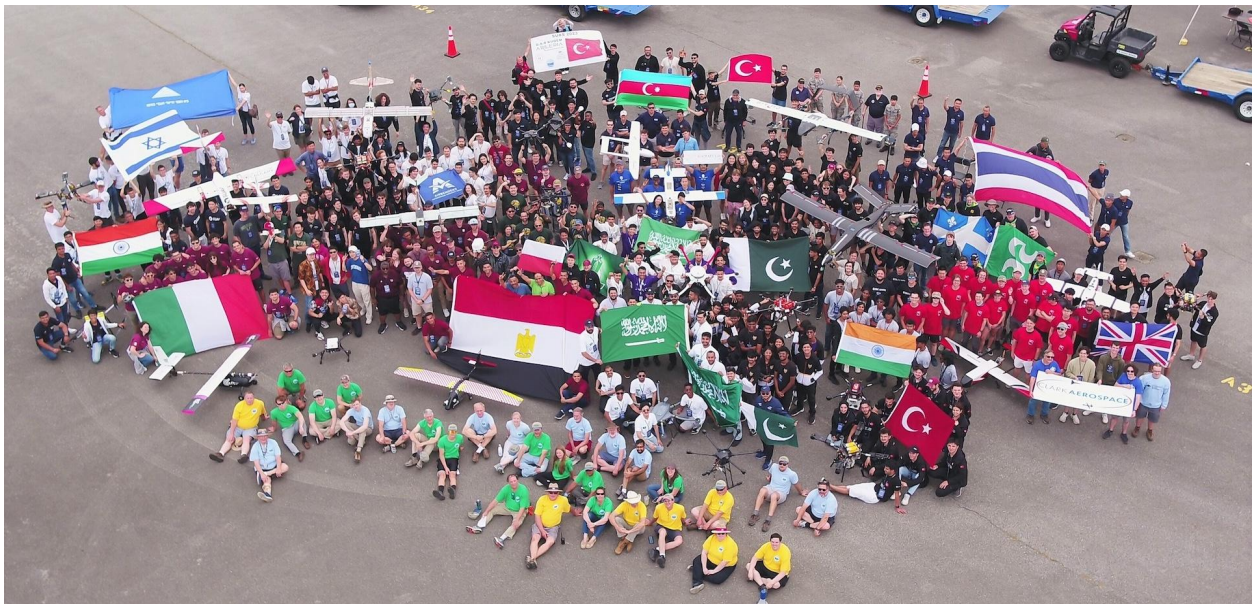
SUAS 2024 Rules

suas-competition.org | robonation.org

This document contains the rules for the 22nd annual Student Unmanned Aerial Systems (SUAS) Competition.



Competition Purpose. The SUAS competition is designed to foster interest in Unmanned Aerial Systems (UAS), stimulate interest in UAS technologies and careers, and to engage students in a challenging mission. The competition requires students to design, integrate, report on, and demonstrate a UAS capable of autonomous flight and navigation, remote sensing via onboard payload sensors, and execution of a specific set of tasks. The competition has been held annually since 2002.

Competition Overview. The competition has two major elements: the (1) Technical Design and Flight Readiness Review Presentation, and the (2) Mission Demonstration. The presentation details a team's UAS design and the team's testing and preparedness, and the demonstration simulates a mission in which the UAS and team is evaluated. The mission consists of autonomous flight, obstacle avoidance, object detection, and air drop. The mission will be held at St. Mary's County Regional Airport (2W6) from June 25th to 27th, 2024.

2024 Mission. Multiple package delivery companies have tasked UAS to deliver packages to customers. These UAS must avoid each other, travel to the customer, identify potential drop locations, and deliver the package to a safe location.

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1. Terms and Conditions

1.1. Registration Fee is Non Refundable

The registration fee is non refundable once a team is accepted into the competition. The registration fee will only be refunded to teams which are not accepted to the competition.

1.2. Passports and Visas

Foreign nationals must have passports and visas to attend the competition. Failure to obtain passports or visas in time will not be cause for any extensions or refunds. Once a team is registered for the competition, you should immediately obtain passports and visas.

1.3. Spirit of the Competition

Teams are expected to compete in a fair and professional manner. Cheating will not be tolerated. Failure to follow the rules may lead to disqualification and removal from the competition without refund. Certain violations may lead to banning the school from the competition for multiple years.

1.4. Rules Subject to Change

The organizers try to provide the best possible rules and competition experience. Sometimes errors are made and situations change. The organizers reserve the right to make changes at any time.

2. Schedules and Deliverables

Deliverables are due by 11:59 pm ET on the date listed. *All deliverables outlined in this section* are collected in the registration portal: robonation.smapply.org.

2.1. Rules Published (September 14th, 2023)

Rules will be posted to the competition website. If necessary, organizers may release updated rules documents with changes after this date.

2.2. Team Registration (October 2nd to November 1st, 2023)

During this period, the team captain can register to compete on the competition's website, suas-competition.org. The registration fee is $1,500 USD and is paid by credit card as part of registration. The registration fee covers teams' participation in the Technical Design and Flight Readiness Review, Mission Demonstration, and meals and t-shirts for 8 team members. Teams' registered guests can purchase a guest ticket, meals, and a t-shirt in advance of the competition.

The registration fee is non refundable once a team is officially accepted into the competition. Up to 125 teams will be accepted into the competition, first-come-first-serve. Accepted teams will be posted on the website within 2 weeks of the end of registration. The registration fee will only be refunded to teams which are not accepted to the competition.

Team Registration: suas-competition.org/2024/registration

2.3. Visa Invitation Letters (May 1st, 2024)

If you are a foreign national and need invitation letters to apply for a visa, you can request one for your team in the registration portal. A valid passport is required to request an invitation letter. Teams may submit up to 2 extra people, beyond the allowed number of attendees specified in the requirements, to serve as backups should someone later be unable to attend.

Following registration, teams should immediately request visa invitation letters for attendees which need one. You should submit all competition team members with this request. An invitation letter will be issued within a week of being requested. All requests or modification requests must be submitted no later than May 8th.

2.4. Team Personnel Registration (May 1st, 2024)

Everyone who may be in attendance must submit the following information: first/last name, email address, phone number, and any dietary restrictions/special needs. All individuals are required to sign and return a liability waiver and youth protection policy acknowledgement form. Individuals have the option to upload a Resume / CV, to be shared with event sponsors.

