Aerospace Robotics Competition

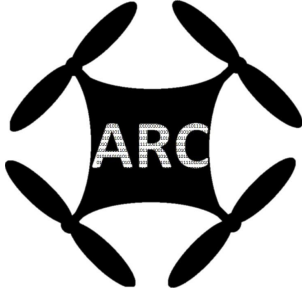
Kickoff and Meet-Your-Mentor Event!

September 21, 2021

LOCKHEED MARTIN

Agenda

- About Us
- Competition
- Logistics
- Resources
- Q&A



ARC: About Us

Who Are We?

ARC California Directors:

Beldon Lin: ARC COO/CTO, Lockheed Martin Operations Analysis

Nikola Atanackovic: ARC California Director, Lockheed Martin Airframe Design

Rayon Harris: ARC Event Coordinator, Lockheed Martin Airframe Design

Fiorella Tello: ARC Communications Lead, Lockheed Martin Airframe Design

Kelsey Hite: ARC Mentor Lead, Lockheed Martin Airframe Design

Marcus Jackson: ARC Technical Support, Lockheed Martin Airframe Design

ARC Objectives

ARC:

- Demonstrate exciting, hands-on building and flying of the UAV
- Develop knowledge of unmanned, autonomous systems
- Develop an understanding of basic aerospace principles

Focus on the aerospace engineering while providing strong introduction to autonomy - a very modern STEM topic

This competition is **relevant**, **challenging**, and **exciting** for high school students

Communication

Mentors:

- LM mentors
  - Teams' go-to for technical issues
  - Resource for educational/professional routes within the aerospace industry

Student Captains:

- One student per team - the primary technical point of contact
- Interface with university and professional mentors

ARC Directors:

- Support logistical and rule book related concerns
- Support minimal technical questions if university mentor is unable to help

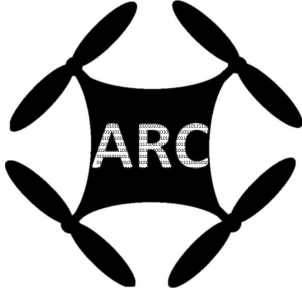
This Year

2021/2022: Three Regional Competitions

- Florida
- New England
- Palmdale, California
  - In partnership with Lockheed Martin
  - 10 Antelope Valley Teams!

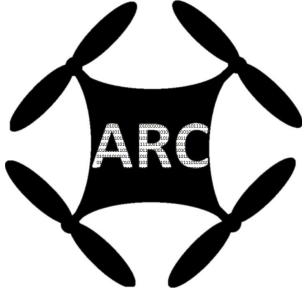
Recommended Schedule

- Participate in virtual engagement through DroneBlocks tutorials
- Achieve human-piloted flight
  - Expect reasonable difficulty
  - Focus on vehicle build and wiring troubleshooting
  - **Recommended Date: mid January**
- Create and built mechanism(s)
  - Test engineering problem solving skills and creativity
  - **Recommended Date: early February**
- Achieve successful autonomous flight
  - Expect this to be the biggest challenge for teams
  - ARC: provide programming resources and training
  - Focus on learning to program autonomous flight then optimizing program for the flight challenge
  - **Recommended Date: mid March**



2021-2022 Competition

Competition Overview



- Combination of exciting hands-on flying and autonomous flight
  - Autonomous Flight (up to 300 pts)
    - Students program vehicle to navigate between waypoints and complete tasks
  - Semi-Autonomous Flight (up to 150 pts)
    - Students fly, retrieve and deliver tennis balls within time requirement
  - Presentation (up to 150 pts)
    - Students provide insight for their vehicle and mechanism details and testing process
  - Technical Inspection
    - Students provide insight on their vehicle and design process

Technical Presentation

- Teams demonstrate understanding of their UAV and discuss details of their design process
  - Opportunity to show-off team creativity!
- Presentations must be submitted at least 7 days prior to competition
- Presentations are graded based on required content prior to competition day
- Presentations graded day-of competition based on presentation style of speakers and slide legibility

Time	Description
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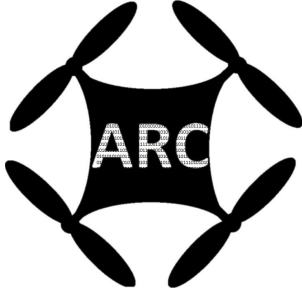
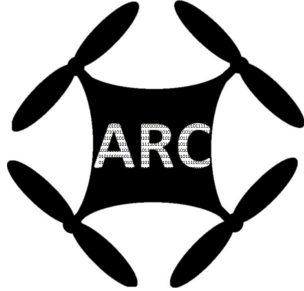
Drone Specifications



