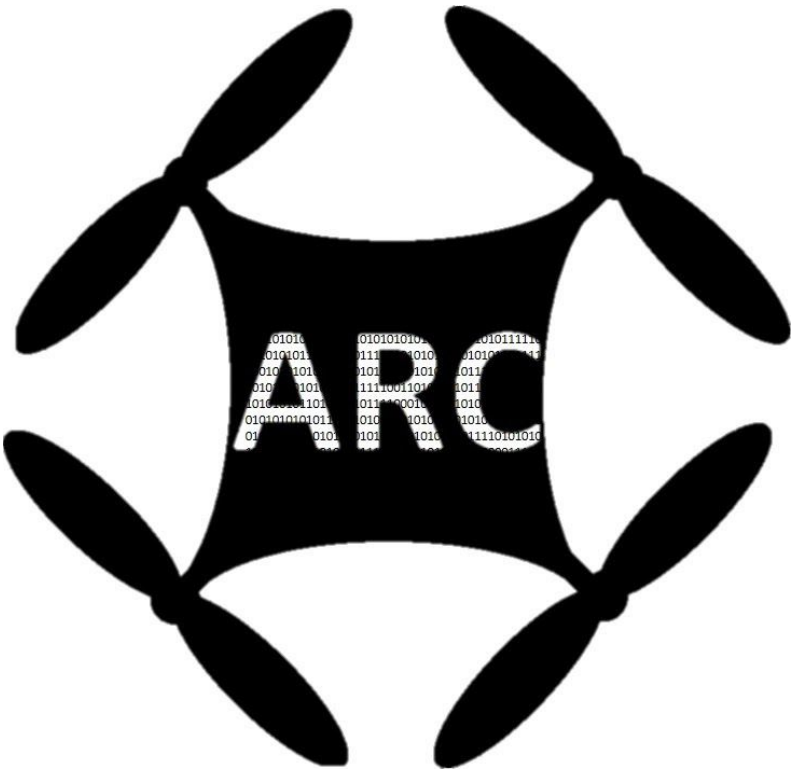

Aerospace Robotics Competition

Rule Book

2020/2021

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Competition Overview

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

- Hands-on flying of unmanned aerial vehicles (UAVs)
- Developing knowledge of unmanned and autonomous systems
- 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 two autonomous missions: an aerobatics challenge and an autonomous mission challenge.
2. Semi-Autonomous: Not applicable for the 2020/21 school 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.

I. Awards

Prizes will be awarded to the top three teams. The top prizes will be awarded based on total score as aggregated from each of the parts of the competition.

1st place:	$500
2nd place:	$250
3rd place:	$125

If only 3 teams attend the competition, only the first place prize will be awarded.; if only 4 teams attend the competition, only first and second place prize will be awarded. All three prizes will be awarded if the team count in attendance is more than 4.

In addition to monetary prizes, additional certificates (non-financial awards) will be given out at the competition day. The winners of these certificates will be chosen by the judges at the competition. These certificates include:

- Most Creative Aerobatic Maneuver
- Best Autonomous Mission Execution

II. 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, but if the advisor cannot attend the competition, notification one month in advance of the event is required in order to register a substitute.

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 after application results are published. 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; please contact the ARC Working Group in Section XIII with questions.

The cost to participate in ARC includes the costs that ARC incurs to host the competition, including insurance, venue costs, and prize money. UAV kits may be purchased at an additional fee, as detailed in the Financial Plan (Reference ARC Website). The cost to participate in ARC does not include any travel fees that the team may acquire should they choose to participate in an ARC region that requires significant travel.

III. General UAV Requirements

Because the 2020/21 competition will be virtual, the following requirement will not apply to a physical drone. Instead, teams will develop a hypothetical design for a drone. This design must comply with the following requirements.

A. UAV
   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. The UAV must have a telemetry radio that allows it to transmit data to a computer. Having the transmitter receive telemetry is not sufficient and will not satisfy this requirement.
   e. Dimensional limits:
      i. Propellers may not exceed 12 inches in diameter.
      ii. The entire system (quadrotor + mechanism + any associated systems) must fit in a 36-inch by 36-inch by 36-inch box.
   f. Battery requirements:
      i. Teams must use a lithium polymer battery.
      ii. Teams must use commercially available batteries; homemade batteries are not allowed.

