

Competition Rules | SUAS 2017

by the AUVSI Seafarer Chapter

www.auvsi-suas.org

This document contains the rules for the 15th Annual Student Unmanned Aerial Systems Competition (SUAS) by the Association for Unmanned Vehicle Systems International (AUVSI) Seafarer Chapter.



Competition Purpose. The AUVSI 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 UAS 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 2003.

Statement of Liability. The Seafarer Chapter of AUVSI and the host organization, their employees and agents, as well as the SUAS committee, are in no way liable for any injury or damage caused by any entry, or by the disqualification of an entry. The Seafarer Chapter and AUVSI at large are not responsible for ensuring SUAS teams operate their UAS systems within the Federal Aviation Administration (FAA) rules and regulations.

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Overview

The competition has three major elements: the Technical Design Paper, the Flight Readiness Review Presentation, and the Mission Demonstration. The paper details a team's UAS design. The presentation details the team's testing and preparedness for the competition. 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 delivery.

SUAS 2017 Mission. There is a lost hiker located in a remote area who has called for help. Search and rescue has tasked an Unmanned Aerial System (UAS) to find the hiker, direct rescue personnel to the hiker's location, and deliver urgent aid supplies.

Competition Location. The competition will be held in June at [Webster Field, St. Inigoes, Maryland](#) of the Naval Air Station (NAS) in Patuxent River, Maryland.

Google Groups. All communication will use the [AUVSI SUAS](#) mailing list on [Google Groups](#). All team members and advisors must join in order to receive important announcements and ask questions. For example, we will announce the instructions for registration via the group.

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 to the rules, point allocations, and prizes.

Spirit of Competition. The judges expect teams to compete in a fair and professional manner. Cheating will not be tolerated. Teams caught cheating will be disqualified, and the school will be banned from competing for 4 years.

Ranks and Awards. There are three major elements of the competition: the mission demonstration, the technical design paper, and the flight readiness review presentation. They are worth 60%, 20%, and 20% respectively of the overall ranking points. There are also awards for which teams earn prize money.

Schedule & Deliverables

This section describes the major elements of the competition, the schedule of events and deliverable due dates, and details for deliverable submission.

Google Calendar. The competition hosts an [AUVSI SUAS Calendar](#) containing the competition events and deliverable due dates. All dates listed here will also be in the calendar. The calendar's events will be updated with details as they become available.

Deliverable Submission. All non-mission deliverables will be submitted via [Google Forms](#). Submission instructions for each deliverable will be communicated at least 2 weeks prior to each deadline. Each team will need a single Google account which has access to Google Drive (to host file deliverables) and YouTube (to host video deliverables). Teams are responsible for ensuring all files and links are accessible by the judges (e.g. publicly viewable).

Document Format. All documents must be submitted as a PDF. The filename and first page of the document must include the university and team name. All documents must have at least 10pt font and 1 inch margins.

Video Format. All videos must be 1080p resolution with 24 frames per second. Teams will be directed to submit videos either as a Google Drive upload, in which case the video format must be MP4, or via Google Forms, in which case teams must provide a link to a YouTube video.

Lateness. Teams are given these deadlines months ahead of time. Failure to meet a deadline will result in either losing all points for the graded element or disqualification from the competition. The judges will evaluate extenuating circumstances for exemption and deadline extension, but only if the judges are notified by email at least 3 days ahead of deadline. The maximum extension grantable is 24 hours.

The following subsections describe the individual deliverables and events.

Draft Rules, Comment Period, Final Rules

(2016-09-15) Draft Rules Released. The judges will release a draft of the rules in order to get feedback from the teams. The rules will be posted to the competition website.

(2016-09-15 to 2016-10-01) Comment Period. During this period, teams must read the rules and should submit questions and comments to the Google Groups. The judges may respond to the comments and adapt the rules.

(2016-10-05) Final Rules Posted. The final rules will be posted to the competition website. The judges reserve the right to change the rules after this date if necessary. Teams will be notified of any rule changes.

Kickoff & Registration

(2016-10-12) Competition Kickoff Meeting. The judges will hold a conference call to discuss the final rules, answer last-minute questions, and otherwise prepare for the competition year. This meeting is purely for the benefit of the team and is not mandatory.

(2016-10-15 to 2016-10-30) Registration Period. During this period, the team captain can submit the following Google Form to register a team. Submissions before 2016-10-15 12:00AM will be ignored. The team captain must also send a registration fee and it must be delivered by the end of this period. Registration is first-come, first-served: the first 50 form submissions that also provide the registration fees will be accepted. The registration fee is \$1,000 USD. The registration fee is non refundable once a team is officially accepted into the competition. The registration fee will only be refunded to teams which are not accepted to the competition. The registration fee must be sent to the following mailing address as a check or money order in USD. The fee must be payable to "AUVSI Seafarer Chapter". The registration fee must be sent to the address in the [Mailing Address](#) appendix.

Registration Form: goo.gl/forms/TkLtiXsMfd8uN9Pu1

Personnel Registration & Base Access Documents

(2017-03-20) Personnel Registration. The team captain will electronically submit a form for each member of the development team and the advisor. This form must also be printed, signed by the advisor verifying rule compliance, and mailed to the judges. The advisor must also state in writing on school letterhead that the school knows the team is representing the school and that the team is traveling for the competition. See the [Mailing Address](#) appendix.

