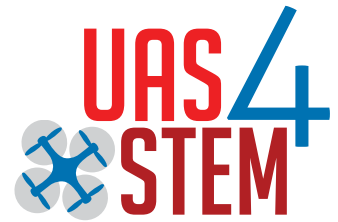


UAS4STEM

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COMPETITION RULEBOOK 2022 V-2.0

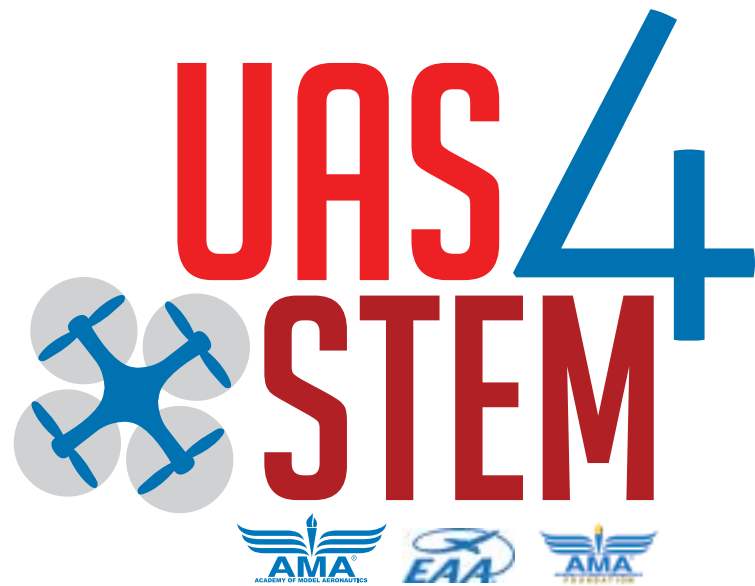


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or (800) 435-9262.

TEAM RULEBOOK

1. CONCEPT OF OPERATIONS (CONOPS)

A small group of people are stranded after a flash flood. While rescuers have determined a search area, they are unsure of the exact whereabouts and conditions of those stranded. Your team has been called upon to provide rapid response, via an Unmanned Aircraft System (UAS), that can support the Search and Rescue (SAR) mission. In order to support this mission, your UAS must comply with Special Instructions (SPINS) for departure and arrival procedures, and then remain within assigned airspace. It will be tasked to search an area for items of interest and to conduct point reconnaissance. As part of this mission you will be required to pick up and deliver a small payload to a designated area.

2. INTRODUCTION

2.1. THRUST

2.1.1. The principal thrust of the UAS4STEM Drone Challenge is the safe application and execution of Systems Engineering principles to develop and operate a sUAS to successfully accomplish the mission tasks.

2.2. SCORED ELEMENTS

2.2.1. The five scored elements of this competition are:

- 2.2.1.1. Flight Plan Report
- 2.2.1.2. Oral Briefing of a Flight Readiness Review (FRR)
- 2.2.1.3. Flight Mission Demonstration-Waypoint Challenge and Target Challenge
- 2.2.1.4. Overall Safety Score
- 2.2.1.5. Team average score from Online Ground School

2.3. OPPORTUNITIES

2.3.1. Student teams will be judged based on their performance and that of their system. Medals will be awarded for top performances. Opportunities for interaction with UAS engineers, scientists and leadership will be provided.

2.4. RULES

2.4.1. The Search and Rescue competition will be based upon the competition rules outlined within this document containing administrative and performance objectives. These rules are aimed at a high school level curriculum. These rules may be updated with clarifications or updates and posted as the official rules for competition. The UAS4STEM committee reserves the right to make changes to these rules and issue updates or addendums at any time.

3. SCHEDULE

3.1. DATES AND LOCATIONS (SUBJECT TO CHANGE) SEE WWW.UAS4STEM.ORG OR REFER TO UAS4STEM EMAIL COMMUNICATIONS FOR UPDATED SCHEDULING INFORMATION.

4. MAJOR ELEMENTS OF THE COMPETITION

4.1. REGISTRATION PROCESS

4.1.1. Once the team manager sends all requested team information and pays the registration fee, AMA memberships for one team manager and up to 10 student team members will be processed and credentials for the virtual ground school will be created.

4.1.2. It is required that all student members of the team successfully complete the online UAS4STEM Ground School course, as a matter of safety and because the team's average score is part of their competition points. Any assistant team managers must enroll as members of the Academy of Model Aeronautics (AMA).