B. Ground Station

Teams must use a ground station to monitor the vehicle during flight. The ground station will be used for the teams and judges to monitor flight characteristics. The ARC kit does not include the ground station computer; a laptop must be provided by the school/team in order to participate. The requirements of the ground station are as follows.

a. Functions:
    i. Return home
    ii. Mechanism trigger
    iii. Start mission
    iv. Note: The ground station CANNOT be used to command the UAV to do any other functions during flight (such as modifying the flight plan in flight, manually commanding [through clicking or any sort of human action] the UAV to fly to a waypoint, etc.)
b. Required Vehicle Parameters to be displayed on Ground Station
    i. UAV GPS coordinates
    ii. Altitude
    iii. Velocity in the X, Y, and Z directions
    iv. Battery level (an additional/separate battery sensor onboard is also acceptable)
c. The ground station must maintain connection to the UAV within 120 ft. This will be tested during Technical Inspection (see Appendix E)
d. Teams may use any open source software that fulfills the requirements stated in the above sections.

C. Sensors
    a. Teams MUST use a GPS sensor that is mounted securely onto the UAV.
    b. Teams may use as many other sensors mounted securely on the UAV as deemed necessary by the team.

D. Performance Requirements:
    a. The quadcopter must be able to lift a 5 kg payload
    b. The quadcopter must be able to fly for at least 20 min at steady level flight
    c. The quadcopter must be able to transmit a video recording.

IV. Presentation

In 2020/2021, presentations will be virtual. ARC Staff will schedule individual Zoom sessions with each team for their presentation.

A. Presentation will be judged based on content and presentation style of speakers.
    a. Each team will submit their presentation as a PDF document for review 7 calendar days before their scheduled presentation date. Teams will be contacted in the weeks preceding with submission directions.
    b. Presentation content will be graded prior to competition day.
    c. Presentation style will be graded when presentations are given on competition day.
    d. If a team does not submit their presentation 7 calendar days prior to the competition date, the team will receive 0 points for the presentation content.

B. Each team will present for 15 minutes (10-min presentation, 5-min Q&A) covering the required details discussed in the scoring section of Appendix B.
C. Presentation Process
    a. Because presentations are due prior to the competition date, the judging panel will share the team's presentation PDF via Zoom.
    b. The timekeeper will give a 1-minute warning prior to the 10-minute limit by virtually raising his/her hand.
    c. Teams will receive a 5-point penalty if the presentation extends past the 10-minute limit.
    d. Presentations will be stopped at the 11-minute mark.
    e. 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.
    f. Time structure for presentation:

Time	Description
2 minutes	Introductions
15 minutes	Presentation
5 minutes	Questions
2 minutes	Closing remarks by ARC Staff

V. Competition Schedule

The schedule for the 2020/2021 competition year will be published on the ARC webpage: http://www.aeroroboticscomp.com/

Within 7 days of competition day, a detailed schedule will be sent to teams. This will include times for each team's presentation and technical inspection as well as the flight order for all flight rounds. During the day of the competition, teams must be prepared for the announced schedule of events. Teams that are not prepared when it is their turn for a given event will not be permitted to participate in that event to avoid causing delay of the competition.

VI. Financial Requirements

Teams selected to participate in ARC will be required to submit a completed Financial Agreement form as linked on the ARC webpage. The Financial Plan must be signed by the team's teacher/leader as well as the school's principal and sent to ARC upon team selection to compete in ARC. Upon receipt of the Financial Plan, teams are officially registered to compete in ARC.

The cost to participate in ARC includes a $400 competition fee. Some regions may be sponsored by an external source, which will be indicated on the ARC webpage and the region's Financial Agreement. If the region is

sponsored, then the $400 competition fee is waived for all schools in that region.