Personnel Registration Form: goo.gl/forms/lwHdcmDdjcS0VcRP2

Printable Form:

www.auvsi-suas.org/static/competitions/2017/auvsi_suas-2017-personnel_registration.pdf

(2017-03-20) Base Access Documents. The competition is held on a naval air base. Each person attending competition, from competitors to guests, will be required to fill out a form and provide documentation in order to get vetted for base access. Failure to obtain passports or visas in time for the submission deadline will not be cause for any extension. International teams should obtain passports and visas as soon as possible. See the appendix sections for [Base Access Form & Documents](#) and [Foreign National Form & Documents](#). These forms must be mailed and received by the provided date. See the [Mailing Address](#) appendix.

Fact Sheet & Technical Design Paper

(2017-04-15) Fact Sheet. The teams will submit a Google Form detailing specific facts about the UAS the team is designing. This is critical for competition logistics and safety. 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

(2017-04-15) Technical Design Paper. The [Technical Design](#) section describes this deliverable. It is a paper detailing the technical design and plan for evaluation of the UAS designed by the team.

Technical Design Form: goo.gl/forms/6AgUVopJGwzDgvph2

Proof of Flight, Safety Pilot Log, Flight Readiness Review

(2017-05-15) Proof of Flight. Teams must provide proof via video that the UAS can be flown safely. Teams must provide a video showing a manual flight showing the safety pilot, UAS takeoff, 5 minutes of UAS flight where the UAS gets at least 1000ft from the safety pilot, and UAS landing. Teams must provide a second video showing the UAS in autonomous mode, transition to manual mode, and manual landing. Teams must provide this video for each potential safety pilot on the primary aircraft in competition configuration.

Proof of Flight Form: goo.gl/forms/ESr0c2kB8EeESk4F2

(2017-05-15) Safety Pilot Log. Safety is critically important for the competition, and vital to safety is the safety pilot's ability to control the aircraft in an emergency. To this end, teams must submit a safety pilot log detailing the manual flights conducted by the safety pilot on the UAS in competition configuration. The pilot must perform and log at least 3 hours of manual flight, 10 takeoffs, and 10 landings. In addition to submitting the form, the faculty advisor must also print and sign the form, endorse it, and mail it. See the [Mailing Address](#) appendix. The team must provide multiple logs, each meeting this specification, for each pair of pilot and aircraft (primary, backup, etc) that might be used at competition.

Safety Pilot Log Form: goo.gl/forms/cosrRRKPRCK3mvSt2

(2017-05-15) Flight Readiness Review. The [Flight Readiness Review](#) section describes this deliverable. It is a video presentation detailing the result of testing and the team's preparedness for competition.

Flight Readiness Review Form: goo.gl/forms/u3QEOoJBfcfVgKyW2

Team Promotional Video

(2017-06-01) Team Promotional Video. Each team is required to submit a promotional video for their team. The video must be no longer than 2 minutes, show the full team, show the UAS in flight, and briefly describe the design. The team can add additional content to the video as desired.

Team Promotional Video Form: goo.gl/forms/j0SPFmFB7zNp4Y5o1

Competition: Check-in, Mission, Awards Banquet

(2017-06-14 3pm - 6pm) Career Fair. After teams have checked in, the 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.

(2017-06-14 4pm - 6pm) Check-In. The teams will check-in to receive base access badges, fill out forms, and complete other logistical tasks. The team captain and at least 50% of the team competitors must be present. Check-in will close to new teams 30 minutes prior to end. 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. At this time, the team will be provided the core mission details and the interoperability connection details.

Waiver:

www.auvsi-suas.org/static/competitions/2017/auvsi_suas-2017-risk_and_liability_waiver.pdf

(2017-06-14 6pm - 7pm) Dinner. The competition will provide a buffet dinner, which teams will be welcome to once they have checked in. Limited dietary restrictions will be accommodated at this meal.

(2017-06-14 6pm - 8pm) Orientation. This is a meeting covering all of the logistics for the week. Teams must be present to receive last-minute updates.

(2017-06-15 7am - 8am) Base Entry. Teams must arrive at the base gate and make it onto the base by 8am. Teams with foreign national students or guests must arrive at the gate no later than 7am. People who aren't on base by 8am might not be allowed entry at a later time.

(2017-06-15 8am) Safety Inspections. 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. Teams will be evaluated in their flight order. If a team fails inspection or is not present, they will be put in the back of the queue for an additional attempt. Failing safety inspection may change the team's mission demonstration order.

(2017-06-15 8am) Individual Team Photos. After a team has passed safety inspection, the entire team will pose for a photograph in front of the competition banner. These photos will be posted to the web with the rest of the competition photos.

(2017-06-15 8am) Interop Testing. Teams will be given the opportunity to test their system's connection with the Interoperability System using the same mission credentials and a representative set of hardware. Teams should begin testing immediately after the team photo. Note that teams which are called to the flight line will need to use an in-pit timeout to extend this testing time.

(2017-06-15 12pm - 7pm) Mission Demonstrations. Mission demonstrations will be started once a critical mass of teams have passed safety inspections and taken their photo. Teams will be given at least 5 minutes notice of transportation to flight line. The team and the equipment will be transported via flatbed trailer to the flight line, after which the setup time will start. Depending on base logistics, the Group Photo may be moved to this time so all teams must be present.

(2017-06-16 7am - 8am) Base Entry. Same as Thursday.

(2017-06-16 8am - 7pm) Mission Demonstrations. Same as Thursday.

(2017-06-17 7am - 8am) Base Entry. Same as Thursday.

(2017-06-17 8am - 4pm) Mission Demonstrations. Same as Thursday.

(2017-06-17 4pm - 5pm) Group Photo. The teams and judges will get together for a competition photo. It will most likely happen after the last flight. Teams and their UAS must be present. Note the Group Photo may be moved to Thursday.

