA application is available here.

We'd like to begin operations under the blanket 400ft COA and then apply for further COA(s) if necessary. We currently have a COA that was granted in addition to our Special Airworthiness Certificate for these aircraft that may be applicable.

Appendix 1 - Grasshopper Operating Manual

1. System Description and Specifications

Grasshopper is an automatic, electric-powered VTOL UA designed to explore heavy lift applications. Four VTOL motors enable the aircraft to take off and land in any area that has a clear view of the sky while carrying a significant payload. One of these payloads is a gas generator that enables long endurance flights.

1.1.Aircraft

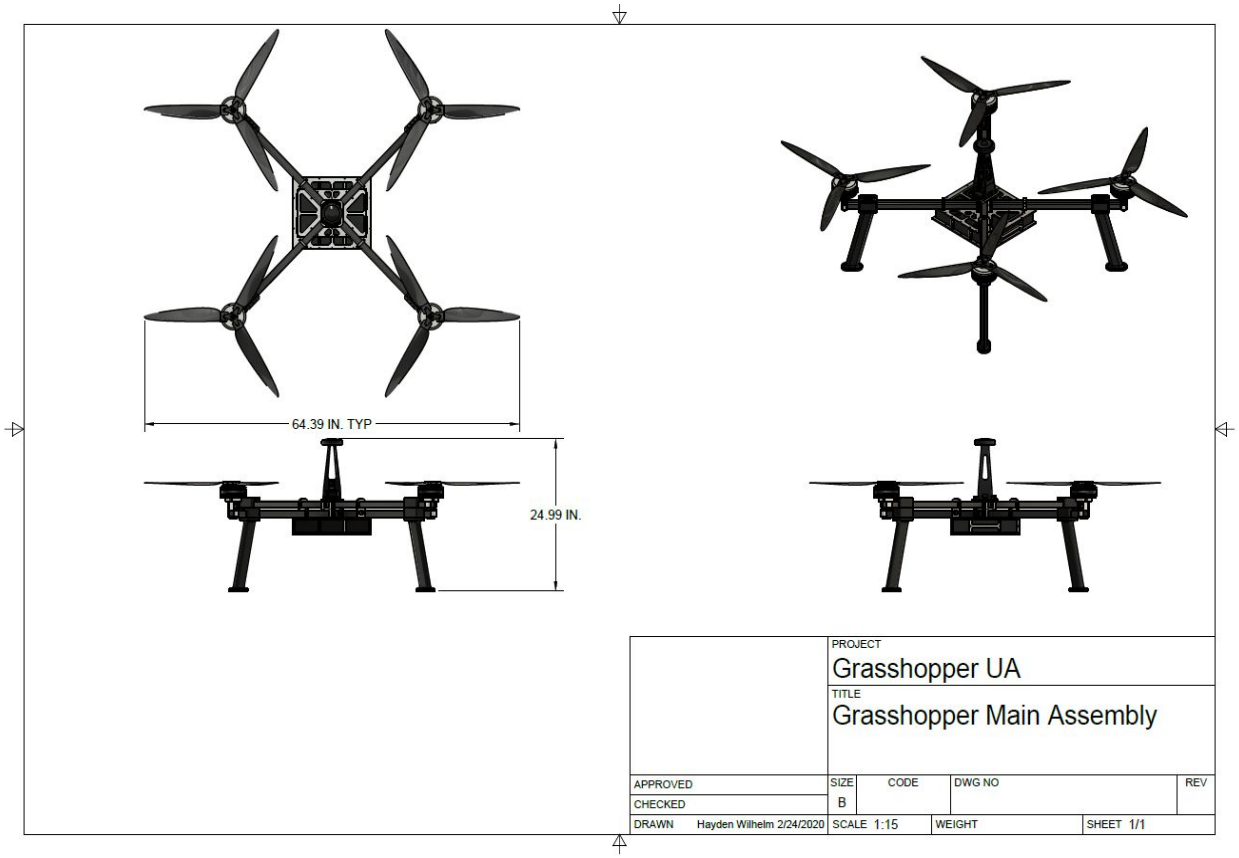

Figure 1: Grasshopper Orthographic Representation.

