Events and Competitions Handbook

for

BSA Drones Playbook

Version 3.0

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Revision History

Name	Date	Reason For Changes	Version
Dave McKeehan	11/20/2019	Initial creation	v1.0
Dave McKeehan	12/5/2019	Switched to 5-foot widths on structures to make stronger and have less waste of piping.	v1.0a
Dave McKeehan	12/13/2019	Released for review & comments	V1.0b
Dave McKeehan	12/27/2019	Updated – added general purpose race guidelines so they are not all repeated in the individual course race modules.	
Dave McKeehan	3/19/20	Updated after professional review by Robert Youens	V2.0
Dave McKeehan	1/20/2021	Updating graphics, names, cleanup	V3.0

1 Introduction

This handbook defines and describes group events, and competitions used in the BSA Drone Playbook. It provides the objectives for the different proficiency levels, event and competition course plans, bills of materials and construction plans for the courses, and provides guidance on how to design your own customized events and competitions.

This handbook also provides common rules and guidelines for running competitions and events. Specific race/event playbook modules will list that event's specific rules/guidelines only.

Drone activities, events and competitions are all designed to be fun while teams and individual pilots demonstrate skills which can satisfy one or more merit badge requirements.

They can be held at any level: Individual, Patrol, Troop, District, Council, Area, Region, or National.

2 Site Selection

Playbook events and competitions are all designed to be able to be held either indoors or outdoors.

All events and competitions in the Playbook are designed to be able to be done either outdoors, or in an indoor gymnasium style space. A 40 x 60 foot horizontal area, with a minimum of a 20-foot vertical space is the standard size (slightly larger than a volleyball court size space).

Calculate the timing and number of participants. While, it is best to have a single course that everyone runs on, if you have a larger number of participants, you may need to build a second, identical course and run it in parallel. The downside, of course, is that will require more judges and race leaders. Mission style competitions take longer to complete than races.

Audience and participant safety is of critical importance when flying drones. Safety netting can be used to protect the audience for indoor events and is recommended for outdoor events as well.

If you have larger spaces, you can design and build larger courses and several examples are included in this handbook. As Scouts advance to the Advanced and Expert proficiency levels, they will want to be flying faster and with more precise control, and a larger course area can give them more room for more elaborate maneuvers.

Make sure you provide adequate spaces. Drones move quickly in 3-dimensions. In addition to the course area, you need to identify the following other areas:

- Pilot/Spotter areas.
- Judge areas
- A Paddock/pit where drones can be setup and prepared for the race – this should be separate from the pilot/spotter areas. You should have some sort of tables to put drones on, benches/chairs for teams preparing their drones, and, if possible, electricity to power battery chargers and tools.
- A spectator area.

3 Course Safety Guidelines

Pilots, spotters and judges must have an unobstructed view of the entire race course.

Safety Netting: Either the race course must be protected with safety netting, or, the Pilots, spotters, judges and spectators must be protected by individual netting or distance. Example layouts are shown below.

- If the course flight area is protected by safety netting, then Pilots, Spotters and Judges must be a minimum of 3 feet away from the safety netting, and the spectators should be a minimum of 15 feet from the safety netting.
- If the course is not protected by safety netting, then the pilot/spotter/judge areas must be protected with safety netting cages with the Pilots/Spotters and Judges at least 3 feet from the netting. Spectators can also be protected by safety netting, or, if unprotected, must be at least 75 feet back from the closest flight area. Judges and spotters should also wear a simple helmet with a full face shield and a solid jacket to protect them from drone strikes.
- Spectators should always be located BEHIND the pilot.
- The Pit area should be protected the same way as the spectator area, and, if possible, located behind the spectator area.

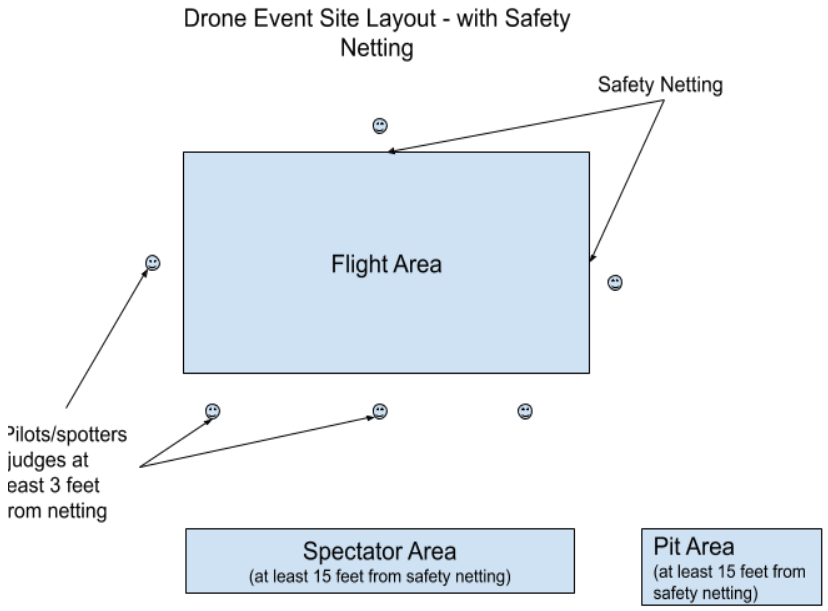
Safety Netting can be expensive. Safety netting around the flight area should have a netting roof, otherwise the drones can easily fly over the netting wall. This adds significant cost to net an entire course area. If the netting is protecting the spectators, then it must be tall enough to provide 4-5 feet of protection above the heads of the spectators.

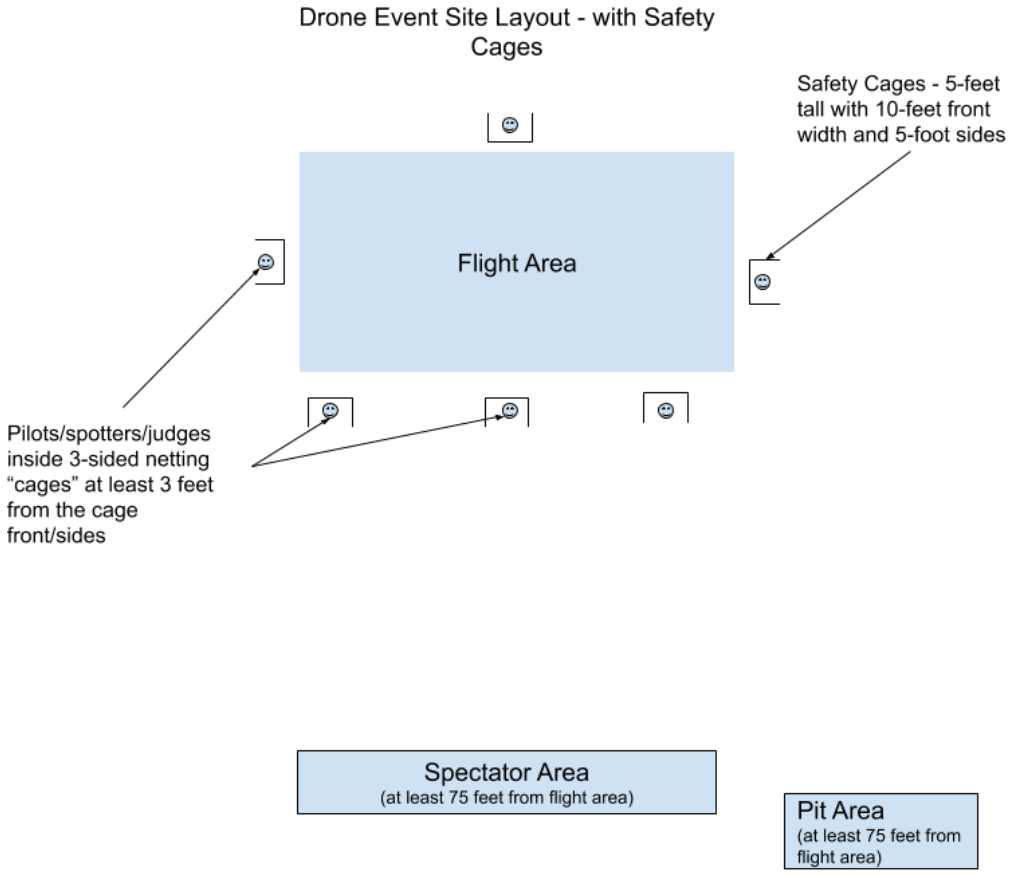
Individual judge/spotters/pilot safety net cages should be low enough that these people can see over the netting and maintain an unobstructed view of the drone and course area. Safety Net cages are typically 5-feet tall, with a 10-foot width facing the course area and 5-foot wide sides. The back can be open. The judge/pilot/spotter should all be trained (and practice) ducking below the cage top if a drone flies towards them.

Spectator Protection: There are two ways to protect spectators. The first is to provide Safety Netting in front of and to the sides of the spectator area. Spectators should be at least 3 feet behind the netting and it must be tall enough to provide 4-5 feet of protection above the heads of the spectators. If no netting is provided for spectators, then they must be at least 75 feet behind the course area.

Spectators shall be provided with a safety briefing and must sign a liability release. The key rules for spectators are:

- Phones MUST be in airplane mode.
- Spectators must be silent and always facing forward watching the drones.
- If a drone flies towards the spectators, they should move to the side away from the flight path. Ducking down is not effective, as the drone can fly down into them, and trying to bat it away with their hands, or other objects is not allowed, and that just diverts the dreon very suddenly into someone else.





Safety warning signs must be used. A flight line perimeter should be defined and highly visible warning signs prominently displayed that look similar to this example.

A first aid kit and attendant should be in a clearly designated area.

