RAD
AERIAL DRONES

REC FOUNDATION

2019-2020
GAME MANUAL

PARTNERSHIP WITH

FTW ROBOTICS

RAD Aerial Drone Competition

REC FOUNDATION

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VLOS PACKAGE DELIVERY & RACING

CONTENTS

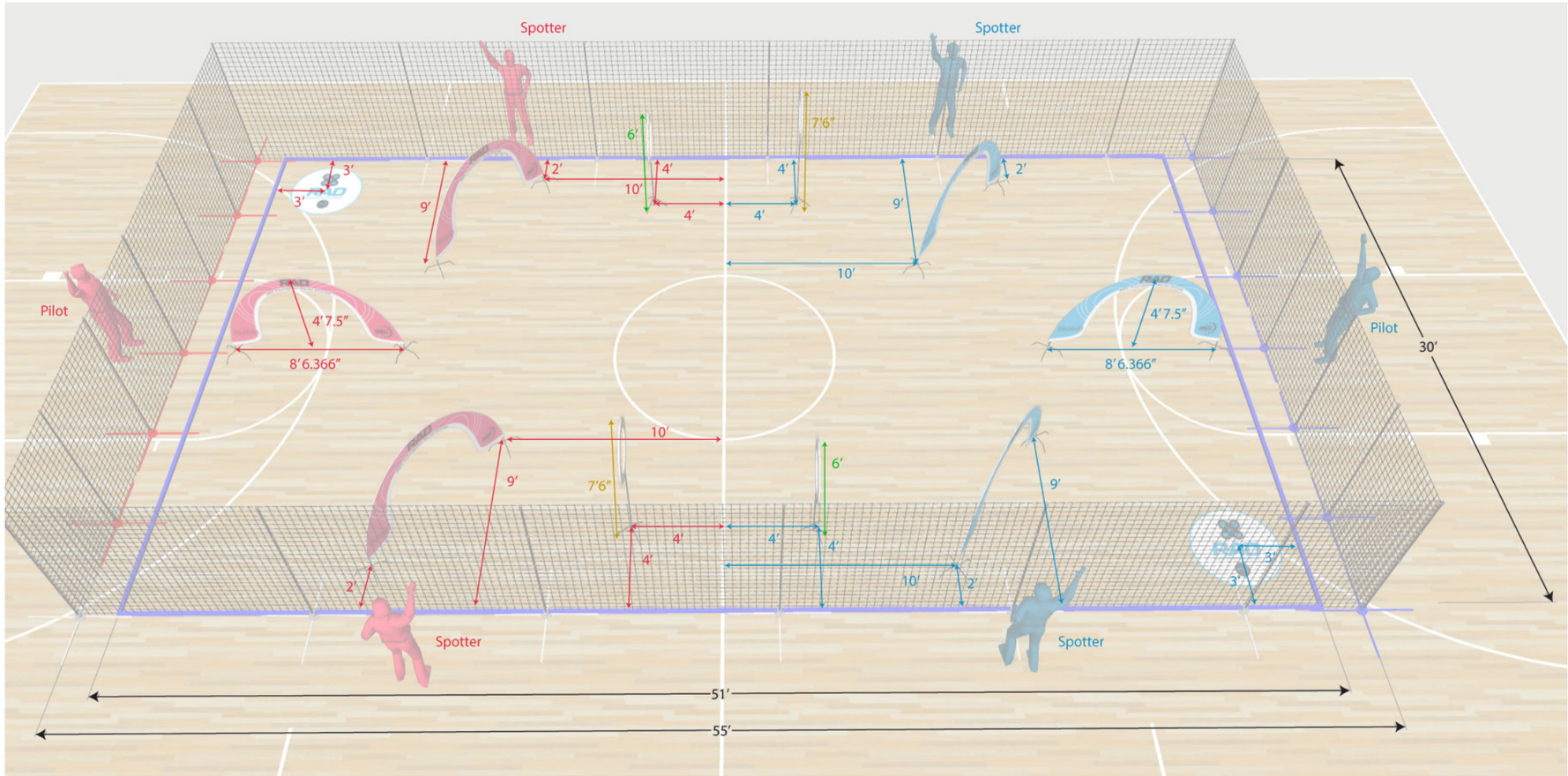
The REC Foundation Aerial Drones (RAD) competition engages students in hands-on STEM learning as they pilot aerial drones and compete in an evolving game, building lifelong skills in communication and leadership and to help enhance their futures in a dynamic workforce.

RAD

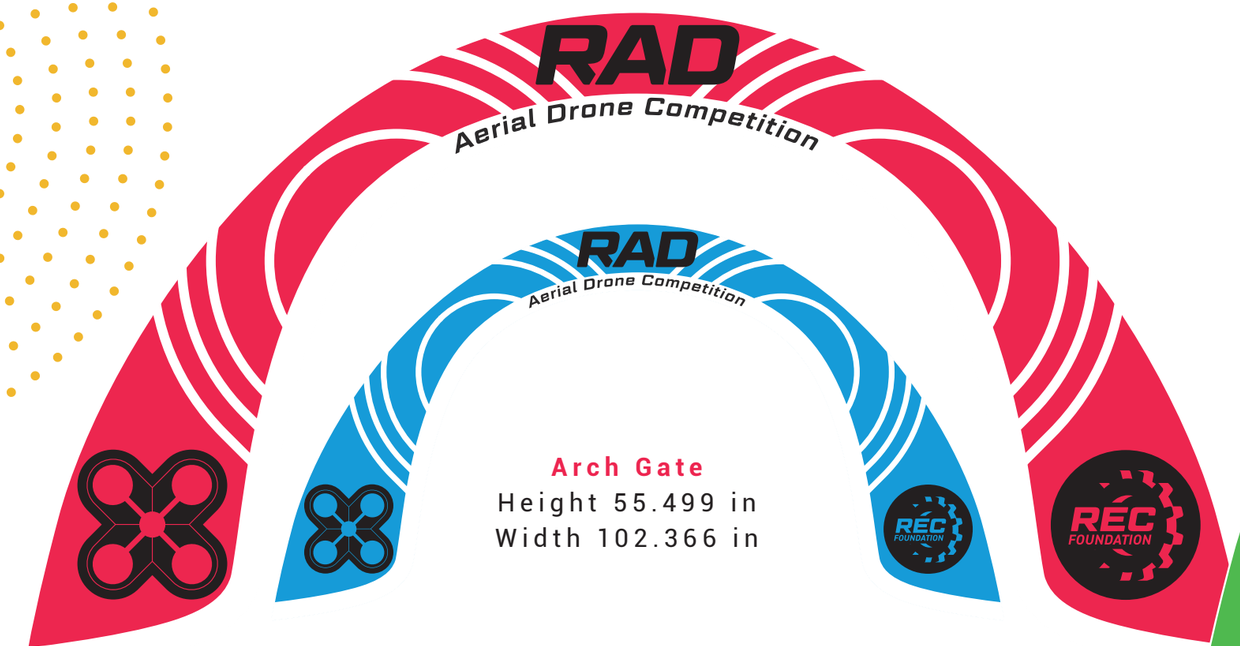
AERIAL DRONE COMPETITION

Overview

Visual Line of Sight Racing (VLOS) Package Delivery & Racing, is played on a 30ft x 51ft Field configured as seen throughout this game manual. Teams are tasked with two challenges using the same field configuration. The first challenge is Package Delivery where one Drone at a time will navigate an Obstacle Course and successfully Deliver a payload accurately to a scoring location before returning to where it started. The second challenge is a head-to-head Race around an Obstacle Course where the objective is to successfully navigate three (3) Laps of the Course with a faster time than your opponent. Awards will be given for the winners of VLOS Package Delivery, VLOS Racing, Precision through Obstacles, a Business Pitch video presentation, best use of a Visual Observer, Attitude, and Top Overall. Not all awards will be given at all Tournaments.