4.1.2.1. It is required that all participants comply with any national and local regulations regarding model aircraft and the national airspace at all times.

4.1.3. By participating in the Search and Rescue competition, the team, advisors and all support members, as well as judges and volunteers, agree to have any pictures of persons, vehicles or equipment photographed and released to the public on web pages, in papers and published trade magazines and journals, or posters.

4.2. VIRTUAL PRELIMINARY COMPETITION

The virtual preliminary competition occurs in the spring. Each team will have the opportunity to schedule an appointment slot with the judges; UAS4STEM email communications will contain information about this process. Appointments will be in Eastern Standard Time, with flexibility offered across time zones.

4.2.1. The virtual preliminary competition will have two components: a proof-of-flight video submission and a virtual Flight Readiness Review (FRR) presentation.

4.2.2. Prior to the competition, a proof-of-flight video shall be submitted to verify that the team's aircraft can fly in a safe manner. This is required for possible advancement to nationals. The aircraft should be in full autonomous configuration for maximum points and perform the following:

1) TAKE OFF

2) FLY TO 3 WAYPOINTS A MINIMUM DISTANCE OF 100 FEET APART

3) RETURN TO LAUNCH FOR LANDING

4.2.2.1. The proof-of-flight video shall identify the school and the team name. The video shall show the ground control station screen and aircraft flight.

4.2.2.2. A link to the team's video posted as a private video on the internet (www.youtube.com is preferred) shall be submitted by the specified date and time deadline.

4.2.2.3. The video shall be no less than 2 minutes and not exceed 3 minutes in length.

4.2.5. The FRR for the preliminary competition shall be an oral briefing presented virtually to a team of judges during which the teams substantiate, with data, their plans to safely accomplish the mission.

4.2.6. The intention is to demonstrate to the judges that the team is ready to compete safely, with low risk, in the flight mission phase of the competition. The FRR shall address the mission tasks the team plans to achieve during flight.

4.2.7. Following the FRR briefing, there will be a question-and-answer period with the judges and a mission-planning software assessment. Five verbal questions from the judges will be presented and worth one point each.

4.2.8. All team members present are encouraged to participate.

4.2.9. The FRR Briefing is a scored element worth TWENTY-FIVE Points. The FRR briefing will be assessed on the team's ability to effectively articulate the scope and depth of the developmental testing performed, the ability of the system design to perform the planned flight tasks, and the preparations made to improve the chances of a successful Flight Mission.

4.2.10. The FRR briefing shall not exceed 30 minutes in duration, followed by a maximum period of 5 minutes where the judges will ask questions regarding the presentation and the team shall answer. A judge will time the presentation, provide a 2-minute warning, and cut off extended presentations as needed.

4.2.11. FRR content and scoring (see below)

Flight Readiness Review (FRR) Presentation Content Guide and Scoring **(25 points total)**

1. Team Member Introductions

Including flight mission roles and experience for all team members. **(10%)**

2. System Overview

Relating to flight tasks planned, expected performance, and any risk evaluation. **(10%)**

3. System Safety

With identified design and operational strategies. **(10%)**

4. Developmental Test Results

Including: test plan schedule (through ground testing to flight testing to mission performance testing), results of testing, and any corrective action taken to improve the effectiveness on mission completion. **(10%)**

5. Evidence of Mission Accomplishments.

Show the judges what you have achieved. **(10%)**

6. Pre-Mission Briefing

Including personnel resourcing for the flight, communication procedures, and go/no-go criteria.

Judges will pose a hypothetical question to gather a teams sense of fallback plans should a technical issue arise during flight mission. **(10%)**

Other scoring factors

Participation and communication skills will be scored by judges factoring in aspects such as clarity, accuracy, logic, precision, relevance, depth, and suitability. Five judges questions will also be posed prior to the mission-planning software assessment. **(10%)**

7. The mission-planning software assessment will be a challenge in which the judges will give a mock mission, and the team must demonstrate how they would program the mission planning software to achieve the mission objective. The team may confer as this is accomplished. To do this, the team will need to have the mission planning software loaded onto the computer they are using for the virtual FRR presentation and share their screen with the judges. Failure to complete previous command will nullify any subsequent commands and the scoring will stop. Consider factors such as "automated take-off" and the setting of a reasonably suited home point as prerequisites to a successful mission. **(30%)**

- *In order to compete, each team member must successfully pass UAS4STEM ground school.*
- *In the case of a tie, team average ground school scores will be utilized to determine placement.*
- *Allowances for technical difficulties that may arise during virtual competitions will be at the discretion of the judges.*

NATIONAL COMPETITION

The national competition is in-person and attendance is by invitation only, extended to the highest scoring teams from the virtual preliminary competition. Teams are responsible for all associated travel, room and board costs. Requirements and scoring for the in-person competition are outlined below. SPECIAL NOTE: Pay particular attention to the time limitations and potential points for each section below. The National Competition FRR rules are modified from the Virtual Preliminary Competition.

