

# SUAS 2023 Rules

by the Seafarer Chapter  
[suas-competition.org](https://suas-competition.org)

This document contains the rules for the 21st 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 Technical Design and Flight Readiness Review Presentation, and the 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 20th to 22nd, 2023.

**2023 Mission.** Multiple package delivery companies have tasked Unmanned Aerial System (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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# Terms & Conditions

## Liability & Media Release

By registering for the competition you waive, release, and forever discharge Seafarer Chapter, Inc and its affiliates, employees, directors, contractors, sponsors, volunteers, and assigns from any and all liability, claims, demands, and causes of action whatsoever, including bodily injury resulting from SUAS or anyone administering emergency assistance, and including risk of loss or damage to personal property to me or other participants, arising out of my presence at or participation in SUAS, whether it results from negligence or any other cause.

By registering for the competition you assign and grant Seafarer Chapter, Inc and its affiliates, employees, directors, contractors, sponsors, volunteers, and assigns the right and permission to use and publish the deliverables, documents, photographs, video, audio, and other electronic representations resulting from participation in SUAS, and release them from any and all liability from such use and publication.

By registering for the competition, you agree to the terms of the waiver and acknowledge that attendance onsite at competition requires completing Personnel Registration and signing the waiver.

Waiver: [suas-competition.org/s/suas-waiver.pdf](https://suas-competition.org/s/suas-waiver.pdf)

## 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.

## Passports & 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.

## Spirit of Competition

The judges expect teams 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.

## Rules Subject to Change

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

# Schedule & Deliverables

This section describes the schedule of events and deliverable due dates.

## Rules & Registration

### Rules Published (September 15th, 2022)

Rules will be posted to the competition website. Judges may make changes after this date as necessary.

### Team Registration (October 1st to November 1st, 2022)

During this period, the team captain can register to compete on the competition's website, [suas-competition.org](https://suas-competition.org). The registration fee is \$1,500 USD and is paid by credit card as part of registration. 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.

Registration: [suas-competition.org/store/suas-registration](https://suas-competition.org/store/suas-registration)

## Visa Invitation Letters

If you are a foreign national and need invitation letters to apply for a visa, you can use the following form to request one. A valid passport is required to request an invitation letter. Invitation letters will be processed in batches following the due dates below, and can take up to 2 weeks to generate after the deadline. 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.

Visa Invitation Form: [forms.gle/NHm1AR1DDH2znPbVA](https://forms.gle/NHm1AR1DDH2znPbVA)

### Standard Letters (November 10th, 2022)

Following registration, teams should immediately request visa invitation letters for attendees which need one. You should submit the advisor and all competition team members to this batch.

### Late Letters (January 15th, 2023)

An additional late opportunity for invitation letters is provided for those who could not submit by the standard deadline. After this deadline, no additional invitation letters will be generated.

# Presentation, Fact Sheet, Personnel Registration

## Technical Design & Flight Readiness Review (May 1st, 2023)

The [Technical Design & Flight Readiness Review](#) is a video presentation detailing the technical design, testing, and preparedness. Please see the section describing this deliverable for the details.

Technical Design & Flight Readiness Review Form: [goo.gl/forms/u3QEOoJBfcfVgKyW2](https://goo.gl/forms/u3QEOoJBfcfVgKyW2)

## Fact Sheet (May 1st, 2023)

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.

Fact Sheet Form: [goo.gl/forms/YH4b2X1pPPeEGfr52](https://goo.gl/forms/YH4b2X1pPPeEGfr52)

## Personnel Registration (May 10th, 2023)

Everyone who may be in attendance must submit the following form. 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.

Personnel Registration Form: [goo.gl/forms/lwHdcmDdjCS0VcRP2](https://goo.gl/forms/lwHdcmDdjCS0VcRP2)

# Competition

## Remote Orientation (June 18th, 2023)

Teams will be sent orientation details via the Google Groups containing important instructions for the competition event. Teams may be sent additional instructions via the Google Groups during the event.