Anyone who doesn't submit the form will be denied entrance, and there will be no exceptions. Do not travel to the competition unless the following form has been filled out. Teams may submit up to 2 extra people, beyond the allowed number of attendees specified in the requirements, to serve as backups should someone later be unable to attend.

2.5. Technical Design and Flight Readiness Review (May 1st, 2024)

The *Technical Design and Flight Readiness Review* is a video presentation detailing the technical design, testing, and preparedness. See 6. Technical Design & Flight Readiness Review for additional details regarding this deliverable.

2.6. Fact Sheet (May 1st, 2024)

Teams must submit the following form detailing facts about the UAS. The details specified in this form must not change after this point without written approval from the judges.

2.7. Battery/Fuel MSDS (May 1st, 2024)

Teams must submit battery specifications, Material Safety Data Sheets (MSDS), and proper disposal procedures, sourced from the battery manufacturer for all batteries. More information detailed in B. Battery/Fuel Guidelines.

2.8. Team Check-in and Orientation (June 25th, 2024)

During check-in, teams will submit any missing forms, receive meal tickets and t-shirts. Teams which fail to check-in may be disqualified. Unexpected delays must be communicated to RoboNation.

Teams are required to attend orientation, covering important instructions for the competition event. Teams may be sent additional instructions via Discord during the event.

2.9. Competition Schedule (June 25th - June 27th, 2024)

The following tables outline the expected schedule for the competition. Teams are strongly encouraged to travel to the competition area ahead of Day 1. Failing to arrive on time at any event may be cause for disqualification, and travel delays will not be cause for extension. Teams must organize their own travel and lodging - neither is provided by the organizers.

Day 3 (June 27th, 2024) serves as a backup weather day. In the event of weather (e.g. rain) on Day 2, those events will move to Day 3. The call will be made 36 hours in advance of Day 1 and be announced on the Discord.

Table 1: SUAS Competition Schedule (Day 1)

Activity	Date/Time
Arrival and Check In: Teams will arrive at St. Mary's County Regional Airport (2W6) at this time.	June 25 9:00AM to 9:30AM
Team Orientation: All participants are required to attend the team orientation.	June 25 9:30AM to 10:45AM
Group Photo: All participants will assemble for a group photo. Teams and their UAS must be present.	June 25 11:00AM
Lunch: Lunch will be served at this time (ticket required).	June 25 11:30AM to 12:30PM

Safety Inspections: The UAS and the ground station will be inspected for safety and competition compliance. Each aircraft instance must be safety inspected. If a team fails inspection or is not present, they will be put in the back of the queue and may be revisited after other teams are inspected as time allows. Teams must pass safety inspection by the end of this period or they will be disqualified. Once teams pass inspection, they are free to leave for the day.	June 25 12:00PM to 5:00PM

Table 2: SUAS Competition Schedule (Day 2)

Activity	Date/Time
Arrival and Setup: Teams will arrive at St. Mary's County Regional Airport (2W6) at this time.	June 26 6:00AM to 6:45AM
Breakfast: Breakfast will be available for purchase.	June 26 6:45AM to 9:00AM
Mission Demonstration: Teams will be given at least 5 minutes notice of transportation from the pits to the flight line. If teams are called but not present, they may be disqualified. The team and the equipment will be transported via flatbed trailer to the flight line, after which the setup time will start.	June 26 7:00AM to 6:00PM
Lunch: Lunch will be served at this time (ticket required).	June 26 12:00PM to 2:00PM
Awards Ceremony: The awards ceremony includes dinner and the presentation of awards. Teams must be present to collect their awards, and award money will be issued within 4-6 weeks after the competition.	June 26 6:00PM to 8:00PM
Cleanup: Following the conclusion of the event, teams will assist the volunteers in cleaning up the event space, which must be left in a condition better than it was found so that the event can be held in future years.	June 26 8:00PM to 9:00PM

3. Logistical Requirements

3.1. Discord (Competition Communications)

All questions, comments, and suggestions should be posted on the SUAS Discord. Teams are encouraged to actively participate in the online community and monitor it for the latest news and updates regarding all things SUAS.

1. Click the RoboNation Discord Invite to create an account and join the RoboNation server.
2. Tap / right-click on SUAS, go to Notification Settings, and click All Messages [instructions].

3.2. Social Media

All media and some announcements are posted to social media accounts. Teams should like and follow RoboNation's social media channels to be notified when the media and announcements are posted.
LinkedIn | Facebook | Twitter | Instagram | Youtube

3.3. Development Team

The development team must consist of undergraduate, graduate, or high school students who attend school full-time for at least one semester during the academic year. Up to 20% of the development team may be composed of graduate students. The team must have at least 1 student from the school being represented, and may have students from other schools. A school may have multiple teams, but a student may only be on 1 team.

3.4. Competition Team

The team of students which participate in the Mission Demonstration. The competition team must be at most an 8 person subset of the development team. The organizers will provide food and other resources for these 8 students (including two lunches and dinner at the awards ceremony). Extra resources may be available for purchase. Members of the competition team may participate onsite or participate remotely (e.g. over the internet), but remote members cannot hold safety-critical roles or perform safety-critical functions.

3.5. Team Captain

One member of the competition team will fill the role of team captain during the competition year. This student will be the primary point of contact for the organizers and judges. All questions, comments, statements, and deliverables must be submitted by the team captain. The judges must be immediately notified of any team captain change.

3.6. Team Adviser

Each team must have a school faculty member/adviser or official point of contact (POC) from the team's school. Teams whose entire team is age 18 years or above are not required to have the adviser or school official travel with the team. Teams with even one team member under the age of 18 must be accompanied by a minimum of two (maximum of 4) designated, registered chaperones, who must travel with the team and take full responsibility for the students at all times. Registered chaperones must complete a background check through Sterling Volunteers during the registration process. The adviser will also be admitted to all competition events, and will be provided food and other resources. The

adviser will be permitted to observe the team at the flight line, but is forbidden from communicating or otherwise assisting the team during setup, mission, or tear down. While the adviser may teach concepts, answer questions, provide high-level guidance, and review deliverables before submission, the students must design, manufacture, and operate the system on their own and must produce all deliverables on their own.

3.7. Safety Pilot

The Safety Pilot used during the year can be a student, the adviser, or non-student. The Safety Pilot must complete The Recreational UAS Safety Test (TRUST) and present the certificate of completion at safety inspection and at the flight line. While the UAS occupies the runway or airspace, the Safety Pilot must not have any other roles and must maintain continuous unaided visual line of sight with the vehicle (no FPV). If the Safety Pilot performs any other tasks during mission time, the mission will be terminated. The Safety Pilot counts as one of the members of the competition team. If the pilot is not a member of the development team, then the pilot is limited to safety related functions and communication, and must not advise or participate in other roles.