One or more class A-B-C fire extinguishers and buckets filled with dry sand for battery fires should be set along the flight line. Shorts within the electronics or punctures to a Lipo battery can cause the aircraft and surrounding foliage to smolder or catch fire. All pilots and spectators should be made aware of the first-aid kit, fire extinguisher's and battery bucket's locations before flying occurs.

4 Pre-Flight Check-in/Rules

There should be a pre-flight check-in station for all events.

Each pilot must read and sign the Event Safety Declaration (note: This should be done as part of event signup in the BSA Drone App, or on a separate form prepared by the event organizers). The Declaration states: *Each participant attests to the fact that he/she has the appropriate experience to participate in the event, or will be assisted by an experienced participant during any and all flights in which he/she may participate. All drones (including control systems, if applicable), used in the event have previously been successfully test-flown and are therefore qualified to be flown in the presence of fellow participants, event officials, and all others who may be in the flight area during the event period. In addition, for competition events, the participant also attests that he/she and any and all model aircraft have previously successfully completed a flight, including, if applicable, all manoeuvres intended or anticipated prior to the specific competition event, or any demonstration flights that may be within the competition event designated time period.* ***AGE CLASS: Youth-Junior: Age 0-14 (by date of event); Youth-Senior: Age 15-18 (by date of event); Adult: Age 19+ (by date of event).***

- **Pass/Fail/Modify**: Each participating drone must be inspected based on the configurations defined for the race. If the drone does not pass inspection, then the participant should be given a short period of time to correct their configuration and get re-inspected (15 minutes max is recommended).
    - Materials and workmanship shall be of satisfactory standards to complete the race. The inspector may disqualify any aircraft which, in his or her opinion, is not safe and airworthy in terms of materials, workmanship, radio installation, radio function, design details or evidence of damage.

  - Some races will require use of ONLY the standard BSA kits. These should have a weigh-in added to verify the weight is within normal tolerances.
  - During the preflight inspection pilots will be asked to remove props and demonstrate that their aircraft is programmed to fail safely in the event that the radio control link is lost. This can be demonstrated by arming the aircraft (with props off), spooling up the motors and then turning off the rc transmitter. The correct response from the aircraft is to either shut down the motors upon losing the control signal or go into an auto hover until radio communications are restored. If the aircraft does not shut down power to the motors or go into auto hover, the aircraft fails the inspection and will not be allowed to fly until proper failsafe is achieved. There are several options for this race depending on drone configuration.
  - No carbon or metal propellers are ever allowed. Plastic propellers must be used at all times and the leading edge of the propellers needs to have been sanded to blunt the edge.
  - No exposed metal on the outside of the drone is allowed. This can become a potential electrical shock hazard in the event of an accident that tear wires apart.
  - The Pilot should walk through their pre-flight checklist in front of the registration person.
- **Pass/Fail**: Verify the FAA registration number is clearly visible and matches the FAA Registration certificate (provided in paper or on-line in the pilot's app).
- **Pass/Fail:** Turn on the controller and verify that the drone is registered with BSA and legal
- **Pass/Fail/Modify:** check the **XYZ** setting in the pilots App to ensure that the drone is limited to 8-12 degree pitch angles to reduce high impact vertical crashes.
- Drones that do not pass inspection are not allowed to race.

5 Race Scoring – General

Races, Competitions and Missions normally determine winners based on the best flight time through the course, with various point additions or subtractions specific to the event factored in.

Races and Competitions normally consist of a set number of laps around the racecourse for each heat, and may include multiple heats. If you have multiple laps per heat, then the fastest time of the laps is the recorded time for that drone-heat (this allows someone who crashed during a lap - a common occurrence, to still get their best lap counted).

Drone crashes will happen. Especially with pilots with less experience, you can expect up to half of the drones to crash in the first lap, until the pilots settle down.

If you have multiple heats per drone, then the best time of the individual heats is the fastest recorded time for that drone. With multiple heats, avoid scheduling the same pilot/drone in back to back heats. Allow each pilot to rest for a heat - this also allows time for small repairs.

There should be three basic awards: 1st place, 2nd place & 3rd place. These need to be captured in the on-line playbook proficiency rating system as they are worth points (100, 50, 25) for the Scouts in advancing their proficiency levels.

Patrol/Cohort Points: The patrols can get awards based on the race results of Scouts in that Patrol/Cohort Points are awarded as follows:

- Determine the average points of the registered pilots from the patrol/cohort by adding up all points won by participating pilots in the race and dividing by the number of pilots participating from that patrol.
- Patrols with the highest point may get an award – that is up to the Race organizer.

Troop Points: The Troop can get awards based on the race results of Scouts in that Troop. Points are calculated the same way as patrol awards – the average of the pilots in the troop participating.

In every course, the route is specified that the pilots are supposed to follow. All gates shall be marked with a Front marking – which can be flags, tape, or other indicators. In addition, the flight perimeter, or flight line, must be marked. This can be done with safety netting, or other markings.

- The drone must go all the way through a gate from the front. If a drone misses a gate the Pilot must go back and fly through the missed gate or flag. Flags extend infinitely into space but pilots should navigate near the flag so that judges can accurately assess the turn. If a pilot does not go back and fly though the missed gate/flag, then that lap is disqualified.
- A drone may not enter from the rear of the gate, unless specifically instructed to as a part of the race course directions. Entering a gate from the rear disqualifies that lap.
- If a drone flies out outside of the flight area and crosses the flight perimeter, that lap is disqualified. If a drone flies outside the flight area 3 or more times in the course of a race, that pilot is disqualified from the entire race and must immediately stop flying.

All events using First-Person-View (FPV) require one or more spotters to help the pilot maintain situational awareness. The spotters must be in close, visual contact with the pilot at all times, and visually monitoring the drone and race area. The spotter notifies the pilot of any safety issues (such as people entering the flight area), and informs the pilot if they missed a gate/flag, or fly outside of the flight area. The Pilot is responsible for their spotters. If a pilot does not have at least one spotter, they are disqualified from that entire race.

Judges should be provided with spiral bound notebooks to record the event in. This helps to eliminate confusion if the pages get out of sequence.

6 Pre-Competition Rules/Guidelines

The Race Leader should review the participant guidelines and how the event is going to be run with everyone just prior to starting the race.

- Guidelines for Everyone
  - Listen and follow ALL instructions from the event leaders.
  - NEVER walk onto the course while drones are flying.
  - The course's flight line defines where the pilot or spectator area ends and the course begins. Point it out, It should be well marked and highly visible. This flight line is not to be crossed.
  - When you retrieve a multirotor after a completed race, ensure you power it down immediately to clear the video channel and to avoid unintentional spooling of the motors and subsequent injury.
  - Point out the location of first aid kit and fire extinguishers.

    - From the time a heat is called to prepare, until the heat has ended, phones of spectators must be on airplane mode, and everyone should be focused on the race to watch out for a run-away drone.
- Pilot Guidelines
    - Fly only in designated areas.
    - Fly only at appropriate times.
    - Keep your multirotor inside the course safety netting, or at least 50 feet away from the spectator area.
    - When finishing a race, land in the designated landing area on the course
    - When flying on the course, you must be positioned within the designated Pilot Area. DO NOT fly from any other area.
    - Only power up your multirotor/video transmitter while in the Start/Finish area on the course.
    - DO NOT power up in the pits or while walking from the pits to the course
    - If you need to check your video channel or change frequency, this MUST be completed between heats.
    - You MUST ensure you have at least one Spotter in the Pilot Area while flying. A Spotter observes the course for dangers such as members of public, animals, other model fliers, low flying aircraft or vehicles.
    - Spotters stand in the Pilot Area to ensure clear communication.
- Spectator Etiquette
    - Please stay away from the pilots within the Pilot Area while they are flying (unless you are acting as a spotter). Clear communication is essential with the pilots for accurate lap scoring, penalties and hazard warnings.

7 Event Stages (General)

This section defines the standard competition/race stages. In some cases, a specific race may modify some of these.

Heat Start: The Event leader calls the start of the heat. If a pilot declares that they have a drone problem prior to the start of the heat, the event leader may either delay the start for 1-2 minutes to allow the pilot to correct the issue, or move them to a different heat.

When the event leader calls the next heat, a four-minute timer starts. Any pilot unable to get their drone to the start area within that window is out for that heat.

Staging: Drones are to be placed in the start/finish area in an unpowered state,

Power On: Drones shall be powered on and initialized, but left in zero throttle mode.

Launch: The event leader calls the launch, usually using an air horn or other starting announcing device.

- If a pilot launches early – this is a false start. The pilot is issued 1 warning for the first false start and the ace will be restarted. On the second false start, the pilot is disqualified for that heat.

- If a drone does not launch for any reason, the pilot is disqualified from that heat and no reruns are allowed.

Run the Race: The pilots run their drones through race course the specified number of laps until they have passed the finish line the final time.

Race Restarts: A race may be restarted by the event leader in the following cases:

- Collapsed obstacles or safety netting
- Fire on the course
- People or other unsafe conditions on the course

8 Types of Group events

The Playbook defines three different kinds of group events.

- Skills and Proficiency Development & Demonstration
- Races & Competitions
- Missions

Each is described below.

8.1 Group event options

The event leaders should decide, in advance, on the race options and configurations. The number of participants should be reviewed a few days prior to the event as that might drive changes.

Races can be run as mixed classes or pilots, or by age classes, which are normally: Youth-Junior: Age 0-14 (by date of event); Youth-Senior: Age 15-18 (by date of event); Adult: Age 19+ (by date of event).

Races can be run in separate or mixed drone configurations. Leaders may run the race with Drones only using the standard introductory kit, or allow performance modifications. Leaders may hold more than one race, one with just the standard kits to demonstrate flight proficiency and a second allowing modifications to the drones - effectively combining flight proficiency and drone construction proficiency.