In addition to the $400 competition fee, teams may elect to purchase a vehicle kit from ARC, with the alternative being that they use or procure their own supplies. 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 $600, and its contents are detailed in Appendix A. Teams electing to purchase an ARC vehicle kit will receive their kit after the signed Financial Plan and initial payment of $100 is received. The balance of the team's ARC fee will be distributed over the school year to allow the team time to fundraise; the precise payment schedule is outlined in the Financial Plan.

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.

VII. Competition Application

Teams wishing to participate in the 2020/2021 ARC competition must apply on the ARC website. The dates for the application window will be published on the ARC website. Teams will be notified by the ARC Working Group if they are chosen to compete. Reference Appendix C for the Application Requirements.

VIII. Scoring

The score sheets and rubrics for technical inspection, the flight rounds, and the presentation will be sent out to teams within one month of the competition date. The scoring method and weight given for each portion of the competition is detailed in Appendix B. Overall, the scoring will break down as follows:

A. Autonomous Mission: up to 150 points
B. Semi-Autonomous Mission: N/A
C. Presentation: up to 150 points
D. Pre-Competition Challenges: 150 points

All the points for each team will be combined before making the determination of team rankings.

IX. Judging

A. Autonomous Judging: 1 referees
    a. There will be 1 referee operating the team's developed code with a checklist of "flight" objectives
B. Pre-Competition Challenges Judging:
    a. There will be 2 judges approving whether the submissions meet the requirements.
C. Presentation content will be judged prior to the presentation date by three judges. On the date of the presentations, only teams' presentation style will be judged by a panel of three judges.

X. Protest Procedure

All questions and protests on the day of competition should be directed to the Flight Manager. For the virtual component of the autonomous portion, please refer to instructions in Appendix B.

XI. Communications

There will be an ARC forum to facilitate communication and collaboration between the schools/teams competing in ARC. Teams can use the forum to pose questions and offer feedback to other teams. While the ARC Staff will monitor the forum, the intent is for teams to support each other as they solve the ARC challenges via the forum. If the ARC Staff notices that a question has not been addressed by a different team, the ARC Staff will respond to resolve the question. Teams should plan to regularly check the forum to support other teams and see if other teams have worked through similar issues; this should be the first place teams inquire to get technical feedback prior to reaching out to the ARC Staff via email.

Any questions for the ARC Staff should be directed to: aero.robotics.comp@gmail.com. The staff can support teams technically, though the forum should be the first point of contact for technical issues. The staff should be the primary point of contact concerning logistics and rule book clarifications.

Questions received by the ARC Staff and posted on the forums 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 Staff and the team. He/she will be included in all communication from the ARC Staff and will receive specific inquiries/requests separate from those sent to the teachers/school staff. Teachers are responsible for ensuring that the school has any required parental consent forms in order for students to be able to communicate with the ARC Staff.

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 joined ARC.

XII. COVID-19

Due to the ongoing COVID-19 pandemic, the ARC Staff may need to adapt or remove any or all parts of the competition in order to ensure the safety of all students, advisors, staff, and volunteers, and to meet federal and local requirements and guidelines, at any point during the competition. These changes may include, but are not limited to, requiring additional safety measures at any in-person event, transitioning in-person activities to virtual activities, and reducing the extent of or entirely cancelling the in-person competition. The ARC Staff will make all attempts possible to communicate any changes with sufficient time for teams to apply the changes to their plans, but due to the changing nature of the pandemic, we ask that teams be flexible and understand that the scope of the challenge may be adapted at any point during the year. **Teams are asked to work remotely: the competition is designed to ensure that all tasks can be done virtually while working in teams. Students and teachers should use proper judgement in ensuring that safety and health of all personnel involved are not compromised.**

The ARC competition is held in multiple locations throughout the US, and each of those regions will have their own local guidelines for COVID-19, which may differ between the regions. The ARC Staff will, on a case-by-case basis, determine if and how competitions in different regions can be held at different levels

of in-person activity. Depending on the federal and local guidelines, it is possible that some regions will hold in-person competitions while others will not, or that all regions will follow the same guidelines. These decisions will be made by the ARC Staff as information becomes available.

If a team cannot meet in person, please contact the ARC Staff to discuss potential options. If any teams have any questions about changes to the competition due to COVID-19, please contact the ARC Staff. A section will be added to the website to keep teams informed on the competition status and answer frequently asked questions about COVID-19's effects on the ARC competition.