3.8. GCS Operator

The Ground Control Station (GCS) operator is responsible for operating the autopilot including setting parameters, uploading mission objectives like waypoints, monitoring for performance and compliance, and intervening as necessary. While the UAS occupies the runway or airspace, the GCS Operator must not have any other roles and must maintain situational awareness of the UAS, the autopilot subsystem, and the ground control station. For example, the GCS Operator cannot operate payloads (e.g. cameras, ODLC review, air drop). If the GCS Operator performs any other tasks during mission time, the mission will be terminated. The GCS Operator counts as one of the members of the competition team.

3.9. Competition Guests

Each team will be allowed to bring additional guests to competition. If desired, these guests may be development team members, but they cannot assist with the mission demonstration. These guests must purchase tickets for access to the competition and awards banquet, and have the option to purchase add-ons for on-site food and a t-shirt. There are a limited number of tickets, food, and t-shirts, which will be distributed first-come-first-served.

4. Technical Requirements

4.1. General Aircraft Restrictions

The team may only fly a single aircraft during the mission. The aircraft must be capable of heavier-than-air flight, and be free flying without any encumbrances like tethers. The max takeoff weight is 55lbs. The UAS must have autonomous flight capabilities to compete.

4.2. Single Design and Backup Instances

The team must use exactly one design throughout the competition. Teams are locked into a specific design upon submission of the Flight Readiness Review. The team may use backup instances of that design during development. The team must use exactly one instance during the Mission Demonstration.

4.3. FAA Vehicle Registration

The vehicle used at competition must be registered using the FAADroneZone, the certificate must be presented at safety inspection and at the flight line, and an external surface of the vehicle must be labeled with the registration number.

4.4. FAA TRUST

The Safety Pilot must complete The Recreational UAS Safety Test (TRUST) and present the certificate of completion at safety inspection and at the flight line.

4.5. FAA Remote ID

The vehicle used at competition must comply with FAA Remote Identification for Drone Pilots (Remote ID). At a minimum, the Remote ID broadcast must include a unique ID for the vehicle and the vehicle position. The broadcast will be verified at safety inspection.

4.6. AMA Safety Code

The aircraft must comply with the AMA Model Aircraft Safety Code except that autonomous operation is authorized at competition, and both free flight and control line are not applicable.

4.7. No Personnel Near Prop Arc When Powered

Personnel must be clear of the propeller arc whenever the motors have the ability to receive power. For example, if the batteries powering the electric motor are connected, personnel are not allowed to be near the prop arc. Software based disarm is not sufficient. Propeller power must be disconnected in order to physically work on the UAS. Teams violating this safety rule may be disqualified.

4.8. Fuel and Batteries

Exotic fuels or batteries will not be allowed. Any option deemed by the organizers as high risk will be denied. All batteries must be brightly colored for identification in a crash, and it is preferred if they are wrapped in bright colored tape. More information detailed in B. Battery/Fuel Guidelines.

4.9. Fasteners

All fasteners must have either safety wire, loctite (fluid), or nylon nuts.

4.10. No Foreign Object Debris

No pieces may depart from the aircraft while in flight, except for the components involved in air drop while attempting that task. Foreign object debris (FOD), like nuts and bolts, must be cleared from the operating area before mission flight time stops.

4.11. Return to Home and Flight Termination Failsafes

The UAS must have either autonomous return to home (RTH) or return to land (RTL), and autonomous flight termination. Both must be activatable by either the Safety Pilot or the GCS Operator. After 30 seconds of communications loss, the aircraft must automatically RTH or RTL. After 3 minutes of communication loss, the aircraft must automatically terminate flight. For fixed wing aircraft, flight termination must be: throttle closed, full up elevator, full right rudder, full right or left aileron, and full flaps down (if equipped). For non fixed wing aircraft, throttle must be closed and all actuators off. The termination system must be designed to touch ground within 500ft over ground of the termination point. The following must be the configured lost comms RTH/RTL and flight termination point.

38.315339, -76.548108

4.12. Mission Flight Boundary

The following are a series of GPS points which form a polygon that is the mission flight boundary (shown via red line in photo). The UAS must remain within this polygon and the altitude restrictions of [75ft AGL (217ft MSL), 400ft AGL (542ft MSL)]. The UAS may only go below 75ft AGL when taking off or landing, but must not go below 75ft AGL when over one of the other runways occupied by other teams. The UAS is out of bounds if it's outside of the polygon or the altitude restrictions, at which point the mission will be terminated. Please refer to A. Flight Area Overview for a detailed view of the mission flight boundary.

38.31729702009844, -76.55617670782419
38.31594832826572, -76.55657341657302
38.31546739500083, -76.55376201277696
38.31470980862425, -76.54936361414539
38.31424154692598, -76.54662761646904
38.31369801280048, -76.54342380058223
38.31331079191371, -76.54109648475954
38.31529941346197, -76.54052104837133
38.31587643291039, -76.54361305817427
38.31861642463319, -76.54538594175376
38.31862683616554, -76.55206138505936
38.31703471119464, -76.55244787859773
38.31674255749409, -76.55294546866578
38.31729702009844, -76.55617670782419

4.13. Runways for VTOL and HTOL

To support multiple teams flying at the same time, there will be three independent runways performing missions simultaneously. One runway supports only aircraft which vertically takeoff and land (VTOL), and two runways can support either VTOL or horizontal takeoff and landing (HTOL, e.g. fixed wing). Teams will be assigned a runway based on the properties of the aircraft. The runways are paved asphalt. The

VTOL runway is approximately 70ft by 75ft, whereas the HTOL runways are approximately 70ft by 600ft. Teams may also use the grass sections adjacent to their assigned runways for takeoff and landing, on the opposite side from the tents, so long as flight paths don't intersect the other runways or the flight line tents. Please refer to A. Flight Area Overview for a detailed view of the runway setup.