REC Foundation | 2019-2020
Aerial Drones (RAD) Game Manual



Arch Gate
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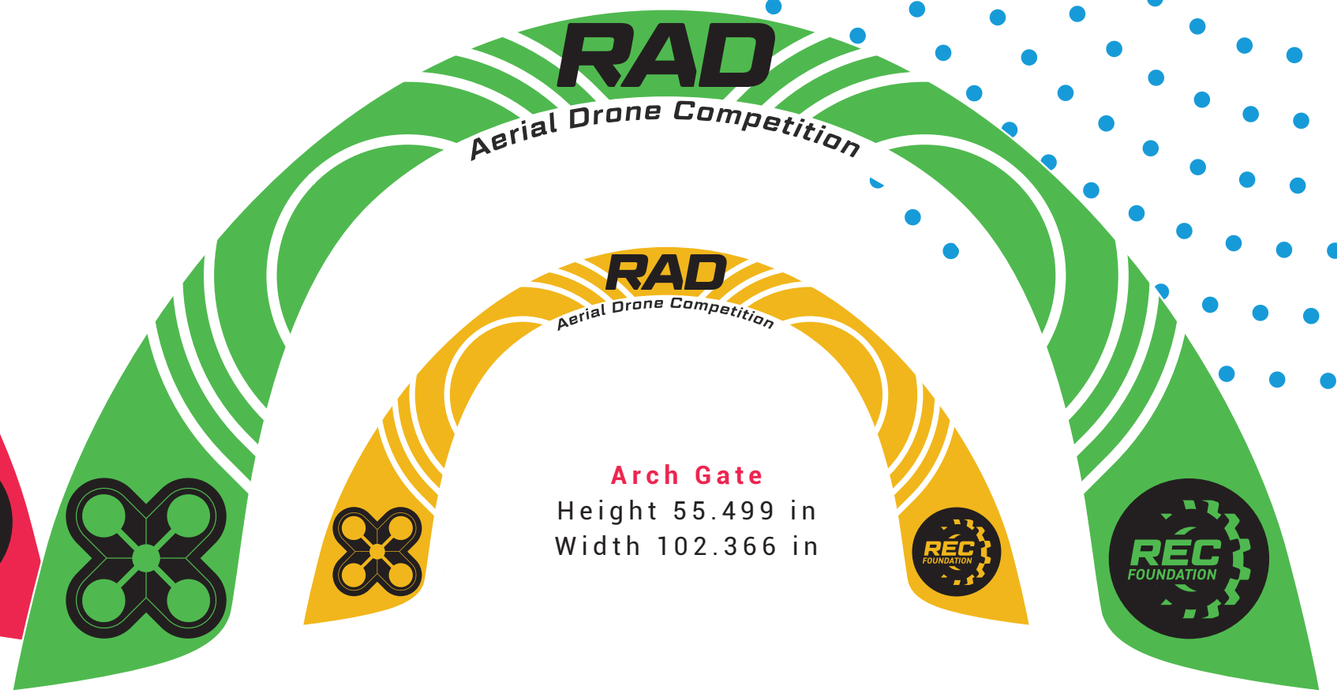
Width 102.366 in



Arch Gate
Height 55.499 in
Width 102.366 in

Definitions

Checked In
A Drone status. A Drone is Checked In when it has been stored in the Hangar.

Checked Out
A Drone status. A drone is Checked Out from the Hangar immediately before a Delivery Attempt or Race.

Completed
An Obstacle status. An Obstacle is Completed when a Drone flies the correct direction through that Obstacle.

Course
The predefined path in the Field that the Drones navigate toward the objective. The Course includes the direction that Drones must navigate through Obstacles.

Delivery Attempt
A single round of VLOS Package Delivery.

Disqualification
The result of a safety violation that results in the team being removed from the Tournament. A Disqualified team is not eligible to win any awards or participate in the tournament.

Failure to Finish
A Penalty for not completing the Course within the time limit.

Field
The volume where the Drones navigate through Obstacles along the Course.

Flight Area
An area designated at the venue where teams are permitted to fly their Drones. At most events, the Field is the only Flight Area.

Formal Warning
The consequence of certain actions as described in the Rules section.

Grounding
A command given by a referee to immediately land a drone.

Hangar
The location where Drones are to be Checked In and Checked Out out during the event.

Lap
A travel distance, once around the Course.

Launch Signal
The signal that the Referee gives the Teams to start a Race.

Major Penalty
The consequence of certain actions as described in the Rules section.

- In the VLOS Race, when one Team is issued a Major Penalty, that Team is automatically given a loss and the opposing Team is given the win. The Team with the Major Penalty will be issued a Race Time in accordance with the Scoring section. The opposing Team will have a Race Time of one second (0:01).
- In Package Delivery, when a Team is issued a Major Penalty, the Team will receive a No Score for that attempt.

Definitions (continued)

Maintenance Hangar

The area within the Hangar where Students may work on their Drone under event supervision. Teams may not work on their Drone in any other location.

Mentor

The Team advisor who instructs and trains the Team. The Mentor may not work on or handle the Drone in any capacity without Students present who are actively learning.

Obstacles

There are two types of Obstacles

1. **Arch Gate**

   An Obstacle that requires a Drone to fly under the Arch Gate. The maximum horizontal opening is 5ft and the maximum vertical opening is 4ft.

2. **Keyhole Gate**

   An Obstacle that requires a Drone to fly through the center of a Keyhole Gate. The inner diameter of the Keyhole Gate is 2ft.

Pad

The area where the Drone(s) will start and finish in both VLOS Racing and Package Delivery. There are two (2) Pads, one for each Team in the VLOS Race, and only one (1) Pad for VLOS Package Delivery.

Landing Pads
75 cm
Polyester
material

Definitions (continued)

Penalty
The amount of time added for a rule violation, Accuracy of Delivery, or Failure to Finish.

Pilot
The Student on the Team that controls the Drone's actions.

Pilot Station
The area where only the Pilots are permitted during the challenge. For a Race, there are two (2) Pilot Stations, one (1) for each Team.

Race
A single Round of VLOS Racing.

Round
A group of Races where each eligible team competes in a single Race. Each Round is used to determine the Race order for the next Round.

Student
The primary Designers, Pilots, Programmers, Builders, Visual Observers, etc. on the Team. The Students do all of the work under the supervision of the Mentors. For a person to be a Student he or she must meet both of the following conditions.

