Competition Rules | SUAS 2020

by the AUVSI Seafarer Chapter

www.auvsi-suas.org

This document contains the rules for the 18th 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 2002.

SUAS 2020 Mission. Multiple package delivery companies have tasked Unmanned Aerial System (UAS) to deliver packages to customers. These UAS must avoid each other, avoid static obstacles like buildings, identify potential drop locations, drop the package to a safe location, and then move the package to the customer's location.

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 drop.

Competition Location. The competition will be held June 17th to 20th 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 advisers must join in order to receive important announcements and ask questions.

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 graded elements of the competition: the mission demonstration, the technical design paper, and the flight readiness review presentation. 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. It is the team's responsibility to monitor the calendar and comply with all deadlines and dates.

Deliverable Submission. All non-mission deliverables will be submitted via Google Forms. Each team will need a single Google account which has access to Google Drive (to host file deliverables and submit forms) and YouTube (to host video deliverables). Teams are responsible for ensuring all links are accessible by the judges (publicly viewable) for the duration of the competition.

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. Document size is limited to 10MB. Teams will upload documents via Google Form submission.

Video Format. All videos must be at least 1080p resolution with at least 24 frames per second. The video name must include the university and team name. Videos must be uploaded to YouTube, and teams will provide a publicly accessible link.

Lateness. Teams are given these deadlines months ahead of time. Failure to meet a deadline will result in either losing points for the graded element or disqualification from the competition. The judges will only evaluate extenuating circumstances for exemption and deadline extension.

The following subsections describe the individual deliverables and events.

Draft Rules, Comment Period, Final Rules

(2019-09-01) 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.

(2019-09-01 to 2019-09-10) 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.

(2019-09-15) 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.

Team Registration

(2019-09-20 to 2019-11-01) Registration Period. During this period, the team captain can submit the following Google Form and send a registration fee to register a team. Registration is first-come, first-served: the first 100 valid form submissions that also provide the registration fees within 7 days of form submission will be accepted. If the registration fee is not received within 7 days, the registration time will be updated to the time at which the registration fee is received. Teams will be notified of application status on a rolling basis. The registration fee is $1,500 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 in USD as a check, money order, or credit card payment. 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

Fact Sheet of Intent

(2020-02-15) Fact Sheet of Intent. The teams will submit a Google Form detailing specific facts about the UAS. The details of the fact sheet should represent the intended system the team will demonstrate. Details can change after this submission without notifying the judges.

Fact Sheet Form: goo.gl/forms/YH4b2X1pPPeEGfr52

Personnel Registration & Base Access Documents

(2020-03-01) Personnel Registration. The team captain will electronically submit a form for each member of the development team and the adviser.

Personnel Registration Form: goo.gl/forms/lwHdcmDdjcS0VcRP2

(2020-03-01) Base Access Documents. The competition is held on a US Naval Air Station. Each person attending the competition, from competitors to guests, will be required to fill out a form and provide documentation in order to be 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

(2020-05-15) Fact Sheet. The teams will submit a Google Form detailing specific 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

(2020-05-15) 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

(2020-06-01) 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 including 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 aircraft instance (primary, backup, etc) that might be used at competition.

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

(2020-06-01) 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. Teams must submit safety pilot logs if they wish to provide the safety pilot. Otherwise, the competition will provide the safety pilot. The safety pilot logs must detail the manual flights conducted by the safety pilot on the UAS in competition configuration. The safety pilot must perform and log at least 1 hour of manual flight, 10 takeoffs, and 10 landings. The team must provide multiple logs, each meeting this specification, for each pair of pilot and aircraft instance (primary, backup, etc) that might be used at competition.

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

(2020-06-01) 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

(2020-06-15) Team Promotional Video. Each team is required to submit a promotional video for their team. The video should show the full team, show the UAS in flight, and have a brief description of the design. The team can add additional content to the video as desired. The video must be no longer than 1 minute.