4.14. Flight Performance Requirements

The following are minimum requirements for UAS flight performance:

- Fly 5 miles at fully loaded weight in a single flight
- Fly waypoints with a max error of 25ft, and the threshold must be configured in the autopilot
- Turn radius of 150ft and be able to stay within the Mission Flight Boundary
- Angle of climb and angle of descent of 20 degrees
- Stay above 75ft AGL when more than 200ft away from the runway
- For vertical takeoff and landing (VTOL), able to use a runway approximately 70ft by 75ft
- For horizontal takeoff and landing (HTOL), able to use a runway approximately 70ft by 600ft

4.15. Ground Control Station (GCS) Display Requirements

Teams must have a display, always viewable by the judges, which shows a map showing the flight boundaries, the UAS position, and all other competition elements. This display must indicate the UAS speed in KIAS or ground speed in knots, and MSL altitude in feet. Teams will not be able to fly without this display. If during the mission the judges are unable to see this display, teams will be required to return to land.

4.16. Safety Material

Teams must have available personal protective equipment (PPE) (tools, gloves, eye protection, hearing protection, etc.), safety risk mitigation (training, checklists, radios, etc.) and equipment to support rapid response to accidents (first aid kit, fire extinguisher, etc.) as needed.

4.17. Onsite Operation of Safety Functionality

The safety functionality must be operated using onsite systems with no dependency on any system not under the team's full control. For example, safety critical functionality cannot have a dependency on the public internet or public cloud providers. Safety critical functionality includes, but is not limited to, return to land and flight termination, manual piloting by the Safety Pilot, commanding the autopilot by the GCS Operator, and failsafe for the air drop.

4.18. No Objects Taller Than 15ft

No antenna masts, balloons, or other objects taller than 15ft will be permitted.

4.19. No Ground-Based Imaging Sensors

No ground based imaging sensors can be used as a replacement for an UAS imaging payload.

4.20. Transport via Flatbed Trailers

The UAS and ground station will be transported from the pits to the flight line via flatbed trailers operated by competition staff. Teams must be able to move equipment from the pit tables to the nearby trailer, from the trailer to the flight-line tent, and back.

4.21. Allowed RF Bands and Management

All RF communications must comply with FCC regulations. Any bands allowed by FCC regulations may be used at competition. Judges use 462 MHz for handheld radios.

The judges will not provide any RF spectrum management. This means that any device can be used in any of the allowed bands at any time. This includes both the flight line and the pits. Teams are encouraged to use hardwired connections when possible. Where possible, teams should use encryption, directional antennas, and RF filters. Each team should expect other teams to be using similar equipment (e.g. same autopilot), and teams must ensure they don't allow invalid connections (e.g. connecting to another team's autopilot). Where possible, teams should use frequency hopping or dynamic channel selection. The judges reserve the right to institute RF management if necessary, but teams may not rely on such.

Teams found intentionally jamming or interfering with another team's communications will be considered cheating.

4.22. Weather and Environmental Factors

There is one physical runway divided into multiple logical runways. The organizers will temporarily suspend the competition if environmental conditions are deemed unsafe. Teams must be able to secure equipment against sudden weather like wind and rain.

The aircraft must be able to operate in any winds experienced at the airfield. Average wind speeds in California, MD in June is ~8 mph, and the record high is 24.2 mph. Systems must be able to operate in temperatures up to 110 degrees Fahrenheit.

Teams will not have to operate during precipitation, but they must be prepared to quickly secure their equipment from sudden precipitation. Fog conditions are acceptable if there is at least 2 miles of visibility. In the event of lightning, teams will be asked to return to their vehicles in the parking lot until the lightning has passed.

4.23. Provisions

The competition will provide the team with a tent for shade, a folding table and chairs, and a single electrical power extension cord from a mobile generator. The competition does not provide internet access.

Teams will be provided a single electrical power cord coming from a mobile generator. The electrical power provided will be 115 VAC, 60 Hz, rated up to 15 amperes. This may not be enough for some ground stations, so teams may need to bring additional generators. There is a possibility the mobile generator may run out of gas at any time during the competition and not be refilled and restarted for some undetermined period of time. Teams must be capable of operating without competition provided electrical power for up to 10 minutes. Teams should use UPS battery backups to mitigate periods without generator power.

4.24. Airfield Notes

Airfield GPS coordinates are 38.31633, -76.55578. Airfield elevation is 142 feet MSL. Airfield magnetic variation is 11 degrees west. The runway is a paved asphalt surface roughly 70 feet wide with no height obstacles. Grass areas within the takeoff/landing area will not be prepared but will be available for use
The airfield and flight boundary includes areas which contain trees that may be taller than 75ft AGL. The Maryland record for tree height is ~140ft (182ft MSL at the airfield). Teams should consider this when setting waypoints over trees.

5. Mission Demonstration (70%)

This section describes the mission demonstration that will be conducted by the team at competition. The demonstration is worth 70% of the total score for the competition.

To receive any points for the mission, teams must get points for the air drop. For example, a team which never flies or only completes waypoints will receive no points for the entire mission demonstration.

5.1. Order of Team Demonstrations

The judges will score all deliverables due before the mission demonstration and produce an initial ranking. Teams will be flown in order of their initial ranking, but the top 10 will be randomly shuffled. Teams will not be notified of the flight order in advance. The judges will attempt to fly as many teams as possible, but if time runs out (e.g. due to weather delays) the teams with lowest initial ranking will not have the opportunity to fly. If there is extra time then the top 10 teams, by total score inclusive of the first mission demonstration, may have the opportunity to fly a second mission in random flight order. The better of the two demonstrations will count.

5.2. Judges

The lead judge stands with the Safety Pilot. The Ground Control Station (GCS) judge sits with the GCS Operator and must have continuous uninterrupted access to a GCS display meeting the GCS Display Requirements.

5.3. Order of Tasking

Teams must successfully takeoff and go above 75ft AGL (217ft MSL) within the first 10 minutes of the mission clock, or the demonstration will be terminated. Upon every takeoff, teams must immediately fly a waypoint lap before attempting other tasks, thereby simulating the trip to the operation area. After the waypoint lap, teams may decide the order of all other tasks.

5.4. Termination and Disqualification

Breaking the rules, risking safety, and accumulating too many penalties may cause mission termination and may cause disqualification.

5.5. Timeline (10%)

UAS must be able to fly missions in a restricted time scenario. This involves setting up the UAS, flying the mission, and tearing down within provided time limits.

The *Timeline* task will be scored via the following equation - where *X* signifies the mission time in seconds and *T* signifies the boolean (0 or 1) use of a timeout:

$$max(0, \frac{1800-X-360T}{1800})$$

If a team breaches the 30 minute mission clock, they will incur large Excess Time penalties.