(2017-06-17 6pm-10pm) Awards Banquet. The awards banquet includes dinner, a keynote speaker, and the presentation of awards. The recommended attire is business casual. Teams must attend to collect their awards and prize money.

Requirements

This section describes the requirements that the team and UAS must meet. Teams which fail to comply with these requirements will be disqualified.

Team Composition

Single Team per School. Each school may only register a single team.

Development Team. The development team must consist of undergraduate or high school students which 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.

Competition Team. The team of students which attends the competition, participates in the Flight Readiness Review (FRR), and participates in Mission Demonstration must be at most a 10 person subset of the development team. The competition will provide food, t-shirts, and other resources for these 10 students. Extra resources may be available for purchase.

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.

Advisor. Each team must have a formal school faculty member/advisor 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 advisor or school official travel with the team, otherwise at least two adults who are a school advisor and/or parent shall travel with the team and shall take full responsibility for the students. The advisor will also be admitted to all competition events, and will be provided food and a t-shirt. The advisor is allowed to advise the team in development but is not allowed to participate in the design, construction, or testing of the UAS. The advisor 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.

Safety Pilot. The safety pilot used during the year, for whom a safety pilot log is required, can be a student, the advisor, or non-student of the school. At competition, you may use the same safety pilot or request a competition volunteer act as safety pilot. The safety pilot will count as 1 of the 10 members of the competition team, regardless of whether it's the advisor or competition volunteer. If the pilot is not a member of the development team, the pilot is limited to safety related functions and may not advise or participate in other roles.

Competition Guests. Each team will be allowed to bring up to 10 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. The team is required to provide the base access details for these guests by the specified deadline.

Aircraft

General Restrictions. The team may only fly a single aircraft at a time 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, and the max airspeed in the competition is 70 KIAS.

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.

Return to Land & 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 the safety pilot and the ground station. After 30 seconds of communications loss, the aircraft must automatically RTH or RTL. After 3 minutes of communication loss, the aircraft must 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.

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, locktite (fluid), or nylon nuts.

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

Autonomous Flight. The UAS must have autonomous flight capabilities to compete. The UAS must fly autonomously for at least 3 minutes to receive any mission demonstration points.

Ground Station

Ground Station Display. Teams must have a display, always viewable by the mission judges, which shows the a map showing the flight boundaries, the UAS position, and all other competition elements. This display must also 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.

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

One Motor Vehicle & One Trailer. Teams may use up to one motor vehicle and one trailer at the flight line. The judges will provide a tent, table, and set of chairs. Additional equipment may be brought by the team. These vehicles cannot assist UAS takeoff or recovery.

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

No Ground-Based Sensors. No ground based sensors can be used.

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. As relevant, 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 or expect such.

Allowed Bands. All RF communications must comply with FCC regulations. 72MHz is allowed for RC control but is highly discouraged. 433MHz is allowed but must use frequency hopping spread spectrum. 462.7Hz is allowed, but the judges will also be using this frequency for handheld radios. 900MHz is allowed. 1.08, 1.12, 1.16, 1.2, 1.24, 1.28, 1.32, and 1.36 GHz are allowed but must use frequency hopping spread spectrum. 1.2GHz to 1.3GHz may only be used for analog or digital video systems. 2.4GHz, 5GHz, and cellular connections are allowed.

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

Weather & Airfield

The judges will temporarily suspend the competition if conditions are deemed unsafe. Teams must be able to secure equipment against sudden weather like winds and rain.

Winds. The aircraft must be able to operate in 15 knot winds with gusts to 20 knots, including during takeoff and landing. There are two accessible runways that are 90 degrees apart. Teams may launch in any direction from the grass.

Temperature. The system must be able to operate in temperatures up to 110 degrees Fahrenheit peak, and 100 degrees Fahrenheit sustained for 12 hours.

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.

Provisions. The judges will provide the team a tent for shade, a folding table, chairs, and a single electrical power extension cord from a mobile generator.

Electrical Power. The electrical power provided will be 115 VAC, 60 Hz, rated up to 15 amperes. This may not be enough for many ground stations, and teams should consider bringing additional generators and UPS battery backups. 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.

Airfield Notes. Airfield coordinates are 38°09'01.5"N, 76°25'29.7"W. Airfield elevation is 22 feet MSL. Airfield magnetic deviation is 11 degrees west. The runway is a paved asphalt surface, roughly 100 feet wide, with no height obstacles. Grass areas within the takeoff/landing area will not be prepared but will be available for use.

Interoperability System

The Interoperability System is a network and web server that teams should interact with during the mission. This system provides mission details and receives mission deliverables. The system provides automatic evaluation for scoring, and is available to teams for testing.

Code Repository & Documentation

Code Repository. The entire Interoperability System is open source so teams can develop and test against the system. The [AUVSI SUAS Interop Github Repository](#) contains all code and documentation. The system will evolve over the year as features are added and bugs are fixed, so teams should Watch the repository to receive notifications.

Documentation. All documentation for the Interoperability System can be found on the [AUVSI SUAS Interop Read the Docs](#) website. This contains instructions for setting up the system, configuring it, integrating with it, and testing with it.

Interaction with System

This section provides a high-level overview of the interaction with the Interoperability System. Teams should refer to the documentation website for details.