Appendix A: Example UAV Supply List

The table included below lists an example of components that are needed for an ARC UAV. components included in the ARC UAV kit. When developing their UAV design to present to the judging panel, teams may use this list as a starting point.

Item	Notes	Link	# of item	Cost per item ($)	Total Cost ($)	Total Balance ($)
Drone kit		https://www.amazon.com/dp/B016W0S1LG/ref=psdc_11608080011_t3_B01DLL6PIA	1	140	140	140
MRobotics	Autopilot + telemetry radios	https://store.mrobotics.io/product-p/mro-pixhawk1-fullkit-mr.htm	1	260	260	400
Lithium polymer (LiPo) batteries		https://hobbyking.com/en_us/turnigy-2200mah-3s-30c-lipo-pack.html	2	15.49	30.98	430.98
Additional propellers		https://www.amazon.com/8pairs-GemFan-Propeller-Flamewheel-Quadcopter/dp/B07G14R4WM/ref=sr_1_5?keywords=Gemfan+1045%28CW%2BCCW%29+Black+Propeller&qid=1569991140&s=toys-and-games&sr=1-5	1	9.99	9.99	440.97
Battery charger		https://hobbyking.com/en_us/imax-b6-50w-5a-charger-discharger-1-6-cells-genuine.html	1	28.98	28.98	469.95
Transmitter		https://www.amazon.com/Flysky-Transmitter-Multirotor-Helicopter-Quadcopter/dp/B07CXL9LCT/ref=sr_1_17?crid=2MSCPOTOVTL2G&keywords=6ch+rc+transmitter+and+receiver&qid=1569991178&s=toys-and-games&sprefix=6ch+%2Ctoys-and-games%2C136&sr=1-17	1	51.68	51.68	521.63
LiPo battery bags		https://hobbyking.com/en_us/lithium-polymer-charge-pack-18x22cm-sack.html	1	3.13	3.13	524.76
Servo			1	5.31	5.31	530.07
Practice drone		https://www.amazon.com/Holy-Stone-Predator-Helicopter-Quadcopter/dp/B0157IHJMQ/ref=sr_1_5?dchild=1&keywords=quadcopter&qid=1594200072&sr=8-5	1	23.99	23.99	554.06
Shipping to			1	20	20	574.06

schools						
Misc. costs	shipping of individual parts, etc.				25.94	**$600**

Appendix B: 2020/2021 Mission Details

ARC is a team competition with multiple parts. For the 2020/21 school year, there will be no semi-autonomous portion. Instead there will just be an autonomous portion and a presentation. The autonomous portion will have a maximum available score of 150 points, and the presentation will have a maximum available score of 150 points. An additional 150 points are available for the pre-competition challenges.

Teams that earned points from the virtual engagement activity will have their point totals added to their final total.

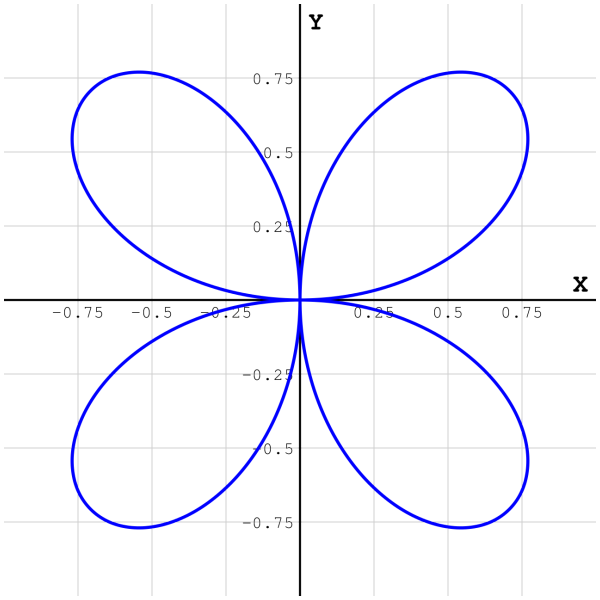
This year, to encourage participation in the virtual engagement activities, bonus points will be awarded to teams that are active in participating and engaging with ARC staff and other students. These points will be added to the final total of each team's score.