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

Competition: Check-in, Mission, Awards Banquet

(2020-06-17 3pm - 6pm) Career Fair. After teams have checked in, 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.

(2020-06-17 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 interoperability connection details.

Waiver:
auvsi-suas.org/s/auvsi_suas-2020-risk_and_liability_waiver.pdf

(2020-06-17 4pm - 6pm) 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 will get their interop credentials as part of check-in and can begin testing immediately after.

(2020-06-17 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.

(2020-06-17 6pm - 8pm) Orientation. This is a meeting covering all of the logistics for the week. Teams must be present to receive last-minute updates.

(2020-06-18 6am - 7am) Base Entry. Teams should arrive at the base gate by 7am. Teams which arrive later than 8am might not be allowed entry. Teams are responsible for budgeting time to go through base entry, drive to the pits, and setup before the competition events.

(2020-06-18 8am) Group Photo. The teams and judges will get together for a competition photo. Teams and their UAS must be present. The photo will not be delayed for missing teams or those still going through base entry.

(2020-06-18 8:30am) Individual Team Photos. After the group photo, teams will individually 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.

(2020-06-18 9am) Safety Inspections. The UAS and the ground station will be inspected for safety and competition compliance. Teams will be evaluated in their flight order. Inspection will include at least a physical inspection, fail-safe and flight termination check, and maximum weight check. 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. Each aircraft instance must be safety inspected.

(2020-06-18 9am) 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.

(2020-06-18 12pm - dusk) Mission Demonstrations. Mission demonstrations will be started once a critical mass of teams have passed safety inspections. 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. If teams are called but not present, they will be disqualified.

(2020-06-19 6am - 7am) Base Entry. Same as Thursday.
(2020-06-19 7am - dusk) Mission Demonstrations. Same as Thursday.
(2020-06-20 6am - 7am) Base Entry. Same as Thursday.
(2020-06-20 7am - dusk) Mission Demonstrations. Same as Thursday.

(2020-06-20 7pm-11pm) 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 may 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 an 8 person subset of the development team. The competition will provide food, t-shirts, and other resources for these 8 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.

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 a t-shirt. 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.

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

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. The team is required to provide the base access details for these guests by the specified deadline.

Unmanned Aerial System

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.

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 Technical Design Paper. The team may use backup instances of that design during development. The team must use exactly one instance during the Mission Demonstration.

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. These must be configured with the location specified in the Mission Flight Boundary Appendix. 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, loctite (fluid), or nylon nuts.

No Unauthorized Air Drop. 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.

Autonomous Flight. The UAS must have autonomous flight capabilities to compete.

Unmanned Ground Vehicle

General Restrictions. The team may use a single Unmanned Ground Vehicle (UGV) at the competition as part of the air drop task. The entire drop payload can weigh up to 64oz. The UGV drive speed may be up to 10 miles per hour.

Drive Termination. The UGV must terminate driving after 30 seconds of communication loss or after driving out of the boundary specified in the Air Drop Boundary Appendix. Drive termination must also be activatable by the safety pilot or the ground station.

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.

Autonomous Driving. The UGV may only drive autonomously.

Ground Station

Ground Station Display. Teams must have a display, always viewable by the mission judges, which shows 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, checklists, 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 for ODLC. No ground based sensors can be used to image objects for the ODLC task. Photos must be taken from the UAS for ODLC.

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. Any bands allowed by FCC regulations may be used at competition. Judges will be using the 462 MHz frequency for handheld radios.

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 wind and rain.

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

Temperature. The system 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.

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 linked off the code repository website. This documentation 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 using the username and password that is provided at Check-In and Orientation.

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

UAS Telemetry Upload & Download. Certain tasks require teams to upload 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. Teams can download recent telemetry from the other UAS for use in moving obstacle avoidance.

Object Upload. Teams must submit objects via the Interoperability System to earn points. The Interoperability Specification defines an object, with details like the set of valid background colors for a standard object.

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.

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 time spent out of bounds 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.