4.3. SAFETY INSPECTIONS

4.3.1. Safety inspections shall include a physical

inspection, and may include a fail-safe check, and flight termination check.

4.3.2. Safety inspections shall be performed on all aircraft by designated competition safety inspectors prior to being allowed to make any competition flight.

4.3.3. The safety inspections are not a scored element. All decisions of the safety inspector(s) shall be final.

4.3.4. Physical inspection of the aircraft shall include:

4.3.4.1. Verify all components adequately secured to vehicle.

4.3.4.2. Verify rotor structural attachment integrity.

4.3.4.3. Visual inspection of all electronic wiring.

4.3.4.4. Check general integrity of any payload system

4.3.4.5. Verification of fail-safe mode operation covered by manual override and pilot-commanded flight termination may be requested by the judges.

4.4. FLIGHT READINESS REVIEW (FRR) BRIEFING

4.4.1. The FRR shall be an oral briefing presented to a team of judges during which the teams substantiate, with data, their plans to safely accomplish the mission.

4.4.2. The intention is to demonstrate to the judges that the team is ready to compete safely, with low risk, in the flight mission phase of the competition. The FRR shall address the mission tasks the team plans to achieve during flight.

4.4.3. Following the FRR briefing, there will be a question-and-answer period, followed by an inspection of the team's UAS, including aircraft, ground station, test data, safety checklists, and other supporting evidence.

4.4.4. All team members present are highly encouraged to participate to maximize points.

4.4.5. The FRR Briefing will be oral only. Teams may use their aircraft or ground control station to demonstrate various aspects of the briefing. TEAMS MAY NOT POWER UP THE AIRCRAFT. ONLY ONE ELECTRONIC DEVICE, LAPTOP OR TABLET MAY BE USED FOR BRIEFING.

4.4.6. The FRR Briefing is a scored element worth TWENTY-FIVE Points. The FRR briefing will be assessed on the team's ability to effectively articulate the scope and depth of the developmental testing performed, the ability of the system design to perform the planned flight tasks, and the preparations made to improve the chances of a successful Flight Mission.

4.4.6.1. The in-person FRR briefing shall not

exceed 15 minutes in duration, followed by a maximum period of 5 minutes where the judges will ask questions and the team shall answer. A judge will time the presentation, provide a 2 minute warning, and cut off extended presentations as needed.

4.4.6.2. The breadth of the presentation will be scored based upon inclusion of the following elements with relative worth in percent:

4.4.6.2.1. Team member introductions including flight mission roles and experience/biographies (10 %)

4.4.6.2.2. A brief system overview relating to flight tasks planned, expected performance, and any risk evaluation. (10%)

4.4.6.2.3. System Safety with identified design and operational strategies. (10%)

4.4.6.2.4. Developmental Test Results including: test plan schedule (through ground testing to flight testing to mission performance testing), results of testing, and any corrective action taken to improve the effectiveness on mission completion. (30%)

4.4.6.2.5. Evidence of Mission Accomplishments. (10%)

4.4.6.2.6. Pre-Mission Briefing, including personnel resourcing for the flight, communication procedures, go/no-go criteria and fallback plans should a technical issue arise during flight mission. (20%)

4.4.6.2.7. Team member participation and communication skills (clarity, accuracy, logic, precision, relevance, depth, and suitability). (10%)

REGARDING PRESENTATIONS:

if the size of the classroom will support it, we will allow the general public to come in and view the oral presentations at nationals. Representatives from other teams (including students, team managers, parents) will not be allowed to view presentations of competitors this season. However, we will be recording all presentations and plan to make those available for all other teams and the public to view next season. Your presentations represent the best of the best. We want to celebrate the level of knowledge and preparation you display, because it is absolutely impressive! We want new teams to have a great example to follow as they get started.

4.5. FLIGHT MISSION REQUIREMENTS

4.5.1. The flight Mission evaluates the teams' ability to conduct a mission operation with their



MAP KEY

- Red outline: No-fly-zone boundary
- Blue outline: Waypoint sequence
- Green outline: Search area
- White Star: Designated Take/Off and Landing Area
- White Circle: Payload delivery Search Area

vehicle. This is the culminating event and a scored element of the competition.