Students must be earning or has earned credit toward a high school diploma/certificate or its equivalent during the six (6) months preceding the RAD World Championship at VEX Worlds in April 2020. Courses earning credits leading up to high school would satisfy this requirement. Students must be born after May 1, 2000 (i.e. who will be 19 or younger at the RAD World Championship). Eligibility may also be granted based on a disability that has delayed education by at least one year.

Team
A group of Students and their Mentors who are registered to compete. Mentors may only assist Students and may not fly the Drone during the challenges.

Visual Observer
The Student(s) on the team who stand in the Visual Observer Station and help the Pilot navigate the course.

Visual Observer Station
The area where only the Visual Observers are permitted during the challenge. For a Race, there are two (2) Visual Observer Station, one (1) for each team.

Safety Rules

S1: No flying of Drones except in designated areas.
Teams may not fly their Drone in any area that is not designated as a flight area and must adhere to the specific rules of that flight area, eg. where to stand when piloting the Drone and when it is OK to retrieve the Drone. Parking lots, fields, hallways, etc. are no-fly zones before, during and after the event. Violations will result in a team being Disqualified from the event and the team will be required to remove the Drone from the venue.

S2: Stay in the Pilot Station.
Once the Drones are placed on the Pad, Pilots must return to and stay in the Pilot Station until the Referee gives the all clear. Violations will result in the Team receiving a Major Penalty.

S3: Fly under the virtual ceiling.
The Drones may not fly higher than ten (10) feet. Teams are encouraged to use software to set the Drone's virtual ceiling to ten (10) feet. Violations will result in a Team receiving a Major Penalty and immediate Grounding.

S4: Fly within the Field perimeter.
The Drones must not pass outside of the Field perimeter. Violations of more than 3-seconds (0:03) will result in a Team receiving a Major Penalty and immediate Grounding. If the Referee determines that there is an instant safety hazard, a Major Penalty will be issued without a 3-second (0:03) countdown and immediate Grounding.

S5: Drones must be stored in the Hangar.
When teams arrive to the venue, they must check their Drones into the Hangar and leave them there until they are called up for queuing to their Race. Once the Race is completed the team must immediately check their Drone back into the Hangar until their next Race, Package Delivery attempt, or the end of the event. Violations will result in a team being Disqualified from the event and the team will be required to remove the Drone from the venue.

S6: Batteries must be charged before Launching.
Teams will not be permitted to Launch if the Drone lights are red, indicating a low battery level. Teams are required to check the battery levels when at the Hangar to ensure that the Drone is ready for flight before placing their Drone on the Pad.

GENERAL

Rules

G1: Treat everyone with respect.
All Teams are expected to conduct themselves in a respectful and professional manner while competing in RAD Competition events. If a Team or any of its members (Students or any adults associated with the Team) are disrespectful or uncivil to event staff, volunteers, or fellow competitors, they may be Disqualified from a current or upcoming Match. Team conduct may also impact a Team's eligibility for judged awards. Repeated or extreme violations of could result in a Team being Disqualified from an entire event, depending on the severity of the situation.

Drone competitions often induce intense, high stress situations. These are good opportunities to model and/or gain experience in handling these situations in a positive and productive manner. It is important that we all exhibit maturity and class when dealing with any difficult situations that may present themselves in both the RAD Competition and our lives in general.

This rule exists alongside the REC Foundation Code of Conduct. Violation of the Code of Conduct can be considered a violation of and can result in Disqualification from a current Match, an upcoming Match, an entire event, or (in extreme cases) an entire competition season. The REC Foundation Code of Conduct can be found at https://www.roboticseducation.org/resources_library/code-of-conduct/

G2: RAD is Student-centered.
Adults may assist Students in urgent situations, but adults should never work on a Drone without Students on that Team being present and actively participating. Students should be prepared to demonstrate an active understanding of their Robot's construction and programming to judges or event staff.

During Match play, it is…

Okay for an adult to provide cheerful, positive encouragement as a spectator.

Not okay for an adult to explicitly shout step-by-step commands from the audience

Violations of this rule could be considered a violation of G1 and/or the REC Foundation Code of Conduct.

G3: Use common sense.
When reading and applying the various rules in this document, please remember that common sense always applies. If there is no rule for an action, and it does not seem dangerous, then that action is legal.

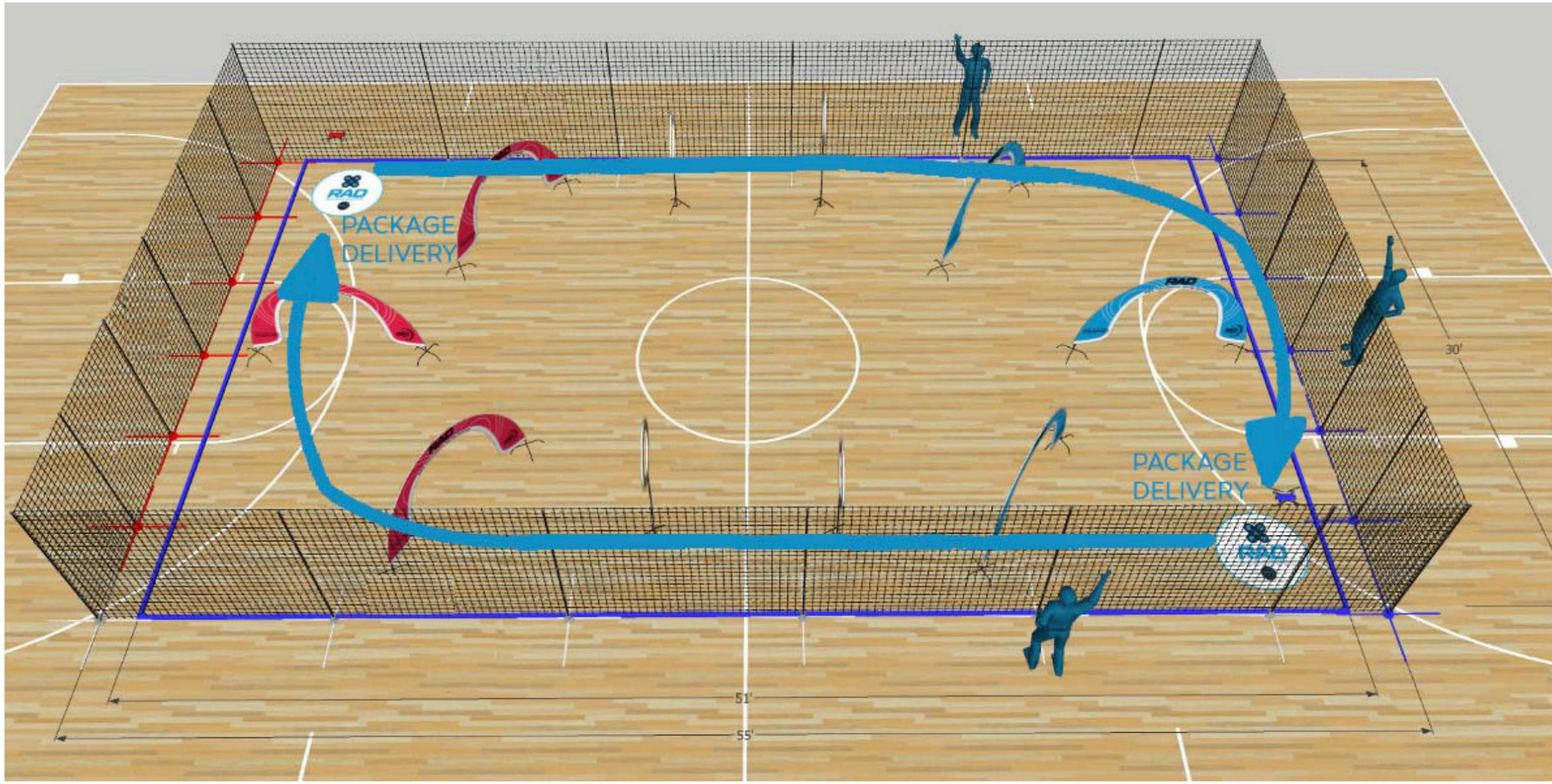
G4: Pilots and Visual Observers <u>are not permitted</u> to use electronic communication devices
during Package Delivery or Racing. Devices with communication features turned off (airplane mode) are permitted. Violations will result in Teams getting a Major Penalty.