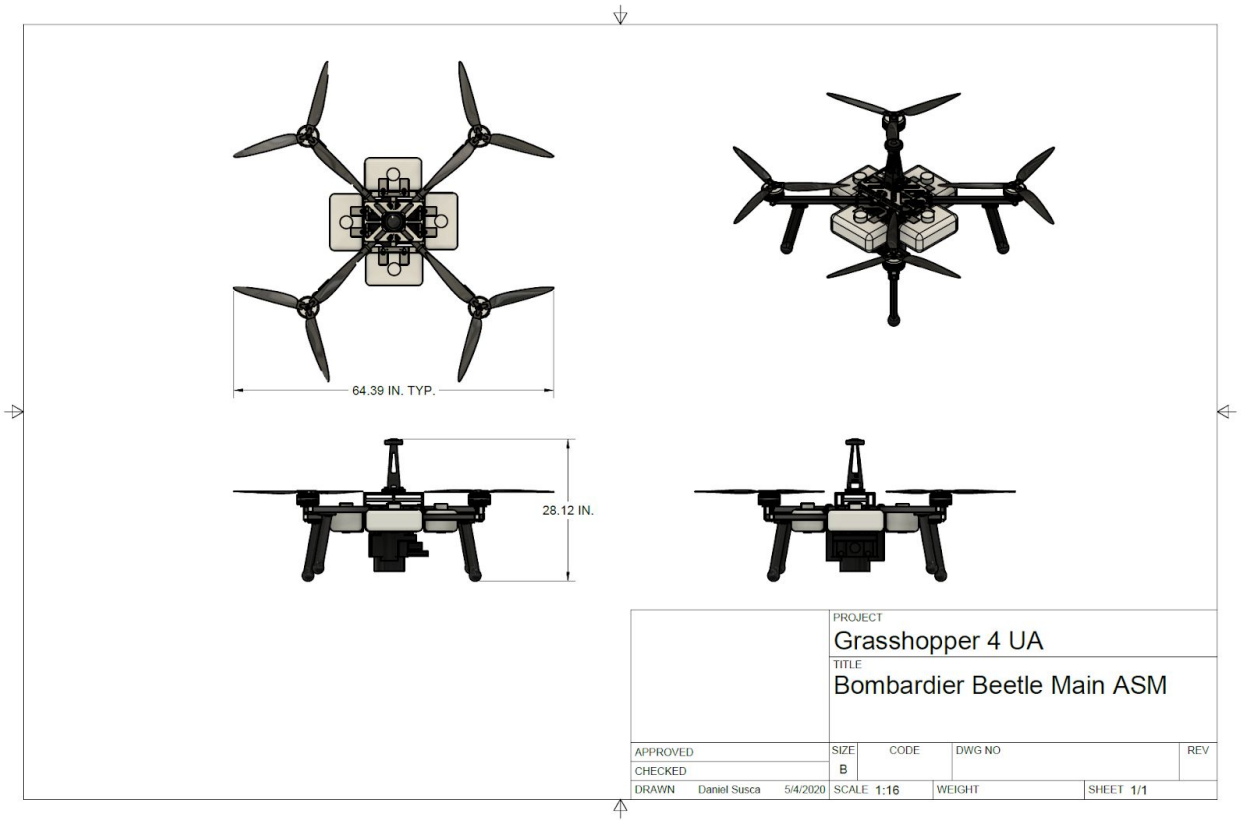

Figure 2: Grasshopper Orthographic Representation with Generator Payload.

Specifications and Limitations	
Empty Weight (no Payload)	60 Pounds
Maximum Weight	110 Pounds
Maximum Weight with Generator Payload	98 Pounds
Maximum Payload Capacity	50 Pounds
Maximum Generator Fuel Capacity	4 Gallons
Length	64.39 Inches
Width	64.39 Inches
Height	41.55 Inches
Max Flight Time with No Payload	18 Minutes
Max Flight Time with Full Payload	11 Minutes
Max Flight Time with Generator Payload	3 Hours
Motor Model	KDE10218XF-105
Propeller Model	KDE-CF305-TP
Operating Temperature Range	10°F -110°F
Maximum Wind Speed	25 Miles Per Hour
Satellite Positioning System	Here 2 GNSS (GPS, Galileo, GLONASS, BeiDou)

Total Battery Capacity	24 Amp-Hours
Nominal Battery Voltage	51.8 Volts
Battery Type	14-Cell Lithium Polymer
Energy Capacity	1243.2 Watt-Hours

Table 1: Grasshopper Specifications and Limitations.

1.2. Ground Station

The ground station consists of a laptop computer with telemetry radio, RC transmitter, and safety and maintenance equipment. Using the laptop computer, the Autopilot Operator issues commands to the vehicle, monitors telemetry data, and is ready to respond appropriately to emergencies. The Autopilot Operator also acts as a VO and will notify the PIC of nearby aircraft and other emerging hazards in the Autopilot Operator. New, automatic mission plans, commands to hover in place, and commands to terminate the operation can be sent to the vehicle while in flight. This is especially useful in responding to potential hazards or unexpected emergencies.

The PIC, or the person that they designate as the person manipulating the RC transmitter, holds the RC transmitter and is responsible for taking over manual control of the vehicle as necessary. The Autopilot Operator and the person manipulating the RC transmitter can both independently control the vehicle. This backup ensures the flight crew can maintain control over the vehicle if either the Autopilot Operator or person manipulating the RC transmitter loses their ability to maintain control. No flight shall be conducted without both the PIC and the Autopilot Operator present.

Figure 3: MP User Interface.