4.5.2. A lead judge will be assigned to each team at the flight line. It is important that all team members follow the instructions of the judges. There will be additional judges assigned who are focused on different aspects of the competition (imagery, autonomy, safety, teamwork, etc.) depending on which tasks the team is planning to accomplish.

4.5.3. Only systems presented in the FRR, inspected by safety inspectors, and included in the preflight brief will be permitted to fly.

4.5.3.1 In order to compete, each team member must successfully pass UAS4STEM ground school.

4.5.3.2 In the case of a tie, team average groundschool scores will be utilized to determine placement.

4.5.4. OPERATIONAL TIMELINE

4.5.4.1. Setup Time = 15 minutes maximum. Setup time begins when the team arrives at the flight line. A lead judge will be assigned to each team and will start a dedicated stopwatch after communicating with the team Captain. After the maximum time, the judge may declare mission start, regardless of the team's readiness to launch the mission.

4.5.4.2. Flying Time = 30 minutes maximum.

4.5.4.2.1. Flying Time shall start at the declaration by the Lead Judge who will have a dedicated Mission Clock Stopwatch. TEAMS MUST KEEP THEIR OWN TIME. ONCE ON THE CLOCK A TEAM MAY NOT ASK FOR REMAINING TIME

4.5.4.2.2. A team may elect to cycle through the takeoff and landing sequence during the flying time more than once for a variety of valid reasons (change batteries, load payload, etc). No points will be lost, but flying time continues to be used.

4.5.4.2.3. Flying time stops when the vehicle has completed flight (landed, crashed, or terminated) and the team has disconnected flight battery. The lead judge will confirm with the team captain that the flying time period has stopped, and the post processing time period starts.

4.5.4.2.4. Teams that are still flying after 30 minutes will be assessed a penalty of one point for each minute over the 30-minute time limit.

4.5.4.2.5. Teams that are still flying after 40 minutes will be disqualified.

4.5.5. MISSION LIMITATIONS

4.5.5.1. Mission Boundaries

4.5.5.1.1. During the entire mission, aircraft shall remain in controlled flight and within the no-fly-zone boundary. A specific no-fly-zone boundary definition will be provided to teams following their FRR. Any vehicle appearing uncontrolled or moving beyond the no-fly-zone boundary during autonomous flight will be subject to immediate manual override. Failure of manual override will result in flight termination.

4.5.5.1.2. After takeoff and before landing, aircraft shall sustain flight at an altitude between 40 feet and 350 feet MSL for the duration of the mission. Flight below 40 feet or above 350 feet during autonomous flight shall require manual override. Failure of manual override will result in flight termination.

4.5.5.2. Takeoff

4.5.5.2.1. Takeoff shall take place within the designated takeoff/ landing area, shown on the competition map.

4.5.5.2.2. Takeoff under manual control with transition to autonomous flight will be permitted but does not count as an

autonomous takeoff.

4.5.5.2.3. The first takeoff will be scored, regardless if it is manual or autonomous. Only autonomous takeoff attempts on the first takeoff will earn points.

4.5.5.3. Landing

4.5.5.3.1. Landing shall take place within the designated takeoff/landing area shown on the competition map.

4.5.5.3.2. Landing under manual control is permitted.

4.5.5.2.3. Any autonomous landing inside of mission time can be scored. This can be as part of a mission or as a Return to Launch mode landing.

APPROVED UAS COMPONENTS

Laptop guidelines

- Each team must provide their own laptop computer.
- Only a single laptop will be allowed on the flight line and with the team during the oral presentation.
- One additional monitor may be used on the flight line. This monitor may only display information from the computer and may NOT be used as an additional video viewing device. Example. You may duplicate a display on a laptop, or this can be the primary display for a desktop. It may not display video from the aircraft.

5.1. Teams will need to purchase UAS components that comply with provided specifications. If parts are damaged or destroyed they may only be replaced with comparable parts with the same specifications.

5.2. Reminder, a maximum of 2 video displays may be used during the competition.

5.3. In the pits and the airfield, the UAS4STEM Competition will ensure that teams are provided shade, a folding table, chairs and a single electrical power extension cord. Teams should plan to provide their own power strip, if required.