- Vehicle must be a quadcopter (4 motors with one propeller each)
- Flight computer must be an ArduPilot capable system
- Propellers may not exceed 12 inches
- The entire system (quadrotor + mechanism + any associated systems) must fit in a **36 inch by 36 inch by 36 inch box**
- Battery must be a lithium polymer (LiPo) battery with no more than 4 cells
- For safety purposes, the vehicle must have a secure location for attaching a tether

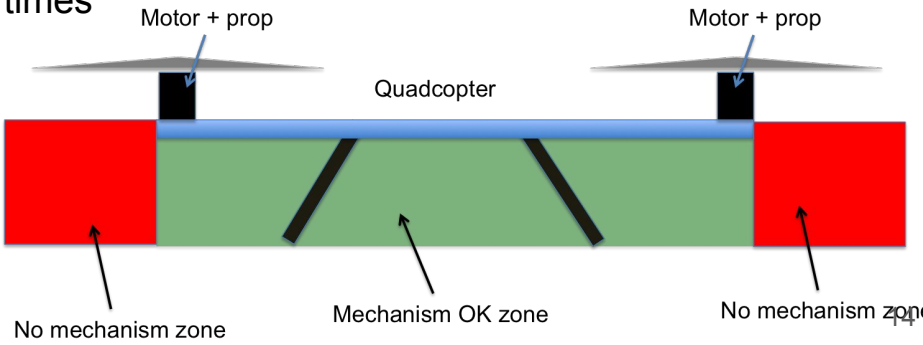
Drone Specifications, cont



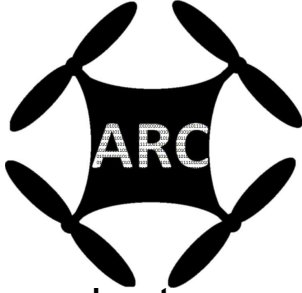
- UAV must be registered with FAA
- Technical Inspection will check for FAA Registration Number
- FAA Website: https://registermyuas.faa.gov/
  - Must be 13 years or older to register
  - Make an account with the FAA
  - Select “Model Aircraft”
  - Pay $5 registration fee
  - Receive UAS registration number
  - Label your UAS with the registration number
- How-To: http://diydrones.com/profiles/blogs/how-to-register-your-drone-with-the-faa

Mechanism Design

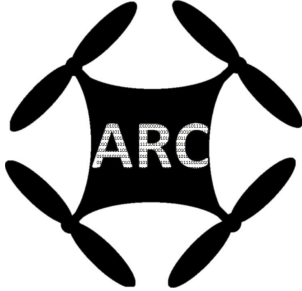
- Teams design and build their own mechanisms for the autonomous and semi-autonomous flight portions
  - The same mechanism may be used for both flight portions or two separate mechanisms
  - If two mechanisms are designed, both will be tested during the Technical Inspection
- Requirements:
  - Must fit within the area under UAV
  - Must stay within 4 feet of the UAV at all times
  - Must remain attached to the vehicle at all times
  - Must not go above the arms during flight / operation



Tech Inspection

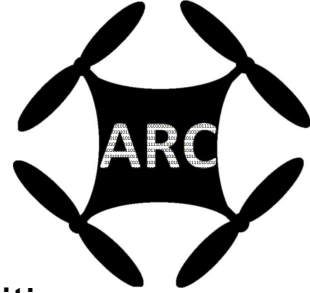


- Teams must pass a Technical Inspection on the day of competition in order to fly
- The Rule Book Appendix E (pg 30) includes the checklist to be used by judges at the competition day
- Teams will not be permitted to fly if their UAV does not pass the Technical Inspection
- Teams must be prepared for Technical Inspection at their assigned time slot
    - Time slots for Technical Inspection will be sent 7 days prior to the competition date



