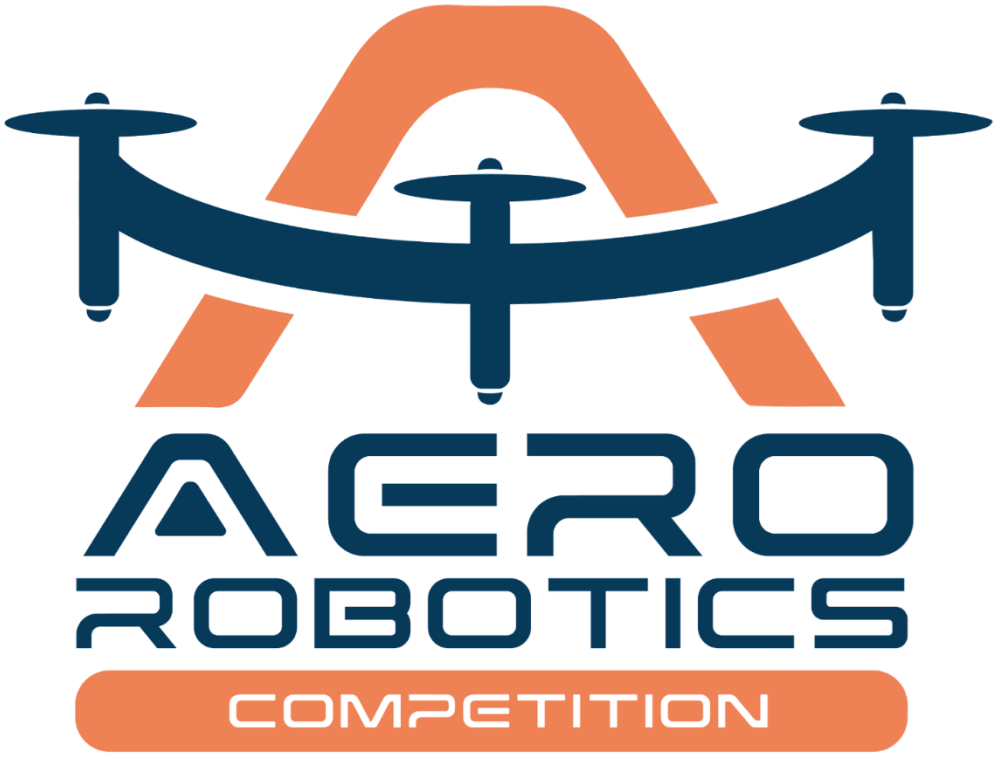

Spring 2024 Rulebook

Aerospace Robotics Competition

03/28/2024

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1. Rulebook Overview

We are excited to have you join us for the 2024 Aerospace Robotics Competition! Jumping into this competition may be a daunting task, so we want to ensure you have all of the resources needed for success.

This rulebook is large, but it is full of important information for teams to reference throughout the season. We highly recommend you read through the entire rulebook at least once, getting familiar with the requirements and noting any questions you may have. We also recommend printing a copy for your team to have on hand during meetings.

Once you have read the entire rulebook, the Table of Contents will be a useful tool for you to return to key sections as needed. We will also be releasing specific smaller documents, including:

- Field specifications
- Scoring rubrics
- Scoring calculation sheet
- Safety guide

Please see https://www.stemed.org/arc to find these documents as they are released.

If you have any questions about the rulebook, you are always welcome to contact Support@stemed.org for assistance. We look forward to a great season!

2. Competition Overview

The Aerospace Robotics Competition (ARC) seeks to ignite a passion for aerospace-related STEM work in high schools around the nation. The competition is built upon three pillars:

A. Hands-on flying of unmanned aerial vehicles (UAVs)
B. Developing knowledge of unmanned and autonomous systems
C. Learning about aerospace engineering principles

By definition, autonomy is acting independently, and ARC allows high school students to create UAVs that do just that. Students will program a UAV to act independently of any human pilot. Aspects of the mission will change each year to encompass new challenges and follow the three pillars of the competition. The UAV for this competition will be a quadcopter, which uses four electric motors with propellers to generate lift. The three pillars of the competition are applied via the following sections, each with a corresponding scoring criterion:

1. Autonomous: The UAV will be required to complete an autonomous task. The exact mission may change from year to year.
2. Semi-Autonomous: A student pilot will be required to fly the UAV in the completion of a task. The exact mission may change from year to year.
3. Presentation: Teams will demonstrate their understanding of the UAV using core aerospace engineering principles. Creativity is encouraged in their design of the UAV and plan for completing the flight missions. This is where teams can showcase their work.

In addition to the above competition portions, all teams must pass a technical inspection in order to compete in the flight portions. The technical inspection confirms the team's UAV complies with the requirements outlined in Section II. It is not scored so it does not contribute to the overall score, but teams will not be able to fly if they do not pass the inspection.

Teams have several choices when developing their competition strategy. First, teams may choose to compete in both the semi-autonomous and autonomous flight portions or choose to fly in only one of the flight portions. Teams are not required to compete in all portions, but they should specify which portions they intend to compete in to competition staff and/or during technical inspection. Additionally, teams may choose to compete with the UAV kit sold by ARC or with their own kit drone.

3. Season Logistics

Regional Competitions

The Aerospace Robotics Competition currently consists of four (4) regions:

- Antelope Valley, CA: AntelopeValley@stemed.org
- New England: NewEngland@stemed.org
- Philadelphia, PA: Philadelphia@stemed.org
- San Diego, CA: SanDiego@stemed.org
- Other: Support@stemed.org

Each region consists of up to twenty (20) teams, with volunteers providing local support and events. Each region also hosts a Regional Aerospace Robotics Competition event annually in April or May.

To participate, all team members must submit a waiver signed by a parent or guardian. Please visit the ARC website (https://www.stemed.org/arc-submissions) for waivers and other submissions.

Please contact your region if you have any questions about your regional event or local support.

National Invitational Event

This year, STEM-ED will be introducing the Aerospace Robotics Competition National Championship! This event will be held in Los Angeles, California, and will be an invitational event for Regional Competition winners. National Championship rules will be released May 1, 2024, and further details will be distributed throughout the 2024 season.

4. Mission Background

You may be wondering: Why autonomy? Why UAVs?

Consider the world we live in today. On one hand, there are constant, cutting-edge advancements in technology. NASA recently landed Perseverance on Mars and successfully executed a powered flight of a drone on another planet. Many countries harbor sophisticated biotech abilities, helping us generate vaccines to combat new and emerging viruses with astounding agility. On the other hand, our world is facing constant crises as well. As the Earth continues to spin, we have seen more disasters, both natural (tornados, earthquakes, tsunamis, wildfires) and human-made (nuclear plant meltdowns, waste buildups, hazardous material spills). How do we reconcile these opposing forces? How can UAV/drone usage make a positive and lasting impact on society?

There are many examples of how drones can be used in disaster management to reduce cost and safety risk, including:

1. Count the number of people at specific waypoints.
2. Create an optimized path between waypoints to guide people to safety
3. Deliver supplies and food to specific waypoints.
4. Assess buildings for structural damage
5. Assess power grid integrity
6. Provide internet access to stranded people

Our mission for the autonomous portion of the competition incorporates such disaster management.

The year is 2024, and your local government has tasked your team with responding to a natural disaster. You are required to perform the following tasks:

- Scouting: Measure GPS coordinates of safe airzones and of fire, then enter coordinates into flight plan.
- Loiter Waypoint: Hover in a safe airzone at the specified GPS waypoint.
- Delivery Waypoint: Release water over the fire at the specified GPS waypoint.

In a real-world application, drones may loiter to transmit or receive information or await further commands. While the competition scope does not include any activity at the loiter waypoint besides hovering, these waypoints are equally important for the drone’s overall mission success.

5. Mission Details

The following subsections give the mission details and scoring equations for the Autonomous, Semi-Autonomous, and Technical Presentation components of the competition. For more details on the mission field components and dimensions, see the 2024 ARC Field Specification Guide.

The below table presents the available points for this year's challenges. Each team may choose to participate in some or all components of the competition, with the following point values available for each task. Virtual Tasks and Technical Presentation Content points will be earned up to one week before the competition date, while all other points are earned in-person at the competition. The total sum of points by the end of the competition will be used to determine awards (see Section 7).