VLOS

Package Delivery

Overview

Visual Line of Sight Racing (VLOS) Package Delivery is played in a 30ft x 51ft Field consisting of one (1) Pad from which to Launch and land and one Target for where the Package should be delivered. Teams have ninety seconds (1:30) to complete the challenge. The accuracy of the Delivery will be assessed along with any Penalties. The Team with the shortest Package Delivery Time will be the Package Delivery Champion.



Game Definitions

Accuracy of Delivery
A Penalty assessed for not Delivering the Package to the center of the Target.

Course
The predefined path in the Field that the Drones navigate while in Package Delivery. The Course includes the direction that Drones must navigate through Obstacles. The layout of the Course for Package Delivery is shown in the below figure.

Delivered
A Package Status. A Package is Delivered when it has been moved from one Pad to another Pad and the Drone is no longer making contact with the Package.

Field
The volume where the Drones navigate through Obstacles through a set Course.

Launch Signal
The signal that the Referee gives the Teams to start the challenge.

Failure to Deliver
In Package Delivery, a Penalty for when the Package never makes contact with the Target for the duration of the attempt.

Finish Point
Where the Drone ends the challenge and the timer is stopped. In Package Delivery, there are four (4) scenarios for a Finish Point as follows.

- The time of the challenge (without Penalties) has reached ninety seconds (1:30).
- A Major Penalty has been issued.
- The Drone returns to the Launch Pad where it started.
- The Team signals to the Referee that they wish to stop the challenge.

Targets
Red & Blue Team
3“ from center
2“ wide rings out
from center

No Score
This is the score given to a Team that receives a Failure to Deliver Penalty.

Package
The payload that a Drone must move from the Pickup Location to the Drop-Off Location. The Package is l x w x h and has a mass of __xx__ grams.

Package Delivery Time
The time from the Launch Signal to the Finish Point plus any Penalties.

Target
The area where the Package is delivered that consists of a three (3) inch diameter center with two (2) inch wide rings expanding from the center.

Scoring

The shortest Package Delivery Time out of two (2) attempts will be used to determine the Package Delivery Champion.

The Package Delivery Time is the summation of the following:

1. The time from the Launch Signal to the Finish Point.

2. Penalties

a. Each Obstacle that is not Completed by the Finish Point is a twenty second (0:20) Penalty. This can occur in two ways

   i. Obstacles that are skipped during the challenge per PD4.

   ii. Obstacles that are beyond the Finish Point (ie. have not been Completed) in the Course per PD4.

b. Flying the wrong direction through a non-Completed Obstacle is a twenty second (0:20) Penalty per PD5.

c. Accuracy of Delivery is a multiple twenty second (0:20) Penalty per PD6cii.

d. Failure to Finish is a ninety second (1:30) Penalty per PD3.

Note: If a team receives a Failure to Deliver Penalty, the team will receive a No Score, all other Penalties and timings are ignored.

VLOS Package Delivery Game Rules

PD1: Pre-Launch Setup.
Setting up before the start of the challenge.

PD2: Pilots only in the Pilot Station.
Each Team is allowed one (1) Pilot in the Pilot Station and up to two (2) Visual Observers in the Visual Observers' Station. Only one (1) Pilot is required, but the use of Visual Observers is encouraged.

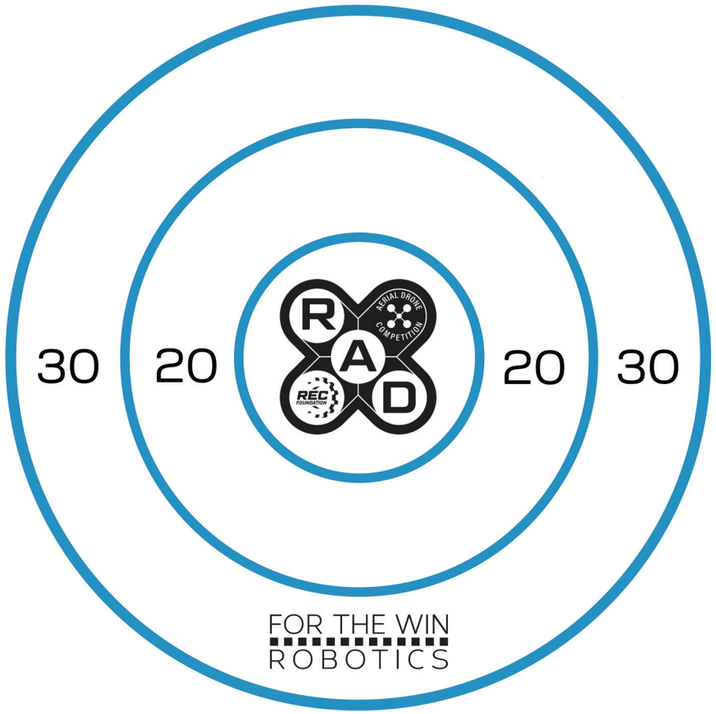
PD3: Finish on time.
Teams will be given ninety seconds (1:30) to complete the challenge by landing their Drone on an Open Pad and signaling the Referee to end the challenge (ie. Finish Point). Violations will result in a Failure to Finish Penalty of ninety seconds (1:30).

PD4: Drones must navigate the Course Completing Obstacles in succession.
If a Drone Completes an Obstacle out of order, all Obstacles that were not Completed up to that point will earn the Team a twenty second (0:20) Penalty. Those missed Obstacles are now considered Completed. Once an Obstacle is Completed, passing through the Obstacle again, in the same Lap, either forward or reverse has no affect. For example, if a Drone Completes the first three Obstacles then mistakenly completes the sixth Obstacle, the Team should not go back and navigate through the fourth and fifth Obstacles and instead should continue on with the Race earning forty seconds worth of Penalties.