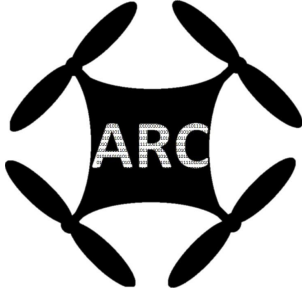
Logistics

Competition Day Details - April, 2022



- A detailed schedule will be sent to teams 7 days prior to the competition
  - Teams not prepared for their scheduled time-slot forfeit that round
  - Flight order as well as order for Presentations and Technical inspection will be randomized
- Flight order may change day-of competition based on:
  - Vehicle damage preventing a team from competing
  - Inclement weather delaying the competition schedule
  - A team's vehicle design not complying with technical requirements and therefore not permitted to compete
- 4 hours will be allotted for autonomous flight
- 2 hours will be allotted for semi-autonomous flight
- *Note: Allotment for flight portions may be updated on day-of competition based on number of teams prepared to fly*
- Official rule book will be available to the teams for reference

Mentors



- Teams will be connected with Lockheed Martin professional mentors to support them technically
  - Note: In some cases, Lockheed Martin mentors are not experts on the competition logistics or rules. Contact the ARC Staff with any ARC logistical questions.
  - ARC Staff is still able to support technical questions if the mentor is unable, but mentor should be the first point of contact.
- Remainder of today's meeting is to meet your mentor!

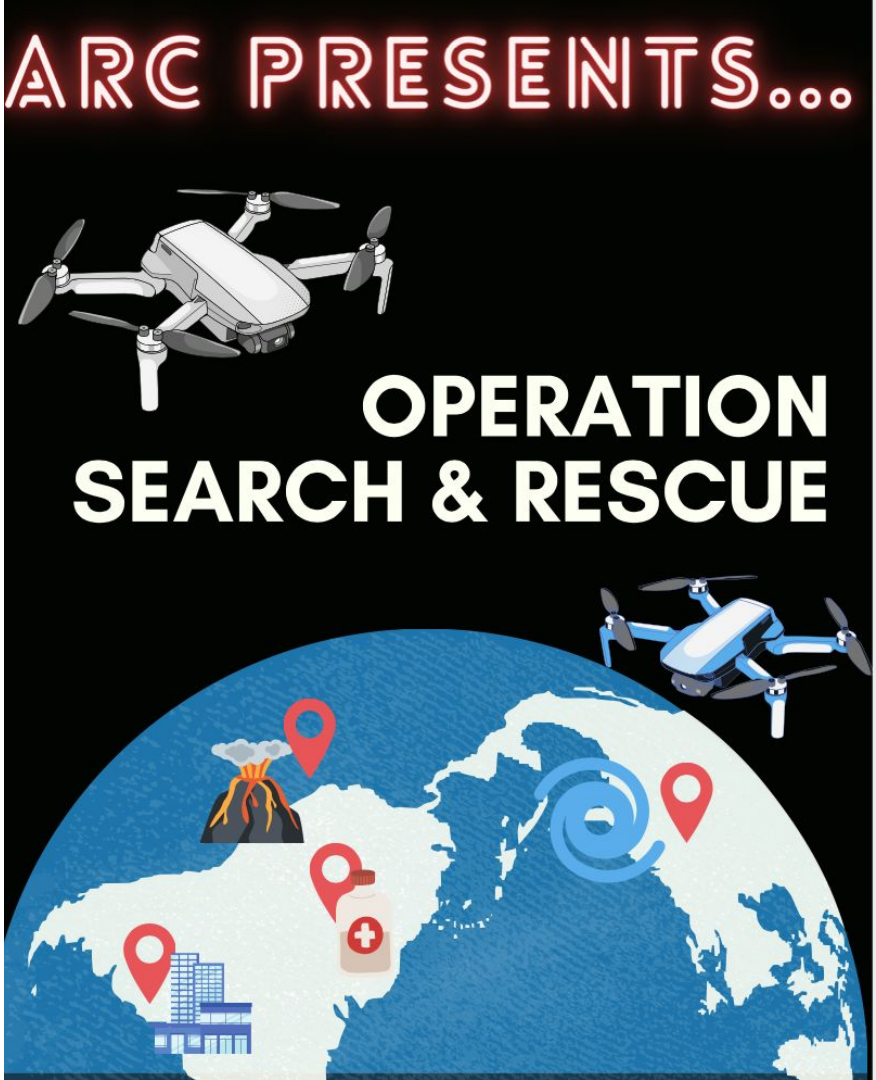
Cost

Cost to compete is the price of the drone (depends on your choice of drone):