Network Connection. At setup time, teams will receive a single ethernet cable with which to connect to the Interoperability System. This connection will provide DHCP and a single static IP address. The IP addresses will be on the subnet 10.10.130.XXX with subnet mask 255.255.255.0. Teams will typically connect this to the WAN port of their router, which will provide a separate subnet for the team's systems. Teams will then connect to the system using the IP address (DHCP or static), username, and password that is provided at Check-In and Orientation. Teams may then use this connection until the end of the mission clock.

Mission Download. Teams must download certain mission details from the Interoperability System.

UAS Telemetry Upload. In order to get maximum points for waypoint accuracy, teams will need to upload valid UAS telemetry at an average of at least 1Hz while the UAS is airborne. Telemetry must not be duplicated, interpolated, or extrapolated beyond what is generated by the autopilot. Teams may upload telemetry faster. Data dropouts will count against the team.

Object Upload. Teams can submit objects via the Interoperability System to earn more points. The [Interoperability Specification](#) defines an object, like the set of valid background colors for a standard target.

Mission Demonstration (60%)

This section describes the mission demonstration that will be conducted by the team at competition. It is for this mission that teams must design a UAS. It is worth 60% of the entire competition.

The mission demonstration is designed to be representative of a search and rescue mission, where mission details are received, the team deploys their system, the UAS flies to the operation area, the UAS searches for clues and for the person of interest, and then the UAS delivers relief supplies via air delivery.

Points and Penalties. There are a series of components for which teams can receive points. Each subsection below contains a component and its worth as a percentage of mission demonstration points. Penalties are also described in the subsections below. Penalties are defined as a percentage of component points. Unlike points, penalties do not have a bound. This means time spent out of bounds can cost the team all points for mission demonstration. If penalties are greater than points, the team will receive a zero for demonstration.

Mission Details and Deliverables. The core mission details will be provided at check-in. The details include the flight boundaries, waypoints, search grid, and air drop position. At setup and during the mission, the Interoperability System will provide the position of the off-axis object and emergent object. All deliverables will be submitted to the judges via the Interoperability System.

Mission and Safety Judge. There will be two types of judges evaluating the team during the mission: mission judges located in the team's tents, and safety judges standing with the safety pilot. The number of judges will depend on volunteer availability, and the individual scores will be merged.

Order of Team Demonstration. The judges will score all deliverables due before the competition week and produce an initial ranking. This ranking will be the order in which teams get a chance to perform mission demonstration. Teams will not be notified of this initial ranking. The judges will attempt to fly as many teams as possible. Each team will need to weigh the risk of not flying with the cost of travel.

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. Teams will be provided at least 20 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, roles and responsibilities, and other information judges should know. Once the other

teams have stopped occupying the airspace and the setup time has elapsed, the judges will start the mission time regardless of team readiness.

Mission Time (80%). Teams will be provided 45 minutes to complete the mission. This is broken down into two periods: flight time and post-processing time. Flight time is when the team occupies the runway or airspace. Post-processing time starts once the UAS has landed, the UAS has cleared the runway, and the team relinquishes the airspace. Post-processing time ends when the team has stopped processing imagery, stopped uploading data through interoperability, and has returned the interoperability network cord to the judges. The ratio of mission time points a team is awarded will be $\max(0, 225 - 5X - Y) / 225$, where X is the team's flight time in minutes and Y is their post-processing time in minutes.

Mission Time Penalty. The team will receive a penalty equal to 1% of mission time points for every second of mission time over 45 minutes.

Timeout (20%). Teams are allowed one timeout to stop the mission clock, and it will cost them these timeline points. The timeout can either be a timeout-in-place or a timeout-in-the-pits. A timeout-in-the-pits can only be called before the team is transported to the flight line, and lasts at least 20 minutes. This timeout also pushes the team to the back of the queue, so the team may not get a chance to fly. A timeout-in-place can be called any time after the team starts moving to the flight line and lasts at least 10 minutes. The team may not perform data processing during the timeout.

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

Autonomous Flight (30%)

UAS which can fly autonomously are cheaper to operate, which means search and rescue 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.

Autonomous Flight (40%). The team receives points if the UAS flies autonomously for at least 3 minutes. Teams will lose 10% of autonomous flight points for each safety pilot takeover into manual flight. Manual takeoff and manual landing will each count as a takeover. Hand launch with autonomous climbout counts as autonomous takeoff. The team is responsible for telling the mission judge (in the tent) and the safety judge (next to safety pilot) whenever the autopilot transitions between modes.

Waypoint Capture (10%). The teams will be given a sequence of waypoints that should be flown during the mission. The teams must fly these waypoints immediately after takeoff, and may attempt the waypoints multiple times. Teams will be graded on whether they can fly the

entire waypoint sequence and get within 100ft of each waypoint. Teams will be evaluated by a human observer at the autopilot station.

Waypoint Accuracy (50%). Teams will be graded on how close they can get to the waypoints in a sequence. Teams may attempt the waypoints multiple times, and the highest scoring sequence will be used. Each waypoint will be weighted equally, and the ratio of points received per waypoint will be $\max(0, (100ft - distance) / 100ft)$. To receive maximum points for waypoint accuracy, teams must upload valid telemetry to the Interoperability System at an average of 1Hz while airborne.

Out of Bounds Penalty. Teams will be given a set of flight boundaries at check-in and orientation. Every time the UAS goes out of these bounds, or if the UAS goes below 100ft MSL or above 750ft MSL, the team will receive a penalty equal to 10% of autonomous flight points. For every boundary violation that risks safety, like by flying over the pits or the flight line tents, the team will receive an additional penalty equal to 10% of autonomous flight points. Teams will be evaluated by human observers.