6. DESCRIPTION OF MISSION TASKS

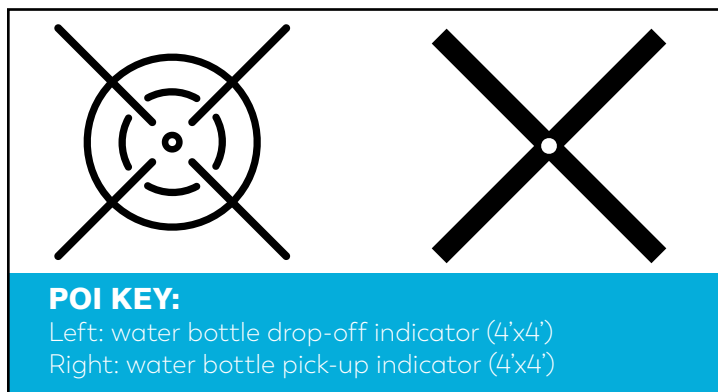
The Flight Mission has been divided into a series of tasks. Teams do not need to complete every task. The available tasks are listed in this section with the associated scoring associated with each task.

6.1. Capture waypoints and commands in sequence. Waypoints and commands will be chosen no less than 50 ft from the "no-fly-zone" boundaries and will be provided to teams following completion of their FRR. Waypoints and commands will be provided to the teams the morning of the competition. Capture waypoints in sequence while in autopilot control with +/- 50 ft accuracy and maintain navigation +/- 50 ft. along the planned flight path. ANY AVAILABLE MISSION PLANNER COMMAND MAY BE ALLOWED DURING WAYPOINT NAVIGATION. This may include, but it is not limited to, loiter, POI (Point of Interest), adjust airspeed, and others.

Failure to complete previous command will nullify any subsequent commands. Example: Waypoint 5 requires hold of 5 seconds. If aircraft fails to hold for proper time, the following waypoints will be scored ZERO. Team must announce to the judges which waypoint and command is being attempted to be scored.

PARAMETER	OBJECTIVE	POINTS
GCS DISPLAY ITEMS	Accurately display current aircraft position. GCS must also display airspeed and altitude to operators and judges. This is a minimum requirement for flight approval.	N/A
TAKEOFF	Achieve controlled autonomous takeoff. Scored on first takeoff attempt. Pilot or ground station operator may activate button or switch to initiate the takeoff. Takeoff is complete when drone reaches an altitude > or = 100ft and hovers for a minimum of 5 seconds	Four points
WAYPOINT NAVIGATION	Capture waypoints and commands in sequence. Waypoints and commands will be chosen no less than 50 ft from the "no-fly-zone" boundaries and will be provided to teams following completion of their FRR. Waypoints and commands will be provided to the teams the morning of the competition. Capture waypoints in sequence while in autopilot control with +/- 50 ft accuracy, and maintain navigation +/- 50 ft. along the planned flight path. ANY ALLOWED MISSION PLANNER COMMAND MAY BE ALLOWED DURING WAYPOINT NAVIGATION. This may include, but it is not limited to, loiter, POI (Point of Interest), adjust airspeed and others. Failure to complete previous command will nullify any subsequent commands. Example: Waypoint 5 requires hold of 5 seconds. If aircraft fails to hold for proper time, the following waypoints will be scored ZERO. Team must announce to the judges which waypoint and command is being attempted.	One point for each waypoint and command achieved in proper order. Maximum 10.
LANDING	Achieve controlled autonomous landing. Scored on first landing attempt. Pilot or ground station operator may activate button or switch to initiate the landing.	Four Points

PARAMETER	OBJECTIVE	POINTS
LOCALIZATION	Determine Points of interest (POI) location within 50 ft.	Points are given based on accuracy of location. 5 points for 0–10', 4 points for 11–20', 3 points for 21–30', 2 points for 31–40', and 1 point for 41–50'.
CLASSIFICATION	Identify item characteristics. Multiple targets will then be used for precision delivery.	One point each
PACKAGE DELIVERY	Water bottle may be picked up and delivered to the designated delivery target icon. One water bottle may be delivered to each target. Teams may descend to 0 altitude for package delivery. Only intact water bottles will be scored. Points are given based on accuracy of location.	5 points for 0–10', 4 points for 11–20', 3 points for 21–30', 2 points for 31–40', and 1 point for 41–50'.
COMPLETE SOLUTION	Locate and classify items of interest.	Six points. Teams must identify the location of all targets and receive a distance score for each target to qualify.



6.2. Six Points Of Interest (POIs) will be in the target area. Three POIs will have a small water bottle containing 8oz of water. Three POIs will be delivery targets. Teams must locate the targets with the water bottles and fly to the target and pick up the water bottle from the target. Water bottles will stand vertically in the center of the target.