Table 1. Competition Point Summary

Event	Task	Max Points	Max Total
Autonomous Flight	Virtual Tasks	200	450
	Fly-Off	250	
Semi-Autonomous Flight	Time Trial	100	400
	Head-to-Head	300	
Technical Presentation	Content	100	150
	Style	50	
Maximum Total Score			**1,000**

Autonomous Competition

Overview

A. Two portions:
    a. Virtual Competition: Virtually-submitted milestone tasks
        i. DUE 7 days before competition
    b. Fly-Off Competition: Live autonomous mission
B. Eligibility:
    a. Task 5: Teams must submit Virtual Task 5 to compete in the fly-off portion
    b. Inspection: Teams must pass technical inspection to compete in the fly-off portion
        i. See General UAV Requirements

Virtual Competition

A. Purpose: Each task is related to the ultimate Fly-Off Competition, so teams that complete all Milestones should be able to successfully complete the Fly-Off Competition.
B. Tasks: See Table 2 below
C. **Task 0 must be completed to be eligible to compete in ANY fly-off portion of the competition**
D. Submission:
    a. Teams must record the drone or any needed equipment (ex. computer screen) in order to demonstrate that the task has been accomplished.
    b. Supporting files should be submitted here: https://www.stemed.org/arc-submissions
    c. Virtual Competition Judges will accept or reject submissions based on a scoring rubric that is based on the description. Teams will receive a decision on their submission within 2-4 days.
    d. Each submission will receive one of two outcomes: accept or reject. If teams receive an “accept”, teams have earned those points. If a team receives a “reject”, the judges have deemed that the team has not accomplished the task OR the submission has insufficient proof that the team has accomplished the task.
    e. Teams are allowed to attempt each task as many times as needed before competition day, regardless of the number of rejections received.
    f. All submissions must be received at least 7 days before the competition. All submissions will be evaluated by competition day.

Table 2. Virtual Submission Tasks

Task #	Task Name	Description	Points

0	Pass TRUST Exam	• Students must complete the short course and successfully pass the FAA TRUST Exam
		  ○ **Legally required to begin flying recreationally.**
		  ○ **New: pilots must print their TRUST Exam certificate and bring it to the competition venue.**
		• Each team member on the roster must submit the TRUST exam confirmation to receive task points.
			15

1	Learn to Fly	• Fly semi-autonomously (student-piloted) for 1 minute. • No requirements for flight beyond successful takeoff and landing; flight time may be spent hovering or maneuvering. • Provide a video to ARC to show completion.	15
2	Takeoff/Landing	• Autonomously take off and land. • Provide a video to ARC to show completion.	20
3	Hover	• Hover the drone without pilot intervention (autonomously) for 30 seconds. • Provide a video to ARC to show completion.	25
4	Waypoint Flight	• Plug in waypoints to your drone and fly autonomously. • Provide a map of the waypoints and a video of your drone flying to the waypoints.	50
5	Mechanism Test	• Hover the drone and drop any object (water balloon, tennis ball, etc.). • Provide a video to ARC to show completion.	75
Maximum Total Score			**200**

Autonomous Fly-Off Competition

A. Purpose: Students combine the skills learned from the virtual tasks to fly an autonomous firefighting challenge.
B. Tasks:
    a. Scouting: Teams must identify GPS coordinates and enter them into their drone.
        i. There will be two (2) waypoints for students to find:
            1. One (1) green waypoint will represent a safe location to fly over.
            2. One (1) red waypoint will represent a fire which must be fought.
        ii. Waypoints will be marked with a large colored square on the field. These squares will be labeled with their GPS coordinates.
        iii. Students must identify the waypoints and enter the correct GPS coordinates into their drone's flight plan.
        iv. The drone's battery must be unplugged while students are on the flying field. Once students have gathered the GPS coordinates and have exited the field, they may then plug in the battery. They must remain outside of the field's perimeter once the battery is connected.
        v. The drone must be tethered before the timer begins. This will ensure teams do not forget to tether their drone while rushing to complete the challenge.
    b. Waypoint Challenge: Teams must successfully fly over assigned GPS waypoint.
        i. There will be one (1) loiter waypoint.
        ii. Teams must loiter over this waypoint for five (5) seconds to allow Flight Judges to ensure the drone has passed over the correct coordinates.
    c. Firefighting Challenge: Teams must successfully drop an eight fluid ounce (8 fl. oz.) water balloon over assigned GPS waypoint.
        i. The water balloon will simulate a firefighting drone quenching a fire.
        ii. The water balloon will be filled to approximately 3.0" wide and 4.5" long.
            1. Note that water balloons may not always meet these precise dimensions. Teams should design and practice using a range of balloon sizes to ensure their mechanism will be capable of handling the water balloon at the competition.
            2. Water Balloon: Zuru Bunch O Balloons
        iii. Teams must create a mechanism and procedure to release the water balloon. Extra points are awarded if this release is completed autonomously.
        iv. Only one water balloon will be dropped and scored.
        v. The quadcopter **may not land** to accomplish this task. Landing will automatically end the attempt.
        vi. The drone must drop from a minimum height of 10 ft.
        vii. The water balloon must be delivered to within 20 ft of the drop waypoint.
        viii. The drone must drop the water balloon while loitering over the waypoint. Drones should not drop the water balloon while traveling.
C. Procedure:
    a. Teams must tether their drone to the middle of the field before the timer begins.
    b. Teams will enter the field to read the GPS coordinates of waypoints.
        i. Students represent human firefighters on the ground. They will identify a safe waypoint, as well as a fire waypoint which is too dangerous for human intervention. They will use their UAV to autonomously quench the fire.
        ii. Teams will use these GPS coordinates to calculate the route that their UAV will travel to complete the mission. Once the route is calculated, the UAV will autonomously complete the mission per the calculated route.

c. After teams have recorded their GPS coordinates and exited the field, they may plug in the drone's battery. Once the battery is connected, students may not enter the field again.
d. There will be one round per team for the autonomous portion.
e. Vehicles must take off autonomously.
f. Vehicles can land autonomously or manually.
g. Vehicles can land anywhere on the field except for over the fire waypoint. Teams who land at the fire waypoint will receive a score of zero, as this simulates the drone landing within a fire. It is recommended that teams return to their home waypoint for landing.
h. See Figure 1 for an example mission field layout.
i. See Figure 2 for flight procedure.

D. Time Requirements:
   a. Teams will receive five (5) minutes to complete this mission.
      i. This five-minute limit includes time to read the GPS coordinates of both waypoints, calculate the flight route, and execute the flight.
      ii. If the UAV is in the air after five minutes, teams may continue the round for one more minute with a fifty (50) point penalty.
      iii. If the drone does not land within six (6) minutes, the team will receive a score of zero (0) for the round.
      iv. Fifty (50) bonus points are awarded for teams who take off within three (3) minutes.
   b. The timer starts when teams are ready to enter the field and begin reading GPS coordinates. The timer runs continuously until 6 minutes have expired.
      i. The Flight Manager will signal the start of the stopwatch for each team to enter the field.
      ii. The timing will stop when the vehicle has landed, signaling the flight is complete.
      iii. If the team has not completed the mission by the 6-minute mark, the Flight Manager will order the team to return their UAV to the home waypoint if the vehicle is airborne.
      iv. The time taken to land the vehicle will be included in the final flight time.
      v. If the team does not land their vehicle within 15 seconds of this direction from the Flight Manager, the team will receive an automatic score of 0 points for this flight round.
   c. Note: If teams do not achieve successful flight, or if their UAV crashes or flips, teams may re-attempt the flight as long as time remains on the 10-minute flight timer.