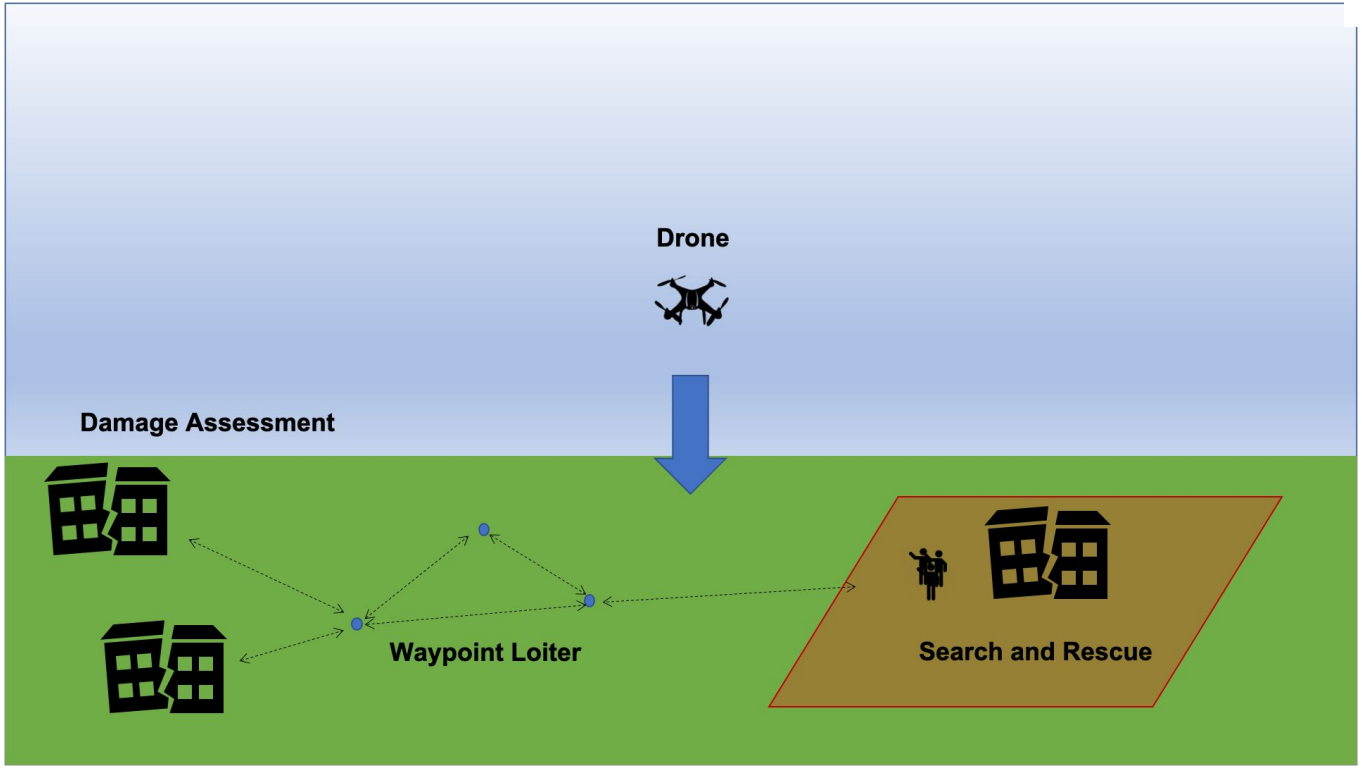
Drone	Cost ($)
DJI Tello	~~130~~ **FREE**
Kit Drone	600
Own-drone that meets specifications	500+

LM ADP Sponsored!

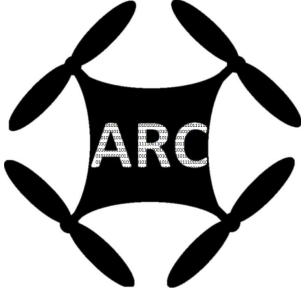
2021-2022 Competition Overview



This year’s mission...