Ground Station Specifications and Limitations	
Ground Station Laptop	Dell Inspiron 15 7000 Series or Equivalent
Ground Station Telemetry Radio	mRo Sik Telemetry Radio
Autopilot Software	ArduPilot Copter
Ground Station Software	MP
Maximum Telemetry Distance	300 Meters
Operating Frequency	915Mhz

Table 2: Ground Station Specifications and Limitations.

Figure 4: Taranis Q X7 RC Transmitter.

Taranis Q X7 RC Transmitter Specifications and Limitations	
Model	Taranis Q X7
Maximum Transmission Distance	1 mile+
Operating Frequency	2.4GHz
Operating Temperature Range	50-113°F

Table 3: Taranis Q X7 RC Transmitter Specifications and Limitations.

2. Weight and Balance

The vehicle is designed so that it does not have to be rebalanced before each flight, either with or without a payload. The payload location is directly centered at the x-axis and y-axis location of the center of gravity of the vehicle so operations with or without a payload will not affect the vehicle's balance. For reference, the figure below defines the aircraft coordinate system.

Figure 5: Coordinate System.

3. Checklists

The PIC will be required to discontinue flight operations of the UA if they determine for any reason that positive control is compromised or the UA is no longer in a condition for safe operation. To mitigate risks associated with possible loss of positive control, the PIC, while conducting the preflight and post-flight inspections, must ensure that all control links, structural components, sensors, flight controls, batteries, and ground station components are in a condition that is safe for flight.

3.1.Pre-Flight

Before every flight, this checklist must be completed sequentially. This configures the aircraft for flight and confirms the aircraft is safe to fly.

Pre-Flight Checklist		
1	Submit NOTAM	Submit a NOTAM not more than 72 hours but not less than 48 hours before flight including the flight location, operational area radius and altitude, time of operation, and the name and phone number of the PIC
2	Airworthiness Certificate	Verify the vehicle's airworthiness certificate is present
3	COA	Verify the vehicle's flight plan is within the limits of the COA, and that the COA is present for inspection
4	Weather	Check weather outlook, wind speed, and direction

5	Verify AO	Check for nearby obstacles, TFR's, or NOTAM's
6	Computer	Verify that it is powered on and has sufficient battery life
7	Fuel Tank (if attached)	Fill, as appropriate for the mission
8	Battery	Verify they are secured and not swollen – then plug in
9	MP	Verify it is running, up to date, and connected to the vehicle
10	Flight Crew	Designate the person manipulating the RC transmitter, VO, and autopilot operator, as necessary
11	Telemetry Antenna	Orient the diversity antennas perpendicular
12	Airframe and Landing Gear	Verify there is no visible damage
13	Propellers	Remove propeller guards, verify no chips or cracks, and verify the direction
14	Motors and ESCs	Verify they are secured, undamaged, and fully connected
15	Payload Capsule	Verify it is connected and fully constrained in all directions of rotation, as appropriate
16	Connections on Pixhawk	Verify they are secured and fastened
17	Pixhawk	Verify lights are as expected
18	Power Supply	Verify status lights are as expected
19	RC Transmitter	Verify it is powered on, has sufficient battery, is throttled down, and the controls are centered
20	GPS	Verify lights are as expected
21	Flight Modes	Verify flight modes match the flight plan
22	Failsafe	Verify failsafe parameters are set as appropriate
23	RC Transmitter Calibration	Recalibrate if necessary
24	Battery Voltage	Verify > 55 Volts
25	Telemetry Signal Strength	Verify 90-100%
26	Altitude	Verify 0 (+/-3) feet
27	GPS	Verify 3D Fix
28	Compass	Verify direction in MP, verify declination, and calibrate if necessary
29	Fuel Valve (if attached)	Turn on
30	Generator (if attached)	Put in IDLE mode, plug in starter controller, and hold starter button until engine begins to fire
31	Generator Starter Controller (if attached)	Release start button, disconnect starter controller, and let the engine idle for 30-60 seconds
32	Generator Mode (if attached)	Switch Generator to RUN
33	Hardware Arm	Long press the GPS button to hardware arm the vehicle

34	Flight Plan	Verify with the flight crew
35	Emergency Procedures	Verify with the flight crew
36	Software Arm	Arm with the RC transmitter or MP and prepare for takeoff

Table 4: Pre-Flight Checklist.

3.2.Post-Flight

After every flight, the PIC should go through this list sequentially while preparing the aircraft for transportation or storage.

Post-Flight Checklist	
Generator (if attached)	Turn the switch to STOP and turn fuel valve off
Batteries	Remove and verify they were not discharged below 3.2V per cell, are not swollen, or excessively hot
Propellers	Check for any chips or cracks and install propeller guards
Motors and ESCs	Verify temperatures are reasonable
Carbon Fiber	Examine for cracks or delamination
Aluminum Components	Check for plastic deformation, as appropriate

Table 5: Post-Flight Checklist.