5.5.1. Setup Time (15 Minutes)

Teams will be provided at least 15 minutes for setup. At setup time teams will receive all other mission details (such as waypoints) from the judges by paper printout. GPS positions will be given in decimal degrees, and altitudes in feet MSL. The last 5 minutes of the setup time must include the pre-mission brief. This brief must include a summary of planned tasks, identification of Safety Pilot and GCS Operator, and other information judges should know. Once the judges determine the airspace is available and the setup time has elapsed, the judges will start the mission time regardless of team readiness.

5.5.2. Mission Time (30 Minutes)

Teams will be provided 30 minutes to complete the mission. Mission time stops once the UAS has landed, the UAS has cleared the runway, and the team relinquishes the airspace. Exceeding the 30 minute mission time will result in large Excess Time penalties.

5.5.3. Teardown Time (10 Minutes)

Teams will be provided 10 minutes to remove all equipment from the flight line tent area.

5.5.4. Timeout (10 Minutes)

A team is allowed one timeout to stop the mission clock, which will cost them the points described in 5.5. Timeline. The timeout must be taken prior to the aircraft capturing its first waypoint. The timeout will last at least ten minutes.

5.5.5. Air Traffic or Weather Mission Pause

In the event that traffic enters the mission airspace or weather becomes unsafe for flight, the mission will be paused at the point the team is notified and the UAS will be required to return to land until the traffic clears the airspace. Teams will be given a penalty-free timeout of at least 5 minutes during which they are permitted to refuel but not otherwise modify the aircraft or process data. Once the airspace is clear the UAS will takeoff, return to the position at which the mission was interrupted, and then the mission will resume from that point.

5.6. Operators (30%)

UAS that can fly autonomously are cheaper to operate, which means organizations can leverage more UAS at the same cost, which means better performance and more missions. Autonomy also keeps the UAS airborne during connectivity loss, a very likely occurrence in real world environments. Autonomy is measured by the number of operators from the competition team needed to run a mission.

The team must have a Safety Pilot and a GCS Operator who are dedicated to manual flight override and autopilot operation respectively. The Safety Pilot and GCS Operator cannot perform any other tasks during the mission. If the Safety Pilot or GCS Operator performs other tasks, the mission will be terminated.

Competition team members who don't have an operator role can only assist with setup, teardown, and during a timeout. During the mission they must stand to the side, not communicate or assist the operators, and observe only. Teams must decide ahead of the mission who is an operator and who is an

observer, these assignments cannot be changed once the mission starts, and must communicate the assignments to the judges ahead of the mission.

The *Operators* task will be scored via the following equation - where *O* signifies the number of operators used. As described below, at least two operators fulfilling the Safety Pilot and GCS Operator roles are required.

$$min(100, \frac{8-O}{6})$$

5.7. Autonomous Flight

UAS that can fly autonomously are cheaper to operate, which means organizations can leverage more UAS at the same cost, which means better performance and more missions. Autonomy also keeps the UAS airborne during connectivity loss, a very likely occurrence in real world environments.

5.7.1. Obstacle Avoidance

Multiple UASs will be flying at the same time during the demonstration in a shared airspace. These UASs will be operated by independent teams which will not be in communication. Teams must avoid other aircraft.

5.7.2. Takeoff and Landing

Takeoff and landing may be performed autonomously or manually.

5.7.3. Waypoints

Teams will be given a sequence of waypoints (GPS positions and altitudes) that must be flown autonomously and the UAS must get within 25ft of each waypoint. This sequence of waypoints represents a singular lap, may be up to 3 miles in length, and include up to 10 positions. Upon every takeoff, teams must immediately fly a singular lap of the waypoint path before attempting other tasks to simulate navigating to the operating area. A full lap must be reflown between each air drop attempt, simulating trips between operating areas. Teams may opt to land at any point to reload payloads or refuel their UAS, so long that the UAS navigates through an entire waypoint lap after each subsequent takeoff. Five full waypoint laps will be required to conduct all five deliveries, thus the total distance flown by the UAS may be up to 15 miles.

An example of a mission flow that conducts four air drops with an intermediary landing for reload and refuel would be as follows:

- Takeoff
- Fly Waypoint Lap (Up to 3 Miles)
- Conduct Air Drop
- Fly Waypoint Lap (Up to 3 Miles)
- Conduct Air Drop
- Land to Re-Load Payloads and Refuel UAS
- Takeoff
- Fly Waypoint Lap (Up to 3 Miles)

- Conduct Air Drop
- Fly Waypoint Lap (Up to 3 Miles)
- Conduct Air Drop
- Land
- Remove UAS from Runway Relinquish Airspace

5.8. Air Drop (50%)

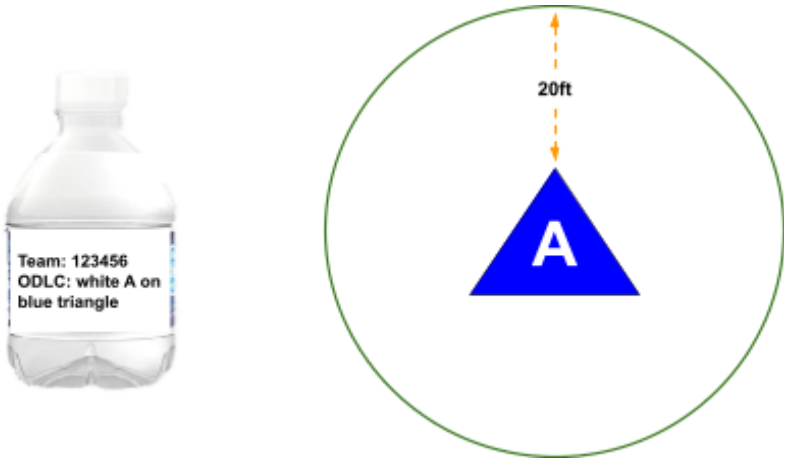
UAS should be able to air drop a payload at a specified position. As with all other mission elements, the UAS must remain above the 75' AGL minimum altitude fence while conducting air drop.

Teams will be given 5 air drop objects at Setup Time. Each air drop object will be a standard 8oz water bottle (example) that will be labeled by the judges with an identifier for the team and a description of the ODLC object that the drop object should be delivered to.

UAS may carry multiple air drop payloads at the same time, or they can land to pick up payloads. The UAS must refly a full waypoint lap before performing another air drop, regardless of whether the UAS lands or not.

Judges may be in the Air Drop Boundary to score the drops, and the ground may be marked to identify the 20ft drop target radius. The objects marking drop targets may be temporarily occluded while judges evaluate drops from another team and clear any debris.