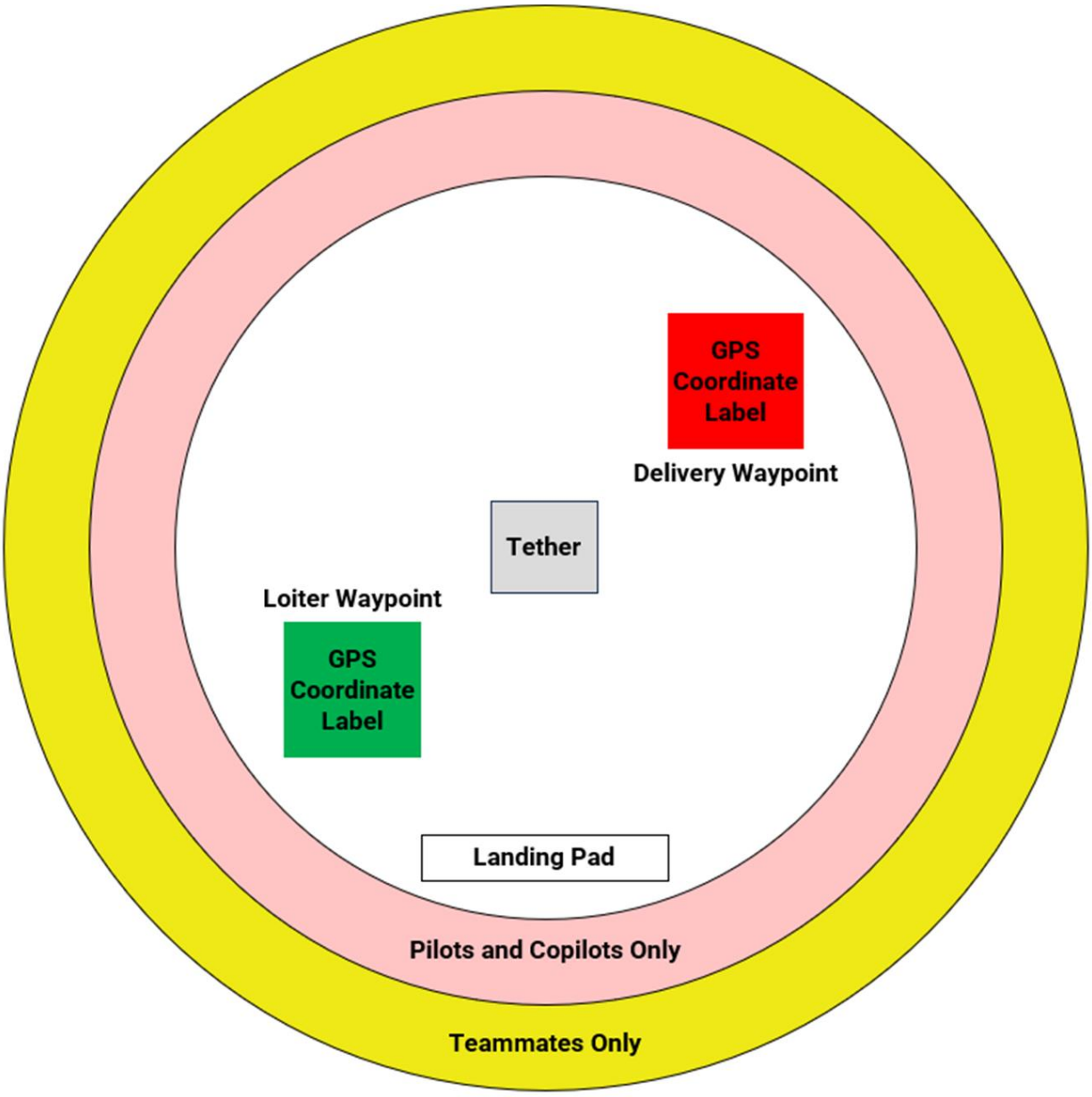

Figure 1. Example Autonomous Mission Field Layout

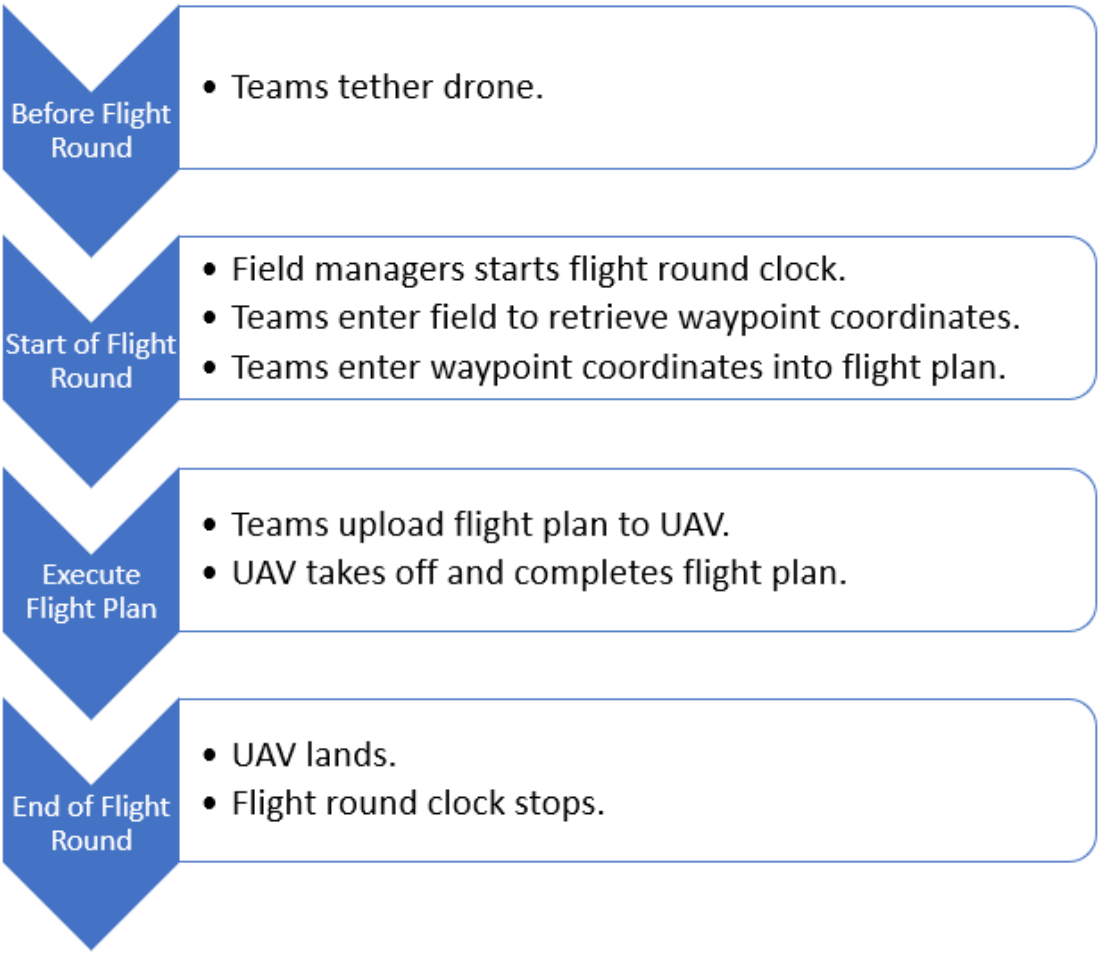

Figure 2. Autonomous Flight Procedure

Autonomous Scoring Equations

A. The virtual competition score is a sum of the earned points for completed tasks

$$Virtual\ Competition\ Score\ =\ Sum(Earned\ Virtual\ Task\ Points)$$

B. The fly-off score is calculated by the following equation:

$$Fly-Off\ Score\ =\ \frac{E}{A}\ +\ L\ +\ S\ -\ P$$

Table 3. Fly-Off Scoring Variable Definitions

Variable	Requirement	Value
E	Water balloon is released, lands within 20 ft. of target, and bursts	100
	Water balloon is released and lands within 20 ft. of target, but does not burst	75
	Water balloon is released but does not land within 20 ft. of target	25
	Water balloon is not released	0
L	Drone successfully flies over both waypoints	100
	Drone successfully flies over one waypoint	50
	Drone does not successfully fly over either waypoint	0
A	Autonomous trigger used to drop water balloon	1
	Manual trigger used to drop water balloon	2
S	Team takes off within first 3 minutes of flight round	50
P	Team takes over 5 minutes, but under 6 minutes, to complete challenge	50
	Team does not land within 6 minutes	DQ*
	No penalty	0
Maximum Total Score		**250**

*A DQ (disqualification) causes teams to lose all points earned during the match, resulting in a total score of zero points for the flight round.

A. Maximum Total Scores:
   a. Virtual Competition: 200 points
   b. Fly-Off Competition: 250 points
   c. Total Autonomous Score: 450 points

Semi-Autonomous Competition

Overview

A. Two portions:
    a. Time Trials: One team at a time completing environment cleanup mission to rank for Head-to-Head Competition and prove capability.
    b. Head-to-Head Competition: Two teams at a time, seeded according to their Time Trial ranking, completing environment cleanup mission.
B. Eligibility:
    a. Time Trials: Teams must successfully complete their Time Trial to compete in the Head-to-Head Competition.
        i. A Time Trial is considered complete if the drone takes off and lands in an upright position.
        ii. Teams do not need to score any points for a Time Trial to be considered complete.
    b. Inspection: Teams must pass technical inspection to compete in the Time Trials or Head-to-Head Competition.
        i. See General UAV Requirements
    c. Task 0: Teams MUST complete Task 0 to participate in any flight rounds.