Things Falling Off Aircraft Penalty (TFOA). If parts fall off the UAS during flight, teams will receive a TFOA penalty equal to 25% of autonomous flight points.

Crash Penalty. If the UAS crashes during flight, teams will receive a crash penalty equal to 35% of autonomous flight points.

Obstacle Avoidance (20%)

UAS must integrate with the national airspace in order to perform missions. Part of this integration means avoiding other UAS and manned aircraft, and avoiding ground obstacles like tall buildings. The UAS should have obstacle avoidance capabilities.

Telemetry Prerequisite. To receive points for obstacle avoidance, teams must upload valid telemetry to the Interoperability System at an average of 1Hz while airborne.

Stationary Obstacle Avoidance (50%). Through the Interoperability System, the teams will be given a set of stationary obstacles. Each stationary obstacle will be a cylinder, with height axis perpendicular to the ground, and bottom face on ground. The cylinders will have a radius between 30ft and 300ft, and height between 30ft and 750ft. Each obstacle will be weighted equally, and each obstacle will be graded all or nothing.

Moving Obstacle Avoidance (50%). Through the Interoperability System, the teams will continuously be given a set of moving obstacles. Each moving obstacle will be a sphere. The spheres will have a radius between 30ft and 200ft, and move between 0KIAS and 40KIAS. Each obstacle will be weighted equally, and each will be graded all or nothing.

Object Detection, Classification, Localization (20%)

UAS should be able to search for clues about the lost hiker's location, and locate the hiker. Teams will have to detect, classify, and localize two types of objects: standard and emergent. A standard object will be an alphanumeric painted onto a colored shape, which represents a clue left by the hiker. The standard object will be at least 1 foot wide with 1 inch thick lettering. One of the standard objects will be located outside the flight boundary. The emergent object is a person engaged in an activity of interest, which in this mission is the hiker. Each object will be weighted equally. Teams may either submit objects via the [Object File Format](#) over USB drive, or via the Interoperability System for more points. Teams should also provide a paper backup of this data, by printing the Object File Format, which will be used in case of an unplanned failure of the judging system.



Search Area & Off-Axis. Teams will be given a search grid which will contain all but one of the objects, and will be given the position of a standard object located outside of the flight boundaries. The off-axis object will be up to 250ft beyond the flight boundary. Teams must not fly over the off-axis object if it is out of bounds.

Object Matching. During scoring, submitted objects are matched with real objects to determine points scored. The judges will use the matching that maximizes the points for the team. Matching is performed separately for manually and autonomously submitted objects.

Imagery. To receive credit for an object, teams must submit a cropped image such that the object fills 25%+ of the image. Judges will decide whether the image is sufficient to resolve the object.

Characteristics (20%). Each object has a set of characteristics, and teams are awarded points for ratio of correct characteristics: $\text{correct characteristics} / \text{total characteristics}$. For standard objects there are 5 characteristics: shape, shape color, alphanumeric, alphanumeric color, and alphanumeric orientation. The interoperability specification provides an enumeration of possible

standard object characteristics. For emergent objects there is one characteristic: a description of the hiker and the scene around the hiker.

Geolocation (20%). Teams are awarded points for accurately providing the GPS location of objects. The ratio of points a team is awarded is $\max(0, (150ft - distance) / 150ft)$ where *distance* is the geodesic distance between the submitted GPS location and the object's true GPS location.

Actionable (10%). Objects which are submitted during the team's first flight will be considered actionable. For the Object File Format, teams will submit an additional USB drive prior to the aircraft landing. Objects submitted as actionable via the Object File Format must not be present in the end of mission submission, as they will be considered an additional object and may incur an extra object penalty. For interoperability, objects which were created and last edited during the first flight will be considered actionable.

Autonomy (20%). Teams may submit objects manually and autonomously. Submission is autonomous if no human assistance is needed from image capture to object submission, and otherwise processing is considered manual. A match gets additional points if it is autonomous. If a team submits a manual and autonomous object that is matched to the same real object, the higher scoring object will be counted, and the lower scoring object won't count as an extra object.

Interoperability (30%). Teams will get more points if objects are submitted via the Interoperability System. It is recommended that teams submit targets this way.

Extra Object Penalty. Each submitted object which isn't matched with a real object will be penalized at 5% of object detection, classification, and localization points. An object will not match a real object if such a match would yield no point value, or if another submitted object has been matched with the real object to yield more points.

Air Delivery (10%)

UAS must be able to deliver urgent aid supplies to the lost hiker, and those supplies must reach the hiker in a usable state. The safety judge must be notified before the UAS attempts the air drop. The aircraft must not fly below the minimum altitude in order to deliver. The drop area may be concrete, soil, asphalt, or grassy field.

Payload. The payload will be a [standard 8oz water bottle](#). Teams will be provided one of these sealed bottles at setup time. Teams can then attach additional equipment to the bottle to ensure that it remains intact upon landing. The total weight of the payload must not exceed 16 oz.

Delivery accuracy. Teams will be given the GPS coordinates of the drop location. This location will be on concrete pavement. Water bottles that are damaged on landing, such that less than 80% of water remains inside the bottle, will receive no points. The ratio of points a team is

awarded is $\max(0, (150ft - distance) / 150ft)$ where *distance* is the distance between the actual and the desired drop location.

Operational Excellence (10%)

Operational excellence will be graded by the mission and safety 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 Paper (20%)

Each team must submit a technical design paper that describes the design of their entry and the rationale behind their design choices. The purpose of the paper is to show the team's overall coordination and systems engineering process, design tradeoffs, final design solution, with a plan to collect analytical evidence and bench/flight test data proving it will safely fly and perform planned mission tasks. The paper must address the mission tasks the team is capable of achieving during flight.