4. Emergency Procedures

The following procedures should be followed during the listed emergency situations.

VTOL Engine Failure

1. Stabilize aircraft as much as possible
2. Crash land and disarm aircraft
3. Immediately go to the crash site with class ABC and class D fire extinguishers

Non-Participating Aircraft Enters The AO

1. Descend and land immediately
2. If it is not possible to avoid other aircraft, disarm the UA
3. If disarmed in flight, proceed to crash site with class ABC and class D fire extinguishers

Loss of Telemetry or RC Connection

1. RTL protocol will commence
2. Wait for reconnection

Battery Capacity Below Minimum Necessary for Flight

1. Ensure all personnel are clear of the area below the aircraft
2. Land immediately in place

Structural Failure in Flight

1. Begin slow descent, if possible
2. Ensure all personnel are clear of the area below the aircraft
3. Land and disarm the aircraft
4. If crash landing, immediately go to the crash site with class ABC and class D fire extinguishers

Generator Stops Running (if attached)

1. Return to the launch location and land immediately
2. Disarm the aircraft and troubleshoot

Appendix 2 - Grasshopper Maintenance and Inspection Program

1. Overview

This document provides standards and procedures for performing maintenance and inspections on the Grasshopper UA.

2. Responsibilities

The owner of the aircraft, SparkCognition, Inc., is responsible for maintaining the aircraft and updating the maintenance log, as appropriate. The PIC is responsible for ensuring the aircraft is in airworthy condition, for reviewing and verifying previous maintenance records, and for logging the flight hours of the UA after any flight operations.

3. Records

An individual logbook will be maintained for the aircraft. This will contain a record of repairs, maintenance, and flight hours. Separate logs will be kept, if determined necessary, for any payloads.

4. Replacement Schedule

All components and systems will be replaced or repaired at the intervals listed below.

Component	Replacement Interval
Electric Motor	As Necessary
Propeller	When Visibly Damaged
Battery	500 Hours
Electronic Speed Controller	10,000 Hours
Telemetry Radio	As Necessary
Carbon Fiber	When Visibly Damaged
Wiring	As Necessary
Landing Gear	When Visibly Damaged
Generator Carburetor (if attached)	

Table 1: Replacement Interval for Aircraft Components.

5. Repairs

Any minor repairs, such as replacement of propellers, landing gear, or aesthetic components, can be performed by the PIC. Any major repairs, such as replacement of an electric motor, repair of carbon fiber components, or modifications to the flight controller, must be performed with oversight by a lead engineer.

6. 20 Hour Inspection

Inspections prior to and after each flight are critical to identifying mechanical issues with the UA. The pre-flight and post-flight inspection procedures can be found in the aircraft operating

manual. In addition to inspections for each flight, the aircraft should be periodically inspected by a lead engineer every 20 flight hours. The following procedure should be used and the inspection should be noted in the aircraft logbook.

Component	Procedure
Carbon Fiber	Verify no chips, cracks, or delamination with visual magnification
Wiring and Insulation	Verify all wiring, connectors, and solder points - ensure there are no signs of excessive heat, unintended binding, or physical damage
Fasteners	Verify they are properly torqued
Aluminum	Verify there are no signs of elongation or plastic deformation with visual magnification
Electrical Components	Verify that there are no signs of excessive heat, swollen capacitors, or darkening on printed circuit boards
Generator (if attached)	Pull spark plugs and clean carbon deposits if present – check gap (nominal is 0.6-0.7mm)

Table 2: 20 Hour Periodic Inspection Procedure.

Appendix 3 - Saphira 1.5 Operating Manual

1. System Description and Specifications

Saphira 1.5 is an automatic, electric powered VTOL UA designed to explore long range, heavy lift applications. It is an incremental development of the Saphira UA registered as N847JP. Four VTOL motors enable the aircraft to takeoff and land in any area that has a clear view of the sky, while the cruise motor and wing enable the aircraft to travel long distances similar to a traditional fixed wing aircraft.