Mission Details and Deliverables. The mission flight boundaries are given in the rules in the Mission Flight Boundary Appendix. The air drop boundaries are given in the rules in the Air Drop Boundary Appendix. The interoperability connection details will be provided at competition check-in. At setup time and during the mission, teams may retrieve all other mission details via the Interoperability System using a mission ID provided at setup time. All deliverables will be submitted to the judges via the Interoperability System.

Judges. The lead judge will likely stand with the team's mission lead. The safety judge will likely stand with the team's safety pilot.

Order of Team Demonstration. The judges will score all deliverables due before the mission demonstration 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.

Order of Tasking. Teams must successfully takeoff and go above 100ft 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. Teams are allowed to attempt other tasks while flying the waypoints, so long as such doesn't require a change in flight path. 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.

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 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 Team Lead and Safety Pilot, 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 (80%). Teams will be provided 40 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. Flight time and post processing time are limited to 30 minutes and 10 minutes respectively. The ratio of mission time points a team is awarded will be $max(0,\ 60 - 5 * max(0,\ X\ -\ 20) - Y) / 60$, 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 3% of timeline points for every second of flight time or post processing time over their respective limits.

Timeout (20%). Teams are allowed one timeout to stop the mission clock, and it will cost them these 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.

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

Autonomous Flight (10%)

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.

Autonomous Flight. The UAS must fly autonomously for at least 3 minutes to receive any mission demonstration points. The team is responsible for telling the safety judge (next to safety pilot) whenever the autopilot transitions between autonomous and manual mode.

Waypoint Accuracy (100%). The teams will be given a sequence of waypoints that should be flown in order during the mission. The waypoint path may be up to 6 miles in length. 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 points for waypoint accuracy, teams must upload valid telemetry to the Interoperability System at an average of 1Hz while airborne.

Manual Takeover Penalty. 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. After every two minutes of manual flight, the team will be assessed an additional manual takeover penalty.

Out of Bounds Penalty. Teams are given a flight boundary in the Mission Flight Boundary Appendix. 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 a penalty equal to 100% 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 50% 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 obstacles. 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 (100%). 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 the ground. The cylinders will have a radius between 30ft and 300ft, and there is no constraint on height. There can be up to 30 stationary obstacles. The ratio of points received for will be $(obstacles\ avoided / total\ obstacles)^3$.

Moving Obstacle Avoidance. Multiple UASs may be flying at the same time at the competition. These UASs will be operated by independent teams which are not in communication. Teams must avoid other aircraft that may be flying in the shared airspace. Through the interoperability system teams can download the telemetry of the other UASs who are uploading telemetry. Note

it is not a requirement to upload telemetry, so teams should build additional methods to sense, detect, and avoid the other UASs.

Object Detection, Classification, Localization (30%)

UAS should be able to search for objects. Teams will have to detect, classify, and localize two types of objects: standard and emergent. A standard object will be a colored alphanumeric (uppercase letter or number) painted onto a colored shape. 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. There may be up to 20 objects. Each object will be weighted equally. Teams must submit objects via the Interoperability 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 search grid can be up to the size of the entire mission flight boundary. 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. Objects may be placed under obstacles.

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 (40%). Each object has a set of characteristics, and teams are awarded points for ratio of correct characteristics: $\textit{correct characteristics} / \textit{total characteristics}$. 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 person in need of rescue and the surrounding scene.

Geolocation (40%). 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 created, submitted, and last edited during the team's first flight will be considered actionable.

Autonomy (10%). 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.

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 Drop (20%)

UAS should be able to air drop a payload at a specified position. 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. Teams may only perform the drop once.

Payload. Teams should design an Unmanned Ground Vehicle (UGV) that can be air dropped to a specified location. The UGV must carry a standard 8oz water bottle (example) that will be provided by the judges at setup time. Upon landing, the UGV should be capable of driving to another location with the water bottle. See the Unmanned Ground Vehicle Requirements.