## Travel Arrival (June 19th, 2023 or earlier)

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 competition.

## Day 1 (June 20th, 2023)

### Arrival & Check-In (7am - 8am)

Teams will arrive at [St. Mary's County Regional Airport \(2W6\)](#) at this time. Each team will be given a specific time via the Google Groups to stagger arrival. Teams which fail to arrive on time may be denied entry, and teams which leave may be denied reentry.



The teams will check-in to fill out forms, complete other logistical tasks, receive meal tickets, and have the option to purchase additional meal tickets (cash only). All attendees must be present. Teams which fail to check-in may be disqualified. Unexpected delays must be communicated to the judges as soon as possible. The team captain will need to provide a signed waiver for all attendees.

Waiver: [suas-competition.org/s/suas-waiver.pdf](https://suas-competition.org/s/suas-waiver.pdf)

#### Breakfast (8am - 9am)

Breakfast will be served at this time (ticket required).

#### Individual Team Photos (9am - 10am)

Teams will individually pose for a photograph in front of the competition banner.

#### Career Fair (10am - 11am)

Students may participate in a career fair hosted by the competition sponsors. Students can use this time to meet potential employers and learn about the companies and their technologies.

#### Group Photo (11am - 11:30am)

Teams and judges will assemble for a group photo. Teams and their UAS must be present. The photo will not be delayed for missing teams.

#### Lunch (11:30am - 12:30pm)

Lunch will be served at this time (ticket required).

#### Safety Inspections (12pm - 5pm)

The UAS and the ground station will be inspected for safety and competition compliance. Inspection will include at least a physical inspection, fail-safe and flight termination check, and maximum weight check. 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.

### Day 2 (June 21st, 2023)

#### Arrival & Setup (6:00am - 6:45am)

Teams will arrive at [St. Mary's County Regional Airport \(2W6\)](#) at this time. Each team will be given a specific arrival time via the Google Groups to stagger arrival. Teams which fail to arrive on time may be denied entry, and teams which leave may be denied reentry. After arrival, teams will set up their systems in the pits to prepare for their mission demonstrations.

#### Breakfast (6:45am - 9am)

Breakfast will be served at this time (ticket required).

### Mission Demonstrations (7am - 6pm)

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. Teams will then conduct their [Mission Demonstration](#), cleanup, and then be transported back to the pits.

### Lunch (12pm - 2pm)

Lunch will be served at this time (ticket required).

### Awards Ceremony (6pm - 8pm)

The awards ceremony includes dinner and the presentation of awards. Teams must be present to collect their awards and scholarships, and teams not in attendance will forfeit these.

### 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.

### Day 3 (June 22nd, 2023) - Rain Day

Day 3 is 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 Google Groups.

# Requirements

This section describes requirements that must be met. Failure to meet these may result in disqualification.

## Coordination

### Google Groups

All communication will be over email through the [SUAS 2023](#) mailing list on [Google Groups](#) ([join a group](#), [participate in a group](#)). All team captains and advisors must join in order to receive important announcements and to ask questions. All questions must be posted via the Google Groups by the team captain and/or advisor. All team members may join the group to receive the announcements and questions and answers. Teams should add the email address [suas-2023@googlegroups.com](mailto:suas-2023@googlegroups.com) to their contacts / address book so notifications don't go to spam folders.

### Google Calendar

The competition hosts an [SUAS Calendar](#) containing the competition events and deliverable due dates. The calendar's events will be updated with details as they become available. It is the team's responsibility to monitor the calendar, rules, and groups to comply with all deadlines and dates.

### Facebook & YouTube

All media and some announcements are posted to social media accounts. Teams should like the [SUAS Facebook Page](#) ([like a page](#)) and subscribe to the [SUAS Youtube Channel](#) ([subscribe to a channel](#)) to be notified when the media and announcements are posted.