6.2.1. Waypoint and Payload Delivery missions are independent of each other. Each must be completed separately before moving on to the other challenge.

6.2.2. The vehicle shall search for items of interest. Each POI will be located within the search area. Each POI will be printed on a 4'x4' vinyl banner material and contain either a pick-up indicator or a drop-off indicator.

6.3. PAYLOAD DELIVERY SPECIFICATIONS

6.3.1. Payload delivery mechanism must be designed and built by team members. No commercially available payload mechanisms allowed. Payload delivery mechanisms may be made from the material of choice for each team. 3D printed, wood, and foam are just examples of allowed materials.

6.3.2. Payload delivery mechanism must be powered by primary battery source. No

additional batteries are allowed on board.
 6.3.3. Payload delivery mechanism may be removeable and installed only for the drop portion of the event.

6.3.4. Each payload delivery mechanism must be capable of carrying an 8oz water bottle.

6.3.4.1. Teams may use any 8oz water bottle. Bottle must be unmolested, as in, complete without any modifications other than removal from larger case to individual unit. If you are using your own water bottles you must notify judges prior to beginning your flight operations.

6.3.4.1.1. If teams are not providing their own water bottles at competition, randomized 8oz water bottles will be utilized.

7. SAFETY REGULATIONS

7.1. FLIGHT OPERATIONS

7.1.1. Flight operations of any type involve some level of risk to personnel and property. It is the responsibility of all personnel involved in and around flight operations to identify, evaluate, and mitigate risks to the maximum extent possible.

7.1.2. When teams are conducting flight tests, extra precautions must be in place to protect team members and others.

7.1.3. It is required that teams use an experienced RC Pilot to act as Safety Pilot for any test flights. This should be one of the mentors assigned to the team.

7.1.4. A Safety Score of a maximum of 10 points will be awarded.

7.2. THE SYSTEM

7.2.1. The system shall provide sufficient information to operators on a continuous basis to ensure that it is operating within no-fly/

altitude boundaries.

7.2.2. The aircraft shall be capable of manual override by the safety pilot during any phase of autonomous flight.

7.2.3. The flight termination system, activated by a single switch, shall be capable of overriding all flight modes and executing the Return-To-Land command.

7.2.4. The aircraft shall automatically Return-to-Land (takeoff location) after loss of primary communications link signal within 5 seconds.

7.3. OTHER

7.3.1. No more than ten (10) team members will be allowed in the mission area.

7.3.2. Closed toe shoes are required to be worn during safety inspections, flight line operations, or when rotors are powered. Open toed shoes/flip flops should not be worn. Anyone wearing open-toed shoes will not be allowed to participate in any activity on the flight line.

7.3.3. Officials have the right to disqualify an entry or a team that they deem to be a hazard.

APPENDIX

AIRFRAME SPECIFICATIONS

- Quadcopter configuration (4 motors)
- 625mm maximum frame size (measured from one side of an arm to the other)
- Autopilot system must cost less than \$500 USD Manufacture Suggested Retail Price (MSRP), including the Global Positioning System (GPS)
 - This is a retail cost, meaning that even if a more expensive autopilot is donated, it is not allowed.
 - It does not have to be a Pixhawk variant, but still recommended
- Maximum of 8 channels
 - These include 4 for the motors, leaving four open to be utilized as the team sees fit
- Options include a camera gimbal, pickup, and drop mechanism controls
- If you use 2 for the gimbal, that leaves only 2 channels for pickup and drop mechanism
- Maximum 4S 4500 battery size 30C rating Batteries may be changed as often as necessary during the competition
- Maximum propeller size 11"
- Up to a 1080p video camera
 - Camera Manufacturer's Suggested Retail Price (MSRP), must be less than \$100 USD
- Up to a 250mw video transmitter
- Any antenna may be used for the video feed system
- 2.4 Ghz RC control system. Any brand legal in the US

- One primary Ground Control Station (GCS) – Meaning only 1 laptop allowed on the flight line
- Maximum of 2 video receivers allowed during the competition
 - One can attach directly to the GCS

CLARIFICATIONS:

- Pickup of bottle requires lifting the bottle to a minimum of 5' AGL in order to receive any points.
- Each team has one opportunity to reset the water bottle during the entirety of the mission; but time does not pause. Teams must fly to a minimum altitude of 10' AGL and request a reset from the judging staff.
- 0-10 points will be allowed for successful pickup and dropoff portions and the amount of autonomy present in the process based on judges discretion.
- Additional points will be awarded based on the location/distance the bottle comes to rest to the center of each target set. Bottles cannot occupy the same drop-off point.
- Unintentional drops will not score.
- Teams must communicate their intentions with judges as they relate to the pickup and delivery of the bottles.