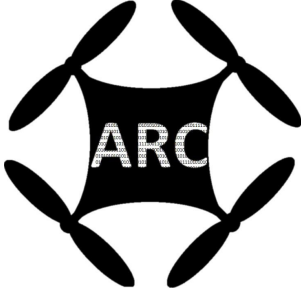
Mission Details



The year is 2022, and your local government has tasked your team with responding to a natural disaster. You are required to perform the following tasks:

- Surveillance Waypoint 1: Count the number of people in need of assistance / rescue
- Surveillance Waypoint 2: Assess building for structural damage
- Loiter at 3 Specific Waypoints

Competition Overview



- Combination of exciting hands-on flying and autonomous flight
  - Autonomous Flight (up to 300 pts)
    - Students program vehicle to navigate between waypoints and complete tasks
    - ***Split between a virtual component and the competition day***
  - Semi-Autonomous Flight (up to 150 pts)
    - Students fly, retrieve and deliver tennis balls within time requirement
  - Presentation (up to 150 pts)
    - Students provide insight for their vehicle and mechanism details and testing process
  - Technical Inspection
    - Students provide insight on their vehicle and design process as well as ensure vehicle airworthiness

Drone Options

Teams have 3 options: DJI Tello drone, Kit drone, or Personal drone

Drone	Autonomous Portion, max points	Semi-Autonomous Portion, max points	Presentation, max points
DJI Tello	240	0	150
Kit Drone	300	150	150
Own-drone that meets specifications	300	150	150
Own-drone that **does not** meet specifications	0	0	150

Autonomous Portion - Waypoint Mission

Autonomous = No human control

1. ***Virtual Competition*** - provides students with a structured set of tasks that gradually build up to the fly-off competition

    a. Teams ***must record the drone*** or any needed equipment in order to demonstrate that the task has been accomplished.
    b. Teams that complete all tasks would be considered in “good shape” for the Fly-Off Competition

Task Number	Task Name	Description	Points (Kit Drone / Tello Drone)
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.	25 / 15
2	Takeoff	Autonomously have the drone take off. Provide a video to ARC to show completion.	25 / 15
3	Hover	Hover the drone without pilot intervention (autonomously) for 30 seconds. Provide a video to ARC to show completion.	25 / 15
4	Mechanism Test	Hover the drone and drop a golf ball. Provide a video to ARC to show completion.	25 / 15
5	Autonomous Flight	Code your drone to fly in a pattern defined by your team for at least 1 minute. The drone must travel in the X, Y, and Z directions. Provide a video to ARC to show completion.	25 / 15
6	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.	25 / 15

Autonomous Portion - Waypoint Mission

2. Fly-Off Competition

a. Teams receive a file with waypoint coordinates

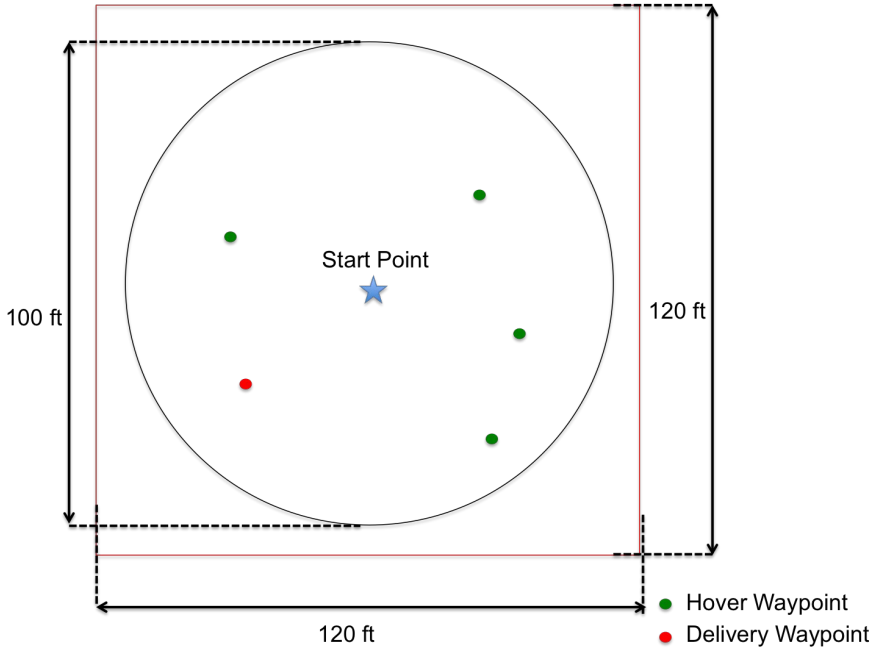
   i. 2 types of waypoint missions: visual surveillance or loiter

b. Teams use waypoint file to calculate UAV route

c. UAV will autonomously complete the mission per the calculated route.

d. Teams can accomplish this with either the kit drone or the Tello drone; ***however, to earn full points, the kit drone must be used.***