## Team

### Development Team

The development team must consist of undergraduate or high school students who attend school full-time for at least one semester during the academic year. The team may have at most 1 graduate student participate during the academic year. 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.

### 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 competition will provide food and other resources for these 8 students. 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.

## 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 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.

## 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, otherwise at least two adults shall travel with the team and shall take full responsibility for the students. 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.

## 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.

## 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.

## Competition Guests

Each team will be allowed to bring up to 8 additional guests to competition. If desired, these guests may be development team members, but they cannot assist with the mission demonstration. These guests will need to purchase tickets for access to on-site food and the awards banquet. There are a limited number of food and banquet tickets which will be distributed first-come-first-served.

# Deliverables

## Submission

All non-mission deliverables will be submitted via [Google Forms](#). Each team will need at least one Google account which has access to Google Drive (to submit deliverables) and Google Groups (to join the mailing list). Teams are responsible for ensuring all links submitted as part of a deliverable are accessible by the judges (publicly viewable) for the duration of the competition.

## Document Format

The following are the requirements of all documents submitted:

- PDF format
- Size limit of 10MB
- 8.5" by 11" paper size
- 1/2 margins
- Single line spaced
- At least 11pt font size
- Time News Roman and/or Arial font
- Filename must include school and team name
- Footer must contain school, team name, and page number

## Video Format

The following are the requirements of all videos submitted:

- MP4 format with H.264 video codec and AAC-LC audio codec
- Size limit of 1GB or 10GB, depending on required length (see upload forms)
- 16:9 aspect ratio and at least 1080p resolution
- At least 24 frames per second
- Filename must include school, team name, and deliverable name
- Early video visual must show school and team name

## Lateness

Teams are given these deadlines months ahead of time. Failure to meet a deadline will result in either losing points or disqualification from the competition. The judges will evaluate extenuating circumstances if communicated in advance of a deadline. The penalty schedule for lateness:

- 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

# Aircraft

## General 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.

## Single Design & 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.

## 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.

## 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.

## 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.

## Fuel & Batteries

Exotic fuels or batteries will not be allowed. Any option deemed by the judges 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.

## Fasteners

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

## 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.

## Return to Home & Flight Termination

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

## Mission Flight Boundary

The following are a series of GPS points which form a polygon that is the mission flight boundary. 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.

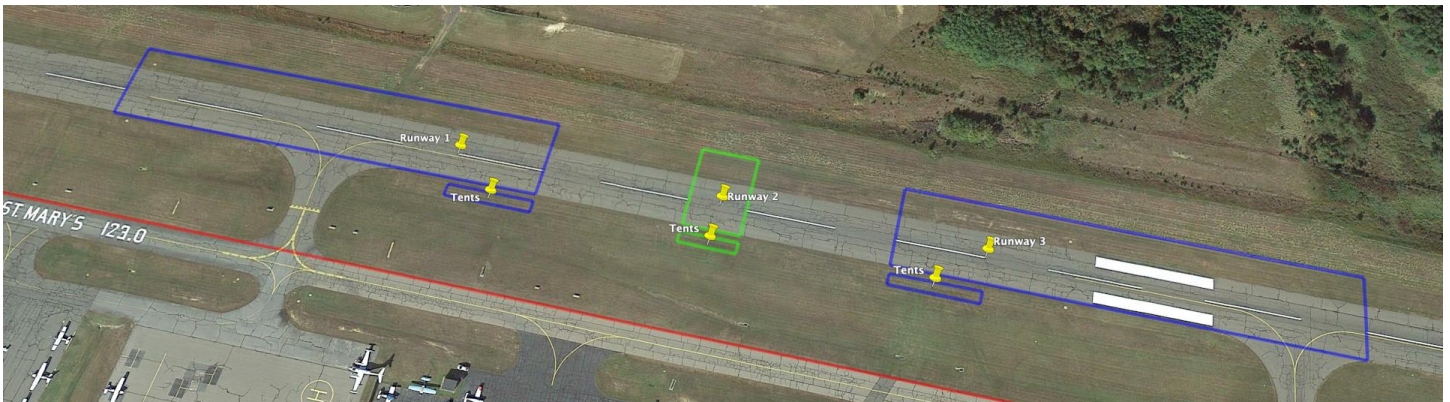
38.31729702009844, -76.55617670782419  
38.31594832826572, -76.55657341657302  
38.31546739500083, -76.55376201277696  
38.31470980862425, -76.54936361414539  
38.31424154692598, -76.54662761646904  
38.31369801280048, -76.54342380058223  
38.31331079191371, -76.54109648475954  
38.31529941346197, -76.54052104837133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