An attempted delivery is classified by any payload that is released by an aircraft in flight, with no dependency on the success of the attempted delivery. Delivered payloads must meet all of the Delivery Requirements to be deemed a successful drop. The air drop score is the ratio of successful drops to total objects (5).



8oz Water Bottle (Left) and Aerial View of ODLC Drop Target and Acceptance Radius (Right)

5.8.1. Air Drop Boundary

The following are a series of GPS points which form a polygon that is the Air Drop Boundary. The ODLC objects will be somewhere within this boundary. The boundary is approximately

70ft by 360ft. Please refer to A. Flight Area Overview for a view of the Air Drop Boundary on Google Maps.

38.31442311312976, -76.54522971451763
38.31421041772561, -76.54400246436776
38.31440703962630, -76.54394394383165
38.31461622313521, -76.54516993186949
38.31442311312976, -76.54522971451763

5.8.2. Delivery Requirements

Each independent air drop payload must be no heavier than 3lbs and must not contain any ability to sustain flight (propulsion, propellers, etc.). The air drop payload must land undamaged and must be safe for humans to be present in the drop area. The payload must be safe to retrieve and safe to handle. Payloads that are delivered in freefall, with no form of retardant mechanism, will not be deemed successful. If the UAS were to drop multiple water bottles at once, only the first dropped bottle will be scored appropriately.

An air drop is considered successful if an undamaged drop object lands and stays within 20ft of the ODLC object matching the air drop object's label.

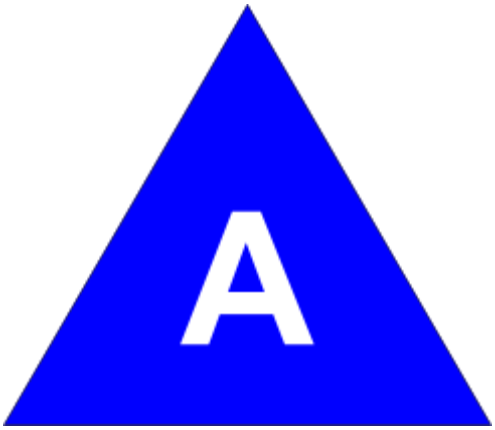
Judges must be able to safely and easily retrieve and separate the air drop object from the air drop payload to verify whether it's undamaged and whether the object label matches the drop location. Separation must not require tools or any instructions. If the judge is unable to separate the air drop object, then the drop will not count.

5.8.3. Object Detection, Classification, and Localization

The delivery location for each payload will be marked by a visible object. Teams must detect, classify, and localize two types of objects: standard and emergent. Each object is located in the Air Drop Boundary and marks the target for each independent drop. A standard object will be a colored alphanumeric (uppercase letter or number) on a colored shape. The standard object will be printed onto 8.5" x 11" paper, cut out, and secured to the ground (e.g. with cardboard backing and tape). The emergent object is a manikin dressed in clothes. There will be at most one emergent object.

Valid shapes for the standard object include: circle, semicircle, quarter circle, triangle, rectangle, pentagon, star, and cross.

Valid colors include: white, black, red, blue, green, purple, brown, and orange.



Standard object (left; white A on blue triangle) and Emergent object (right; manikin dressed in clothes)

5.9. Operational Excellence (10%)

Operational excellence will be graded by the judges as a subjective measure of team performance. This will evaluate things like operation professionalism, communication between members, reaction to system failures, attention to safety, and more.

5.10. Penalties (Unlimited)

The team will be penalized as follows throughout the mission demonstration. Penalties are defined as a percentage of achievable component points. Unlike points, penalties do not have a bound. This means going over the allowed time can cost the team full points for mission demonstration. If penalties are greater than points, the team will receive a zero for demonstration. Teams cannot score points while generating a penalty.

5.10.1. Excess Time (0.5% Per Second)

The team will receive a penalty equal to 0.5% of demonstration points for every second of mission time over limits.

5.10.2. Things Fall Off Aircraft (10% Per Item)

If parts fall off the UAS during flight, teams receive a penalty equal to 10% of demonstration points.

5.10.3. Crash (50% Per Crash)

If the UAS crashes during flight, teams will receive a penalty equal to 50% of demonstration points.

5.10.4. Collision with Other UAS (50% Per Collision)

If the UAS collides with another team's UAS, both teams will receive a penalty equal to 50% of demonstration points. If a team is in their runway's dedicated airspace, then they will not receive a penalty for the collision, and only the offending team will receive a penalty.

5.10.5. Out of Bounds (Mission Termination)

Teams are given a flight boundary in the Mission Flight Boundary. If the UAS goes out of these bounds then the mission will be terminated and the UAS will be required to immediately return to land. Teams will be evaluated by human observers and by judges at the GCS.

5.10.6. Manual Takeover (Return to Land)

With exception to takeoff or landing, the aircraft must fly the rest of the mission autonomously. Any transition to manual flight will require the aircraft to return to land. If the aircraft takes off again, the aircraft must fly the waypoint path again before attempting other tasks. This penalty will indirectly cost timeline points.

6. Technical Design and Flight Readiness Review (30%)

Teams must submit a video presentation covering their Technical Design and Flight Readiness. Judges will review this presentation to determine whether teams are ready enough to attend competition, and may disqualify unprepared teams. The submitted video presentation must meet the following requirements:

- Maximum length of 20 minutes
- 16:9 aspect ratio and at least 1080p resolution
- At least 24 frames per second
- Early video visual must show school and team name
- Hosted on YouTube*

**If your team cannot access YouTube, please contact autonomy@robonation.org for proper instruction.*

The *Technical Design and Flight Readiness Review* will be scored via the percentages shown alongside each section. Late submission or additional modifications past the deadline of the *Technical Design and Flight Readiness Review* will result in the following penalties/deductions:

Up to 6 Hours Late	-10% Penalty
Up to 24 Hours Late	-50% Penalty
Up to 48 Hours Late	-90% Penalty
Beyond 48 Hours Late	Disqualification

6.1. Introduction (5%)

This section must include a visual and verbal identification of the School and Team name. The entire development team and an introduction to the competition team (name, experience, role) must also be given.

6.2. Requirements and Acceptance Criteria (5%)

This section should show how the team analyzed the competition requirements and developed acceptance criteria for the system and its components. For example, the team may infer from the timeline and flight tasks that the UAS must have a specific minimum flight time and speed to achieve full points.

6.3. System Overview (5%)

This subsection should give an overview of the entire system and how it's operated by the team.