The paper must be typed on 8.5" by 11" paper, single spaced, with at least 1" margins and a 10-point font, and use either Times New Roman or Arial font. Each page must have a footer containing the school, team name, and the page number. The paper must not exceed 20 pages including the title and references page. The following subsections contain the sections a team's paper must have, and the relative weighting of those sections.

Systems Engineering Approach (20%)

This section of the paper describes the systems engineering approach to UAS design.

Mission Requirement Analysis. Teams need to analyze the tasks to determine what requirements are placed on the UAS, what are the design tradeoffs for those requirements, and which systems need to be built to complete these tasks.

Design Rationale. This section should start with the environmental factors (e.g. team qualifications, budget, etc.) and mission requirements (e.g. tasks, point system, etc.), and describe the flow of decisions which led to the final design. For example, how the object task influences camera choice which influences aircraft choice which influences autopilot choice. It should describe the tradeoffs of design options and the rationale for the final solution. For example, for a fixed-wing aircraft what are the high-level tradeoffs between a high-wing and low-wing design.

Programmatic Risks & Mitigations. This section should identify and describe the risks inherent in designing and building a UAS. It should provide the likelihood and the impact of these risks as well as the methods used to mitigate them.

System Design (30%)

This section of the paper describes the design of the UAS system. For each system, the paper should describe what was chosen or built, why it was chosen, and what implications it has for task performance.

Aircraft. This section 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 labelled diagram of the airframe and a table containing all relevant metrics.

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

Imaging System. This section 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.

Object Detection, Classification, Localization. This section should provide a description of how both manual and automatic processing is performed (e.g. algorithms).

Communications. This section should describe the hardware used for communication between the aircraft and ground station, and between systems on the ground. It should list the frequencies used and for each, identify the type of data that is sent. This section should include a block diagram of the communications system.

Air Delivery. This section should describe the mechanism used to drop the payload and the modifications, if any, made to the payload to ensure safe delivery. Furthermore, it should describe the approach used to determine optimal drop time.

Cyber Security. This section should define potential cyber security threats and describe how the team addressed them in their ground station and aircraft design to protect their aircraft, payload, and data.

Test & Evaluation Plan (30%)

This section describes the tests that have been conducted and the plans for future mission tests. The team must provide quantitative results.

Developmental Testing. This section should describe the tests that were conducted during the construction of the UAS as well as the rationale for conducting them. It should also identify any changes to the system made as a result of this testing.

Individual Component Testing. This section should describe a comprehensive testing plan to verify that individual components work according to specification for operation in isolation. The list of components should at least include autonomous flight, imaging, object detection /

classification / localization, communications, and air delivery. It should include quantitative results and an interpretation.

Mission Testing Plan. This section should describe a team's plan to conduct full mission tests. It should include a discussion of predicted results as well as backup strategies if the results are not as expected.

Safety, Risks, & Mitigations (10%)

Safety is a top priority for the SUAS competition. This section describes the potential safety risks and the steps taken to mitigate them.

Developmental Risks & Mitigations. This section should describe any safety risks posed by the development process, and what was done to mitigate them.

Mission Risks & Mitigations. This section should identify any safety risks posed by the competition mission and autonomous flight, and describe the design decisions made to mitigate them.

Operational Risks & Mitigations. This section should identify any risks present in the operating procedures for testing and flight, as well as detail the steps taken to ensure aircraft and personnel safety.

Writing Style (10%)

The SUAS competition values clear and concise communication. Teams will be judged on their quality of writing.

Clarity. The paper should be easily understandable to engineers from various fields (i.e. mechanical engineering, computer science, electrical engineering, etc). It should clearly define all terms and symbols, label all accompanying illustrations, and ensure that all points are expressed as clearly as possible.

Accuracy & Precision. Data and facts presented in the paper should be free from errors. All assumptions relevant to data analysis should be clearly stated and challenged for legitimacy. Experimental or analytical data should be accompanied by error bars or confidence bounds.

Logic. The paper as a whole should make sense and not contain any contradictions. The conclusions should be supported by logical analysis. The flow of decisions should be clear.

Relevance, Depth, Suitability. The included data and analysis should be carefully selected to provide detailed insight into the UAS without being irrelevant to the competition. The writing style should be appropriate for the intended audience.

Flight Readiness Review (20%)

The flight readiness review is a presentation where teams demonstrate that their system is mature enough to compete. This readiness must be demonstrated with data. Judges will review this presentation to determine whether teams are ready enough to attend competition, and they may decide to disqualify unprepared teams.

The flight readiness review will be a video presentation submitted prior to attending competition. The video must be no longer than 15 minutes. The following sections contains the sections a team's presentation must have, and the relative weighting of those sections.

Experience, Roles, Responsibilities (5%)

At the start of the presentation, each member of the competition team must introduce themselves and provide the following information.

Experience. Team members should state their class year at their university, the number of years they've been on the team, and their degree of experience with UAS technologies.

Roles and Responsibilities. Team members should identify their role and their responsibilities on the development and competition team, and what they will do on the flight line.

System Overview & Planned Tasks (10%)

Teams must provide an overview of their system and identify the tasks they are planning to attempt.

System Overview. This section should contain a *brief* overview of the mechanical, electrical and software systems of the UAS. Note that the overview need not be very detailed, as the specifics of the system will already have been discussed in the technical design paper.

Planned Tasks & Expected Performance. In this section, teams should classify each of the mission tasks into one of two categories: attempting and not attempting. Furthermore, teams should indicate how confident they are about successfully completing each of these tasks.