*Mission Flight Boundary (Red)*

## Runways for VTOL & 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.



*Runways and Flight Line Tents*

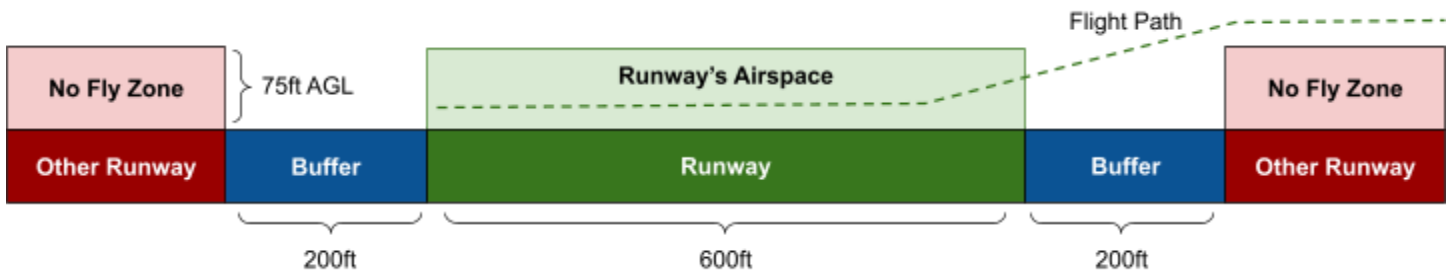
## Flight Performance

The following are minimum requirements for UAS flight performance:

- Fly 12 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



Sample flight profile for horizontal takeoff & landing (e.g. fixed-wing)

## Air Drop Payloads

### General Restrictions

The air drop payload includes everything that separates from the aircraft during an air drop, including the object being dropped. The aircraft may contain multiple air drop payloads, one per dropped object. Each air drop payload must weigh 5lbs or less.

### No Sustained Flight

The air drop payload cannot have any means to sustain flight (e.g. propulsion, propellers).

### Safe Landing

The air drop payload must land gently and must be safe for humans to be present in the drop area. The payload must be safe to retrieve and safe to handle.

### Air Drop Boundary

The following are a series of GPS points which form a polygon that is the air drop boundary. The air drop positions will be somewhere within this boundary. The boundary is approximately 70ft by 360ft.

```

38.31442311312976, -76.54522971451763
38.31421041772561, -76.54400246436776
38.3144070396263, -76.54394394383165
38.31461622313521, -76.54516993186949
38.31442311312976, -76.54522971451763

```



*Air Drop Boundary (Purple)*

## Ground Station

### Ground Control Station (GCS) Display

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.

### Safety Materials

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.

### 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.

### No Objects Taller than 15ft

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

### No Ground-Based Imaging Sensors

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

## 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.

## Radio Frequency (RF)

### No RF Management

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.

### Allowed Bands

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.

### Intentional Interference

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

## Weather & Airfield

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

### Winds

The aircraft must be able to operate any winds experienced at the airfield. Average wind speeds in Hollywood, MD in June is ~8 mph, and the record high is 24.2 mph.

### Temperature

Systems must be able to operate in temperatures up to 110 degrees Fahrenheit.

### Precipitation & Visibility

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 until the lightning has passed.