Races should have multiple heats and laps normally, although the event leaders may elect to modify these guidelines,

- Normally, each drone runs the course alone.
- Each heat should consist of a minimum or 3 laps around the course.
- With a small number of participants, or limited time, the race may run with only 1 heat. Larger races may have multiple heats. Multiple heats can be organized by units (e.g. patrols, cohorts, or troops), with the 1st and 2nd place winners in a single or tiered run-off heat(s).

8.2 Skills and Proficiency Development & Demonstrations

Skill and Proficiency events are designed to help Scouts master different flying skills. There are four Flight Control modules defined in the Playbook, one for each of the four proficiency levels: Beginner, Intermediate, Advanced and Expert.

Typically, one Scout at a time practices their skills in these courses.

Flight Control Modules Summary

Level	Objectives	Maneuvers
Beginner	Master basic flying skills using line of sight flying and progressing to flying using the drone camera feed.	● Preflight Prep Checklist ● Learn Controller Basics ● Take off & Landing ● Hover ● Walking the dog hover ● Square Dance - level horizontal, diagonal and forward/back ● 360 degree yaw ● Postflight checklist
Intermediate	Master complex maneuvers and advanced flight modes (AFM), moving faster with more precise control.	● Line of sight control at a distance ● 45 degree ascent & descent ● Figure 8 ● Dizzy up ● Square dance & reverse square dance ● Arch ● Boomerang ● AFM: Auto route, Smart RTL, Loiter, Geofencing, Guided Mode ● Fast flight around obstacles
Advanced	Learning advanced racing maneuvers, Camera Control, more advanced flight modes, and improving high speed precision control using First Person Viewing modes (FPV). Some of these modes require additional hardware option kits.	● Bank Turns ● Braking Turns ● AFM: Level-2 Guided mode ● AFM: Follow Mode ● Camera Control: Reveal shots, Tracking shots, Panning Shots, Flying Upwards Shots, Orbit shots, Overhead following shots ● FPV: precision flying in, around, & through obstacles ● FPV: full speed precision flying
Expert	Perform full missions, involving multiple activities and capabilities, usually in a	● Emergency Preparedness Mission ● Search & Rescue Mission ● Specialized surveying

	competition.	● Law Enforcement Mission ● Environmental Science Mission ● Traffic Safety & Analysis Mission ● Fire Fighting Mission ● BSA High Adventure Base Missions

8.3 Races & Competitions

Races can be held anywhere, in a gymnasium, warehouse, parking lot, open fields and even in forests and other wilderness areas. On all cases, the goal is to get through the course without crashing, while following the prescribed course. There are three classifications of races:

- **Circuit Racing:** Two or more drones fly through a course at the same time. Pilots are ranked in the order they cross the finish line. If a pilot crashes then they are out. If a pilot misses a gate they need to go back and pass it.
- **Time Trials:** A test of a drone's speed through a course, in which the finishing time is recorded. Typically, only 1 drone is flying at a time, to help avoid crashes.
- **Freestyle:** This is a form of competition where the Scout has to perform all sorts of maneuvers and their own unique aerobatic moves to try to impress the audience and judges with their skill and precision control.

Races Summary

Level	Objectives	Notes
Beginner	Flight control competition using basic maneuvers in a simple course and demonstrating proficiency in Beginner level, line of sight basic flight maneuvers.	● Course using cones and a center circle to perform basic line of sight flight maneuvers in a time trial on a single altitude level. ● 1 drone on the course at a time ● Scoring reflects proficiency in the basic maneuvers, demonstration of good flight path control, and proper preflight and postflight of the drone.
Intermediate	Time Trial competition using complex maneuvers in a complex course, moving faster with more precise control.	● Course uses more complexity - flying around obstacles involving multiple turns, loops, figure 8's, etc. Also adds multiple altitude levels. Uses a mixture of line of sight and first person viewing using controller display. ● 1 drone on the course at a time ● Scoring reflects flight path control proficiency balancing speed and precision control
Advanced	Master FPV flight modes, faster speeds, more precision on control in circuit races, Time trials, and Freestyle competitions.	● Course uses tighter spacing and width of hoops, adds tunnels and very tight turns and direction changes. Focusing more on first person viewing flight, and optionally can include FPV goggles ● FPV: high speed precision flying in, around, & through obstacles

		● Multiple drones on the course for circuit races. ● Scoring reflects flight path control proficiency balancing speed and precision control
Expert	No expert level race is defined in the playbook	Troops can design different courses and run any kind of race. Course design recommendations are provided in this handbook.

8.4 Missions

Missions are courses where multiple different objectives must be completed based on a defined scenario. Scouts are scored on how well they complete each objective and their overall time and other factors. These are typically suited for Advanced or Expert pilots who have mastered complex and precise maneuvers with their drones.

Expert Advanced Missions: These competitions focus on one specialty area and include a complex mission that must be accomplished, with multiple goals to be achieved. These will often require option kits to be added to the basic drone kit.

There will also be four major missions, each built around the activities and structure of the current BSA High Adventure Bases (Northern Tier, Philmont, Seabase and Summit). The course layout will reuse structures and individual elements to allow event hosts to reconfigure their courses for the different high adventure base missions. These allow a "virtual" visit to the kinds of activities and environment found at the high adventure bases, promotes those bases for trips, and builds interest in those bases.

Note: These are example ideas, and the final missions would be developed in conjunction with staff at the national High Adventure sites to best represent their site.

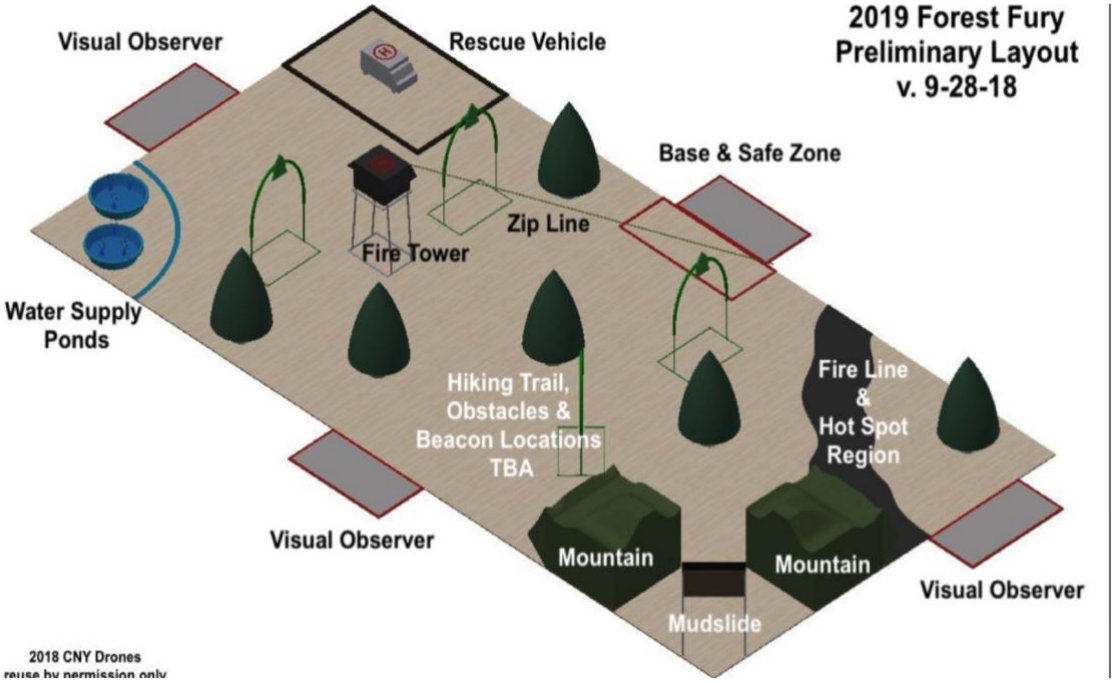
Northern Tier Mission: Your patrol is going to the Northern Tier High Adventure Base for an exciting canoe expedition. To prepare for this adventure, you and your patrol must plan a canoe expedition, and simulate, using your Drones, that trek and solve some of the unforeseen events that can happen.

- Plan your route: Identify your objectives for your canoe expedition, then fly over the different routes to map out and plan your trek. You have to identify the best route, taking into account the length and difficulty of portages, plan campsites, emergency procedures and contingency plans. (Set up course showing the different bases and areas and features, for example, Crownlands will have old trapper cabins, abandoned gold mines, etc.)
- Radio Emergency - your Interpreter's radio has died. Use your drone to fly back to a base, get a new radio and return it to your crew.
- Avoiding high water and rapids
- Other scenarios (not all emergencies)

An example of a potential mission and course is listed below.