A. Autonomous Competition: Tello Drone Programming
    a. Tasks:
        i. This year due to COVID, the autonomous portion will be done completely virtually. Teams will submit Python code that we will run on our Tello Drones. Teams will have an opportunity to test their code before the competition through both the DroneBlocks simulation and a live testing session. There will be two missions: one is an acrobatic mission and another is a waypoint navigation mission.
        ii. This mission is designed to build off DroneBlocks lectures.
    b. Rules:
        i. Teams will have to program a Tello drone to complete two different missions.
            1. Mission A: Aerobatics. The drone must complete a series of maneuvers that draw out complex shapes as well as maneuvers. The sequence of shapes and maneuvers are described in the document. Teams will also have to come up with their own maneuvers, and judges will score the maneuver based off the creativity, complexity, and execution of the maneuver.
            2. Mission B: Waypoint navigation. The drone must fly through different waypoints and accomplish different tasks at each waypoint. Teams will not be given the list of waypoints; however, teams will be judged on accuracy of the execution and the speed at which the Tello drone was able to accomplish the task
        ii. Due to our inability to meet and to level the playing field, teams will submit code to the competition judges who will then run their Python code on ARC-owned Tello drones. The judges will then take the Python code and run it while judging the execution of the code. <u>We will not take DroneBlock code blocks.</u> Please make sure to use the Python template found

here: **(Will release GitLab link in Jan. 2021).**

iii. Mission definition:

1. Mission A:
    a. The mission will be split into two parts: the drone will first fly a sequence of maneuvers defined in section c) and then the drone will fly a sequence of maneuvers defined by the team. Teams are allowed to use any functionality that is already built into the Tello drone as well as create additional maneuvers.
    b. The team designed maneuvers must not exceed more than 3 minutes.
    c. The tello drone must fly a four-leaf clover pattern similar to as shown in Figure 1 (does not need to follow the coordinates but must generate the given shape):



[Wikipedia]

    d. The quadcopter will start at (0,0, ground level) and must land at (0,0, ground level) at the end of mission

2. Mission B:
    a. Teams will be given a waypoint list with what to accomplish at each waypoint. Teams must fly through the series of waypoints and accomplish the task at each waypoint.
    b. The quadcopter will start at (0,0, ground level) and must land at (0,0, ground level) at the end of mission
    c. The variations of waypoints are the following:
        i. Waypoint A: Loiter for 5 sec
        ii. Waypoint B: Turn on the video stream, take a 360 video while hovering, turn off the video stream
        iii. Waypoint C: Flip upside down and back
        iv. Waypoint D: Circle the waypoint at a 2 m radius and take a 180 video of the waypoint
    d. Teams will not have the actual list of waypoints to beforehand. Teams are encouraged to create their own list of waypoints for testing.

e. The number of waypoints will not exceed 10.

iv. Code

1. The code must follow the following structure: compute route, generate 3D plot of route, and fly the route. Teams must use matplotlib to generate a 3D interactive flight path that will allow judges to see what the flight path the quadcopter will fly.
2. The code submitted to judges must be through a Github/Gitlab link that teams provide. Teams must create a code repository online and give us access to the code such that it can be run. Please see the tutorials site for instructions on how to use Github/Gitlab.
3. Teams must comment their code sufficiently that judges will have an understanding of what is being processed.
4. The team's code must follow the template defined in the example code Gitlab link **(Will release GitLab link in Jan. 2021).**
5. If the team's code runs into an error that is traced to be from their code, the team will earn zero points. Teams are able and encouraged to request that judges verify that there are no errors that show up when they run their code; however, teams may only *request it 3 times.* Teams are highly encouraged to thoroughly test their code before submitting.
6. Teams must use **Python 3**. Do not use Python 2.x Furthermore, the only libraries that will be available are the following: Matplotlib, numpy, scipy, os, sys, and time as well as any that are specified within DroneBlocks lecture videos.
7. Teams will have live sessions to test out their code virtually on an actual Tello drone. Teams will be limited to 2 total sessions.