## Provisions

The competition will provide the team 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.

## Electrical Power

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.

## 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.

## Trees

The 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.

# 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.

## Overview

### 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 5 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 5 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.

### Mission Details

The mission flight boundaries are given in the rules in the [Mission Flight Boundary](#). The air drop boundaries are given in the rules in the [Air Drop Boundary](#). At setup time teams will receive all other mission details from the judges by paper printout. GPS positions will be given in decimal degrees, and altitudes in feet MSL.

### 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](#).

### 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 the waypoint path before attempting other tasks, thereby simulating the trip to the operation area. After the waypoints, teams may decide the order of all other tasks.

### Termination and Disqualification

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

### Points and Penalties

There are a series of components for which teams can receive points. Each subsection below contains a component and it's worth as a percentage of mission demonstration points. Penalties are also described in the subsections below. 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.

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 the waypoints will receive 0 points for the mission.

## 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.

### Setup Time (15min)

Teams will be provided at least 15 minutes for setup. 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.

### Mission Time (100%, 30min)

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. The ratio of mission time points a team is awarded will be  $\max(0, 1800 - X) / 1800$ , where X is the team's mission time in seconds.

### Timeout Penalty (20%)

Teams are allowed one timeout to stop the mission clock, and it will cost a penalty equal to 20% of timeline points. A timeout can only be taken at the flight line, after the mission clock starts, and before the UAS captures its first waypoint. The timeout will last at least 10 minutes.

### Excess Time Penalty (5% per second)

The team will receive a penalty equal to 5% of timeline points for every second of mission time over limits.

### Air Traffic Mission Pause

In the event that traffic enters the mission airspace, 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.

### Teardown Time (10min)

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

## Operators (30%)

UAS that are more autonomous are cheaper to operate, which means organizations can leverage more UAS at the same cost, which means better performance and more missions. Autonomy is measured by the number of

operators from the competition team needed to run a mission. The ratio of autonomy points awarded will be  $(8 - X) / 6$ , where  $X$  is the number of operators used inclusive of the Safety Pilot and GCS Operator.

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 assist with setup and teardown, but during the mission 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.

## 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.

## 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.

## Takeoff and Landing

Takeoff and landing may be performed autonomously or manually.

## Waypoints

The 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. Upon every takeoff, teams must immediately fly the waypoint path before attempting other tasks, thereby simulating the trip to the operation area. The waypoint path may be up to 10 miles in length.

## Manual Takeover Return to Land Penalty

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.

## Things Falling Off Aircraft Penalty (10%)

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

## Crash Penalty (25%)

If the UAS crashes during flight, teams will receive a penalty equal to 25% of demonstration points.

## Collision Penalty (50%)

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.

## Out of Bounds 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.

## Object Detection, Classification, Localization

UAS should be able to search for objects. 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 an air 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.



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

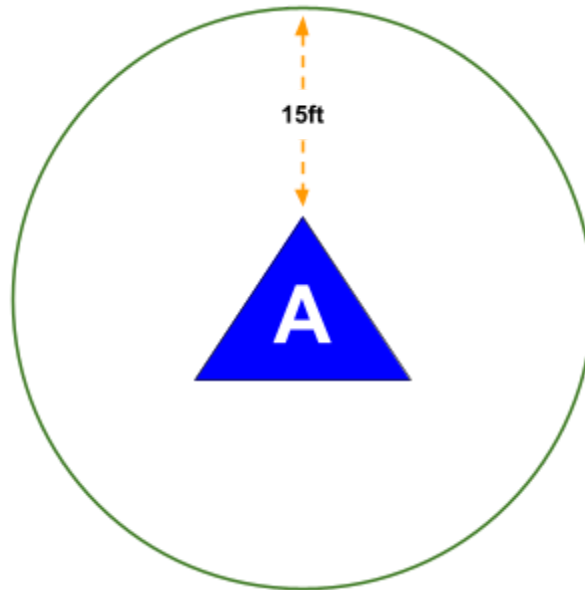
Valid shapes for the standard object include: circle, semicircle, quarter circle, triangle, square, rectangle, trapezoid, pentagon, hexagon, heptagon, octagon, star, and cross. Valid colors include: white, black, gray, red, blue, green, yellow, purple, brown, and orange.