Autonomous Portion, cont



Semi-Autonomous Portion - Payload Delivery

Semi-Autonomous: Human assisted flight, human in-control

Sequence

1. Pilots use mechanism on UAV to retrieve a tennis ball from a staging area
2. Tennis balls are released through hoops in the flight arena
    a. Note: Hoop diameter varies with increased point value for smaller hoops
3. Pilots may drop up to 5 tennis balls within the flight round (5 minutes)
    a. Note: Pilots must only retrieve and drop 1 tennis ball at a time

Semi-Autonomous Portion, cont

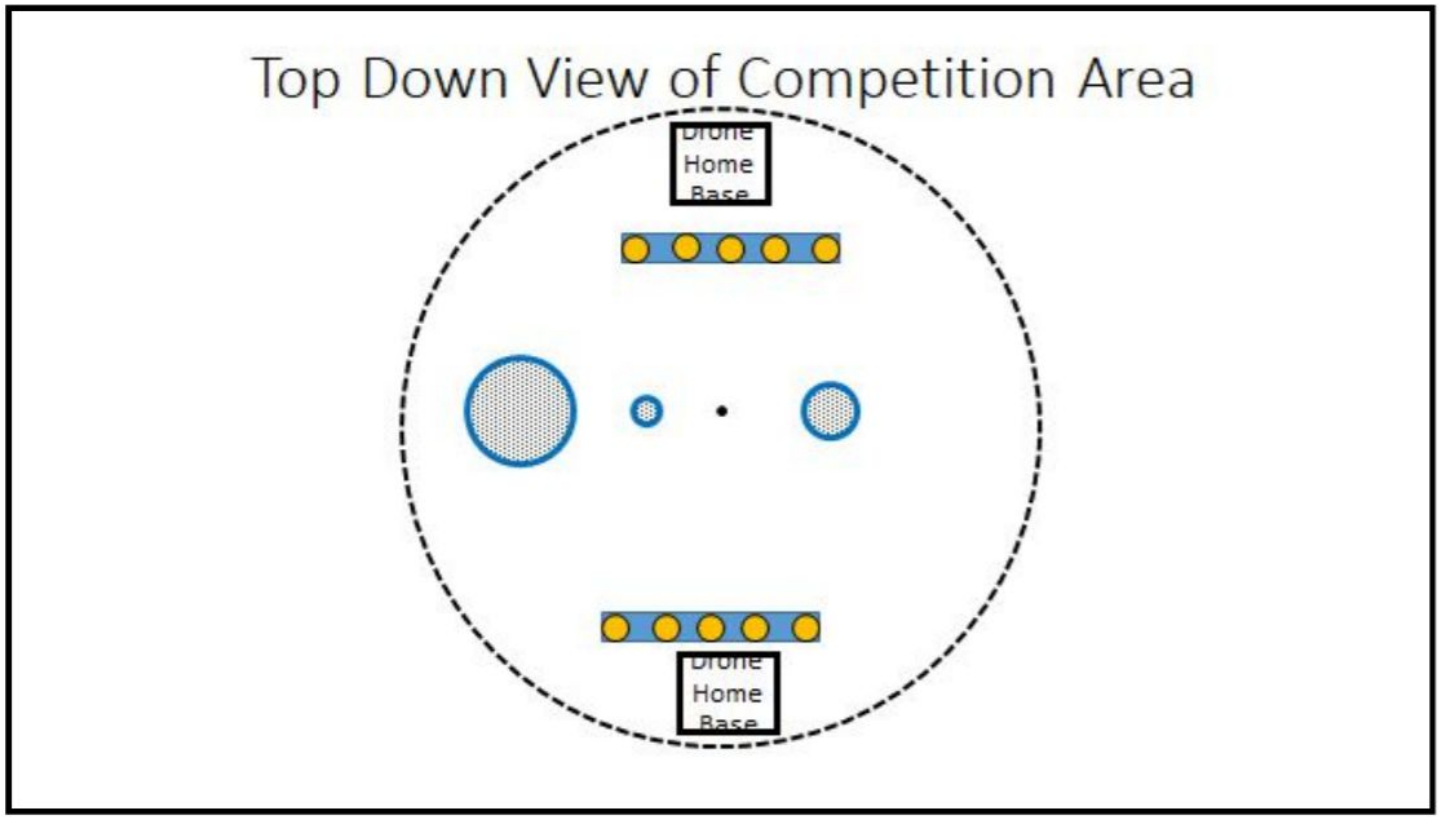
Scoring:

- $S = avg(F)$
- $F = 150 * \frac{RoundScore}{BestRoundScore}$
- $RoundScore = (B_1 + B_2 + B_3 + B_4 + B_5) * \frac{RoundFlightTime(120sec)}{TeamFlightTime(s)}$
    - Bx=score of tennis ball number x
        - Large hoop, Bx = 20
        - Med. hoop, Bx = 35
        - Small hop, Bx = 50

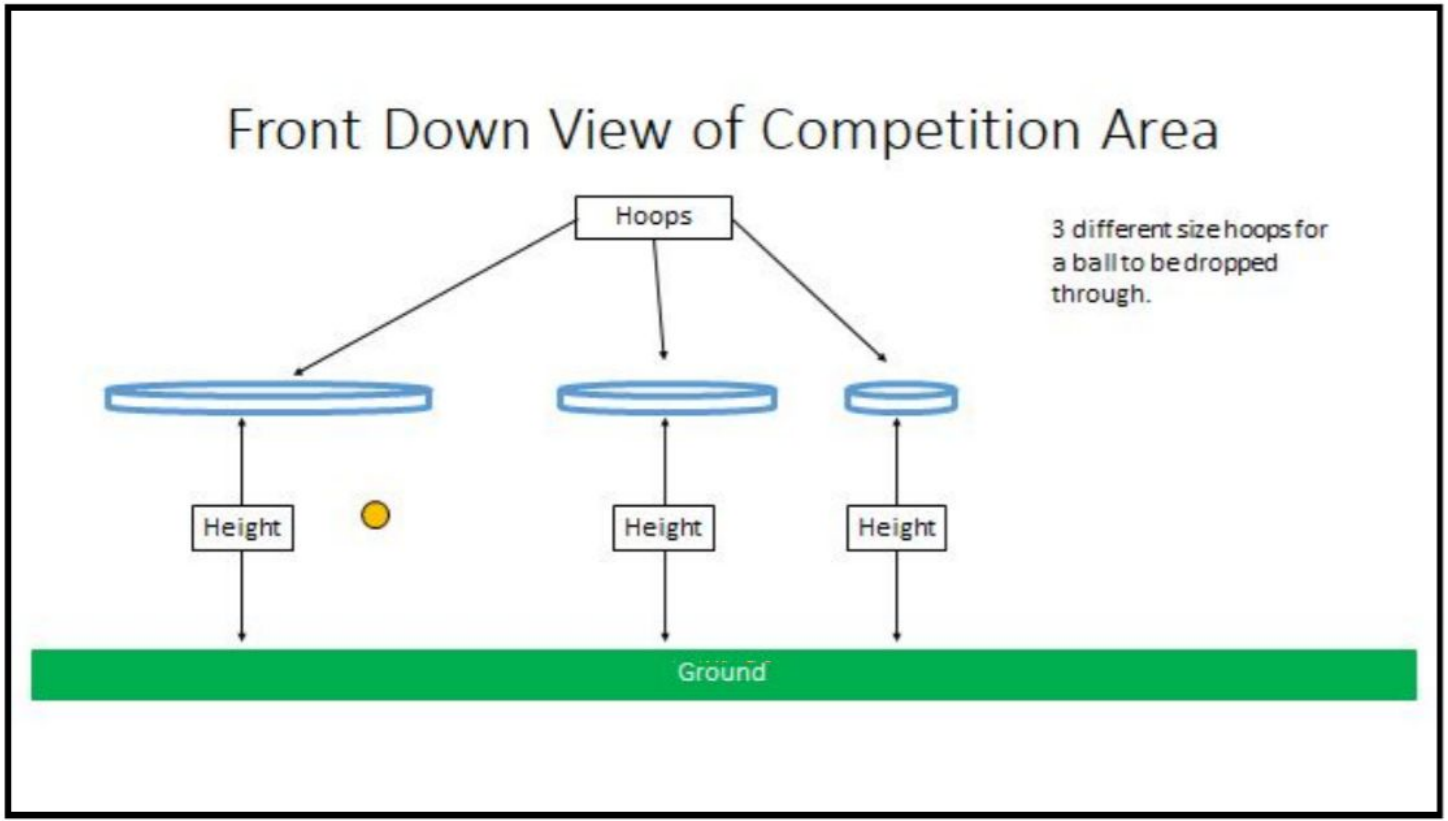
Penalties

- Team will receive a score of 0 if they collide with another team
- Teams will lose 50% of their total score if their mechanism falls off during flight