1.1.Aircraft

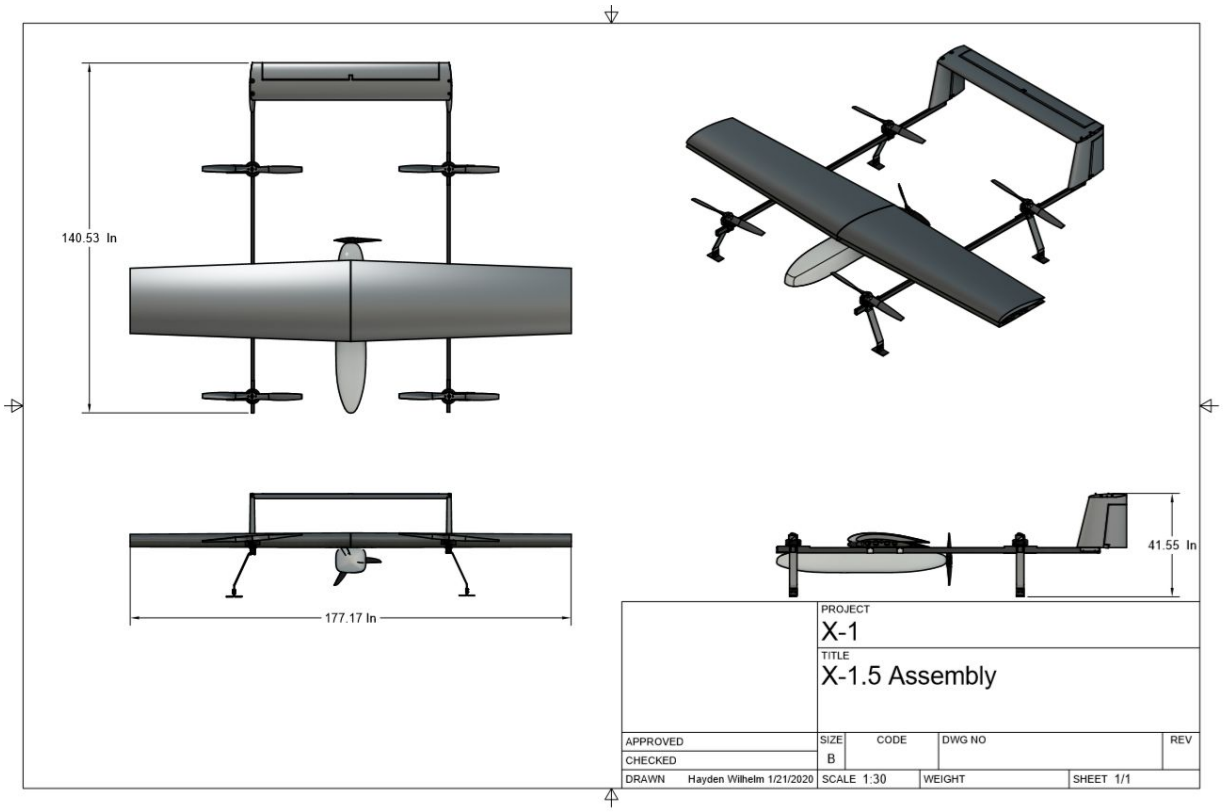

Figure 1: Saphira 1.5 Orthographic Representation.

Specifications and Limitations	
Empty Weight (no Payload)	130 Pounds
Maximum Weight	150 Pounds
Maximum Payload Capacity	20 Pounds
Length	140.53 Inches
Wing Span	177.17 Inches

Height	41.55 Inches
Max Flight Time (Including VTOL)	11 Minutes
Maximum Range with Full Payload	7.5 Miles
Cruise Speed	50 Miles Per Hour
Maximum Speed at Sea Level	100 Miles Per Hour
Stall Speed at Sea Level	35 Miles Per Hour
VTOL Motor Model	MAD M30 Pro
VTOL Propeller Model	FLUXER Shine 40x13.1
Cruise Motor Model	Hacker Q100-6L
Cruise Propeller Model	Mejzlik 24x19 Triple Blade
Operating Temperature Range	10°F -110°F
Maximum Wind Speed	25 Miles Per Hour
Satellite Positioning System	Here 2 GNSS (GPS, Galileo, GLONASS, BeiDou)
Total Battery Capacity	32 Amp-Hours
Nominal Battery Voltage	51.8 Volts
Battery Type	14-Cell Lithium Polymer
Energy Capacity	1657 Watt-Hours

Table 1: Saphira 1.5 Specifications and Limitations.

1.2. Ground Station

The ground station consists of a laptop computer with telemetry radio, RC transmitter, and safety and maintenance equipment. Using the laptop computer, the Autopilot Operator issues commands to the vehicle, monitors telemetry data, and is ready to respond appropriately to emergencies. The Autopilot Operator also acts as a VO and will notify the PIC of nearby aircraft and other emerging hazards in the operating area. New, automatic mission plans, commands to hover in place, and commands to terminate the operation can be sent to the vehicle while in flight. This is especially useful in responding to potential hazards or unexpected emergencies.

The PIC, or the person that they designate as the person manipulating the RC transmitter, holds the RC transmitter and is responsible for taking over manual control of the vehicle as necessary. The Autopilot Operator and the person manipulating the RC transmitter can both independently control the vehicle. This backup ensures the flight crew can maintain control over the vehicle if either the Autopilot Operator or person manipulating the RC transmitter lose their ability to maintain control. No flight shall be conducted without both the PIC and the Autopilot Operator present.

Figure 2: MP User Interface.