## Air Drop (50%)

UAS should be able to air drop a payload at a specified position. The air drop payload must meet the [Air Drop Payload Requirements](#), and the aircraft must not fly below the minimum altitude or the drop will not count.

Teams will be given 5 air drop objects at setup time. Each air drop object will be a standard 16.9oz 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. An air drop is considered successful if an undamaged drop object lands and stays within 15ft of the ODLC object matching the air drop object's label. The air drop score is the ratio of successful drops to total objects (5).





*Drop object (left) and aerial view of drop target (right; ODLC within 15ft radius circle; not to scale)*

UAS may carry multiple air drop payloads at the same time, or they can land to pick up payloads. If the UAS carries multiple air drop payloads, drops must have at least 15 seconds of separation. If the UAS lands to pick up payloads, the UAS must re-fly the waypoints before performing another air drop.

Judges may be in the Air Drop Boundary to score the drops, and the ground may be marked to identify the 15ft drop target radius. The objects marking drop targets may be temporarily occluded while judges evaluate drops from another team and clear any debris.

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.

## 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.

# Technical Design & Flight Readiness Review (30%)

Teams must submit a video presentation covering their Technical Design and their Flight Readiness. Judges will review this presentation to determine whether teams are ready enough to attend competition, and may disqualify unprepared teams. The presentation is worth 30% of the total score for the competition.

The video must meet the [Video Format Requirements](#) and must be 15 to 20 minutes in length. Each section contains the relative point value and should take a proportional amount of time in the video. No points will be given for sections involving tasks not attempted.

## Introduction (5%)

The introduction section must:

- Visually and verbally name the University and Team
- Show the entire development team
- Introduce the competition team (name, experience, role)
- Give a brief overview of the UAS

## Technical Design (50%)

The Technical Design section should show the team's overall coordination, systems engineering process, design analysis and tradeoffs, and a detailed description of the solution.

### Requirements & Acceptance Criteria (10%)

This subsection analyzes the competition requirements and develops 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.

### Design Overview (10%)

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

### Imaging & ODLC (10%)

This subsection should identify the camera used by the UAS and describe its capabilities. It should provide a detailed analysis to demonstrate that the chosen camera can resolve objects of the size required by the competition. This subsection should also describe the ODLC system including any image processing algorithms or techniques used.

### Air Drop (10%)

This subsection should describe the payload and mechanism used to drop the payload. Furthermore, it should describe the approach used to determine optimal drop time.

## Communications (10%)

This subsection 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.). This section should include a block diagram.

## Aircraft (10%)

This subsection should describe the design and fabrication of the airframe and surfaces, along with a discussion of the aircraft's aerodynamics and propulsion system. It should include a labeled diagram(s) of the airframe and a table containing all relevant metrics.

## Autopilot (10%)

This subsection should identify the autopilot used by the UAS and describe its capabilities and how they map to the competition tasks. It should also provide a description and picture of the associated ground control station (GCS).

## Obstacle Avoidance (10%)

This subsection should describe the algorithm(s) used to update the flight plan so as to avoid obstacles.

## Alternatives Considered (10%)

This subsection describes 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.

## Safety, Risks, & Mitigations (10%)

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

## Flight Readiness (40%)

The Flight Readiness section must demonstrate the system is mature and safe enough to compete. Readiness must be demonstrated with data.

## Imaging & ODLC Performance (10%)

This subsection should describe the tests performed on the imaging & ODLC subsystem and performance observed. This subsection should provide statistics such as the average resolution of the objects in the images. It should also discuss the team's strategy for ensuring the best image quality.