Drop Accuracy (50%). Teams are given the GPS coordinates of the drop location. To receive points, the UGV and water bottle must land without damage. The percentage of points awarded for a drop is 100% for within 5ft distance, 50% for within 15ft distance, 25% for within 40ft distance, and 0% for beyond 40ft distance, where $distance$ is the distance between the actual and the desired drop location.

Drive to Location (50%). Teams are given the GPS coordinates of a destination. Upon landing, the UGV should drive to this location with the water bottle and stop. Teams are awarded points if the UGV stops within 10ft of the specified location without going out of bounds.

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 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 analysis and tradeoffs, final solution, tests which were conducted and performance data, and expected task performance. The paper must address the mission tasks the team is capable of achieving during flight, and if a team elects not to include certain elements (e.g. air drop) it should be so stated.

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 10 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.

Payload Design (40%)

This section of the paper describes the payload the UAS uses to complete mission tasks.

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

Autonomous Flight Design (40%)

This section of the paper describes the aircraft and flight systems used to achieve autonomous flight while carrying the payload used to achieve mission tasks.

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.

Safety, Risks, & Mitigations (20%)

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 describe any safety risks posed by the competition mission, autonomous flight, and testing, and what was done to mitigate them.

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 10 minutes. The following sections contains the sections a team's presentation must have, and the relative weighting of those sections.

System Overview & Planned Tasks (20%)

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 obstacle avoidance. In particular, it should include statistics on the number of obstacles tested against, and the number of 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 that was collected, 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 Drop Performance. This section should contain a description of the testing conducted on the air drop task and provide statistics such as number of times drops were attempted, the number of times the payload has survived the landing, and the average distance from the target the payload has landed.

Mission Testing (30%)

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.

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 top 5 teams will receive prize money.

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.

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 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

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:
auvsi-suas.org/s/auvsi_suas-2020-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