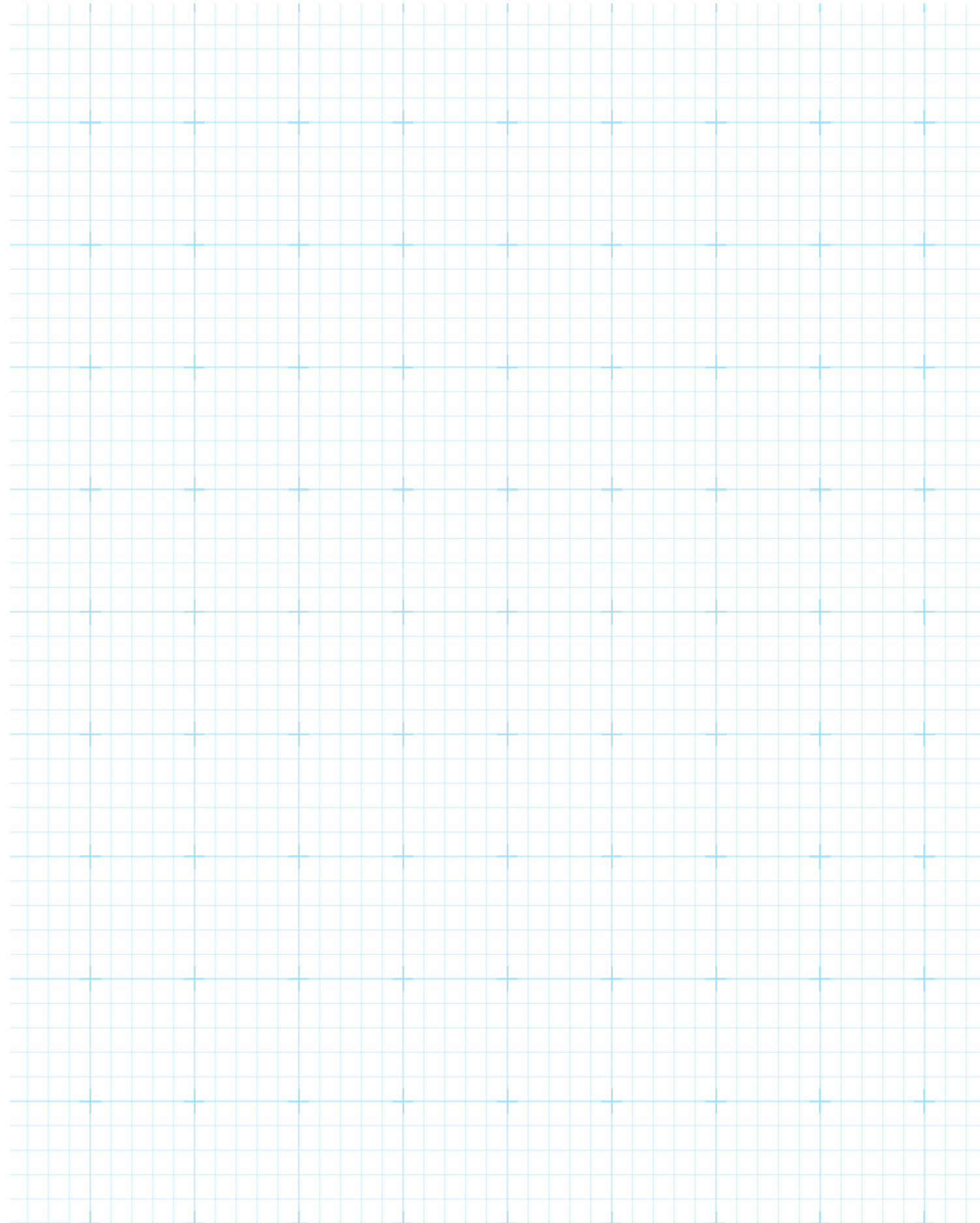
SAMPLE MISSION SET AVAILABLE UPON REQUEST.

If you'd like to receive a sample mission parameter set (and associated correct mission setup for grading) to assist your team, reach out to UAS4STEM staff via email education@modelaircraft.org.