## Air Drop Performance (10%)

This subsection should describe the tests performed on the air drop subsystem and performance observed. This subsection should report statistics such as number of times drops were attempted, the number of drops considered successful, and the 90th percentile distance from the target the payload landed.

## Communications Performance (10%)

This subsection should describe the tests performed on the communications subsystem and performance observed. This subsection should report range, throughput, and packet loss statistics for all radio communication.

## Aircraft Performance (10%)

This subsection should describe the tests performed on the aircraft and performance observed as compared to the [Flight Performance Requirements](#). This subsection should report the number of flights and flight hours.

## Autopilot Performance (10%)

This subsection should describe the tests performed on the autopilot and performance observed. This subsection should report the number of autonomous flights conducted by the team and the average amount of time spent in manual mode per flight. This subsection should report statistics such as number of waypoints attempted, the number of waypoints hit, and the average waypoint miss error.

## Obstacle Avoidance Performance (10%)

This subsection should describe the tests conducted to verify obstacle avoidance and performance observed.

## Mission Testing (10%)

This subsection describes 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. They should provide the scores from each full mission test, the average across all tests, and the expected performance.

## Proof of Safe Flight (30%)

This subsection 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

## Summary (5%)

This section should summarize the entire presentation.

# Awards & Scholarships

This section describes the awards and scholarships given to teams at the competition.

## 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 scholarship money.

## 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 scholarship money.

## Special Awards

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

# Appendix

The Appendix contains additional reference material the teams will need at some point during the year. Similar to the rules, these details are subject to change.

## Mailing Address

Seafarer Chapter  
Post Office (P.O.) Box 141  
California, MD 20619

**WARNING:** Only the United States Postal Service (USPS) can deliver mail to a PO Box. If you cannot ship directly with USPS, you must use a service which can handoff to USPS for the last mile delivery. Otherwise, your mail will be returned to you. Failure to properly mail is not a cause for extensions or refunds.

## 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.

Due Date	Milestone
October 1st	<p>Competitive Analysis Complete</p> <ul style="list-style-type: none"> <li>● Review of past rules to understand evolution</li> <li>● Review of past designs from other teams based on published deliverables</li> <li>● Review of current rules for latest requirements</li> </ul> <p>Technical Design Complete</p> <ul style="list-style-type: none"> <li>● Mission requirements analysis</li> <li>● Competitive strategy</li> <li>● System design</li> <li>● Component design</li> <li>● Integration design</li> <li>● Test &amp; evaluation plan</li> <li>● Safety, risks, and mitigation</li> <li>● Developmental milestones &amp; schedule</li> </ul>
November 15th	<p>Components Initial Version</p> <ul style="list-style-type: none"> <li>● Required hardware and software licenses ordered and delivered</li> <li>● Aircraft manufactured / assembled</li> <li>● Code complete for MVP features</li> <li>● Ready to begin testing of all components</li> </ul>
December 15th	<p>Components Complete</p> <ul style="list-style-type: none"> <li>● Manual flights on aircraft, empty and loaded to simulate gross weight</li> <li>● Ground testing for networking, imaging, air drop mechanism, etc.</li> <li>● Plans developed to iterate based on lessons learned from component testing</li> </ul>
February 15th	<p>Integration Initial Version</p> <ul style="list-style-type: none"> <li>● Autonomous flights on aircraft, empty and loaded for gross weight</li> <li>● Networking, imaging, air drop, etc from the aircraft</li> </ul>
April 1st	<p>Integration Complete</p> <ul style="list-style-type: none"> <li>● Complete end-to-end mission demonstration</li> <li>● Plans developed to iterate based on lessons learned from integration testing</li> <li>● Backup instances manufactured to mitigate failures</li> </ul>
May 1st	<p>Prepared for Competition</p> <ul style="list-style-type: none"> <li>● Multiple simulated mission demonstrations</li> <li>● Plans and checklists for packing, setup, mission operation, and teardown</li> <li>● Operator training and practicing to maximize human performance</li> <li>● Completion of Technical Design &amp; FRR Presentation, and Fact Sheet</li> </ul>