PD5: Drones should avoid going through Obstacles in the wrong direction. If a Drone passes through an Obstacle in the wrong direction and the Obstacle has not been Completed for the current Lap, the Team will earn a twenty second (0:20) Penalty. This Penalty will only be applied once per Obstacle per Lap.
Note: If a Drone passes through an Obstacle in the wrong direction, and then skips that Obstacle, the Drone will receive both Penalties. However, if the Drone Completes an Obstacle and then flies back through it in the wrong direction, there is no Penalty.

PD6: Deliver the Package and returning to the Pad.
The Package Delivery challenge follows the following sequence of events.

a. Before the start of the challenge, place the Drone fully on the Pad with the Package in its possession.
b. At the Launch Signal, the Drone follows the Course to the Target .
c. Once over the Target, the Drone attempts to Deliver the Package to the Center of the Target. The following Penalties for accuracy of Delivery will be assessed after the Finish Point and the Package has come to rest.
    i. Failure to Deliver – If the Package never contacted the Target from Launch to Finish Point. This results in a No Score



    ii. Accuracy of Delivery – A twenty second (0:20) penalty multiplied by the number ring, counting from the center (the 0th ring), that the Package is contacting. If the Package is contacting multiple rings, the higher number ring is counted. Eg. If the Package is contacting both the 2nd and 3rd ring, then a 60-second Penalty will be assessed as seen in the diagram above. If the Package makes contact with that Target, but does not end up on the Target at the Finish Point, the Team will receive the Penalty as if the Package is touching the 9th Ring (there are only 8 Rings).
d. Once the Package is delivered the Drone follows the Course to the Pad where it started and lands, ie. Finish Point.

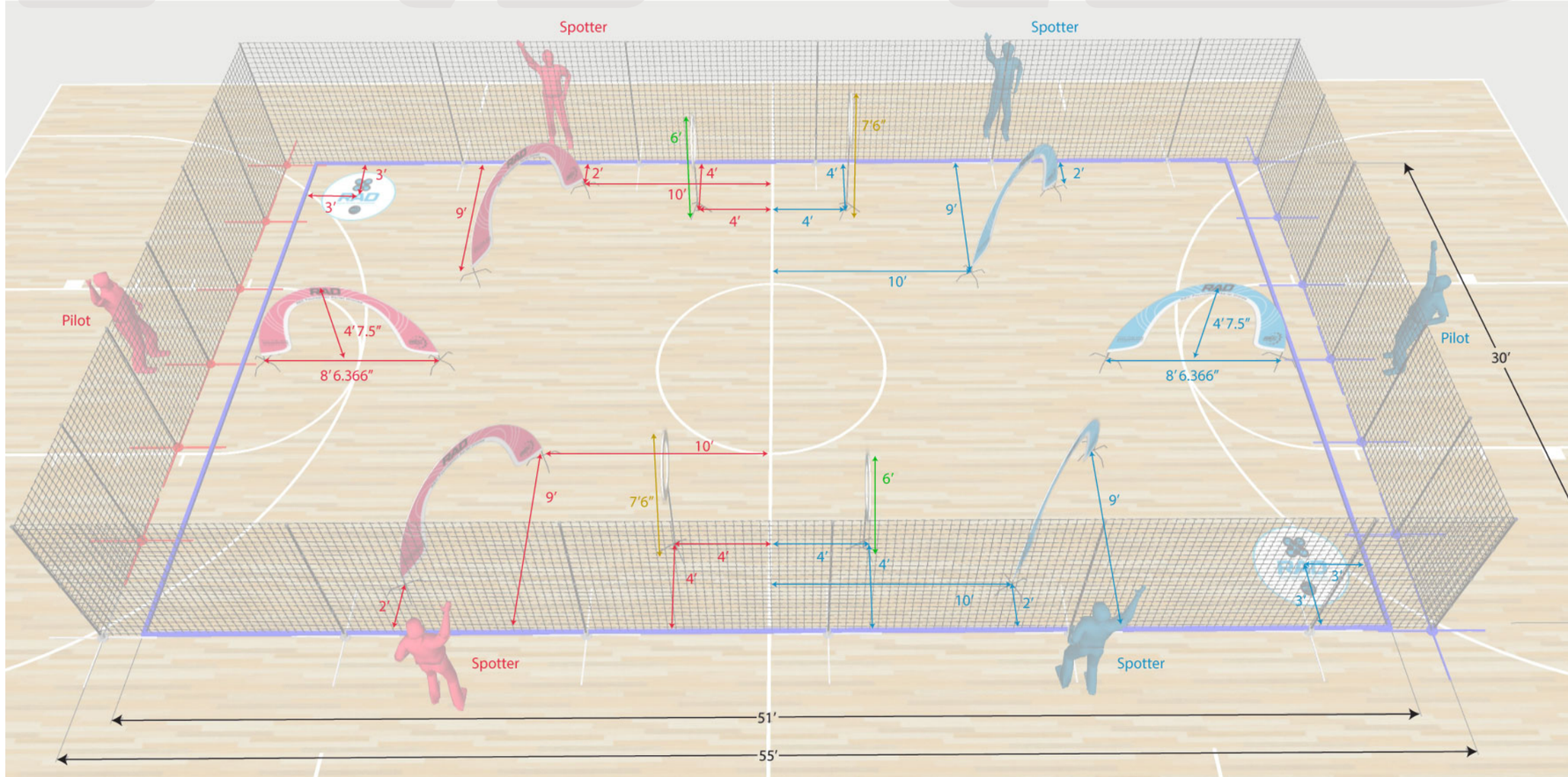
PD7: Re-adjustment for Delivery is permitted.
A Drone can move the Package as many times as it wishes on the Target until the Drone Completes the next Obstacle or time runs out.

VLOS

Racing

Overview

Visual Line of Sight Racing (VLOS) is played in a 30ft x 51ft Field with a total of ten (10) Obstacles consisting of six (6) Arch Gates and four (4) Keyhole Gates. Two Drones occupy the Field at the same time, starting from opposite sides of the Course. The time is recorded for each Team and starts when the Launch Signal is given and ends when that Team's Drone completes three (3) Laps of the Course. The Team with the lower Race Time, including Penalties receives the Win.



RACING

Game Definitions

Course
The predefined path in the Field that the Drones navigate while Racing. The Course includes the direction that Drones must navigate through Obstacles.

Finish Point
Where the Drone ends the challenge and the timer is stopped. In Racing, there are four (4) scenarios for a Finish Point as follows.

1. The Team's Drone has landed on its Pad after completing three (3) Laps, this can only be done after flying through at least ten Obstacles, ie. a drone cannot simply take off and land to stop the timer per R9.
2. The time of the Race (without Penalties) has reached three minutes (3:00).
3. A Major Penalty has been issued.
4. The pilots signal to the Referee that they wish to stop the challenge.

Note: In Racing there are two Finish Points, one for each Team. The Race does not stop for the opposing Team when the first Team reaches its Finish Point unless a Major Penalty was issued. That is the only case where both Teams are stopped due to one Team's actions.

Race
A Race consists of a Drone completing three (3) Laps. The time starts when the Drone lifts off of the Pad and ends when the Drone lands on the Pad.