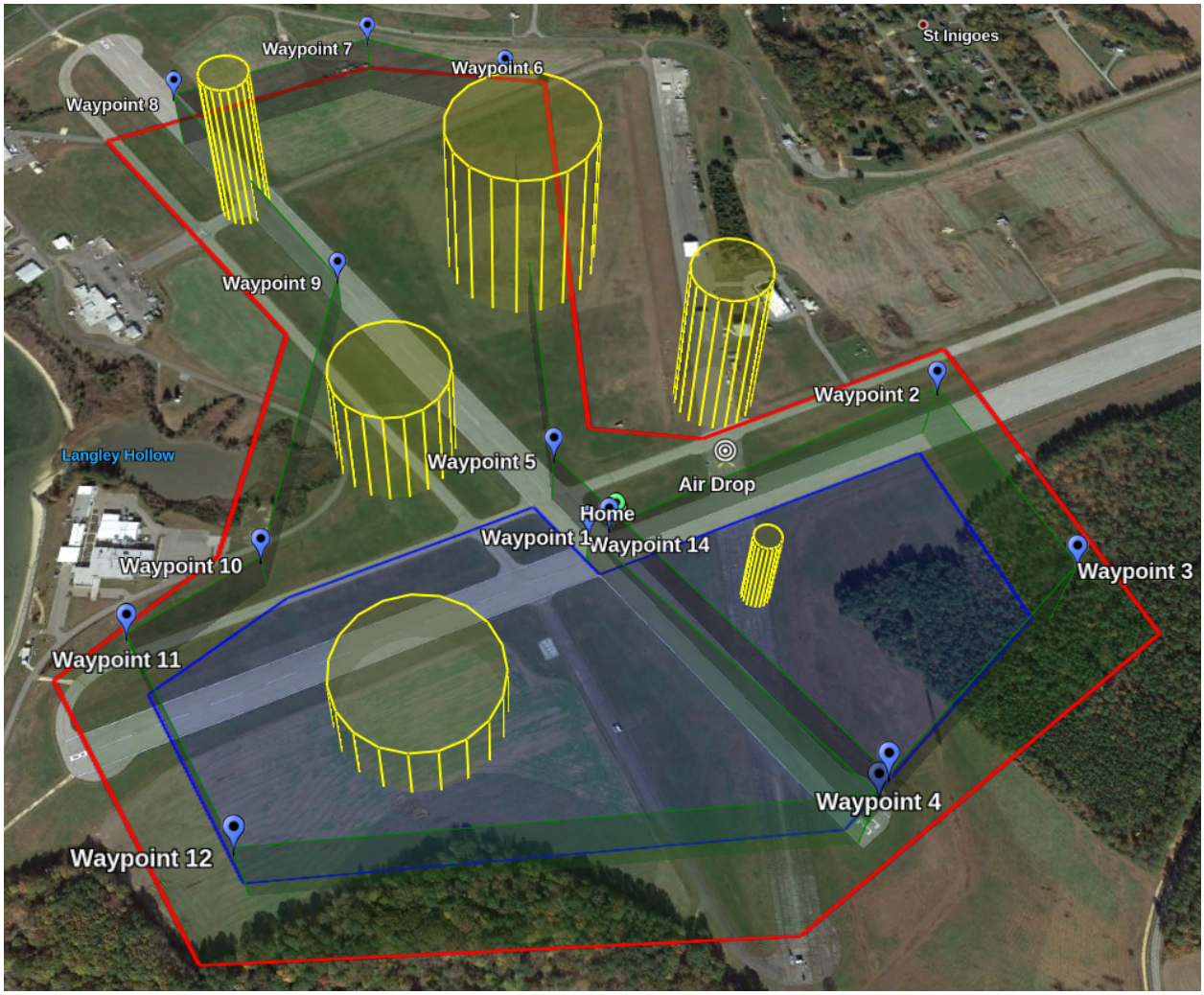
Foreign National Form & Documentation

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: **UNCLASSIFED**, 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 Adviser, 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 (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



Sample Mission Map. Red polygon is the flight boundary. Blue polygon is the search grid. Yellow cylinders are the stationary obstacles. The green line is the waypoint path.

Mission Flight Boundary

The following are a series of GPS points which form a polygon that is the mission flight boundary. The UAS must remaining within this polygon and within the altitude restrictions of [100ft MSL, 750ft MSL].

N38-08-46.57	W076-25-41.39
N38-09-05.85	W076-25-43.26
N38-09-06.80	W076-25-53.28

N38-09-02.14	W076-26-07.30
N38-08-51.24	W076-25-56.43
N38-08-40.80	W076-25-58.61
N38-08-35.72	W076-26-05.16
N38-08-25.67	W076-25-57.49
N38-08-26.59	W076-25-33.65
N38-08-37.54	W076-25-16.34
N38-08-50.45	W076-25-23.56
N38-08-46.07	W076-25-35.95

The UAS may only go below 100ft MSL for takeoff and landing over their assigned runway. One assignable runway extends to the north and to the west, the other runway extends to the south and to the east. Teams will be assigned a runway based on their flight line tent, both of which will be assigned at setup time. Teams may also use the grass sections adjacent to their assigned runways for takeoff and landing, so long as flight paths don't intersect the other runway, the flight line tents, or the taxi way to the pits. Teams are unsafe out of bounds if their UAS goes over the non-assigned runway and is under 100ft MSL.

Assignable Runways. The Red runway extends to the North and West, the Blue to the South and East.

Flight Line Tents. The Red tents will be assigned the Red runway, the Blue tents the Blue runway.

The following must be the configured lost comms RTH/RTL and flight termination point.

N38-08-41.20	W076-25-45.90

Air Drop Boundary

The following are a series of GPS points which form a polygon that is the air drop boundary. The air drop position and UGV drive location will be somewhere within this boundary. The UGV must remain within this polygon while driving, and must automatically terminate drive if it leaves the boundary.

N38-08-46.20	W076-25-36.00
N38-08-46.90	W076-25-34.20
N38-08-44.10	W076-25-33.90
N38-08-43.50	W076-25-35.80