# Change Log

Version	Release Date	Change Log
2023.04	2023-03-09	<ul style="list-style-type: none"> <li>Removed Promotional Video deliverable</li> </ul>
2023.03	2022-10-14	<ul style="list-style-type: none"> <li>Added collision penalty between teams</li> <li>Clarified format of mission details like GPS format</li> </ul>
2023.02	2022-09-18	<ul style="list-style-type: none"> <li>Mission updated to require air drop points to receive any mission points</li> <li>Clarified that there will be at most one emergent object</li> <li>Added the waypoint path can be up to 10mi in length</li> <li>Updated sample HTOL flight profile in flight performance requirements</li> <li>Corrected change log to be consistent with “top 5 teams” reflow</li> </ul>
2023.01	2022-09-01	<p>SUAS 2023 initial rules release. Compared to SUAS 2022:</p> <p>Overall:</p> <ul style="list-style-type: none"> <li>Dropped 2022 COVID exceptions</li> <li>Eliminated interop server and associated tasks</li> <li>Reformatted the rules to make it easier to navigate via headings</li> </ul> <p>Schedule &amp; Deliverables:</p> <ul style="list-style-type: none"> <li>Reorganized onsite to use 2 days plus rain day</li> <li>Visa invitation letters will be processed in 2 batches</li> <li>Technical Design, Proof of Flight, Safety Pilot Log merged into FRR</li> <li>Personnel Registration deadline moved to May</li> <li>Check-in and awards ceremony moved to same venue as mission</li> </ul> <p>Requirements:</p> <ul style="list-style-type: none"> <li>Removed competition-provided safety pilot; team must bring one</li> <li>Clarified what the safety pilot is allowed to do (e.g. no FPV)</li> <li>Added required GCS Operator role</li> <li>Removed bringing team trailers and vehicles to the flight line</li> <li>Removed wind limits for flight; must handle any seen at event</li> <li>Added flight performance requirement (e.g. turn-radius, takeoff range)</li> <li>Added GCS judge and requirement for GCS display to be viewable</li> <li>Added no-power to propellers when physically working on UAS</li> <li>Added dedicated section for air drop payload requirements</li> <li>Added additional requirements for document and video submission</li> <li>Added lateness penalty and clarified disqualification timeline</li> <li>Added components originally in Appendix (e.g. flight boundary)</li> <li>Updated runways, flight boundary, RTH point, and air drop boundary</li> </ul> <p>Mission Demonstration:</p> <ul style="list-style-type: none"> <li>Top 5 teams may get opportunity to fly second mission demonstration</li> <li>Waypoint path increased to 10 miles of distance</li> <li>Out of bounds terminates mission without zeroing all points</li> <li>Teams now drop 5 air drop objects of heavier weight</li> <li>Air drop locations are no longer known in advance, they must be</li> </ul>



		<p>identified through ODLC objects which are no longer evaluated directly</p> <ul style="list-style-type: none"><li>● Dropped waypoint accuracy, stationary obstacles, and mapping tasks</li></ul> <p>Technical Design Paper (TDP):</p> <ul style="list-style-type: none"><li>● Eliminated the paper and merged its contents into the presentation</li></ul> <p>Flight Readiness Review (FRR):</p> <ul style="list-style-type: none"><li>● Increased the length of the video to accommodate new sections</li><li>● Integrated the Technical Design, Proof of Flight, Safety Pilot Log</li><li>● Changed the sections and relative weightings</li></ul> <p>Awards &amp; Scholarships:</p> <ul style="list-style-type: none"><li>● 1st, 2nd, and 3rd will receive plaques in addition to trophies</li></ul> <p>Appendix:</p> <ul style="list-style-type: none"><li>● Added a suggested developmental milestones</li><li>● Removed the sample mission map</li></ul>
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