Ground Station Specifications and Limitations	
Ground Station Laptop	Dell Inspiron 15 7000 Series or Equivalent
Ground Station Telemetry Radio	jD-RF900Plus
Autopilot Software	ArduPilot Plane
Ground Station Software	MP
Maximum Telemetry Distance	15+ miles
Operating Frequency	915Mhz
Operating Temperature Range	32-105°F

Table 2: Ground Station Specifications and Limitations.

Figure 3: Taranis Q X7 RC Transmitter.

Figure 4: FrSky R9 and R9M Radio Control System.

Taranis Q X7 RC Transmitter Specifications and Limitations	
Model	Taranis Q X7 With FrSky R9 and R9M
Maximum Transmission Distance	6 mile+
Operating Frequency	2.4GHz
Operating Temperature Range	50-113°F

Table 3: Taranis Q X7 RC Transmitter Specifications and Limitations.

2. Weight and Balance

The vehicle is designed so that it does not have to be rebalanced before each flight, either with or without a payload. The payload location is directly centered at the x-axis location of the center of gravity of the vehicle so operations with or without a payload will not affect the vehicle's x-axis balance. This optimizes the aircrafts stability in forward flight. When considering the y-axis and z-axis balance, the vertical lift motors and control surfaces have sufficient margin to accommodate any configuration of the 20lb payload within the payload area. For reference, the figure below defines the aircraft coordinate system.

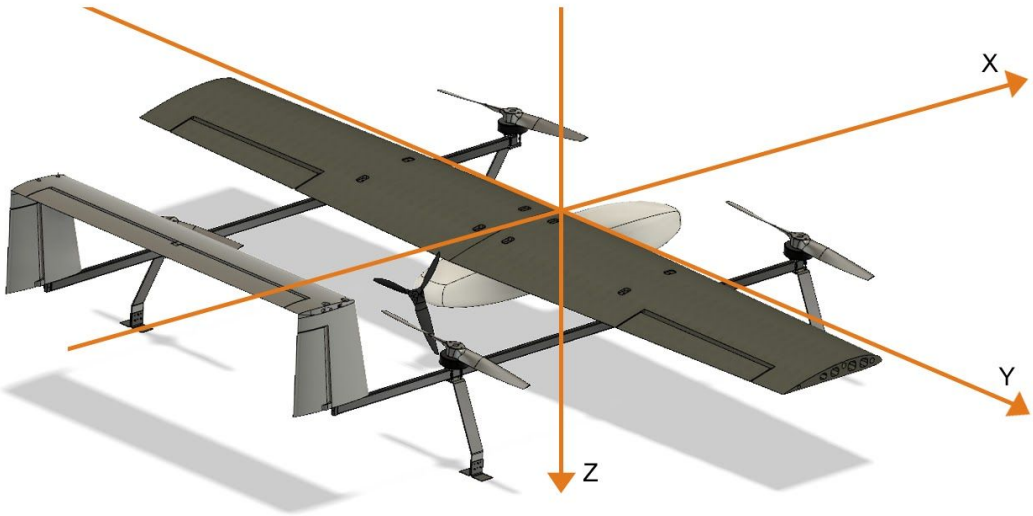

Figure 5: Coordinate System.

3. Checklists

The PIC will be required to discontinue flight operations of the UA if they determine for any reason that positive control is compromised or the UA is no longer in a condition for safe operation. To mitigate risks associated with possible loss of positive control, the PIC, while conducting the preflight and post flight inspections, must ensure that all control links, structural components, sensors, flight controls, batteries, and ground station components are in a condition for safe flight.

3.1.Pre-Flight

Before every flight, this checklist must be completed sequentially. This configures the aircraft for flight and confirms the aircraft is safe to fly.

Pre-Flight Checklist	
Submit NOTAM	Submit a NOTAM not more than 72 hours but not less than 48 hours before flight including the flight location, operational area radius and altitude, time of operation, and the name and phone number of the PIC
Airworthiness Certificate	Verify the vehicle's airworthiness certificate is present
COA	Verify the vehicle's flight plan is within the limits of the COA, and that the COA is present for inspection
Weather	Check weather outlook, wind speed, and direction
Verify Flight Area	Check for nearby obstacles, TFR's, or NOTAM's
Computer	Verify that it is powered on and has sufficient battery life
Battery	Verify they are secured and not swollen – then plug in
MP	Verify it is running, up to date, and connected to vehicle
Flight Crew	Designate the person manipulating the RC transmitter, VO, and Autopilot Operator, as necessary
Telemetry Antenna	Orient the diversity antennas perpendicular
Airframe and Landing Gear	Verify there is no visible damage
Propellers	Remove propeller guards, verify no chips or cracks, and verify direction
Motors and ESCs	Verify they are secured, undamaged, and fully connected
Payload Capsule	Verify it is connected and fully constrained in all directions of rotation, as appropriate
Connections on Pixhawk	Verify they are secured and fastened
Pixhawk	Verify lights are as expected
Power Supplies	Verify status lights are as expected
RC Transmitter	Verify it is powered on, has sufficient battery, is throttled down, and the controls are centered
GPS	Verify lights are as expected
Flight Modes	Verify flight modes match the flight plan
Failsafes	Verify failsafes are set as appropriate
RC Transmitter Calibration	Verify in MP and recalibrate if necessary
Battery Voltage	Verify > 55 Volts
Telemetry Signal Strength	Verify 90-100%
Airspeed	Verify 0 (+/-3) knots
Altitude	Verify 0 (+/-3) feet
GPS	Verify 3D Fix