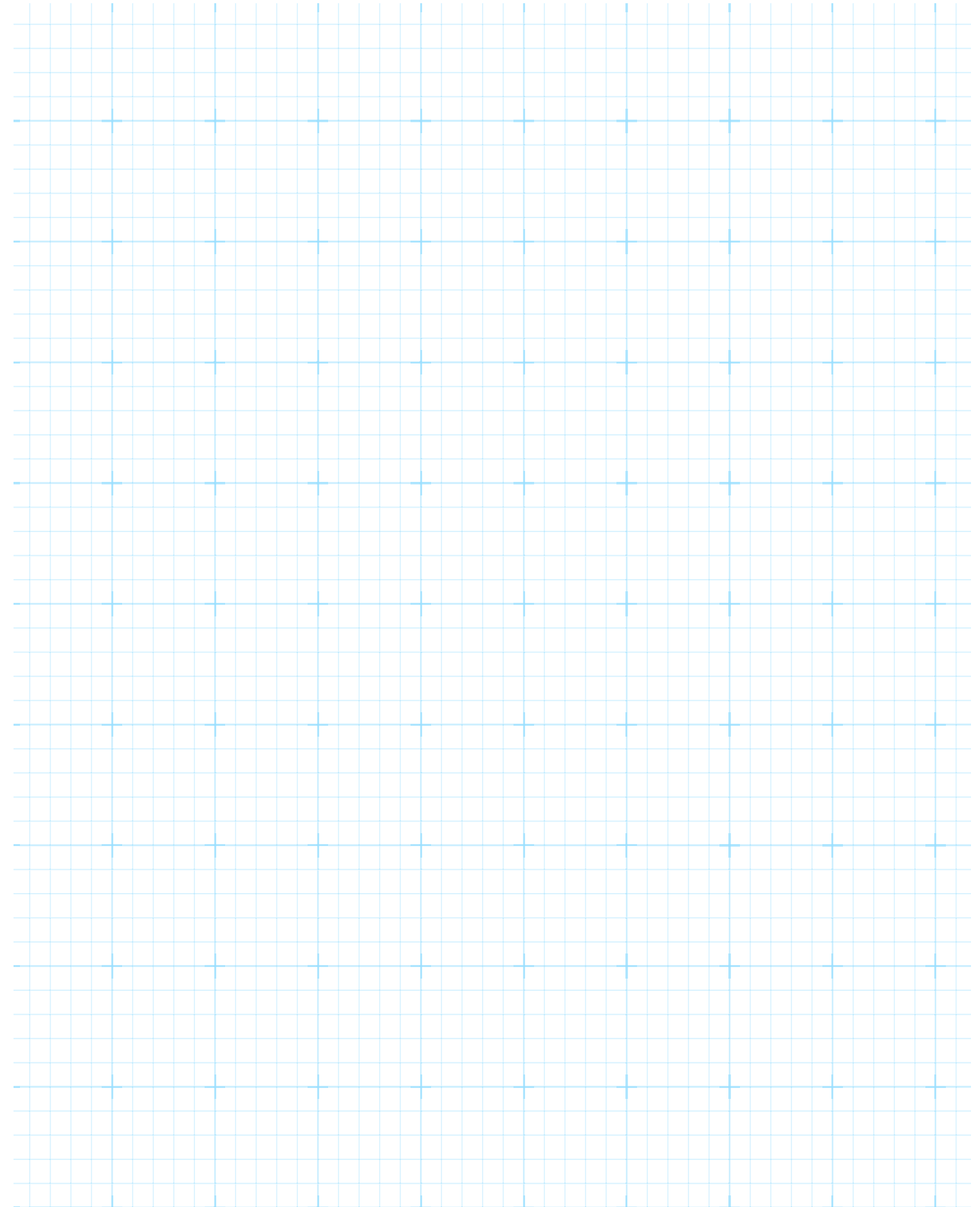
If you would prefer to purchase a complete bundle of drone components for UAS4STEM, that option is available via Ready Made RC. They offer two bundles to choose from: a basic bundle if you already have a transmitter, batteries and charger or an all-inclusive bundle that also contains a transmitter, batteries and charger. Details at www.readymaderc.com.

If you have any questions about your airframe or components, please contact UAS4STEM National Director Archie Stafford at archie@modelaircraft.org

NOTES



NOTES





Live the moment, capture impossible videos.

The Skydio 2+ drone enables autonomous aerial cinematography with the tap of a button, so you can achieve mind-bending shots while enjoying heart-stopping adventures.