6.4. Imaging/ODLC Design and Testing (10%)

This section should identify the camera used by the UAS and detailed analysis to demonstrate that the chosen camera can resolve objects of the size required by the competition, alongside the team's strategy for ensuring optimal image quality. This section should also include a description of the ODLC system including any image processing algorithms or techniques used should also be given. An overview of tests performed on the imaging & ODLC subsystem and performance observed should also be given. Statistics such as the average resolution of the objects in the images should be clearly presented.

6.5. Air Drop Design and Testing (10%)

This section should describe the payload and mechanism used to drop the payload. Furthermore, it should describe the approach used to determine optimal drop time. A detailed overview of the tests performed on the air drop subsystem and performance observed should also be given. Statistics such as number of air drop attempts, air drop success rate, and the 90th percentile distance from the target the payload landed should be clearly presented.

6.6. Communications Design and Testing (10%)

This section should describe the hardware used for communication between the aircraft and ground, and between systems on the ground. It should list the frequencies used and for each, identify the type of data that is sent, and expected performance (range, throughput, etc.). An overview of the tests performed on the communications subsystem and performance observed should also be given. Statistics such as tested range, throughput, and packet loss statistics for all radio communication should be clearly presented alongside a block diagram of the communications subsystem.

6.7. Aircraft Design and Testing (10%)

This section should provide an overview of the design/fabrication of the airframe and all control surfaces, while also providing an overview of aircraft's aerodynamics and propulsion systems. All tests performed on the aircraft and the performance observed (as compared to the Flight Performance Requirements) should also be discussed. A labeled diagram of the aircraft and table containing all relevant metrics (such as number of flights and flight hours) should also be shown/described.

6.8. Autopilot Design and Testing (10%)

This subsection should identify the autopilot used by the UAS and describe its capabilities in regards to how they map to the competition tasks. An overview of the tests performed on the autopilot and performance observed should also be given. Statistics such as number of autonomous flights, average amount of time spent in manual mode per flight, number of waypoints attempted, the number of waypoints hit, and the average waypoint miss error should be clearly presented.

6.9. Obstacle Avoidance Design and Testing (10%)

This section should describe the algorithm(s) used to update the flight plan so as to avoid obstacles. It should also describe the tests conducted to verify obstacle avoidance and performance observed.

6.10. Alternatives Considered (5%)

This section should describe the alternative design choices which were considered but not selected, and the rationale for not selecting these alternatives. For example, the team may not have chosen a specific alternative because it didn't meet the acceptance criteria or was more costly than the selected option.

6.11. Safety, Risks, and Mitigations (5%)

This section should describe the potential safety risks and the steps taken to mitigate them. It should include risks during the development process and during the mission.

6.12. Full Mission Testing (5%)

This section should describe full mission testing with the competition UAS and the competition team which will operate it. The subsection should describe in detail the mission tests conducted by the team and use the results to provide evidence that the system is capable of competing. Statistics regarding scores from each full mission test, the average across all tests, and the expected performance should be clearly presented.

6.13. Proof of Flight (5%)

This section must show the flights with the following characteristics. Teams may speedup sections of the video (e.g. show at 4x speed) to save time, but must show at normal speed when showing critical moments (e.g. UAS reaches 1000ft from pilot). There must be videos for each instance of the aircraft (e.g. primary and backup), and every Safety Pilot that may be used at competition. Each flight video must be visually labeled with the Safety Pilot's name and the aircraft's identifier. **Insufficient Proof of Safe Flight will immediately yield disqualification.**

Required flights per aircraft instance and Safety Pilot:

1. Manual flight showing takeoff, getting 1000ft from the Safety Pilot, and landing.
2. Autonomous flight, getting 200ft from the Safety Pilot, a transition to manual mode, and manual landing.
3. Autonomous flight showing the system can meet all Flight Performance Requirements, with takeoff and landing that is either autonomous or manual.

6.14. Summary (5%)

This section should summarize the entire presentation.

7. Awards

This section describes the awards given to teams at the competition. Teams must be present to collect their awards, and award money will be issued within 4-6 weeks after the competition.

7.1. Overall Ranking

Trophies and plaques will be awarded to the teams which ranked first, second, and third. Plaques will be awarded to the teams which ranked fourth and fifth. The top 5 teams will receive award money.

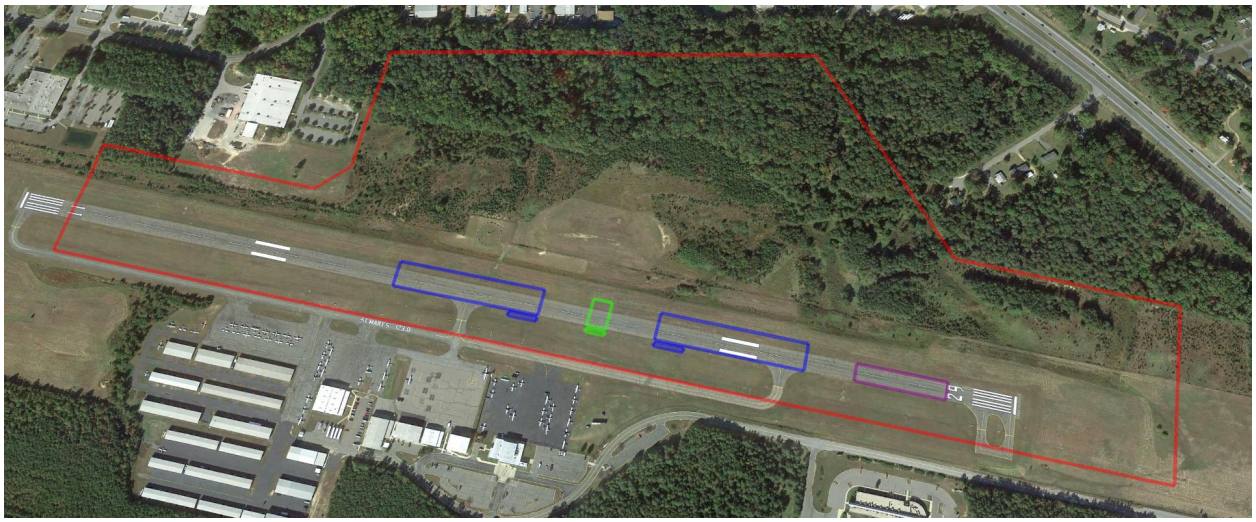
7.2. Best in Class

There are two awards for best in class: Best in Technical Design & Flight Readiness, and Best in Mission. For each best in class award received, the team will receive a plaque and award money.