Fuselage	Ensure battery compartment is closed and secured
Compass	Verify direction in MP, verify declination, and calibrate if necessary
Hardware Arm	Long press the GPS button to hardware arm the vehicle
Flight Controls – MP Loop	Ensure proper deflection in Stabilize mode while rolling and pitching the vehicle by hand
Flight Controls – RC Loop	Ensure proper deflection from RC transmitter inputs
Flight Plan	Verify with flight crew
Emergency Procedures	Verify with flight crew
Software Arm	Arm with the RC transmitter or MP and prepare for takeoff

Table 4: Pre-Flight Checklist.

3.2.Post-Flight

After every flight, the PIC should go through this list sequentially while preparing the aircraft for transportation or storage.

Post-Flight Checklist	
Batteries	Remove and verify they were not discharged below 3.2V per cell, are not swollen, or excessively hot
Propellers	Check for any chips or cracks and install propeller guards
Motors and ESCs	Verify temperatures are reasonable
Carbon Fiber	Examine for cracks or delamination
Aluminum Components	Check for plastic deformation, as appropriate

Table 5: Post-Flight Checklist.

4. Emergency Procedures

The following procedures should be followed during the listed emergency situations.

VTOL Engine Failure

1. Stabilize aircraft as much as possible
2. Crash land and disarm aircraft
3. Immediately go to the crash site with class ABC and class D fire extinguishers

Cruise Motor Failure

1. Immediately transition to VTOL mode
2. Return to launch location and land

Non-Participating Aircraft Enters The AO

1. Descend in VTOL mode and land immediately
2. If it is not possible to avoid other aircraft, disarm the UA
3. Proceed to crash site with class ABC and class D fire extinguishers

Loss of Telemetry or RC Connection

1. RTL protocol will commence
2. Wait for reconnection

Battery Capacity Below Minimum Necessary for Flight

1. Ensure all personnel are clear of the area below the aircraft
2. Land immediately in place

Structural Failure in Flight

1. Begin slow descent, if possible
2. Ensure all personnel are clear of the area below the aircraft
3. Land and disarm the aircraft
4. If crash landing, immediately go to the crash site with class ABC and class D fire extinguishers

Appendix 4 - Saphira 1.5 Maintenance and Inspection Program

1. Overview

This document provides standards and procedures for performing maintenance and inspections on the Saphira 1.5 UA.

2. Responsibilities

The owner of the aircraft, SparkCognition, Inc., is responsible for maintaining the aircraft and updating the maintenance log, as appropriate. The PIC is responsible for ensuring the aircraft is in airworthy condition, for reviewing and verifying previous maintenance records, and for logging the flight hours of the UA after any flight operations.

3. Records

An individual logbook will be maintained for the aircraft. This will contain a record of repairs, maintenance, and flight hours. Separate logs will be kept, if determined necessary, for any payloads.

4. Replacement Schedule

All components and systems will be replaced or repaired at the intervals listed below.

Component	Replacement Interval
Electric Motor	As Necessary
Propeller	When Visibly Damaged
Battery	500 Hours
Electronic Speed Controller	10,000 Hours
Telemetry Radio	As Necessary
Carbon Fiber	When Visibly Damaged
Wiring	As Necessary
Landing Gear	When Visibly Damaged

Table 1: Replacement Interval for Aircraft Components.

5. Repairs

Any minor repairs, such as replacement of propellers, landing gear, or aesthetic components, can be performed by the PIC. Any major repairs, such as replacement of an electric motor, repair of carbon fiber components, or modifications to the flight controller, must be performed with oversight by a lead engineer.

6. 20 Hour Inspection

Inspections prior to and after each flight are critical to identifying mechanical issues with the UA. The pre-flight and post-flight inspection procedures can be found in the aircraft operating manual. In addition to inspections for each flight, the aircraft should be periodically inspected by

a lead engineer every 20 flight hours. The following procedure should be used and the inspection should be noted in the aircraft logbook.

Component	Procedure
Carbon Fiber	Verify no chips, cracks, or delamination with visual magnification
Wiring and Insulation	Verify all wiring, connectors, and solder points - ensure there are no signs of excessive heat, unintended binding, or physical damage
Fasteners	Verify they are properly torqued
Aluminum	Verify there are no signs of elongation or plastic deformation with visual magnification
Electrical Components	Verify that there are no signs of excessive heat, swollen capacitors, or darkening on printed circuit boards

Table 2: 20 Hour Periodic Inspection Procedure.