Race Time
The time from the Launch Signal to the Finish Point plus any Penalties used to determine the winner of the Race and the Wildcard Teams from the Round.

Scoring

Teams will advance to the next Round by winning the Race or by being designated as a Wildcard Team.

To win the Race, the Team must have a faster Race Time than their opponent.

To be a Wildcard Team, the Team must have lost the Race and have the fastest Race Time of the other Teams who lost their Race in that same Round.
Note: Rounds could have zero, one or two Wildcard Teams per T4.

Each Team will have its own Race Time for each Race. The Race Time is calculated from the sum of the following.

1. The time from the Launch Signal to the Finish Point.
2. Penalties

a. Each Obstacle that is not Completed by the Finish Point is a twenty second (0:20) Penalty. This can occur in two ways:
   i. Obstacles that are skipped during a Lap per RG4.
   ii. Obstacles that are beyond the Finish Point (ie. have not been Completed) in the Course per RG3.
b. Flying the wrong direction through a non-Completed Obstacle is a twenty second (0:20) Penalty per RG5.
c. Failure to Finish is a three minute (3:00) Penalty per RG3.

VLOS Racing Game Rules

R1: Pre-Race setup.
Before the start of each Race, the two Teams competing in the Race must place their Drone fully within the top surface of their assigned Pad with no part of the Drone hanging over the edge of the Pad. There are five (5) Obstacles between each Pad, ie. the Drones will start a half a Lap apart from each other.

R2: Pilots and Visual Observers only in the Pilot and Visual Observer Stations.
Each Team is allowed one (1) Pilot in their assigned Pilot Station and up to two (2) Visual Observers in the Visual Observer Station. Only one (1) Pilot is required, but the use of Visual Observers are encouraged to be there to relay information to the Pilot.

R3: Finish the Race.
The Drones will Race for three (3) Laps, launching at the start of Lap 1 and landing at the end of Lap 3, on its Pad, before three minutes (3:00) have elapsed. Violations will earn the Team a Failure to Finish Penalty of three (3:00) and the Team will also be assessed a twenty second (0:20) Penalty for each of the remaining Obstacles that have not been Completed.
Note: Drones do not need to land on their Pads between Laps.

R4: Drones must navigate the Course Completing Obstacles in succession.
If a Drone Completes an Obstacle out of order, all Obstacles that were not Completed up to that point will earn the Team a twenty second (0:20) Penalty. Those missed Obstacles are now considered Completed. Once an Obstacle is Completed, passing through the Obstacle again, in the same Lap, either forward or reverse has no affect. Eg. If a Drone Completes the first three Obstacles then mistakenly completes the sixth Obstacle, the Team should not go back and navigate through the fourth and fifth Obstacles and instead should continue on with the Race earning forty seconds worth of Penalties.

R5: Drones should avoid going through Obstacles in the wrong direction.
If a Drone passes through an Obstacle in the wrong direction and the Obstacle has not been Completed for the current Lap, the Team will earn a twenty second (0:20) Penalty. This Penalty will only be applied once per Obstacle per Lap.
Note: If a Drone passes through an Obstacle in the wrong direction, and then skips that Obstacle, the Drone will receive both Penalties. However, if the Drone Completes an Obstacle and then flies back through it in the wrong direction in the same Lap, there is no Penalty.

R6: Drones may not purposely collide with other Drones.
A Drone may not change its flight path from the natural flight path of navigating the Course to intentionally obstruct the path of another Drone. Violations of this rule that cause the opposing Drone to be disrupted or disabled will result in a Major Penalty. Violations of this rule that cause Drones to brush by each other without noticeably delaying either Team will result in a Formal Warning.

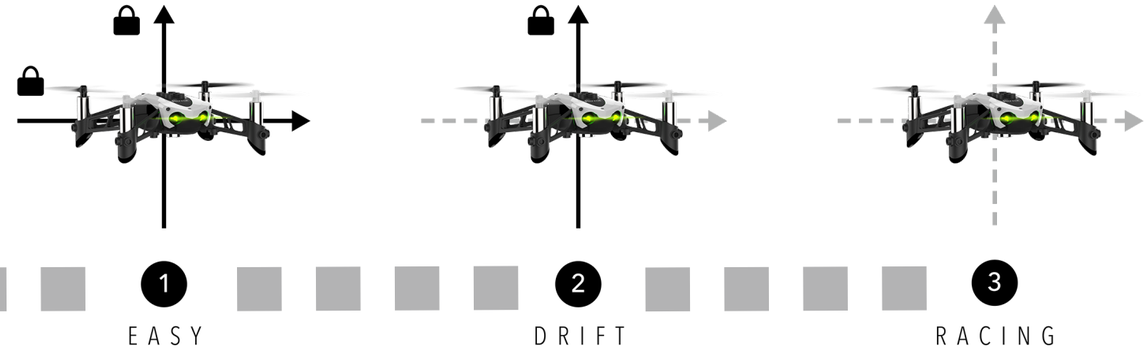
R7: The Drone in front has the right-of-way.
If a Drone catches up to its opponent, it is the responsibility of that Drone to avoid a collision. If a collision occurs that was not the result of a RG9 violation, and the collision caused the Drone in the front to be disrupted or disabled the Drone attempting to pass will receive a Major Penalty. If the collision was a minor without causing a noticeable delay, the Drone attempting to pass will receive a Formal Warning.

R8: Two (2) Formal Warnings during Races equal a Major Penalty.
Anytime a team receives a second Formal Warning, that team will immediately be issued a Major Penalty. Formal Warnings do not get reset (ie. do not get removed) between Laps or Races. For example, if a team gets a Formal Warning in the first Round, then a second Formal Warning in the third Round, the team will be immediately issued a Major Penalty.

R9: Drones must fly through at least ten (10) Obstacles.
To complete the Race, the Drone must fly through at least ten (10) Obstacles in course order and direction. Violations will result in the Team given a Launch to Finish Point time of three minutes (3:00).
Note: The Race time will be 3:00 plus Penalties.

DRONE

MAMBO FLY



Overview

In VLOS, Teams will use unmodified Mambo Fly Drones for both challenges. These Drones can be purchased online. https://www.ftw-robotics.com/shop

Drone Rules

D1: Drones must pass Inspection when it is checked into and out of the Hangar each time.
If it does not pass inspection, the Team must move the Drone to the Maintenance Hangar until the Drone passes inspection.

D2: Teams must use the Parrot Mambo Fly
In its standard configuration with the four (4) Hulls attached.

D3: Teams may utilize the Gripper
Accessory for Package Delivery attempts.

D4: Teams must have all four (4) propellers attached.
When in a Race, teams will be required to use either red propellers or blue propellers for Referees and spectators to identify each of the two (2) drones in the Race. Teams must use a least two (2) colored propellers on their drone for identification purposes. Non-identifying propellers may be either white or black.

D5: Teams must use a Parrot Flypad to control the Drone.
When checking the Drone out of the Hangar, the Team must verify that the Flypad is paired with their Drone by doing a quick launch and land sequence.