B. Detailed Scoring Calculations

a. Autonomous

i. The autonomous portion scoring will be split between the two missions:

ii. $M_{auto} = M_1 + M_2$

iii. Mission 1 (M_1)

1. Teams that successfully complete the given aerobatic routine will receive 25 points.
2. The other 25 points will be given based off how the team's designed aerobatic routine. The judges will score the aerobatic maneuver based off the following three criteria:
    a. Complexity (out of 8 points)
    b. Creativity (out of 8 points)
    c. Execution (out of 9 points)
3. Teams that exceed the 3 min limit for their maneuver will automatically lose 5 pts.

iv. Mission 2 (M_2)

1. The score will take into account the completion of each task as well as the speed of compared to other teams:
2. $M_2 = (w_1 / w_{total}) * 50 + (t_{fastest}/t) * 30 + 20 * (b)$
3. w_1 = number of waypoints completed by team
4. w_total = total number of waypoints
5. t_fastest = fastest time out of all teams
6. t = time recorded
7. b = 0 if 3D plot not generated; b = 1 if 3D plot generated

b. Presentation (150 points maximum)
    i. Content
        1. Team organization and dynamics (up to 2.5 points)
        2. Team schedule (up to 5 points)
        3. Team strategy - how does your team plan to win (up to 10 points)
        4. Programming design, methodology, and process (up to 15 points)
        5. Programming testing process (up to 15 points)
        6. Vehicle design process (up to 5 points)
        7. Overview of vehicle and components (up to 15 points)
        8. Mechanism(s) design (up to 10 points)
        9. View of entire system (front, top, side) with primary dimensions (height, width, and length) (up to 5 points)
            a. Please label important dimensions in the picture
        10. Vehicle performance estimation (up to 10 points)
        11. Overview of teams's thoughts on virtual ARC (up to 5 points)
        12. List of parts/materials used (up to 2.5 points)
    ii. Presentation Style
        1. Slides are legible (up to 10 points)
        2. Presenter speaks clearly and audibly (up to 10 points)
        3. Presenter speaks professionally and is well-prepared (minimal mannerisms such as "Uh", "You know") (up to 10 points)
        4. Photos/Models/Videos are present (up to 10 points)
        5. Presenter speaks to the room, not to their slides/facing the screen (up to 10 points)
        6. More details for the presentation will be sent out separately as the competition date nears. Please follow those guidelines as the presentations will be judged based on those guidelines

Appendix C: Application

Note: Each team must submit an application **via the online application site (no paper applications will be accepted)** consisting of their team members and one faculty advisor (required). It is suggested, but not required, that the team size be no more than 5 students.

High School Name:
Address:

Faculty Advisor: Email:
Phone Number:

Team Name:
Number of students:
Team Captain:
Team Captain Email:

Team Concept (answer the following questions with at least one paragraph response)

a) 2020/21 is a different year for ARC since it will be 100% virtual. What does your team hope to gain from this year?
b) What is your team's strategy for completing the ARC challenge? Attach a document detailing your team's timeline for key project milestones and resources (people) responsible for each milestone.
c) Describe your team's and team members' experience with robotics, vehicle design, and programming.
d) Describe your faculty advisor's experience with robotics, vehicle design, and programming.
e) Team-building activities are important to maintain optimism and camaraderie but will be difficult this year. How will your team remain excited for ARC despite the virtual nature of the 2020/21 competition?

Only 1 attachment is required this year: the milestone. See Appendix F for example application submissions. Teams may (but are not required to) use these references to re-populate for their submission.