Developmental Testing (50%)

Testing is vital to proving the readiness of a team's UAS for completing the mission. In this section, teams must detail the testing they conducted on individual components of the UAS to ensure they work according to specification. Data must be presented and described how it demonstrates readiness.

Types of Developmental Testing. This section should describe the types of testing conducted by the team (i.e unit testing, simulations, etc) and the rationale behind choosing to conduct each type of test.

Autonomous Flights. This section should identify the number of autonomous flights conducted by the team and the average amount of time spent in manual mode per flight. It should also discuss the process of tuning the aircraft for autonomous takeoff, flight, and landing.

Waypoint Accuracy. This section should contain a description of the testing conducted on waypoints and provide statistics such as number of waypoints attempted, the number of waypoints hit, and the average waypoint miss error.

Obstacle Avoidance Performance. This section should describe the types of tests conducted to verify both static and moving obstacle avoidance. In particular, it should include statistics on the number of obstacles tested against, and the number of static and moving obstacles avoided.

Imaging Performance. This section should contain an overview of the tests conducted on the imagery system and 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.

Detection & Classification Performance. This section should contain an overview of the testing conducted on the autonomous detection and classification algorithms, the data the testing was conducted on, and the results of the testing.

Localization Performance. This section should contain a description of the testing conducted on the localization algorithms, the number of objects on which localization was tested, and the average localization error identified.

Air Delivery Performance. This section should contain a description of the testing conducted on the air delivery task and provide statistics such as number of times air delivery attempted, the number of times the payload has survived the landing, and the average distance from the target the payload has landed.

Mission Testing (25%)

This section describes the full mission testing with the competition UAS and the competition team which will operate it.

Full Mission Tests. This section should describe in detail the mission tests conducted by the team and use the results to provide evidence that the system is capable of completing the planned tasks. It should discuss whether the testing that was conducted provided sufficient coverage, any flaws that it exposed in the system, and the subsequent corrective actions that were taken.

Estimated Score from Full Mission Tests. Teams should grade their full mission tests based on the rubric provided in the Mission Demonstration section. They should provide the scores from each full mission test, the average across all tests, and their expected performance.

Poster Display (10%)

Teams are required to bring a 48" by 36" poster to be displayed for the duration of the entire competition. It should contain the name of the team and university. It must provide an overview of the UAS system, as well as a brief discussion of testing results and expected performance. The poster should be formatted like an [academic poster](#). The intention is for the poster to provide a summary of a team's UAS for the judges and the other teams that will be walking around during the competition. Judging of the posters will be conducted independently of the FRR presentation. They will be judged on quality of content, comprehensiveness, clarity, and aesthetics.

Awards & Prize Money

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

Overall Ranking

Trophies 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 overall ranking will be worth prize money: the higher a team ranks the more prize money the team will receive.

Best In Class

There are three awards for best in class: best in technical design, best in flight readiness review, and best in mission. For each best in class award received, the team will receive a plaque and prize money.

Completed Tasks

Each team which completes eligible tasks will receive prize money. Tasks include autonomous flight, obstacle avoidance, object detection / classification / localization, and air delivery. A task attempt is eligible if the team gets at least 25% of points for the task.

Special Awards

A single team will be selected for each special award. For each special award received, the team will receive a plaque and prize money. The special awards are Best Overall High School Award, Best Overall Rotary Wing Award, Dawn Jaeger Tenacity Award, Dr. Arthur Reyes Safety Award, JustJoe Sportsmanship Award, and Cyber Security Award.

Appendix

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

Mailing Address

U.S. Postal Service:
AUVSI Seafarer Chapter
Post Office (P.O.) Box 141
California, MD 20619
301-862-1246

UPS or FEDEX:
AECOM
46591 Expedition Drive, Suite 100
Lexington Park, Maryland 20653
ATTN: Mr. Tim Piester
301-862-1246

Base Access Form & Documentation

Each competition attendee must fill out the following form. Foreign Nationals must their use Passport as the ID. A photocopy of IDs must be sent with form. The same ID must be presented at check-in. These forms, ID photocopies, and other sensitive data must not be sent electronically; we will only accept them via mail. See the [Mailing Address](#) appendix.

Base Access Form:

www.auvsi-suas.org/static/competitions/2017/auvsi_suas-2017-base_access_form.pdf

- Block 25: Leave blank, to be filled in by judges
- Block 26, 27, 28: Leave blank, not required for this event
- Block 30: Must return passes to competition director by end of event
- Block 31: Must be signed