- **Emergency Preparedness-1 Forest Fires:** A wildfire is burning out of control. Isolated firefighters are running short on vital supplies. A potential mudslide puts hikers in harm's

way. Will your drone team be prepared to help? (based on CNY Drones 2019 Forest Fury competition - note: need to ascertain if we can get permission to use this)



- Navigate at low altitude through a forest trail checkpoints and obstacles
- Deliver fire suppressants to hot spots using thermal imaging, (grappling arm/hook and release system)
- Deliver supplies to firefighters using a locational beacon, (grappling arm/hook and release system)
- Land and take off from unsteady mountain surfaces
- Activate a zip line delivering a forest ranger from a fire tower to a safe zone. (grappling arm/hook and release system)
- Map a safe hiking trail to get to the fire area.
- Rescue hikers from an imminent mudslide (time trial) (grappling arm/hook and release system)
- Return to a moving vehicle

9 Course Design

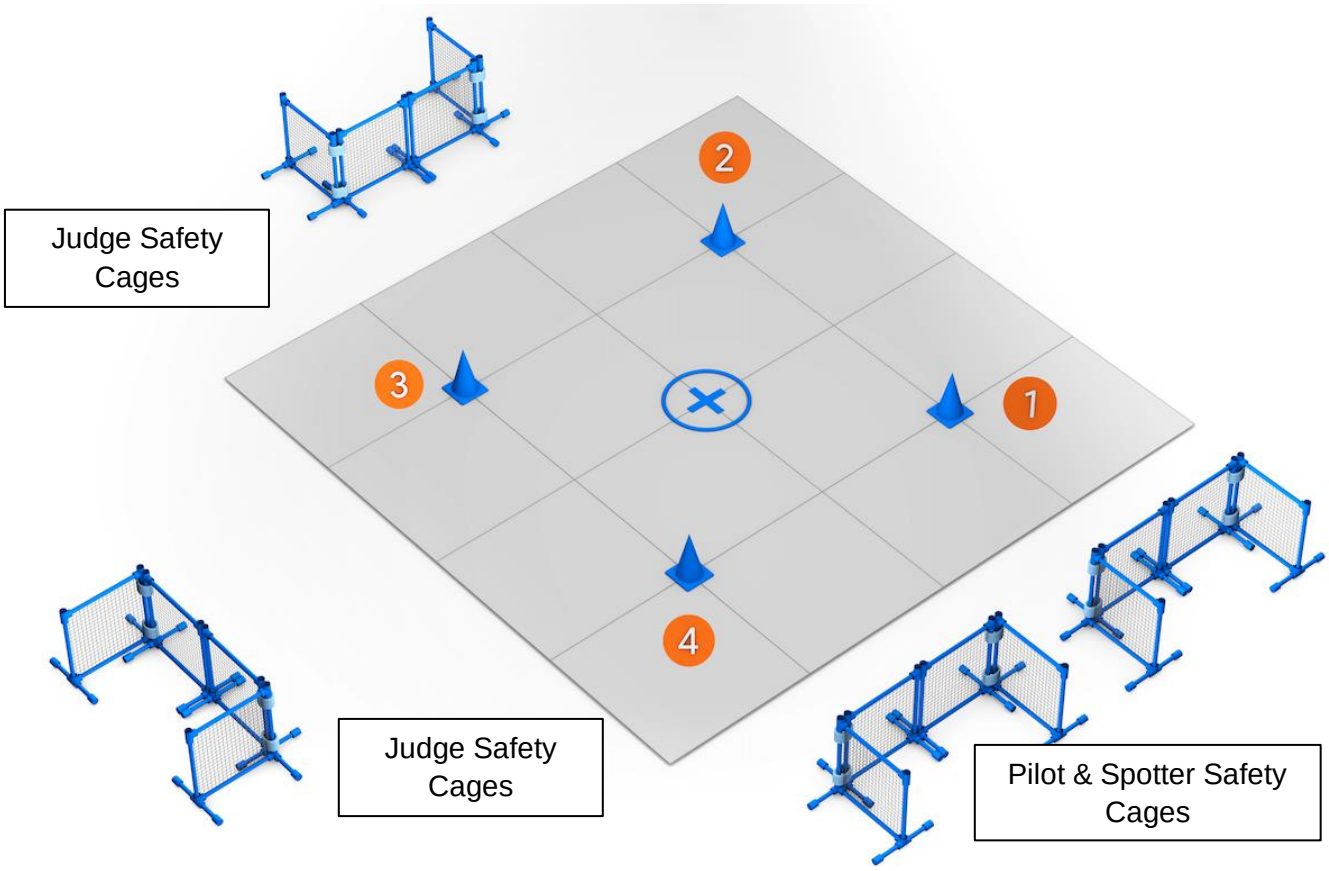
Recommended courses are provided for each of the proficiency levels and for the missions. The Beginner proficiency level should be a very simple course focusing on the same flight skills developed in the Beginner Flight Control Module. Once Scouts have mastered the beginner level, then courses should get more complex and difficult.

The section on Course Construction defines different reusable bases, gates and obstacles, and safety net sections. Courses can be built from these elements and they are designed so that they can be reused and repurposed for many different events and competitions.

When setting up a course for the Intermediate, Advanced & Expert levels, remember there is no set course or limit! Apart from the usual air gates and flags, other objects around you can be incorporated into your racing tracks too, such as trees, goal posts, bushes, and indoor obstacles. Obstacles at different heights will also make flying a lot more dynamic and feels more 3D. Since these events are usually run in a large area, make it clear to the pilots which parts of an obstacle they should enter and depart. Suggestions are included in the individual obstacle definitions.

9.1 Beginner Level Courses

The objective of the Beginner level is to build basic drone flying skills, learn about drones, and build Scouts' confidence in their ability to fly a drone. Scouts should be allowed to start flying very quickly. Race instructions are to be found in the Beginners Race Playbook Module. The recommended course for the Beginner is shown below;



9.1.2 Beginner's Race, Course Build Specs

This course is a simple course to build Scout's confidence in their flight skills. This simple course essentially runs the entire event at a single altitude. The course consists of the following elements. These costs represent typical costs at big-box hardware stores (e.g. Lowes. Home Depot, etc.)

Element	Quantity	Unit Cost	Extended cost
Judge/Pilot safety cage	3	$46.59	$139.77
Flight line marking stakes (36-inch wood landscape stakes for outdoors - Can use small buckets of sand to hold stakes indoors - they can double as fire pits for batteries)	14	$0.75	$10.50
Twine for flight line marking	160 feet	$3.48	$3.48
Safety Cones (pylons)	4	$8.96	$35,84
Rope/painter's tape & zip ties	Per design	$5.00	$5.00
Total			**$194.57**

Note: Painter's tape is recommended for indoor floor markings, as it can easily be removed after the event, and it comes in different colors and widths to make it easy to see.

1. Starting Point: Pick the center spot and tape an X about 2-feet by 2-feet to mark the starting point.
2. Hover Zone: Mark out a 5-foot diameter circle around the starting point and mark it with painter's tape or a 16-foot long piece of colored rope.
3. Place four safety cones (pylons) as shown in the diagram to make a 20 x 20 foot square
4. Use some simple stakes and twine to mark the perimeter of the flight line 10 feet beyond the safety cones.
5. The safety Flight Line is 10 feet outside the 4 cones.
6. Assemble 3 Safety Gates, and place 3 feet from the flight line as shown in the diagram.
7. Mark the audience/spectator area and Pit Area behind the pilot, and 75 feet behind the flight line.

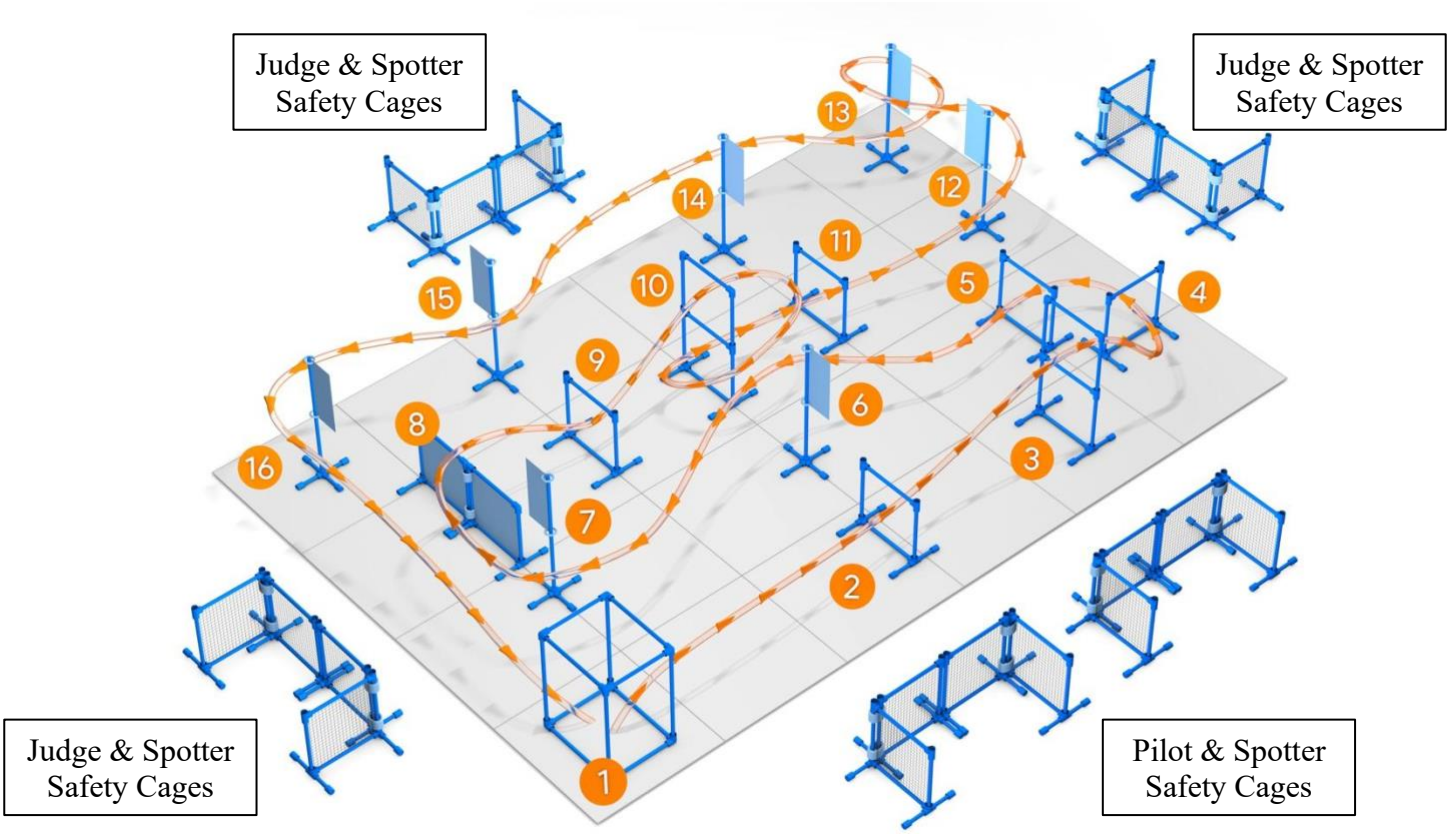
9.2 Intermediate Level Courses

The objective of the Intermediate level is to build drone flying proficiency. These courses should be more challenging and require more precise flying skills. A recommended intermediate course is provided below, and leaders are encouraged to develop their own courses utilizing the spaces available to them. This course is much larger than the Beginner's course, allowing for more complex flying with 3-D altitude changes.