7.3. Special Awards

A single team will be selected for each special award. For each special award received, the team will receive a plaque and award money. The special awards are Dawn Jaeger Tenacity Award, Dr. Arthur Reyes Safety Award, JustJoe Sportsmanship Award, and Most Innovative Award.

A. Flight Area Overview



Red: Mission Flight Boundary
Purple: Air Drop Boundary
Blue: HTOL Runways
Green: VTOL Runway

B. Battery/Fuel Guidelines

Teams are required to understand and follow battery/fuel safety best practices based on the battery/fuel chemistry selected by the team. For questions or assistance, please contact Cheri Koch at ckoch@robonation.org / 850-642-0536.

BATTERIES

All batteries can become a hazard if not handled properly. Lithium-ion chemistry batteries may become damaged and create a hazard if misused/abused, representing the greatest risk to people, facilities, and the environment. The following safety rules and requirements must be followed:

1. Teams must submit battery specifications, Material Safety Data Sheets (MSDS), and proper disposal procedures, sourced from the battery manufacturer for all batteries.
2. Teams must keep a hard copy of the battery safety documentation for all batteries on-site at all times.
3. Teams must bring a LiPo safe bag(s) adequate for the lithium batteries used.
4. Each team must understand and follow their own country's regulations as well as those of the host nation.
5. All batteries must be stored, used, and maintained in accordance with manufacturer guidelines.
6. Teams are required to inspect their batteries daily for signs of swelling, heat, leaking, venting, burning or any other irregularities. Lithium batteries that become too warm during use or have become swollen or malformed must be removed from use and reported to the Technical Director or RoboNation.
7. Lithium batteries that do not hold a charge must be removed from use and reported to the Technical Director.
8. A team member must be present at all times to monitor charging batteries.
9. At the competition site, if any of the above battery conditions are observed students must immediately notify the Technical Director or RoboNation and provide the battery specifications and safety information.
10. Failed or failing Lithium-ion batteries must be handled in accordance with manufacturer's safety and disposal guidelines. In the absence of specific guidelines, batteries must be placed in a LiPo safe bag, which must then be placed in a bucket, covered with sand, and placed in a designated safety zone.

FUEL

1. Only use approved containers for fuel storage and handling.
2. Store flammable liquids in well-ventilated areas and away from heat.
3. Don't store more flammable liquid than is needed for 1 day's operation.
4. Always power off equipment while refueling.
5. Teams must provide their own fuel specific spill kit in the event of a fuel spill.
6. Ensure that fuel caps remain properly closed whenever not actively refueling.
7. No smoking is allowed.

C. Suggested Developmental Milestones

The following are a suggested (optional) set of developmental milestones for new teams to be competitive at the competition. Once an initial system is operational, teams may want to follow an Agile process instead.

Target Date	Milestone
October 1st	Competitive Analysis Complete ● Review of past rules to understand evolution ● Review of past designs from other teams based on published deliverables ● Review of current rules for latest requirements Technical Design Complete ● Mission requirements analysis ● Competitive strategy ● System design ● Component design ● Integration design ● Test & evaluation plan ● Safety, risks, and mitigation ● Developmental milestones & schedule
November 15th	Components Initial Version ● Required hardware and software licenses ordered and delivered ● Aircraft manufactured / assembled ● Code complete for MVP features ● Ready to begin testing of all components
December 15th	Components Complete ● Manual flights on aircraft, empty and loaded to simulate gross weight ● Ground testing for networking, imaging, air drop mechanism, etc. ● Plans developed to iterate based on lessons learned from component testing
March 1st	Integration Initial Version ● Autonomous flights on aircraft, empty and loaded for gross weight ● Networking, imaging, air drop, etc from the UAS
April 1st	Integration Complete ● Complete end-to-end mission demonstration ● Plans developed to iterate based on lessons learned from integration testing ● Backup instances manufactured to mitigate failures
May 1st	Prepared for Competition ● Multiple simulated mission demonstrations ● Plans and checklists for packing, setup, mission operation, and teardown ● Operator training and practicing to maximize human performance ● Completion of deliverables

D. Change Log

Version	Release	Change Log
2024.01	14 Sep 2023	SUAS 2024 initial rules release. Compared to SUAS 2023: Overall: ● Transition to RoboNation ● Split Requirements into Logistical and Technical Requirements Schedule & Deliverables: ● Migrated registration to new platform: robonation.smapply.org ● Updated Deadlines ● Converted Competition Dates into Table Format ● Removed assigned times for teams during Check-In ● Changed Remote Orientation to In-Person Orientation Logistical Requirements: ● Migrated from Google Groups to RoboNation Discord Technical Requirements: ● Added FAA Remote ID Requirement That Broadcasts ID/Position ● Reduced Flight Performance Distance Requirement to 5mi (From 12mi) Mission Demonstration: ● Updated Flight Order Randomization and Second Flights to Top 10 Teams ● Reduced Required Waypoint Distance to 3mi (From 10mi) ● Limited Waypoint Path To Be Up to 10 Points (For Easier Data Entry) ● Added UAS Must Re-Fly Waypoints Between Drops (Laps) ● Reduced Air Drop Payload to 8oz Water Bottle (From 16oz) ● Reduced Air Drop Max Payload Weight to 3lb (From 5lb) ● Increased Air Drop Radius to 20ft (From 15ft). ● Clarified Air Drop Must Land and Stay Within Drop Radius to Count ● Updated the Air Drop Payload Must Land Undamaged (From Gentle) ● Merged ODLC Section with Air Drop To Reflect Task Merging ● Decreased Valid Sets of Colors/Shapes for ODLC Technical Design & Flight Readiness Review: ● Clarified Proof of Safe Flight Requirements ● Combined Design and Testing Sections Appendix: ● Re-Organized Appendix ● Added Appendix B. Battery/Fuel Guidelines ● Removed Seafarer Mailing Address ● Moved Map's View Depicting Flight Boundaries and Runways
2024.02	25 Sep 2023	Logistical Requirements: ● Allow for 20% Graduate Student Team Composition (Instead of Only 1) ● Remove maximum number of guests per team (Competition Guests) Technical Requirements:

		● Corrected RTL/RTH Point Coordinates (Typo in 2024.01) Appendix: ● Removed Need for Internal Cell Balancing from B. Battery/Fuel Guidelines ● Removed Restriction on Battery Swapping Only in Flight Village from B. Battery/Fuel Guidelines