Foreign National Form & Documentation

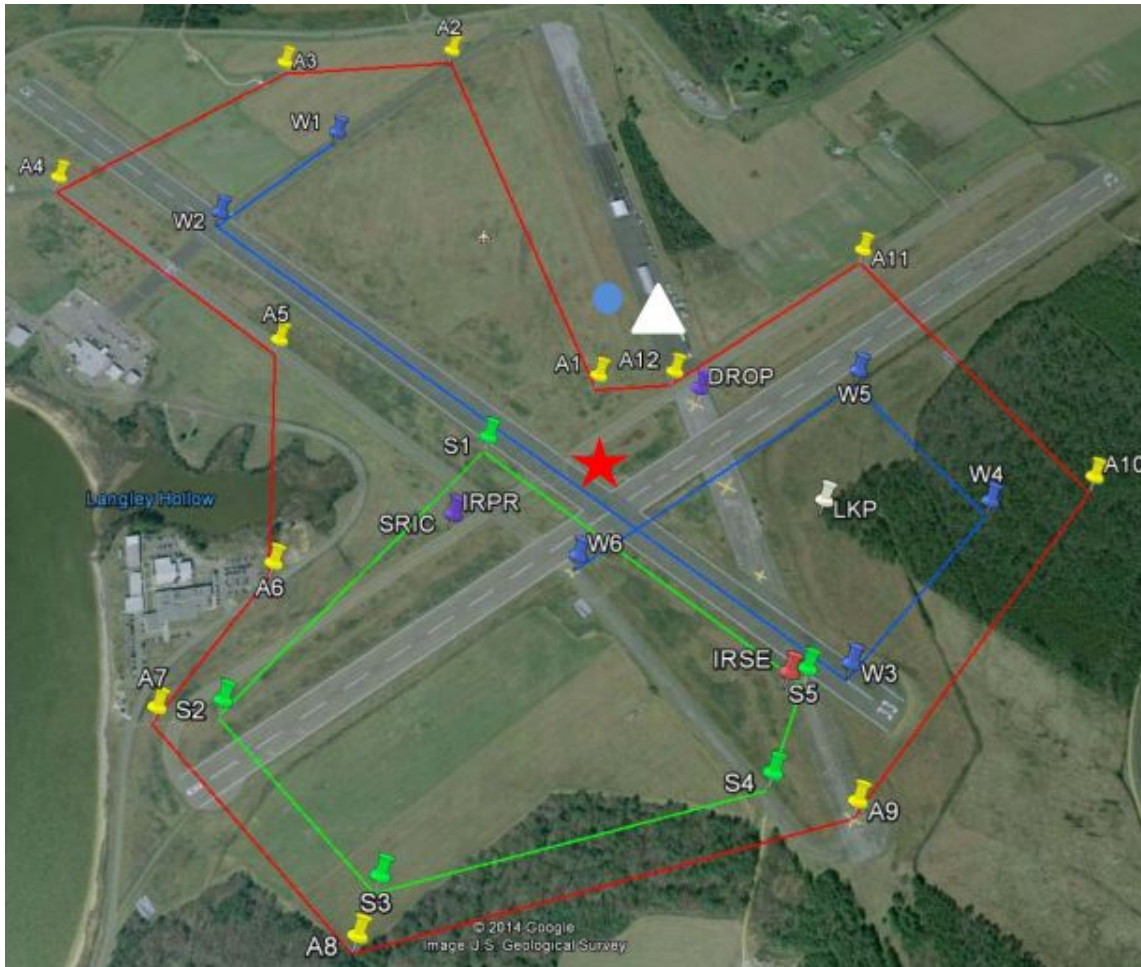
Any team which will have foreign nationals attend competition must mail an additional letter to gain base access. The team must send a letter on university letterhead that is signed by a responsible university official. See the [Mailing Address](#) appendix for the address. The letter must contain at least:

- Purpose of visit: **UNCLASSIFIED**, Students from this (name of University or College) will participate in the Association for Unmanned Vehicle Systems International (AUVSI) Student UAS (SUAS) Competition to be held at Webster Field, St. Inigoes, Maryland. Student teams will inspect and check their airplane and system, and will fly the vehicle

around a prescribed course at Webster Field under the guidance and supervision of Navy Government personnel and other AUVSI officials and volunteers.

- Confirmation that the visitation is strictly limited to the dates and times of the SUAS competition held at Webster Field, MD.
- For each foreign national, provide: Full Legal Name, Place of Birth (POB), Date of Birth (DOB), Country of Citizenship, Country of Residence, Title/position (Team Lead, Team Member, Faculty Advisor, Guest, Sponsor, etc.), Passport / Visa / Resident Alien “Green Card” number and expiration date. A photocopy of the passport or green card must also be included.
- Include University address, and phone and fax numbers.
- A responsible University official (a Dean, Department Head, or Senior Faculty official), other than persons listed on the request, shall sign the letter. The official name and position, and the date, must be typed on the letter, along with the official’s written signature and date.

Sample Mission Map



- White Triangle: Pit Area Tents (same each year)
- Red Star: Flight Line Tents (same each year)
- Red Outline: No-Fly Zone Boundary
- Yellow Pins: Boundary Judge Stations
- Blue Outline: Waypoint Sequence
- Green Outline: Search Area
- Blue Circle: Off-Axis Object
- DROP Pin: Air Drop Location

Object File Format

The Object File Format is a folder containing target files. Each target submitted by the team gets 2 files in the folder, both of which start with a number unique to the target, where one has the extension "json", and the other has either the extension "jpg" or "png". The "json" extension file

must contain a JSON formatted target conforming to the [POST /api/targets](#) data segment. A “jpg” extension file must be a JPEG image, and a “png” extension file must be a PNG image. The team will copy this folder to a USB drive provided by the judges. If the team is attempting actionable objects, the team will be provided 2 USB drives.

Target JSON specification:

auvsi-suas-competition-interopability-system.readthedocs.io/en/latest/specification.html#post--api-targets

Example folder structure for 2 targets:

- myteam/
 - 1.json
 - 1.jpg
 - 2.json
 - 2.png

Example JSON file:

```
{  
  "type": "standard",  
  "latitude": 38.1478,  
  "longitude": -76.4275,  
  "orientation": "n",  
  "shape": "star",  
  "background_color": "orange",  
  "alphanumeric": "C",  
  "alphanumeric_color": "black",  
}
```

The judges will ignore target files which are not proper JSON or do not conform to the specification. The judges will ignore target images which are not in either JPEG or PNG format.