This course is set on a 40 x 60 foot space. In the drawing below, the dashed grid lines are at 10-foot intervals. Course instructions are to be found in the Intermediate Race Playbook Module.

Objects:

a. Launch Gate
b. ½-inch Standard Gates
c. ¾" Double Tower Gate
d. Hurdle
e. Flags



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9.2.1 Intermediate Race, Course Build Specs

This course is a moderate complexity course to challenge Scout's flight skills. The course consists of the following elements

Element	Quantity	Unit Cost	Extended cost
Launch Gate	1	$19.32	$19.32
3/4 inch closed obstacle base	1	$11.72	$11.72
½" Open Obstacle Base	7	$7.17	$50.19
¾" Open Obstacle Base	2	$7.70	$15.40
½" Standard Gate	5	$3.13	$15.63
Double Tower Gate	2	$8.06	$16.12
Hurdle	1	$15.80	$15.80
Flag	7	$5.64	$39.48
Flight line marking stakes (36-inch wood landscape stakes for outdoors - Can use small buckets of sand to hold stakes indoors - they can double as fire pits for batteries)	20(6)	$0.75	$4.50[1]
Twine for flight line marking	180 feet	$3.48	$0.00[1]
Safety Cages	5(2)	$46.59	$93.18[1]
Painter's Tape Floor Markings & zip ties/twine[2]	Per design	$10.00	$10.00
Total			**$291.34**

Notes:

1) These costs assume reuse of common parts from the beginner's race. The beginner's course used 3 Safety Cages, so only 2 more need to be built for the Intermediate course. similar savings apply to the flight line marking stakes and twine.
2) Painter's tape is recommended for floor markings, as it can easily be removed after the event, and it comes in different colors and widths to make it easy to see.

- It may help to mark out a grid using twine to make it easier to find the right places to set up your obstacles. They should be roughly in the locations shown, but do not have to be exactly placed.
- Assemble and set up your obstacles around the course.
- Use some simple stakes and twine to mark the perimeter of the flight line 10 feet beyond the course area.
- Assemble 2 Safety Gates, and place them 3 feet from the flight line as shown in the diagram.
- Mark the audience/spectator area and Pit Area behind the pilot, and 75 feet behind the flight line.

9.3 Advanced Level Courses

The objective of the Advanced level is to demonstrate mastery of FPV flight modes, faster speeds, more precision on control in circuit races, Time trials, and Freestyle competitions.to build drone flying proficiency. These courses should be more challenging and require more precise flying skills. A recommended advanced course is provided below, and leaders are encouraged to develop their own courses utilizing the spaces available to them. This course is the same size as the Intermediate course.

This course is set on a 40 x 60 foot space. In the drawing below, the dashed grid lines are at 10-foot intervals. Course instructions are to be found in the Advanced Race Playbook Module.

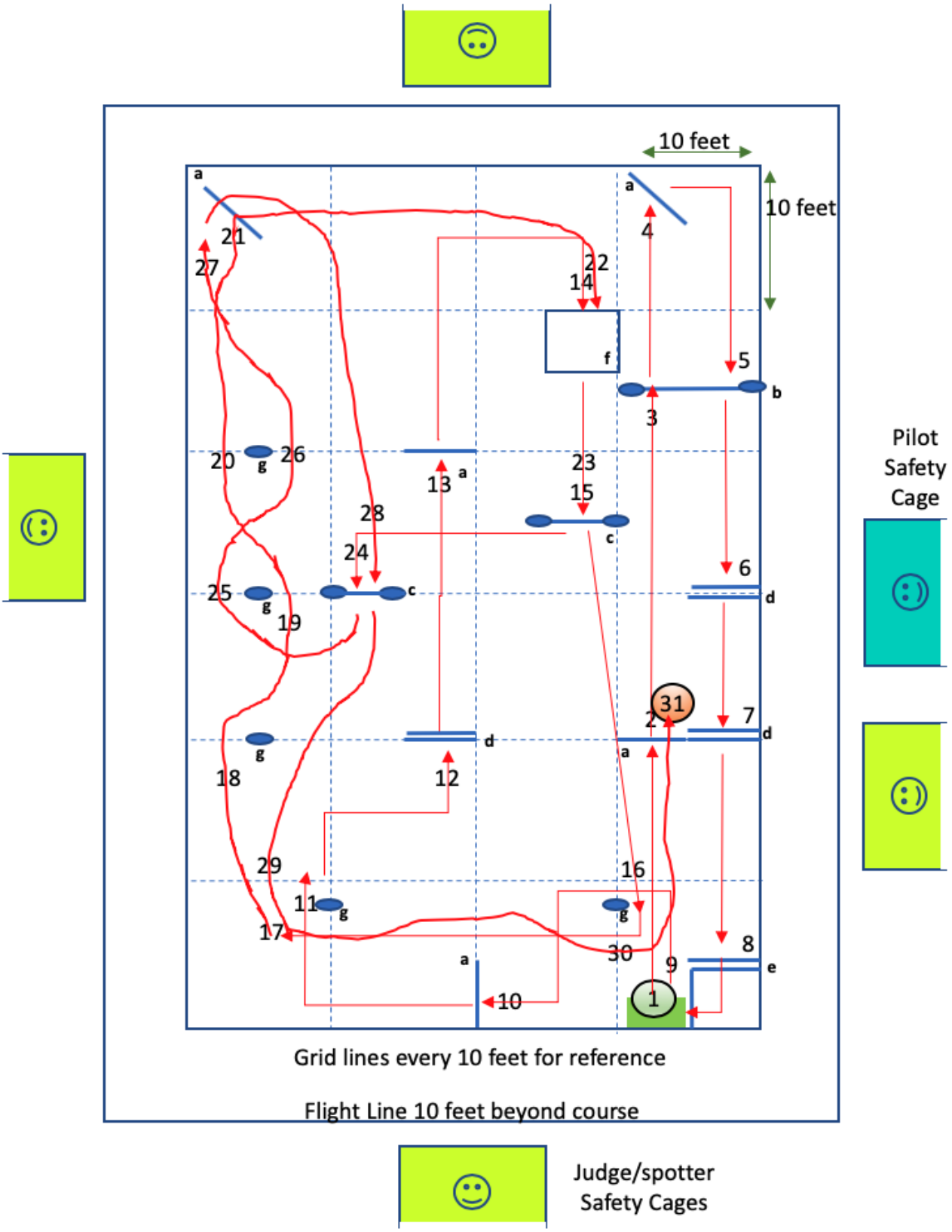
Objects:

a. ½ inch Standard Gates
b. Full Hurdle
c. Half Hurdle
d. Double Tower Gate
e. Offset 90-Degree Tower Gate
f. Dive Gate
g. Flags

The green box under "1" is the starting point. The red "31" is the ending point.

Gate "2" is used as a timing gate. The drone takes off from "1", and the race timing starts as it passes through Gate "2". The time ends when it passes through that same gate at step "31".

Advanced Race Course example



9.3.1 Advanced Race, Course Build Specs

This course is a complex course with many tight turns and elevation changes to challenge Scout's flight skills. The course consists of the following elements

Element	Quantity	Unit Cost	Extended cost	Notes
Dive Gate	1	$13.34	$13.34	
3/4 inch closed obstacle base	1(0)	$11.72	$0.00[1]	For dive gate
½" Open Obstacle Base	10(2)	$7.17	$14.33[1]	For hurdles, standard gates & 90 degree offset gate
¾" Open Obstacle Base	4(2)	$7.70	$15.39[1]	For double tower and offset gates
½" Standard Gate	5(0)	$3.13	$0.00[1]	
Double Tower Gate	4(2)	$8.06	$16.12[1]	
Offset 90-degree Tower Gate	1	$11.19	$11.19	Basically 1 standard gate and 1 double tower gate
Full Hurdle	1(0)	$15.80	$0.00[1]	2 standard gates plus fabric & mini flags
Half Hurdle	2	$8.68	$17.35	A standard gate plus fabric and mini flags
Flag	5(0)	$5.64	$0.00[1]	
Flight line marking stakes (36-inch wood landscape stakes for outdoors - Can use small buckets of sand to hold stakes indoors - they can double as fire pits for batteries)	20(0)	$0.75	$0.00[1]	
Twine for flight line marking	180 feet	$3.48	$0.00[1]	
Safety Cages	5(0)	$46.59	$0.00[1]	
Painter's Tape Floor Markings & zip ties/twine[2]	Per design	$10.00	$10.00	
Total			**$97.72**	

Notes:

1) These costs assume reuse of common parts from the beginner and intermediate race courses.
2) Painter's tape is recommended for floor markings, as it can easily be removed after the event, and it comes in different colors and widths to make it easy to see.