Appendix 5 - SparkCognition Large UA Operating Standards

1. Overview

This document provides crew requirements and standards for operating SparkCognition over 55lb UA. While operating the UA, the flight crew is required to follow any FAA authorization requirements in addition to the contents of this document.

2. Environment

All flights will be conducted from ground based control stations and will not involve moving vehicles or manned aircraft. The AO will be pre-approved by the FAA through the COA process and prior permission will be obtained for flights over property, if necessary.

2.1. Meteorological Conditions

The PIC will ensure that there is a minimum weather visibility of 3 miles from the control station. If operations will be conducted during civil twilight (30 minutes before sunrise or 30 minutes after sunset) then anti-collision lights are required. Night operations are only permitted through an FAA approved COA.

2.2. Wind Limits

Operation of the aircraft is not permitted if winds are extremely strong or gusty. The operational limits of the aircraft are outlined in the aircraft operating manual. Ultimately, it is the PIC's decision to fly or not in any windy conditions.

2.3. Flight Crew Area

Before each flight, the PIC will designate an area to be used by the flight crew. If necessary, this area may be marked off with safety cones or another temporary barrier. Any other personnel present should stay clear of this area during operations.

2.4. Flight Boundary

During the pre-flight brief, the PIC will determine the AO boundary. This area will be contained within a FAA approved COA. If the UA departs this area, or if an aircraft approaches this area, then the PIC will initiate appropriate emergency procedures.

3. Safety and Risk Mitigation

Having safe practices and preparing risk mitigation strategies will lead to the best outcomes for each flight. While the team as a whole can prepare for safe operations, ultimately it is the responsibility of each member of the flight crew to ensure that operations are conducted safely and risk is mitigated adequately. Each member of the flight crew has the ability and responsibility to make known and stop any unsafe operation.

3.1. Flight Crew Uniform

All members of the flight crew will wear full length pants and closed toe shoes. Hats and sunglasses are highly recommended.

3.2. Safety Vests

While operations are being conducted, all flight crew may wear safety vests that identify them as a member of the flight crew. Any personnel that are present but not a member of the flight crew should avoid any interactions with the flight crew unless an emergency arises.

3.3. Emergency Equipment

During all operations, a Class ABC Fire Extinguisher, a Class D Fire Extinguisher, and a first aid kit will be present. The PIC and VO will carry cell phones in case of emergencies and personal transportation will be available.

3.4. Other Equipment

If necessary, a temporary tent will be used for shade and foldable tables will be available to support ground station equipment. The flight crew will ensure that they have adequate water, sunscreen, insect repellant, and any other necessary personal items for the duration of the flight operation.

4. Flight Crew

The aircrafts are designed to have a 2-4 member flight crew. At minimum, a PIC and VO are required to operate each aircraft. During any operation, the aircraft will remain within VLOS of the PIC and/or VO during the entire flight. If necessary, as determined by the PIC, a Autopilot Operator and Payload Operator may be included as members of the flight crew.

The flight crew is the most important component required for a successful flight. Because of this, no person is permitted to act as a member of the flight crew if they know or have reason to know of any physical or mental condition that would interfere with the safe operation of the UA, are fatigued from lack of sleep, or under the influence of alcohol, prescription medications, or any other substance that interferes with the safe operation of the UA.

4.1. PIC

The PIC must possess, at minimum, a 14 CFR § 107 pilot certificate.

The PIC is responsible for defining the AO before each flight, ensuring the AO is clear of any obstacles or hazards, reviewing any restrictions or regulations pertaining to the flight, verifying meteorological conditions, conducting a thorough preflight inspection of the UA, providing a pre-flight brief to the flight crew, and safely operating the aircraft.

The PIC may not operate the UA in a careless or reckless manner and may only fly one aircraft at a time.

4.2. VO

The VO is required to assist the pilot with maintaining terrain and obstacle clearance, seeing and avoiding other aircraft, and identifying any non-participating personnel or vehicles approaching the AO.

The VO must possess, at minimum, a 14 CFR § 107 pilot certificate. Each observer will be ground based and will only observe one aircraft. At no point during a flight will the aircraft be operated outside VLOS of a VO.

4.3.Autopilot Operator

The Autopilot Operator, if required by the PIC, is responsible for interacting with MP, the associated computer, and the ground-based telemetry radio.

If the PIC determines that an independent Autopilot Operator is not required for the flight, then the VO can serve as the Autopilot Operator. During the pre-flight procedure, the VO can assist the PIC by arming the UA.

The Autopilot Operator will have adequate knowledge of MP, as determined by the PIC.

4.4.Payload Operator

Some payloads may require an additional ground-based operator for full functionality. If this is necessary, as determined by the PIC, then the payload operator will be responsible for providing any control inputs to the payload.

The Payload Operator will have adequate knowledge of the payload system, as determined by the PIC.