Semi-Autonomous Portion, cont



Semi-Autonomous Portion, cont



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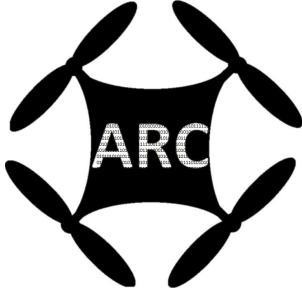


Resources

Kit: Hardware

Category	Part	# of parts
Drone/Quadcopter Hardware	Servo	1
	Motor	6
	Arms	4
	Legs	2
	Propellers	6
Accessories	Zip ties	8
	Dual sided tape	2 or 3

Drone Hardware

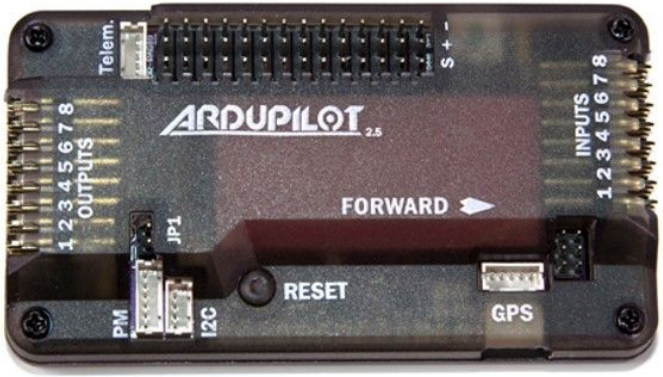
Propellers

Motors

Kit: Electronics

Category	Part	# of parts
Drone Electronics	Autopilot: APM 2.8	1
	Autopilot: Pixhawk	1
	Electronic Speed Controller	4
	Power Cord	2
	GPS: for APM	1
	GPS: for Pixhawk	1

Autopilot: APM 2.8



Autopilot: Pixhawk

Kit: Radios and Batteries

Category	Part	# of parts
Radios	Telemetry 900MHz	1 set
	Transmitter	1
	Receiver	1
Batteries	Lithium Polymer (LiPo) Battery	2
	Battery Charger	1
	LiPo Bag	1

LiPo Battery

Transmitter/Receiver

LiPo Bag

Battery Charger

Kit: Needed supplies that are NOT included

- Ground station computer
- Tools
- Additional accessories (tape, glue, etc.)
- Software
- Supplies for mechanism design
- Pilot

Tutorials Website

Tutorials Saved Here

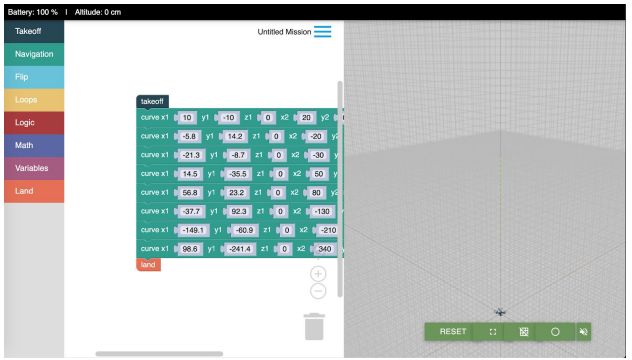
- Drones 101
- Fundamentals (Competition, Kit, Financial Plan)
- Aerospace Sciences (Forces, Propulsion)
- Software (Onboard vs Offboard)
- Programing
- Hardware
- Autonomy
- System Integration
- Team Dynamics
- Safety
- Flying/Testing

DroneBlocks

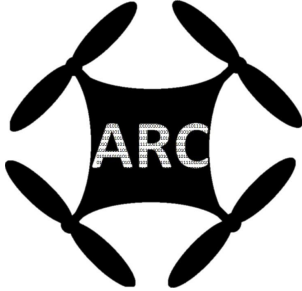
DroneBlocks is an online drone programming curriculum based around the DJI Tello Drone

Online simulation environment developed such that most of relevant curriculum can be used done in-browser

FREE access for students through ARC



A fun and accessible curriculum for students of all ages/education



Questions?

Email: nikola.atanackovic@lmco.com