1. It may help to mark out a grid using twine to make it easier to find the right places to set up your obstacles. They should be roughly in the locations shown, but do not have to be exactly placed.
2. Assemble and set up your obstacles around the course.

3. Use some simple stakes and twine to mark the perimeter of the flight line 10 feet beyond the course area.
4. Assemble your Safety Gates, and place them 3 feet from the flight line as shown in the diagram.
5. Mark the audience/spectator area and Pit Area behind the pilot, and 75 feet behind the flight line.

10 Course Elements Construction

The courses are designed to reuse the same sets of obstacles, objects and safety net panels, and to be able to swap bases with upper segments of obstacles.

Obstacles 8-feet tall or shorter are recommended to be built from Schedule 40, ½-inch diameter PVC. Obstacles taller than this need heaver duty PVC pipes. The sizes are listed for each obstacle.

Safety Netting segments are recommended to be built from Schedule 40, 1-inch diameter PVC to have more strength.

10.1 Components & Pricing

Prices are based on list prices without tax from big-box home improvement stores like Lowes or Home Depot.

Name	Price	Photo
4-way PVC fitting – side outlet Tee (slip). Note – many stores do NOT carry these in stock. They can be ordered through the store or from Amazon. Avoid "furniture grade" – it is more expensive.	½" - $1.50 ¾" - $1.67 1" - $2.74	
90-elbow (slip)	½" - $0.24 ¾" - $0.47	

Tee (slip)	½ inch - $0.40 ¾ inch - $0.59 1 inch - $1.34	
45 Degree Elbow (slip)	½ inch- $0.88 3/4 inch – 1.14	
4-way cross (slip)	½” - $1.44 ¾” - $2.88	
End cap (slip)	½” - $0.46 ¾” - $0.60 1” - $0.78	
Side Outlet Elbows (slip)	½” - $1.78 ¾” - $1.98 1” - $2.68	

5-way fitting	½” - $2.54	
Schedule 40 10-foot PVC pipe (in bundles of 10)	½” - $1.55 each ¾” - $1.90 each 1” – 2.81 each	
PVC Primer	4-oz - $4.59	
PVC Cement	4-oz - $3.99	
Bird Netting (roll 7’x100’)	$19.98	

10.2 Summary of event objects and approximate costs

Item	Individual Cost	Cost with base
½-inch Open Base	$7.17	n/a
¾-inch Open Base	$7.70	n/a
¾- inch Closed Base	$11.72	n/a
½” Simple Beginner’s Gate	$3.98	$11.15
½” Standard Gate	$3.13	$10.30
¾” Standard Gate	$4.03	$11.73
¾” Double Tower gate	$8.06	$15.76
90 Degree Offset Gate	$11.19	$28.06
Hurdle	$15.80	$30.14
¾-inch Launch Gate	$19.32	$31.04
¾-inch Dive Gate	$13.34	$36.78
½” Flag	$5.64	$5.64
Safety Cage	$46.59	$46.59
1-inch 10x10 feet Safety Net	$29.11	$29.11

10.3 Obstacle Bases

The obstacle bases are meant to be interchangeable between all of the obstacles of the same size PVC pipe. There are two variations of bases. Open Bases and Closed Bases. If you are careful and follow the instructions on which parts to glue and which to not glue, you can convert any open base to a closed base.

10.3.1 Open Obstacle Base

The open obstacle base is normally used for obstacles that are 2-dimensional. The open base is the core of both base types.

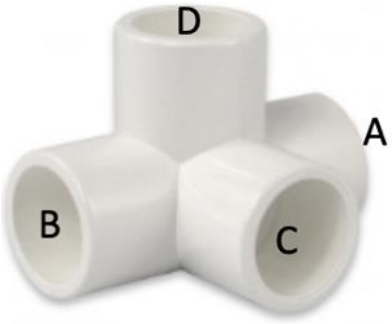
½" Bill of Materials:

- 1 each 5-foot, ½" PVC pipe segment, cut from a 10-foot pipe section
- 4 each 2-foot, ½" PVC pipe segments, cut from a second 10-foot pipe section.
- 2 each 4-way Side Outlet Tee, ½" PVC slip fittings
- 4 each, ½" end cap PVC slip fittings

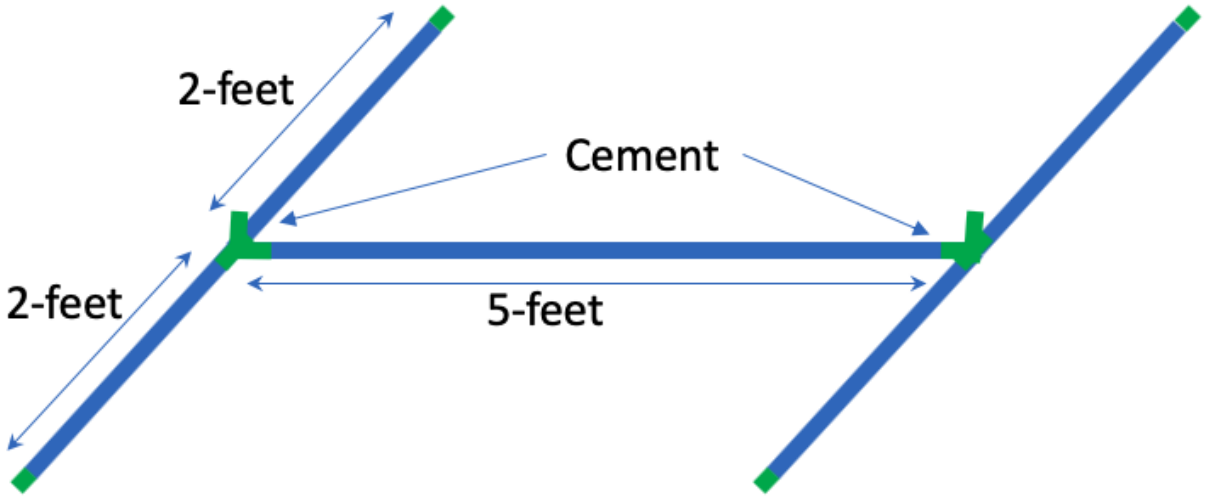
¾" Bill of Materials:

- 1 each 5-foot, 3/4" PVC pipe segment, cut from a 10-foot pipe section
- 4 each 2-foot, 3/4" PVC pipe segments, cut from a second 10-foot pipe section.
- 2 each 4-way Side Outlet Tee, 3/4" PVC slip fittings
- 4 each, 3/4" end cap PVC slip fittings

Assembly



1. Cut the PVC pipe sections, clean the ends of any burrs or shavings.
2. Prime 4 end caps and one end of the four 2-foot pipe segments and then cement one end cap on each pipe segment. These are the stabilizing "feet" of the base.
3. Put two each of the 2-foot pipe segments into the holes A & B of each of the two 4-way fittings. DO NOT CEMENT these so that it is easier to transport.
4. Prime both ends of the 5-foot pipe segment and Hole C of the 4-way fittings. Put some cement on one pipe segment end and insert it into the 4-way fitting.
5. Lay this assembly flat on the ground with the "D" hole facing up.
6. Now, cement the other end of the 5-foot pipe segment to the other foot, making sure that all four feet are flat on the ground.
7. Your open obstacle base is now complete.



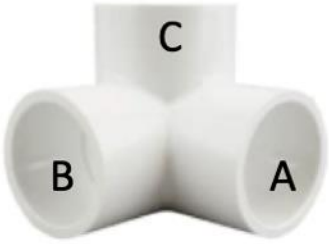
10.3.2 Closed Obstacle Base

The closed obstacle base is normally used for 3-dimensional obstacles, such as launch and dive gates. It is a flat square base.

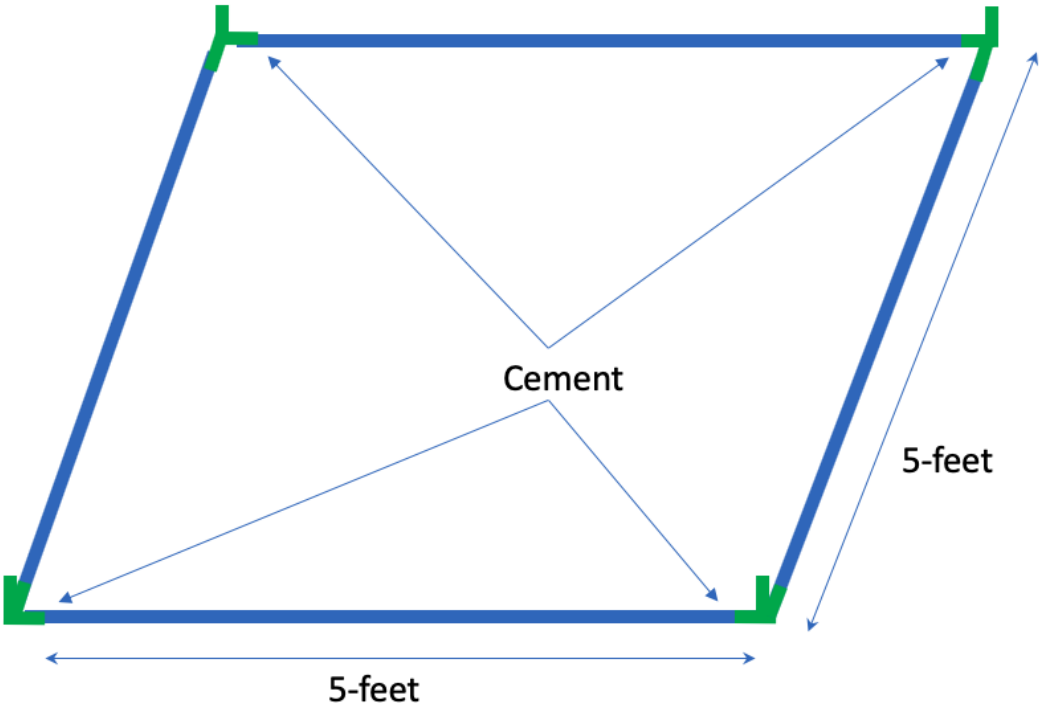
Bill of Materials:

- 4 each 5-foot, ½" PVC pipe segment, cut from two 10-foot pipes
- 4 each Side Outlet Elbow, ½" fittings

Assembly



1. Cut the PVC pipe sections, clean the ends of any burrs or shavings.
2. Prime both ends of two of the 5-foot pipe segments and hole A of two side outlet elbows and hole B of the other two side outlet elbows. Take each pipe and cement the primed "A" hole to one end of the pipe and the primed " B" hole of the other fitting to the pipe. Repeat the process of the second pipe.
3. Slip the remaining 5-foot pipe segments into the unprimed holes A & B but DO NOT CEMENT these pipes in so that you can take the base apart to transport it easily. Note: if you have the space, it ss easier to set this up if all four pipes are glued into the fittings.
4. You should now have a square 5x5 foot base with the "C" holes all facing the same direction.