Time Trial

A. Purpose: Students prove their ability to fly a safe and controlled mission before flying against another team.
B. Tasks: See Head-to-Head Competition rules. The Time Trial will be identical to the Head-to-Head Competition, with the exception that only one team will be flying per Time Trial round.

Head-to-Head Competition

A. Purpose: Students will learn to semi-autonomously pilot their drones, communicate between the pilot and copilot, and avoid their opponent while completing a challenge to clean their environment.
B. Tasks:
    a. Teams must pick up tennis balls and wiffle balls and deliver them to hoops in the center of the flying field.
        i. Hoops will be of varying diameters with varying points associated with them.
            1. Large Hoop = 20-inch diameter
            2. Medium Hoop = 16-inch diameter
            3. Small Hoop = 12-inch diameter
            4. All hoops have approximate height of 2.75 feet
C. Procedure:
    a. Teams must tether their drone to the middle of the field before plugging in batteries.
    b. There will be a maximum of 4 semi-autonomous rounds.
    c. Drones will be piloted by 1 student pilot.
    d. Teams may select 1 copilot to assist the student pilot.
    e. Pilots and copilots must wear safety glasses. Hard hats are recommended.
    f. Pilots will fly their vehicles to retrieve tennis balls and wiffle balls from queue areas on the ground then drop these balls through hoops to score points.
        i. Wiffle balls represent recyclable items and may only be delivered into the middle hoop.
        ii. Tennis balls represent trash and may only be delivered in the large and small hoops.
        iii. Once the ball is in the hoop, the score will be awarded.
        iv. There is no limit to how many balls teams may carry at once.
    g. Teams may only pick up balls from their staging area; they may not pick up their opponent's tennis or wiffle balls.
    h. If the hoop is knocked over by either drone, the hoop will be ineligible to have balls dropped into for the rest of the round.
    i. During flight, intentional collisions/interference are prohibited. **Teams causing a collision will be disqualified.**
D. Time Requirements:
    a. There will be a 5-minute time limit for each flight round.
    b. The Flight Manager will signal the start of the flight round by instructing teams to arm their drones. The 5-minute stopwatch starts at this time.
    c. Each team will pick up and deliver up to 4 tennis balls and 4 wiffle balls through the hoops.
        i. A ball pick-up is defined as the ball leaving the ground while attached to the drone and in the air for more than 2 seconds.
        ii. Tennis Balls: Penn Championship Tennis Balls, Extra-Duty Felt
        iii. Wiffle Balls: Franklin Sports Indestruct-A-Ball Plastic Training Balls
    d. Teams have 5 minutes to drop all tennis and wiffle balls. If a team finishes this task early, they should land their vehicle at their vehicle home (See Figure 3).
    e. If a team's drone flips or is damaged, team members may not enter the arena to retrieve their drone. The team must wait until the round's time is complete or until the opposing team's drone is also incapacitated. At this point, the round will be considered complete, and teams may retrieve their drones at the instruction of the Flight Manager.
    f. If either team is still airborne when 5 minutes have passed, the Flight Manager will instruct the pilot to land the vehicle.

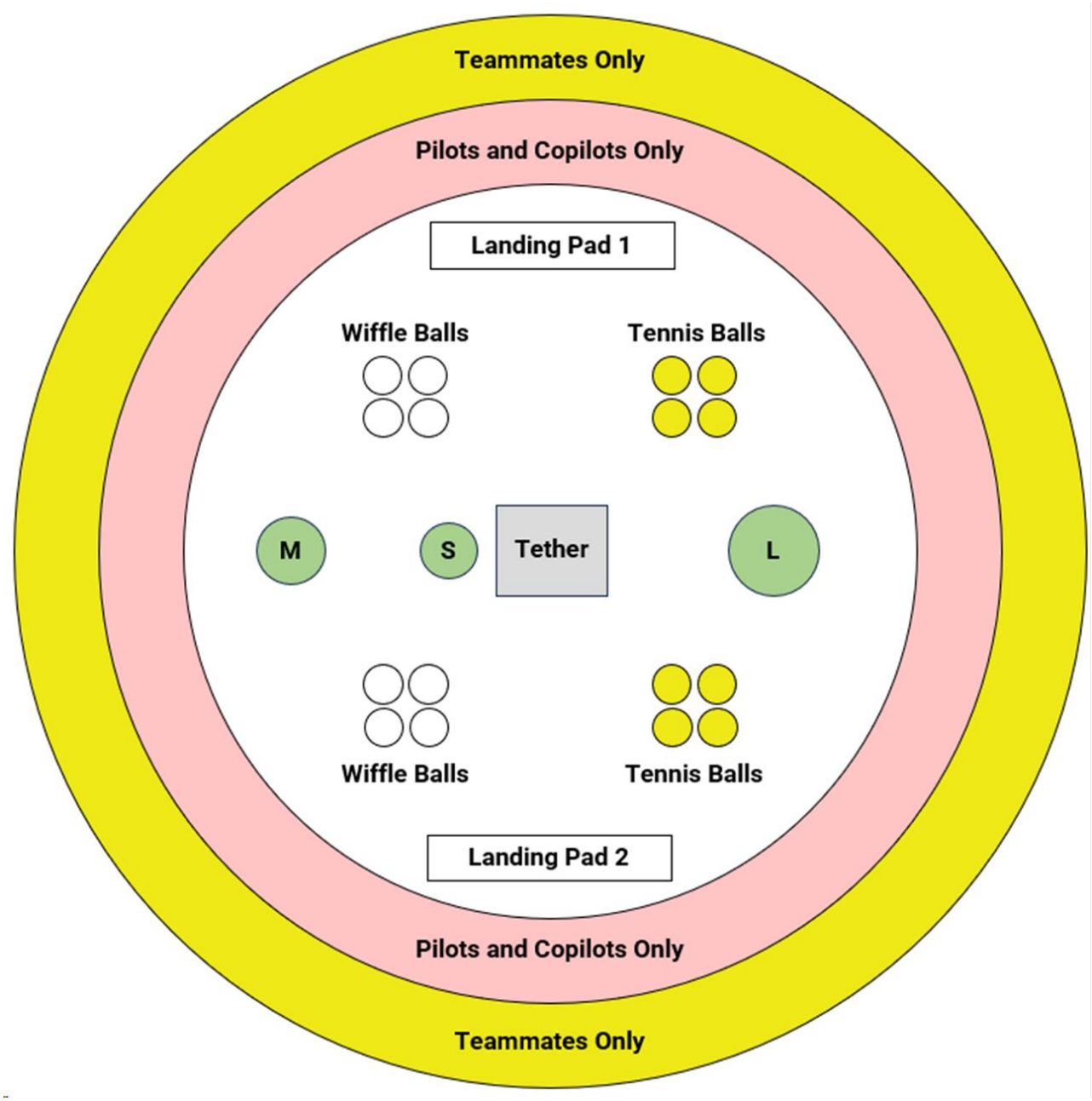

Figure 3. Semi-Autonomous Mission Field Layout

Semi-Autonomous Scoring Equations

A. Time Trial score:
   a. Note: Teams must take off and land without damage to the drone to qualify for time trial points.
   b. Teams receive their Head-to-Head Competition seed according to the following ranking method:
      i. Score (see Head-to-Head Competition scoring equations)
      ii. Number of wiffle balls delivered into hoops
      iii. Number of tennis balls delivered into hoops
      iv. Time
   c. Teams receive the following points for their respective rank:

Table 4. Time Trial Scoring

Rank	Points
1st	100
2nd	95
3rd	90
4th	85
5th	80
6th	75
7th	70
8th	65
9th and beyond	60
No flight	0

   d. NOTE: Regional leadership teams may opt to bypass the Time Trial rounds due to time constraints. Regional Coordinators will inform teams if their local region will not be holding Time Trials. All teams in affected regions will receive 100 points for their Time Trial scores.