D6: Teams are permitted to use a spare Drone.
Teams are permitted to have a second Drone as a spare in case catastrophic damage happens to their primary Drone. Teams may not use both Drones a the same time, and the spare must be kept in the Hangar. Teams may also borrow a Drone from another Team if the other Team agrees.
Note: The purpose of this rule is to keep a Team in the tournament even if their Drone crashes and is not able to be fixed before their next flight.

Video Presentation

Overview

In some tournaments, Video Presentations will be judged. The Team with the best presentation will be awarded The Best Business Pitch Presentation Award. The Team with the best business idea will be awarded The Best Business Pitch Idea Award.

Presentation Topic

Drones are used in commercial applications all over the world. This includes use in agriculture, construction, inspection, commerce, real estate and a host of other work-related functions. Teams are to research a commercial application of Drone technology and create a business plan on how they would use funding to start a business that creates value and jobs in the community. Teams will be judged on a business pitch video presentation that promotes their business plan, as if it were given to potential investors.

Presentation Rules

P1: The video must be no longer than 4-minutes (4:00) in length including credits.

P2: The video may be your team speaking, a voice over storyboard, a voice over PowerPoint or any other video format of your choosing.

P3: Students must be the ones who research, design, write, edit, film, and produce the video. Mentors should have the very limited role of giving direction except for teaching the concepts of how to do something specific. The students should be as good as the final product and able to produce a similar result on their own in the future without the aid of a Mentor.

P4: The video must be posted or uploaded to YouTube, SchoolTube, Youku, or an equivalent free video posting service. The link provided to the Event Partner must open right to the video and not require a password, login or present any other impediment. Note: Links to Google Drive or Dropbox or any other “cloud drive” are not permitted.

Tournament

Overview

The tournament consists of two (2) parts. Teams will compete both in Racing and in Package Delivery. Teams will have a minimum of two (2) Races and exactly two (2) attempts at Package Delivery. There will be a Race Champion and a Package Delivery Champion. In events that have Judging, the rankings from Racing and Package Delivery plus input from the Judges will result in an Overall Champion. Events can also choose to give various Judge awards based on interviews, performance and observation.

Definitions

Hangar
Area where Drones are kept during the tournament when not competing in a Race or Package Delivery.

Judge
The person or persons who will interview the Teams for judged awards.

Practice
Results from Practice Races and Practice Package Delivery will not be recorded or used to determine any awards or rankings. These may or may not be offered at every Tournament depending on the schedule. Teams must follow all Safety Rules during Practice.

Referee
The person or persons who oversee the Race and Package Delivery portions of the tournament. This person is ultimately responsible for the time, score and enforcement of the rules. There are three (3) Referees

- Two (2) Pilot Referees who stand next to each Pilot and are responsible for Penalties and safety rules.
- One (1) Head Referee who stands along the long side of the field opposite the spectators and is responsible for timing and any violations including safety rules.

Round
In the Race portion of the Tournament, where each Team that is eligible runs a single Race.
All teams will get to play in Race in both of the first two Rounds. In succeeding Rounds, Teams are eliminated until a single Team becomes the VLOS Race Champion.

Wildcard Team
The Team with the lowest Race Time in the Round from among all of the Teams that lost their Race in that Round.

Tournament Rules

T1: Referee rulings are final.

Teams that are given Major Penalties or Formal Warnings may not appeal to anyone but the Referee who gave that Warning. Once the Referee has explained why the violation has been given, the Team may not argue even if they disagree with the ruling. The only option for the Team is to ask for clarification on what infraction occurred. Once the Team understands, even if they disagree, the appeal is over. Safety violations that cause a team to be Disqualified from the Event are to be appealed to the Event Partner and the Event Partner's ruling is final.

T2: Photographs and video recordings

Will not be used to settle disputes.

T3: Teams will play in Races using the following procedure:

a. Teams will be randomly assigned an opponent for their first Race. Once all Teams have played in that Round, the Teams that won will move onto the second Round and will be assigned an opponent that lost its first Race, ie. the Teams that had won in the first Round play against the Teams that had lost. Teams will be paired based on their Race Time.

b. Teams that won their Race in Round 2 will move onto Round 3. If there are an odd number of winning Teams then one (1) Wildcard Teams will move onto Round 3, if there are an even number of winning Teams, then two (2) Wildcard Teams will move onto Round 3. Teams are paired up based on Race Time, with Wildcards ranked below the winners.

c. Rounds continue in the same manner as described in T3b until there are only two winning Teams from that Round. At this point, no more Wildcard Teams are used and one final Round is played to determine the Race Champion.

d. Races will be scheduled so that the top seed races against the bottom seed in the next round, the second to top seed races against the second to bottom seed and so forth, ie. 1 vs 12, 2 vs 11, 3 vs 10, 4 vs 9, 5 vs 8, and 6 vs 7 if there are 12 teams in the Round.

e. Ranking for Races in a Round follow the below criteria.

1. Winner of the Race
2. Race Time
3. Least amount of Penalty time added
4. Ranking in previous Round

T4: Teams will be given two (2) attempts at Package Delivery.

The best score in Package Delivery will be used to determine the Package Delivery Champion. If there is a tie, the following is used in the following order to break the tie.

1. Package Delivery Time for the attempt that has the highest score.
2. Second highest score
3. Package Delivery Time for the attempt that has the second highest score.
4. Third highest score
5. Package Delivery Time for the attempt that has the third highest score.
6. If the tie cannot be broken at this point, both Teams are declared Champion.

T5: Drones must be stored.

In the Hanger when not competing.

Appendix: A

Hangar Check-in and Check-out Procedure

Checking In the Drone

When Checking In the Drone, the Drone will only be accepted if the following conditions are met.

1. The Team's number is clearly written on the Drone.
2. All 4 Hulls are attached securely.
3. All 4 Propellers are attached securely.
4. At least 2 of the Propellers are the correct color for the Team's next Race. Teams may not have both Blue and Red propellers on their Drone at the same time.
5. The battery has been completely removed.
5. The battery has been connected and the Drone turns on indicating that the battery level is good, ie. green lights are flashing. If red lights are flashing, the battery is dead and the team must replace the battery before taking the Drone out of the Hangar.
6. The Team does a Joystick connection check by launching and immediately landing the Drone using the Joystick.
7. The Team turns off the Drone, ie. the green lights on the Drone turn off.

Checking Out the Drone

When Checking Out the Drone, the Team will only be allowed to take the Drone once the following conditions are met.

1. The Team's number is clearly written on the Drone.
2. All 4 Hulls are attached securely.
3. All 4 Propellers are attached securely.
4. At least 2 of the Propellers are the correct color for the Team's next Race. Teams may not have both Blue and Red propellers on their Drone at the same time.

Provide Space for Teams to fix their Drone within the Hangar.

If a team is unable to check-in or check-out their Drone due to an inspection violation, the team should move their Drone to the Maintenance Hangar. Only students on the Team may work on the Drone. If they need help from their Mentor, the Students should leave the Drone and talk to their Mentor, describing the issue to their Mentor, then return to the Drone to correct the issue themselves. If the Team is still struggling, the Mentor may be escorted to the Maintenance Hangar by event personnel to inspect the Drone only if the Students on the Team are present and actively learning.