10.4 Gates

Gates force a pilot to better control their horizontal and vertical position to fly through the gate without hitting the edges. Gates can be directly on the ground, elevated, and in towers or ladders, allowing for many different configurations. Gates are normally built separately from the base. The above bases can be used with the gates indoors or outdoors. If you are holding an outdoor course on a potentially windy day, you need to make sure the wind does not blow the gates down. There are two options recommended in this handbook.

- Option 1: use some form of sandbag laid across the feet of a standard base to hold the base down.
- Option-2: get some 3-foot lengths of ¼-inch rebar or similar metal stakes. Hammer them into the ground 1-foot deep, and then slip the legs of the gate over the rebar and do not use one of the bases.

10.4.1 Simple Beginner Gate

A simple beginner's gate is a simple gate that can be used with Beginner courses, as it provides a taller, less obstructed opening. It fits on the standard base, or it can be attached to the ground outdoors with rebar sections.

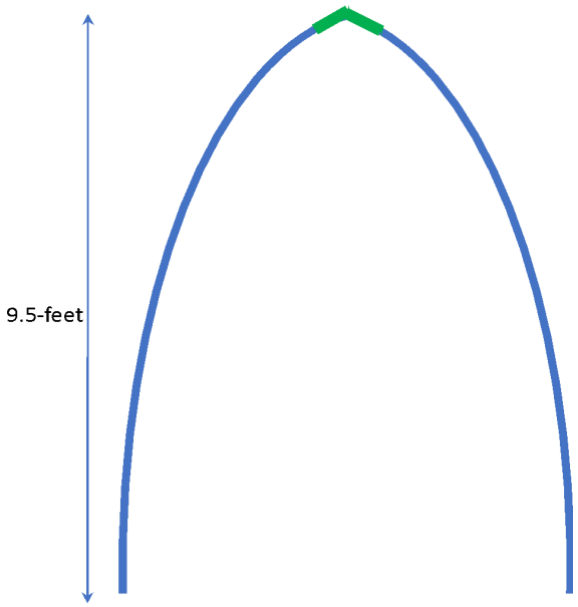
The gate is 5-foot wide at the bottom and a little more than 9.5-feet tall and looks like a beehive. A short piece of bright colored caution tape can be taped across the top of the beehive to indicate the direction to enter this gate.

Bill of Materials:

- 2 each 10-foot, ½" PVC pipe segments
- 1 each 40-degree ½" fitting

Assembly

1. Connect the two 10-foot pipes together using the 45-degree fitting. Do not cement them.
2. Place the other ends of the two 10-foot pipes into the base.



10.4.2 ½ inch Standard Gate

A standard gate is a 5-foot x 5 foot square opening. Single gates are normally made of ½" PVC.

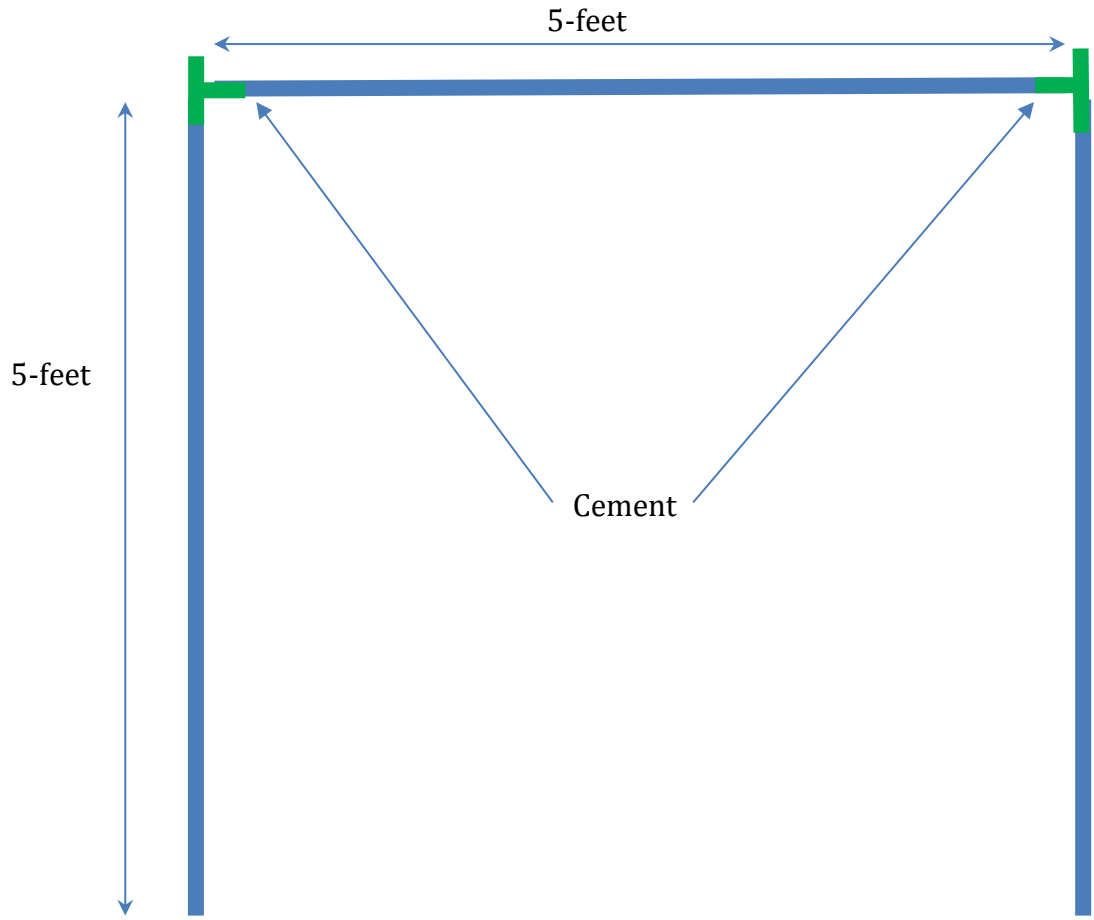
A short piece of bright colored caution tape can be taped across the top of the gate to indicate the direction to enter this gate when setup in a course.

½" Bill of Materials:

- 3 each 5-foot, ½" PVC pipe segment, cut from a 10-foot pipe section
- 2 each Tee, ½" fittings

Assembly

1. Cut the PVC pipe sections, clean the ends of any burrs or shavings.
2. Prime both ends of one of the 5-foot pipe segments and hole C on both Tees, then cement the two Tees to the pipe.
3. Slip the remaining 5-foot pipe segments into hole C of the Tee fitting holes but DO NOT CEMENT these pipes in so that you can take the gate apart to transport it easily.
4. You should now have a square 5x5 foot base with 2 open fitting holes at the tops.



10.4.3 3/4 inch Standard Gate

This standard gate is the same dimensions of the single height gate but made of ¾-inch PVC so that gates can be stacked.