B. The Head-to-Head Competition score is calculated by the following equation:

$$Head - to - Head\ Competition\ Score\ =\ average(Round\ Score)$$

$$Round\ Score\ =\ [T\ +\ W\ +\ B\ +\ L]\ *\ P$$

$$B\ =\ N_1B_X\ +\ N_2B_y\ +\ N_3B_z$$

Table 5. Semi-Autonomous Scoring Variable Definitions

Variable	Requirement	Value
T	Successful tennis ball pickup (max 1)	20
W	Successful wiffle ball pickup (max 1)	30
B_x	Tennis ball scored in largest hoop	10
B_y	Wiffle ball scored in medium hoop	25
B_z	Tennis ball scored in smallest hoop	25
N_x	Number of balls scored in largest hoop	#
N_y	Number of balls scored in medium hoop	#
N_z	Number of balls scored in smallest hoop	#
L	End round landed on landing pad	50
P	Team causes collision during flight	0
	Team's mechanism falls off during flight	0.5
	No penalty	1
Maximum Total Score		**300**

C. Maximum Total Scores:
   a. Time Trial: 100 points
   b. Head-to-Head Competition: 300 points
   c. Total Semi-Autonomous Score: 400 points

Technical Presentation

Overview

A. Two portions:
   a. Content: Team presentation slides will be graded for content prior to the competition day.
      i. **DUE 7 days before competition**
   b. Style: Teams will present their slides, along with any desired visual aids, for a judging panel at the competition.

B. Procedure:
   a. Teams must submit their presentation slides as a PDF by 7 calendar days before their assigned regional event.
      i. Please submit your slides here: https://www.stemed.org/arc-submissions
      ii. Teams who do not submit their slides will:
         1. Receive a score of 0 for content.
         2. Present for a style score without use of their slides.
      iii. The presentation must be in Microsoft PowerPoint, Google Slides, or a similar format. Anything other than slide format will be immediately graded as 0 points.
   b. Teams will present to a panel of Presentation Judges at the competition to receive their presentation style score.
   c. Because presentations are due prior to the competition date, the judging panel will have the PDF of the team's presentation loaded on a computer and hooked-up to a projection system prior to the team's scheduled presentation time.
      i. Teams are not required to bring any items with them to the presentation.
         1. There will be a table available for displaying their UAV or any other relevant items if the team chooses to do so.

C. Time Requirements:
   a. Teams will have 15 minutes to present - see Table 6 below.
   b. The timekeeper will give a 1-minute warning prior to the 10-minute limit by silently raising his/her hand.
      i. Teams will receive a 5-point penalty if the presentation extends past the 10-minute limit.
      ii. If a team exceeds 10 minutes, that time will be deducted from the 5 minutes to answer questions; similarly, if a team's presentation is less than 10 minutes, they will have extra time for questions.
      iii. Presentations will be stopped at the 11-minute mark.

Table 6. Presentation Procedure

Task	Time Limit
3 minutes	Set up presentation and visual aid (if applicable)
10 minutes	Presentation
5 minutes	Questions
2 minutes	Clean up presentation

Technical Presentation Scoring

A. Content Scoring: See Table 7
   a. Content will be scored prior to the competition day.

Table 7. Presentation Content Score Values

Task Description	Max Score
Team organization and dynamics	2.5
Team schedule for project completion	5
Financial strategy/budget	10
Programming methodology and process	15
Mission overview and strategy Why are your team and UAV a good choice for disaster response? How does your team plan to succeed in either/both mission(s)?	20
Vehicle Overview	10
Mechanism and protection system design	10
Flight testing procedure and results	20
View of entire system (front, top, side), with primary dimensions (height, width, length) clearly labeled	5
List of parts/materials used	2.5
Maximum Total Score	**100**

B. Style Scoring: See Table 8
   a. Style will be scored by judging panel at the competition.

Table 8. Presentation Style Score Values

Task Description	Max Score
Slides are legible	10
Presenter speaks clearly and audibly	10
Presenter speaks professionally and is well-prepared Minimal mannerisms such as “um” or “you know”	10
Photos/models/videos are present	10
Presenter speaks to the room Not to slides/screen	10
Penalty: Presentation runs over time	-5
Maximum Total Score	**50**

C. Maximum Scores:
   a. Presentation Content: 100 points
   b. Presentation Style: 50 points
   c. Total Technical Presentation Score: 150 points

Field Specifications

See Table 9 below for links to field components. See the 2024 ARC Field Specification Guide for further details on field specifications and building a practice field.

Table 9. ARC Field Components

Use	Component Link*	Use	Quantity	Price*
Tether System	Twine	Tether Line	1 [500’ Spool]	$14.99
	Cinder Block	Tether Base	1	$2.11
	Landing Pad	Takeoff/Landing	1	$8.99
Semi-Auton Field	Wiffle Balls	Payload	1 [Pack of 6]	$6.99
	Tennis Balls	Payload	1 [Pack of 12]	$11.99
Auton Field	Water Balloons	Payload	1 [Pack of 210]	$17.99

*Prices and availability are subject to change. ARC may interchange supplies for comparable products if necessary.

6. General UAV Requirements

Overview

As outlined in the overview, teams may choose to purchase ARC's UAV kit ("Kit Drone") or procure their own UAV components ("Self-Designed Drone"). All UAVs must comply with the following requirements, which will be inspected during the Technical Inspection. UAVs must pass the Technical Inspection in order to fly during the competition. **Teams must operate their vehicles safely; safety requirements are listed in Appendix B.**

The following requirements are for both Kit Drones and Self-Designed Drones. If your team chooses to use an unaltered Kit Drone, it will automatically meet all eligibility requirements.

Drone Specifications

FAA Requirements

Two rules are being implemented this year to fulfill legal requirements for drone operation. Teams must comply with the following in order to fly at the competition.

First, the FAA legally requires that pilots complete the short course and successfully pass the FAA TRUST Exam. Any students who will be piloting a drone must complete this task before flying. Any students who will be piloting a drone at the competition venue must print their FAA TRUST Exam certificate and carry it on their person while at the event. **Students who do not have proof of completion of the FAA TRUST Exam will not be allowed to pilot their drone at the competition.**

The FAA has also begun legally requiring that drone locations be broadcast during flight using a Standard Remote ID. Please see the FAA website for further details. Teams are advised to use a component such as the Hex Cube ID Serial to fulfill this requirement. **Drones that are not equipped with a Standard Remote ID broadcast module will not be allowed to fly at the competition.**

Competition Requirements

A. General Requirements:
   a. The UAV must have 4 motors with 1 propeller each.
   b. The UAV may not have any lifting surfaces other than the 4 propellers.
   c. The UAV must be registered by the FAA, and the registration number must be visible.
   d. STEM-ED supplied Drone Kit details can be found in Appendix A
   e. All parts attached to the UAV must remain within 4 ft. of the UAV at all times during operation.
   f. Dimensional limits:
      i. Propellers may not exceed 12 inches in diameter.
      ii. The base plate of the center of the quadcopter must not be more than 7 inches from the ground when the quadcopter is on the ground
      iii. The overall drone dimensions must not exceed 36 inches by 36 inches by 36 inches when placed on the ground with the propeller attached and aligned outwards.
   g. Battery requirements:
      i. Teams must use a lithium polymer battery.
      ii. Battery cannot have more than 4 cells.

iii. Teams must use commercially available batteries; homemade batteries are not allowed.
iv. Teams must use proper battery usage/storage techniques as outlined in Appendix D.

h. Multi-bladed (more than 2-bladed) propellers are allowed.
i. Teams are encouraged but not required to cover the electronics with a protective shield or material.
j. To ensure the safety of all students and spectators, each vehicle must have a secure location where a tether can be attached by a carabiner.
    i. The competition tether will be 55 ft of polypropylene twine with a weight tied in the length to prevent it from interfering with the propeller. See Figure 4 below.
    ii. The tether will be secured to the ground on one side and a carabiner on the other side.
    iii. Teams should use a tether for all flights regardless of if they are in competition or not.
    iv. NOTE: A tether system will be provided at the competition; there is no need to bring a set.

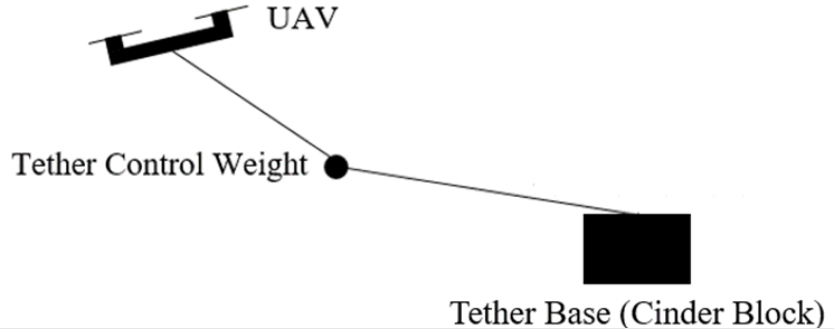

Figure 4. Drone Tether Setup

B. Sensors:
    a. Teams MUST use a GPS sensor that is mounted securely onto the UAV.
    b. Any sensors that are not included in the ARC drone kit will not be allowed in the 2024 season.
        i. Please reach out to ARC with any questions when purchasing comparable sensors to ensure they will be approved for competition use.
            1. All decisions will be made as an attempt to honor ARC's mission of accessibility, affordability, and aerospace by avoiding highly advanced and costly sensors and instead focusing on achieving success with the basic drone kit that is available to all teams. Teams should focus on using these components, as well as practicing their piloting skills, to complete the competition instead of purchasing additional sensors.