Appendix D: UAV Safety Requirements

A. 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:
        i. Safety nets and/or tethers of at least 30-lb-rated wire/rope
        ii. Enclosed room, empty of any people, with a window from the outside for view
B. 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)
C. Lithium Polymer (LiPo) Safety
    a. Charging
        i. Charging must be done under competition supervision in designated location.
        ii. Proper LiPo battery balance charger must be used to ensure safety.
        iii. Battery must not be charged over 4.2 V per cell.
        iv. Charging battery is not to be left unattended.
    b. Care/Usage
        i. Puffy batteries:
            1. This is hydrogen released from cell.
            2. Excess buildup/puffiness is a fire hazard.
            3. Follow disposal process.
        ii. Battery cells should not be discharged below 3V.
            1. If they are, dispose of the battery following the appropriate process - reference (viii) below.
        iii. Do not drop or puncture (impact will cause damage).
        iv. Charging damaged batteries (puffy or punctured) may result in fire.
        v. Batteries must be stored in a consistent room temperature (50–80 degrees F) environment.
        vi. Batteries must be stored in a proper container (i.e., provided LiPo battery bag).
        vii. Teams are advised to take precautions during travel to competition location, especially with the LiPo batteries; LiPo batteries must always be stored in the provided LiPo battery bag.
        viii. Disposal
            1. Batteries must be discharged prior to disposal.
                - Note: Batteries SHOULD NOT be discharged below 3V per cell unless they are being disposed of
            2. To dispose, take the battery to either the local battery site or to a local hobby shop.
        ix. Fire

1. See this guide for fire safety guidelines in case of battery fire: https://www.riversideca.gov/fire/pdf/forms/2012/H-12-001.pdf

D. UAV Safety Operations
   a. Referees will have full authority over LiPo batteries.
   b. Testing by teams onsite:
      i. Teams need to ask referees for permission and go to a referee-specified testing area.
      ii. 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 need to make sure 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 also needs to make sure 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.

E. 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 also needs to make sure that there is one teammate on the manual override transmitter outside the flying area, and that all teammates involved in flying are wearing proper gear (safety goggles and hard hat). Hat must be a construction-style hard hat; if teams are unsure as to what a construction hard hat is, please contact the ARC Working Group.
   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 dependent on the phase of competition.
   g. Once flying is done, the referee needs to give approval before a teammate enters 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 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 E: Technical Inspection Requirements

The following checklist will be used during Technical Inspection.

Technical Inspection Checklist 2020/2021

Because ARC 2020/21 is virtual, there will be no technical inspection. However, when developing your UAV design, teams may reference this checklist to understand what safety requirements are needed for ARC UAVs for a typical competition.

	PASS	FAIL
Battery and propellers removed for inspection	_____	_____
Aircraft Identification		
UAV displays FAA number while flying	_____	_____
Battery Safety		
Team use LiPo with no more than 4 cells (4s)	_____	_____
Battery not over 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 Equipment		
All team members have safety goggles and hard hats	_____	_____
Vehicle Body Assembly		
Legs safely and securely attached	_____	_____
Motor arms safely 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 either 3DRobotics Ardupilot (Pixhawk, APM 2.6 etc.) or the DJI NAZA	_____	_____
Motor cut-off is programmed in transmitter		

and demonstrated through a switch on transmitter _____ _____

Ground Station (GS)

Onboard computer connects with ground station _____ _____

Ground station displays necessary vehicle information:

Quadrotor GPS coordinates _____ _____

Altitude _____ _____

Velocity X, Y, Z _____ _____

Battery level _____ _____

Mechanism Design

Note: if the team has multiple mechanisms, each must be inspected

Self designed and built _____ _____

Fits within area of the vehicle and beneath arms _____ _____

Mechanism does not fall off (complete tug test) _____ _____

Mechanism remains within 4 ft of vehicle during operation _____ _____

Vehicle Demonstrations

GS and vehicle communicate within 120 feet:

Physical test by walking vehicle away from GS _____ _____

Teams provide technical spec of radio _____ _____

GS can command vehicle to return home _____ _____

GS cannot control vehicle otherwise _____ _____

Pilot can switch between manual flying mode

and autopilot mode (and vice versa) within a few seconds _____ _____

Autonomous flight mode can be overridden by pilot

(checked via ground test) _____ _____

Mechanism does not fall off during flight _____ _____

Autonomous route determined through computer output

(mock waypoint file demonstration) _____ _____

Appendix F: Example Application Attachments

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*	

File saved here: Example Budget and Funding Plan

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									

File Saved here: Example Milestone

Version	Notes	Date Released
1.0	Public release of competition rule	12/11/2020