Appendix: B

Queuing Procedure

Five minutes before the start of a Scheduled Race or Package Delivery attempt.

- Teams check their Drone out of the Hangar
- Teams report to the Holding Area
- Teams should be ready in the Holding area to move into the Field and place their Drone on the Pad as soon as the Head Referee gives the "All Clear"

Immediately before the Scheduled Race, after the All Clear from the Previous Race or Package Delivery attempt.

- Teams place their Drone on the Pad.
- Teams turn on the Drone and Flypad and test the connection by Launch and Land sequence.
- Teams reposition Drone after testing the connection leaving Drone on Pad.
- Pilots move to the Pilot Station.
- Visual Observers move to the Visual Observer Station.

End of the Race or Package Delivery attempt

- Teams stay in the Stations until the Head Referee gives the "All Clear"
- Once the "All Clear" is given, the Pilot retrieves the Drone.
- If from a Race, the Drone is then checked back into the Hangar.
- If from a Package Delivery, the Team resets the Drone for a second attempt (see section above)
- After the second attempt at Package Delivery, the Drone is checked back into the Hangar.

Appendix:C
Referee Responsibilities

There are two types of Referees, Head Referee and Pilot Referees

Head Referee
The Head Referee stands along the long side of the field, opposite the spectators.

The job of the Head Referee is the following.
1. Keep the Timing of the Race and Package Delivery attempt.
2. Watch for Safety Violations.
3. Keep the Event on schedule
4. Inform teams of violations and Major Penalties.
5. Make the final judgement call if there is a dispute.

Pilot Referee
The Pilot Referee stands next to the Pilot. For Racing, there are two Pilot Referees. For Package Delivery, only one Pilot Referee is required. Each Pilot Referee is responsible for one Drone and keeps track of that one Drone at all times.

1. The job of the Pilot Referee is the following.
   Supervise all activities done by the Team from when they enter the Field with the Drone to when they leave the Field with the Drone.
2. Watch for Safety Violations
   a. If at any point, the Drone leaves the field for more than 3-seconds, the Pilot Referee commands that the Pilot Ground the Drone in a safe manner. This might mean that the Pilot Referee first commands that the Pilot "Releases all controls" so that the Drone hovers. Then land the Drone in a safe manner.
   b. If at any point, the Drone goes toward an observer, such as the spectators. The Pilot Referee commands the Pilot to "Release all controls" and Ground the Drone.
3. Keep track of Penalties

Appendix D:
Quick Reference Guide

Reference guide to measurements and or dimensions:

Field Layout
VLOS Racing is played in a 30ft x 51ft Field with a total of ten (10) Obstacles consisting of six (6) Arch Gates and four (4) Keyhole Gates. Two Drones occupy the Field at the same time, starting from opposite sides of the Course.

Gates

1. **Arch Gate**
   An Obstacle that requires a Drone to fly under the Arch Gate. The maximum horizontal opening is 5ft and the maximum vertical opening is 4ft.

2. **Keyhole Gate**
   An Obstacle that requires a Drone to fly through the center of a Keyhole Gate. The inner diameter of the Keyhole Gate is 2ft.

Target
The area where the Package is delivered that consists of a three (3) inch diameter center with two (2) inch wide rings expanding from the center.

Package
The payload that a Drone must move from the Pickup Location to the Drop-Off Location. The Package is l x w x h and has a mass of xx grams.

Challenge Timing
Teams have ninety seconds (1:30) to complete the challenge.

FOR THE WIN ROBOTICS

RAD AERIAL DRONES

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Appendix E:

Example schedule used in RAD: VLOS Racing. Twelve teams competing in VLOS racing.

Round 1	Red Team	Score	Blue Team	Score
1.1	Random		Random	
1.2	Random		Random	
1.3	Random		Random	
1.4	Random		Random	
1.5	Random		Random	
1.6	Random		Random	
Round 2	**Red Team**	**Score**	**Blue Team**	**Score**
2.1	Top Winner		6th Place Who Lost	
2.2	2nd Place Winner		5th Place Who Lost	
2.3	3rd Place Winner		4th Place Who Lost	
2.4	4th Place Winner		3rd Place Who Lost	
2.5	5th Place Winner		2nd Place Who Lost	
2.6	6th Place Winner		Top Team Who Lost	

Round 3	Red Team	Score	Blue Team	Score
3.1	Top Winner		2nd Wildcard	
3.2	2nd Place Winner		1st Wildcard	
3.3	3rd Place Winner		6th Place Winner	
3.4	4th Place Winner		5th Place Winner	
Round 4	**Red Team**	**Score**	**Blue Team**	**Score**
4.1	Top Winner		2nd Wildcard	
4.2	2nd Place Winner		1st Wildcard	
4.3	3rd Place Winner		4th Place Winner	
Round 5	**Red Team**	**Score**	**Blue Team**	**Score**
5.1	Top Winner		1st Wildcard	
5.2	2nd Place Winner		3rd Place Winner	
Round 6	**Red Team**	**Score**	**Blue Team**	**Score**
6.1	Top Winner		2nd Place Winner	

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Appendix F:

Example Schedule with Scoring

Round 1	Red Team	Score	Blue Team	Score
1.1	Team 1	98 sec	Team 2	115 sec
1.2	Team 3	78 sec	Team 4	113 sec
1.3	Team 5	105 sec	Team 6	210 sec
1.4	Team 7	190 sec	Team 8	144 sec
1.5	Team 9	145 sec	Team 10	65 sec
1.6	Team 11	100 sec	Team 12	118 sec
Round 2	**Red Team**	**Score**	**Blue Team**	**Score**
2.1	Team 10	70 sec	Team 6	205 sec
2.2	Team 3	80 sec	Team 7	175 sec
2.3	Team 1	215 sec	Team 9	219 sec
2.4	Team 11	125 sec	Team 12	82 sec
2.5	Team 5	121 sec	Team 2	122 sec
2.6	Team 8	145 sec	Team 4	136 sec

Round 3	Red Team	Score	Blue Team	Score
3.1	Team 10	63 sec	Team 8	190 sec
3.2	Team 3	75 sec	Team 11	135 sec
3.3	Team 12	95 sec	Team 1	92 sec
3.4	Team 5	180 sec	Team 4	145 sec
Round 4	**Red Team**	**Score**	**Blue Team**	**Score**
4.1	Team 10	85 sec	Team 11	83 sec
4.2	Team 3	97 sec	Team 12	110 sec
4.3	Team 1	62 sec	Team 4	68 sec
Round 5	**Red Team**	**Score**	**Blue Team**	**Score**
5.1	Team 1	87 sec	Team 4	72 sec
5.2	Team 11	64 sec	Team 3	68 sec
Round 6	**Red Team**	**Score**	**Blue Team**	**Score**
6.1	Team 11	62 sec	Team 4	59 sec
Team 4 is the Racing Champion				

Winner of Race Winner of Race Wildcard Team

RAD
AERIAL DRONES

REC FOUNDATION

Tel: + 1 903 401 8088

Email: support@roboticseducation.org

Website: www.roboticseducation.org

Address:

1519 Interstate 30 West

Greenville, Texas 75402