C. Mechanism Design:
    c. Teams will need to design and build their own mechanisms to fulfill the flight portion(s).
    d. The mechanism must be attached to the UAV and must fit within the area of the UAV arms and beneath the arms when on the ground. See Figure 5 below for clarification.
    e. The mechanisms must be designed to NOT go above the motor arms of the UAV at any time during flight.
    f. No part of the mechanisms should be designed to fall off of the UAV during any part of the competition unless indicated otherwise in the portion rules.
    g. If this does occur, regardless of if it was or was not intentional, 50% of the score will be deducted.
    h. Teams may use different mechanisms for different portions of the competition

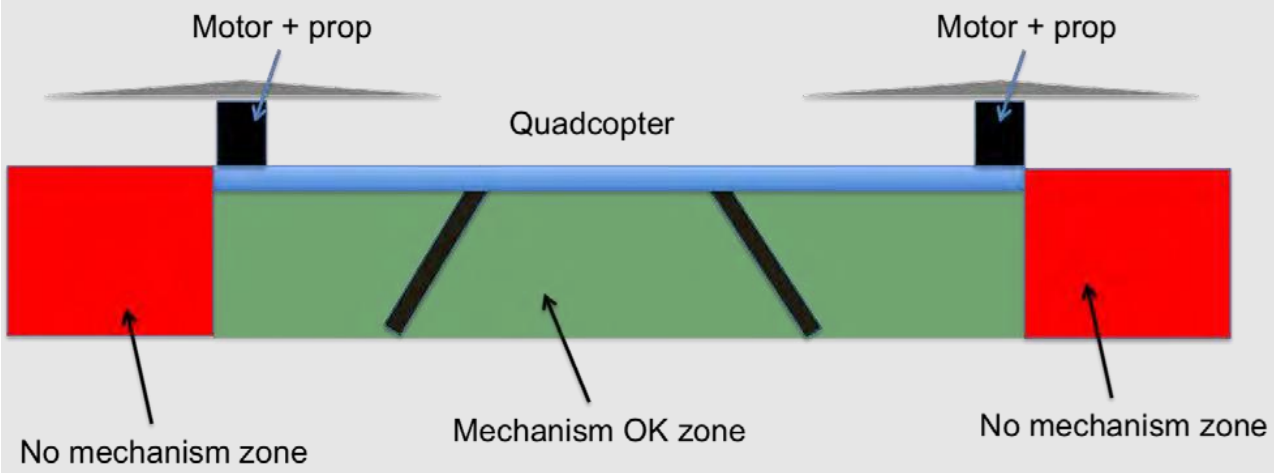

Figure 5. Mechanism Allowable Zones

7. Awards

Prizes will be awarded to the top three teams overall, the top team in each event, the top team in sportsmanship, and the top team in mechanism design. The overall top prizes will be awarded based on total score as aggregated from each of the three parts of the competition. The event prizes will be awarded based on the total score from the respective event. The winners of the sportsmanship and mechanism design awards will be selected by judges and event staff at the end of the competition day. Teams must successfully fly at the competition (take off and sustain flight for over 30 seconds) in order to be eligible for prize money.

Teams may win multiple awards in the overall and event categories. Teams who win one of these awards will not be selected for the sportsmanship or mechanism design awards.

Table 10. Awards

Achievement	Award	Min. Teams*
1st Place, Overall	$1,000 Invitation to ARC National Championship	3
2nd Place, Overall	$750 Invitation to ARC National Championship	4
3rd Place, Overall	$500 Invitation to ARC National Championship	5
1st Place Autonomous	$200	8
1st Place Semi-Autonomous	$200	8
1st Place Technical Presentation	$200	8
Sportsmanship	$100	10
Mechanism Design	$100	10

*The minimum number of teams must compete in the competition for each award to be granted. For example, if there are only four teams at a regional competition, only the first and second place overall prizes will be awarded. Competitions with ten or more teams will grant all awards.

8. Judging

The following judges will be scoring each event:

A. Autonomous Judging: 2-3 referees plus the Flight Manager
    a. The Flight Manager will monitor the entire playing field.
    b. There will be 1 referee monitoring the time clock and the ground station.
    c. There will be 1-2 referees monitoring the vehicle's waypoint flight and payload delivery.
B. Semi-autonomous Judging: 2 referees plus the Flight Manager
    a. The Flight Manager will monitor the entire playing field.
    b. Each referee will be assigned to one team
C. Pre-Competition Challenges Judging:
    a. There will be 2 Virtual Competition Judges approving whether the submissions meet the requirements.
D. Presentation content will be judged prior to competition day by three Presentation Judges. During the presentations on competition day, teams' presentation style will be judged by a panel of three Presentation Judges.

9. Participation Requirements

Team Requirements

All members of the team must be full-time high school students. One adult advisor is required and must be listed on the team's application. The advisor may be a teacher, parent, coach, or other adult community member. The advisor is required to attend the competition; if the advisor cannot attend the competition, notification one month in advance of the event is required in order to register a substitute. Team members must have a parent or guardian sign and submit a waiver to participate in the competition (https://www.stemed.org/arc-submissions).

The pilot for the team must be a student member of the team. Each team must also have a student captain, who will be identified by the team. While there is no limit on size, it is recommended that the team size should be no larger than 5 students to ensure all team members have an active role. There is no student participant age limitation, as long as they are full-time high school students. Homeschooled students are eligible to either join a local high school team or create their own team if they are full-time high school students.

Financial Requirements

The registration fee assists with expenses that ARC incurs to host the competition, including insurance, venue costs, and prize money. The cost to participate in ARC does not include any travel fees that the team may acquire when participating in a Regional Competition or the National Championship.

The cost to participate in ARC includes a $450 competition fee. Some regions may be sponsored by an external source, which will be indicated on the ARC webpage. If the region is sponsored, then the $450 competition fee is waived for all schools in that region.

In addition to the $450 competition fee, teams may elect to purchase a vehicle kit from ARC, with the alternative being that they use (existing, or previous year) or procure their own supplies. However, if teams choose to proceed with their own supplies, their drone must meet competition requirements. Teams must indicate their choice on their competition application and again on their financial plan. There are two different costs to compete (and associated payment plans) depending on this choice. The ARC vehicle kit costs $850, and its contents are detailed in Appendix A.

Hence, the total cost to compete in ARC includes the competition fees (if in a non-sponsored region) and the kit costs (if the team elects to purchase the kit). This cost does not include any travel expenses. It also does not include the cost of a ground station laptop, which is required for the autonomous portion of the competition.

Financial support can be requested through the STEM-ED website before the season begins; for the 2024 season, requests were due December 1st, 2023. Teams who plan to compete again during the 2025 season will be receiving notifications when the financial support application is available.

Application

Teams wishing to participate in the ARC competition must submit an application in order to compete. This application can be found on the STEM-ED website, and it is due by February 4, 2024. Each team must submit an application **via the online application site (no paper applications will be accepted)**. Reference Appendix E for example application submissions. Teams may (but are not required to) use these references to help populate their submission.

10. Regional Competition Event

Schedule

The schedule for the 2024 competition season will be published on the STEM-ED webpage: http://www.stemed.org/.

Prior to the competition day, regional ARC leadership will reach out to teams to confirm that they intend to compete in both the semi-autonomous and autonomous mission. Once that is established, a detailed schedule will be sent to teams within 7 days of competition day. This will include times for each team's presentation and technical inspection as well as the flight order for all flight rounds.

There will be approximately 3 hours dedicated to the semi-autonomous flight rounds and 1 hour for the autonomous flight rounds. The exact number of flight rounds within the time dedicated to each flight portion may vary, but all teams will be given equal opportunities for competing. Success in each flight round is independent of other flight rounds; i.e., if a team does not receive a score in one flight round, the team may still compete in the other flight rounds. The flight order for each flight round will be randomized and will be published within one week of the competition. Teams must be prepared to compete per the flight order; teams not ready to fly during their scheduled turn will forfeit the opportunity to compete in that flight round/portion.

The flight order and number of flight rounds may be subject to change on the day of competition at the discretion of the Flight Manager due to circumstances such as, but not limited to:

A. Vehicle damage preventing a team from competing
B. Inclement weather delaying the competition schedule
C. A team's vehicle design not complying with technical requirements and therefore not permitted to compete

If the Flight Manager updates the schedule of flight rounds or the flight order on competition day, this update will be announced prior to each flight round. If the flight order is changed such that teams must be prepared to fly sooner than initially scheduled, there will be a 10-minute preparation period prior to the flight round to ensure teams do not suffer from the change of flight order.

Teams may be given the opportunity for a re-run of a specific flight round due to interference. Participation in a re-run is at the discretion of the Flight Manager. This re-run is available if a team's flight score was adversely affected by interference. If the Flight Manager does not think that the interference affected the final results, he/she will not give the team the opportunity for a re-run. Examples of interference include but are not limited to:

A. A team's vehicle crashes during semi-autonomous due to another vehicle intentionally colliding with it.
B. A team is unable to complete the autonomous portion because a different team's radio was on, causing radio interference.

Location

Details of the sites for the competition will be sent to registered teams via email. For competition preparation, teams may obtain historical weather conditions for the competition locations at www.weatherbase.com or www.weatherunderground.com. Competition portions may be rescheduled, moved indoors, or cancelled at the discretion of the event leadership based on the event-day weather.

11. Additional Details

Communications

Any questions for the ARC National Leadership Team should be directed to: support@stemed.org. Please first reach out to assigned Regional Coordinators and other regional volunteers for technical assistance as well as any local competition details. The national leadership should be the primary point of contact concerning competition logistics and rulebook clarifications.

Questions received by the ARC National Leadership Team may be posted to the FAQ page on the ARC website if the staff feels the question may be applicable to more than one team.

Each team is required to have a student captain. The student captain will be responsible for facilitating conversation between the ARC leadership and the team. He/she will be included in all communication from ARC volunteers and will receive specific inquiries/requests separate from those sent to the teachers/school staff. Team captains should be prepared to distribute information to teammates and collect required information to respond to ARC volunteers in a timely manner. Teachers are responsible for ensuring that the school has any required parental consent forms in order for students to be able to communicate with ARC volunteers.

As available, mentors may be connected with the teams. The exact mentor structure will vary by region, and details will be communicated after teams have registered for ARC.

The following email addresses may be used to ask questions or request support:

- To reach local support:
  - Antelope Valley, CA: AntelopeValley@stemed.org
  - New England: NewEngland@stemed.org
  - Philadelphia, PA: Philadelphia@stemed.org
  - San Diego, CA: SanDiego@stemed.org
  - Santa Fe, NM: SantaFe@stemed.org
- To reach ARC National Leadership Team:
  - Support@stemed.org

ARC volunteers are continually creating more resources, so teams may receive information about future developments, such as office hours or forums. Teams may reach out to the ARC National Leadership Team to request any new resources; please remember that ARC volunteers have full-time careers and limited availability, so not all requests will be fulfilled.

Protest Procedure

All questions and protests on the day of the competition should be directed to the local Flight Manager. For the virtual component of the autonomous portion, please contact the ARC National Leadership Team. Flight Managers and the ARC National Leadership Team will have the final say on all rules and judging disputes.

Appendix A: ARC Kit UAV Supply List

The table included below lists all components included in the ARC UAV kit. Teams may elect to supplement the kit with additional components or may choose not to purchase the ARC kit should they wish to use alternate components. Note: A computer/laptop is not included in this list but is needed for the ground station components of the competition. STEM-ED, Inc. ascertains that nothing in this list or elsewhere in this document constitutes an endorsement for any example suppliers provided herein.

Please visit this link for the most up-to-date parts list: ARC Drone Kit; see Table A1 for current components as of the rulebook release. Teams who choose to purchase a drone kit through STEM-ED will receive the components listed at this link. Teams are welcome to purchase these components directly from their suppliers instead of through STEM-ED. Alternate components may also be used, as long as the completed drone follows all General UAV Requirements (see Section 6).

Table A1. Drone Kit Components

Component	Link	Includes	Price
Drone Kit	HolyBro Drone Kit	Structure, flight controller (Pixhawk 6C), power module, GPS module, telemetry radio, motors, electronic speed controllers, and propellers	$524.99
Transmitter & Receiver	Flysky Transmitter/Receiver	FS-i6X transmitter and FS-iA6B receiver	$54.99
Drone Battery	LiPo Battery	(x2) CNHL 2200mAh 3S LiPo battery with XT60 connector	$28.99
Servo Battery	Tenergy NiMH Battery	NiMH 6V 2000mAh battery with Hitec connector	$11.99
Servo	Deegoo Torque Servo	(x4) MG996R 55g metal gear torque digital servo	$20.99
Spare Propellers	HolyBro Propellers	(2 pairs) HolyBro spare propellers	$11.59
Battery Charger	LiPo/NiMH Battery Charger	Battery charger for drone and servo batteries	$44.17
Battery Monitor	CAMWAY Battery Monitor	(x5) battery monitor for LiPo battery	$12.95
Remote ID Module	CubePilot Remote ID Module	Remote ID module to fulfill FAA requirements	$39.00
Total			**$749.66**

Appendix B: UAV Safety Requirements

General Safety

A. All UAVs must use all of the required safety materials.
B. UAVs must only be used in netted areas or when tethered. Any indoor UAV use must be approved by your faculty advisor.
C. We highly recommend the use of the following for testing:
    a. Safety nets and/or tethers of at least 30-lb-rated wire/rope
    b. Enclosed room, empty of any people, with a window from the outside for view

Certification

A. Each UAV must be registered with the FAA and must display FAA number while flying (written in black marker on the UAV or on masking tape on the vehicle and must be visible)

Lithium Polymer (LiPo) Battery Safety

A. Charging
    a. Charging must be done under competition supervision in a designated location.
    b. Proper LiPo battery balance charger must be used to ensure safety.
    c. Battery must not be charged over 4.2 V per cell.
    d. Charging battery is not to be left unattended.
B. Care/Usage
    a. Puffy batteries:
        i. This is hydrogen released from the cell.
        ii. Excess buildup/puffiness is a fire hazard.
        iii. Follow the disposal process.
    b. Battery cells should not be discharged below 3V.
        i. If they are, dispose of the battery following the appropriate process - reference (viii) below.
C. Do not drop or puncture (impact will cause damage).
D. Charging damaged batteries (puffy or punctured) may result in fire.
E. Batteries must be stored in a consistent room temperature (50–80 degrees F) environment.
F. Batteries must be stored in a proper container (i.e., provided LiPo battery bag).
G. Teams are advised to take precautions during travel to competition locations, especially with the LiPo batteries; LiPo batteries must always be stored in the provided LiPo battery bag.
H. Disposal
    a. Batteries must be discharged prior to disposal.
        i. Note: Batteries SHOULD NOT be discharged below 3V per cell unless they are being disposed of
    b. To dispose, take the battery to either the local battery site or to a local hobby shop.
I. Fire
    a. See this guide for fire safety guidelines in case of battery fire: https://www.riversideca.gov/fire/pdf/forms/2012/H-12-001.pdf

UAV Safety Operations

A. Referees will have full authority over LiPo batteries.
B. Testing by teams onsite:
    a. Teams need to ask referees for permission and go to a referee-specified testing area.
    b. The team needs to brief the referee on the type of testing they want to perform (run up, telemetry check, etc.) including procedures. The referee can reject any attempts to do any testing deemed unsafe.
C. The pilot needs to call out to the surrounding area that they are turning on the UAV and ensure that no one is within 5 ft. of the UAV, other than the teammate plugging in the battery.
D. Referees will ensure only one teammate is near the UAV and has everything (electronics, ESC, motors, power distribution board, sensors, and receivers) plugged in correctly before giving the LiPo batteries to the teammate.
E. The referee will also ensure one teammate has the tether in hand in case of "fly- aways"; the pilot is paying attention to the UAV and is ready to respond in case the motors suddenly turn on; and all teammates involved in the testing are wearing proper gear (safety goggles and hard hat, hard gloves for the one plugging in the battery).
F. The teammate is then allowed to plug in the batteries and perform whatever tests are needed, all under the supervision of the referee.
G. After the team has finished testing, one teammate can approach the UAV to unplug the battery and hand it to the referee for inspection and holding/charging.

Competition Flying Safety

A. Only one teammate is allowed to go into the flying area to plug and unplug the battery.
B. The referee and the teammate need to make sure that no one is near the UAV except for the teammate plugging in the battery.
C. The referee will also ensure that there is one teammate on the manual override transmitter outside the flying area, and that all teammates involved in flying are wearing safety glasses. Hard hats are recommended but not required.
D. Once the referee gives the approval, the teammate may plug the battery into the UAV electronics and secure the battery to the UAV.
E. The teammate holding the transmitter may not arm the UAV until the other teammate is out of the flying area AND the referee gives approval.
F. Team needs to follow rules during flight depending on the phase of competition.
G. Once flying is done, the referee needs to give approval before a teammate enters the flying area. The referee can give approval when it sees the UAV on the ground, receives notification from the team that they are done, and makes sure that the transmitter is on and the throttle is held at 0%.
H. The teammate shall immediately unplug the battery from the UAV electronics.
I. Once the battery has been unplugged, the other team members enter the flying area to help retrieve the UAV.

Appendix C: Technical Inspection Checklist

Technical Inspection

Team Name: _____

Caution: Vehicle is to be presented with battery and propellers removed

Portion	Intent to Compete	Qualified
Technical Presentation		
Semi-Autonomous Portion		
Autonomous Portion		

		Pass	Fail
Inspection	Battery & propellers removed	☐	☐
Aircraft ID	UAV displays FAA number while flying	☐	☐
Battery Safety	Team uses LiPo with no more than 4 cells (4S)	☐	☐
	Battery not charged over 4.2V per cell	☐	☐
	Battery not discharged below 3V per cell	☐	☐
	Team stores battery in proper container	☐	☐
	Battery not puffy or showing visual signs of damage	☐	☐
Safety Equip.	All team members have safety goggles	☐	☐
Vehicle Body Assembly	Legs safely and securely attached	☐	☐
	Motor arms safety and securely attached	☐	☐
	Propellers no larger than 12 inches diameter	☐	☐
	System stays within the size limitations	☐	☐
	Vehicle has no more than 4 propellers and 4 motors	☐	☐
	Frame supports all components	☐	☐
	Vehicle size matches team's technical plans	☐	☐
Vehicle Electronic Components	Electronics/wires securely attached (no dangling wires)	☐	☐
	GPS sensor mounted securely to vehicle	☐	☐
	Receiver matches transmitter choice	☐	☐
	Autopilot is 3DRobortics Ardupilot (Pixhawk, APM 2.6, etc.)	☐	☐
	Motor cut-off is programmed in transmitter and demonstrated through a switch on transmitter	☐	☐
Mechanism Design	Self-design and built	☐	☐
	Fits within area of the vehicle and beneath arms	☐	☐
	Mechanism does not fall off (complete tug test)	☐	☐
	Mechanism remains within 4ft of vehicle during operation	☐	☐
	Egg protection system does not exceed drone requirements	☐	☐
Vehicle Demonstration	Pilot can switch between manual flying mode and autopilot mode (and vice versa) within a few seconds	☐	☐
	Mechanism does not fall off during flight	☐	☐
Ready to Compete		☐	☐

Team Captain Initials: _____ **Inspector Initials:** _____

Appendix D: Scoring Sheets

The following images are examples of scoring sheets that may be used by competition judges.

Autonomous Scoring Sheet

Team Name: _____ **Round Number:** _____

Yes	No	Water Balloon
☐	☐	Released
☐	☐	Burst
☐	☐	Within 20ft of Target
☐	☐	Autonomous Trigger

Yes	No	Waypoint
☐	☐	Fly over green WP
☐	☐	Fly over red WP

	Takeoff/Landing
☐	Takeoff within 3mins
☐	No takeoff within 5mins
☐	No landing within 15secs of 6mins

Notes/Questions:

Flight Judge Initials: _____ **Team Captain Initials:** _____

Final Score: _____/250 **Score Judge Initials:** _____

Semi-Autonomous Scoring Sheet

Team Name: _____ **Round Number:** _____

Hoop	Ball
Large	Tennis: ☐ ☐ ☐ ☐
Medium	Wiffle: ☐ ☐ ☐ ☐
Small	Tennis: ☐ ☐ ☐ ☐

	Mechanism
☐	Successful tennis ball pickup
☐	Successful wiffle ball pickup

	Landing
☐	End round on landing pad

	Penalty
☐	Cause collision with opponent
☐	Mechanism falls off

Notes/Questions:

Flight Judge Initials: _____ **Team Captain Initials:** _____

Final Score: _____/300 **Score Judge Initials:** _____

Presentation Scoring Sheet

Team Name: _____ **Round Number:** _____

Task Description	[Max]	Score
Slides are legible	[10]	
Presenter speaks clearly and audibly	[10]	
Presenter speaks professionally and is well-prepared (Minimal mannerisms such as "um" or "you know")	[10]	
Photos/models/videos are present	[10]	
Presenter speaks to the room (Not to slides/screen)	[10]	
Penalty: Presentation runs over time	[-5]	
Total	[50]	

Final Score: _____ **Score Judge Initials:** _____

Final Score

Team Name: _____ **Scoring Judge Initials:** _____

Auton. Fly-Off

	Score
E	
L	
A	
P	
Score = $\frac{E}{A} + L + S - P$	

Semi-Auton. Head-to-Head

	Score		
T			
B			
L			
P			
Score = $[T + W + B + L] * P$			

Final Score

Challenge	Task	Score	[Max Score]	Final Rank
Auton.	Milestones		[200]	/
	Fly Off		[250]	
	Total		**[450]**	
Semi-Auton.	Time Trial		[100]	/
	Fly Off		[300]	
	Total		**[400]**	
Presentation	Content		[100]	/
	Delivery		[50]	
	Total		**[150]**	
Total			[1000]	/

Awards Considerations:

Final Awards: _____

Appendix E: Example Application Attachments

See files:

- Example Budget and Funding Plan
- Example Milestone

Budget			
Category	*Item*	*Cost*	*Payment Due Date*
ARC Fees	Registration	$100	1-Oct-20
ARC Fees	Payment #2	$200	4-Nov-20
ARC Fees	Payment #3	$200	20-Dec-20
ARC Fees	Payment #4	$200	28-Feb-21
ARC Fees	Payment #5	$300	4-Apr-21
Team Costs	Team Building Activities	$75	1-Mar-21
Team Costs	Team Shirts	$150	15-Apr-21
Travel	Bus Fee	$50	1-May-21
Travel	Gas	$50	1-May-21
Travel	Hotel Rooms	$100	1-May-21
Travel	Food	$100	1-May-21
Total Costs:		$1,525	

Funding Plan		
Source	*Amount*	*Scheduled Receipt Date*
School STEM Funds	$500.00	1-Oct-20
Grant	$500.00	1-Jan-21
Local Sponsors	$350.00	15-Feb-20
Amount Needed	*$175.00*	

Action Item	Action Owner	Start Date	End Date	Duration	Project Completion Graph								
					September	October	November	December	January	February	March	April	May
Register for ARC	Mrs. Smith	9/1/2020	9/15/2020	2 weeks									
Complete Fundraising Packet	Joe	9/15/2020	9/30/2020	2 weeks									
Contact Sponsors	Joe	10/1/2020	10/15/2020	2 weeks									
Study ARC Material	Joe, John, Jack	10/15/2020	12/31/2020	10 weeks									
Study Programming	Jane	10/15/2020	12/31/2020	10 weeks									
Pilot Training with Practice Drone	John	1/1/2021	2/15/2021	6 weeks									
Build Drone	Jack, Joe, Jane	1/1/2021	2/15/2021	6 weeks									
Develop Competition Strategy	John	1/15/2021	1/31/2021	2 weeks									
Trouble Shoot Drone Problems	Joe, Jack	2/15/2021	3/15/2021	4 weeks									
Practice Flying Drone	John	3/15/2021	4/15/2021	4 weeks									
Program Drone	Jane	2/15/2021	4/1/2021	6 weeks									
Practice Autonomous Competition	Jane, John	4/1/2021	4/30/2021	4 weeks									
Prepare Presentation	Joe, John, Jack, Jane	5/1/2021	5/7/2021	1 week									
Attend Competition	All			1 day									

List of Abbreviations

Abbreviation	Meaning	Page
ARC	Aerospace Robotics Competition	5
LiPo	Lithium Polymer (Battery)	31
NiMH	Nickel-Metal Hydride (Battery)	31
UAV	Unmanned Aerial Vehicle	5

Revision History

Version	Notes	Date Released
A	Initial release	01/13/2024
B	Increased details and corrected mistakes	03/28/2024