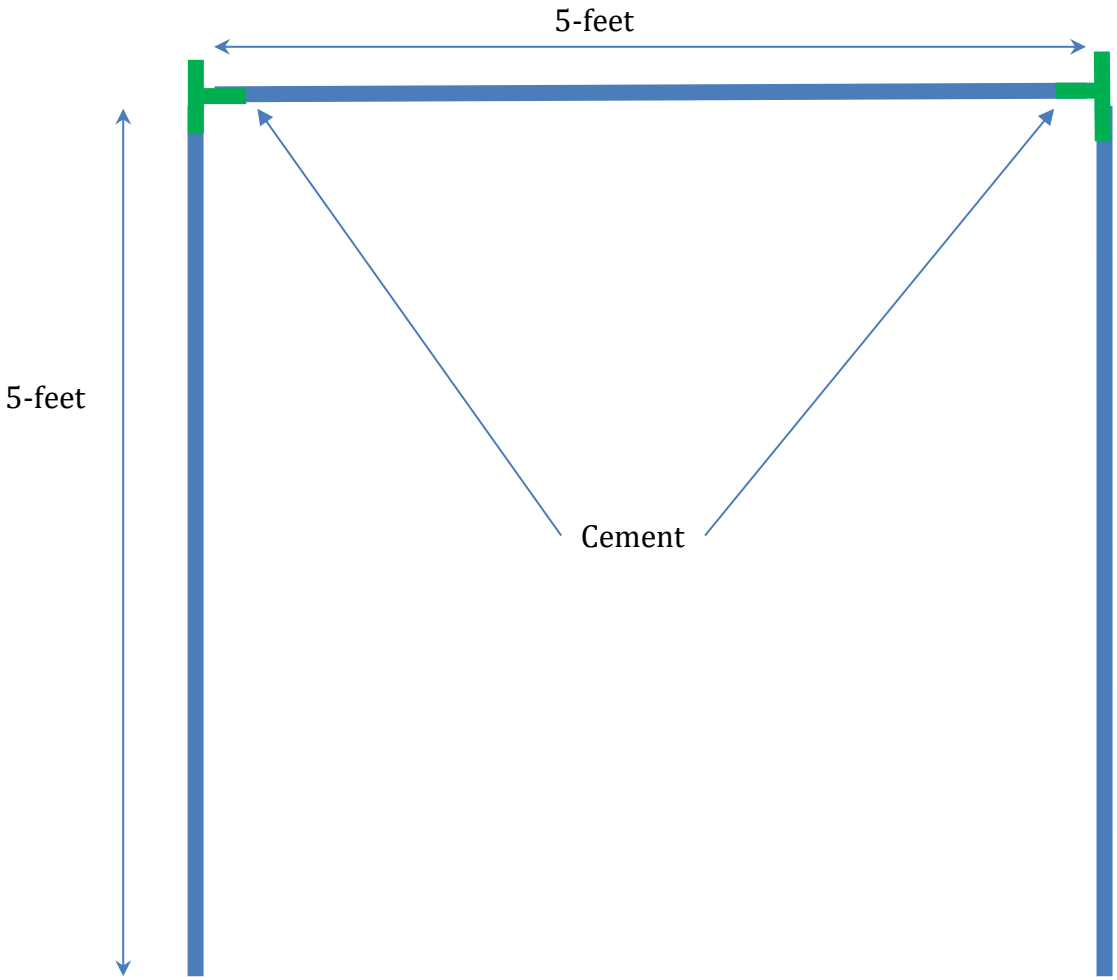
A short piece of bright colored caution tape can be taped across the top of the gate to indicate the direction to enter this gate when setup in a course.

½" Bill of Materials:

- 3 each 5-foot, 3/4" PVC pipe segment, cut from a 10-foot pipe section
- 2 each Tee, 3/4" fittings

Assembly

1. Prime both ends of one of the 5-foot pipe segments and hole C on both Tees, then cement the two Tees to the pipe.
2. Slip the remaining 5-foot pipe segments into hole C of the Tee fitting holes but DO NOT CEMENT these pipes in so that you can take the gate apart to transport it easily.
3. You should now have a square 5x5 foot base with 2 open fitting holes at the tops.



10.4.4 Double Tower Gate

A Double Tower Gate is two ¾-inch standard gates stacked on top of each other. These make the pilot fly up to go through the upper gate, and then they can circle around and go through the lower gate. Tower Gates can be used in conjunction with standard lower gates to force pilots to slow down and fly up and down through the sequence of gates.

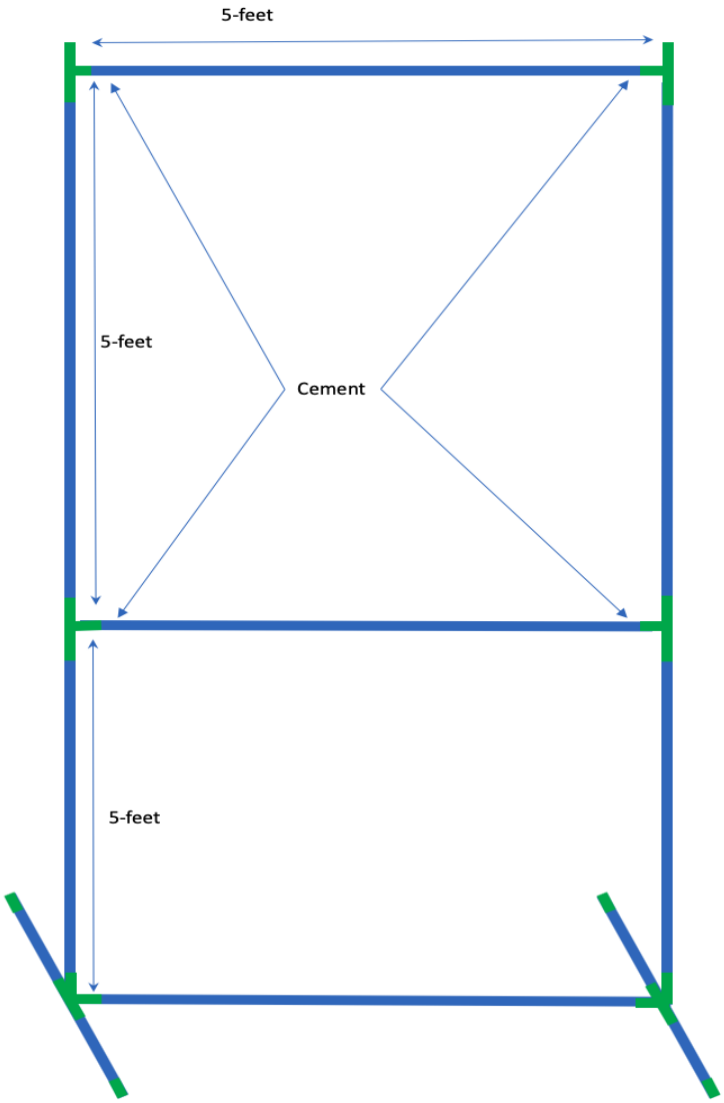
A short piece of bright colored caution tape can be taped across the top of the gate to indicate the direction to enter this gate when setup in a course. If you are not using the lower part, criss-cross several pieces of caution tape of cloth flags to indicate this part is not to be flown through. If flying through both sections – mark the tops appropriately.

Bill of Materials:

- 2 each 3/4" standard gates
- 1 each 3/4 ' open obstacle base

Assembly

1. Make two ¾-inch Standard Gates and stack them vertically on top of the open base.



10.4.5 Offset 90 degree Tower Gate

The offset 90-degree Tower Gate it a combination of a ¾-inch standard gate with a Double tower gate that are joined at a 90 degree offset. Pilots enter the upper gate of the tower and must immediately turn and dive down to exit through the lower standard gate.

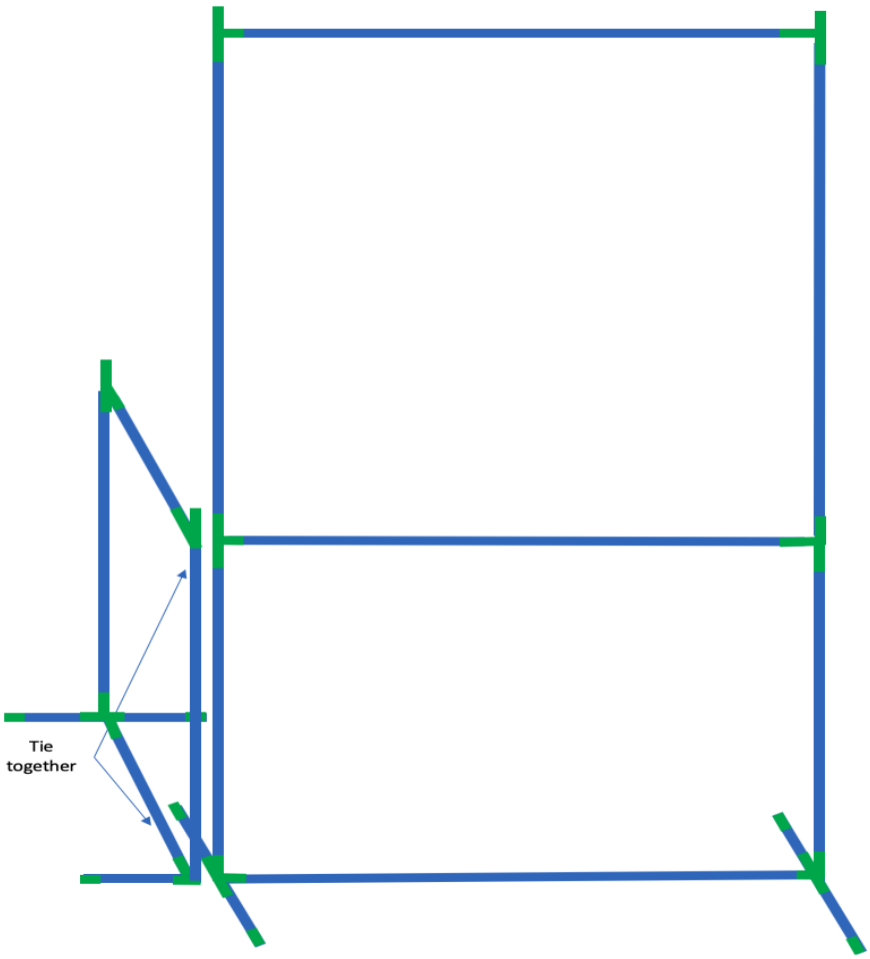
A short piece of bright colored caution tape can be taped across the top of the top double tower gate to indicate the direction to enter this gate when setup in a course. If you are not using the lower part, criss-cross several pieces of caution tape of cloth flags to indicate this part is not to be flown through. Then mark the top of the 90-degree standard gate to show which side to enter.

Bill of Materials:

- 1 each 1/2"standard gate with ½" open obstacle base
- 1 each ¾-inch double tower gate. With ¾" open obstacle base
- Tie wraps or twine or duct tape to tie the gates together

Assembly

2 Setup a 1/2" standard gate on an ½" open base and a tower gate, on an ¾" open base. next to each other at a 90 degree angle.
3 Remove the foot on the ½" open base that would overlap the foot of the ¾" base.
4 Using twine or zip ties, tie the two gates together at the points shown.



10.4.6 Launch Gate

A launch gate is a horizontal square gate used to start a race by forcing the pilot to lift their drone straight up and through the gate. It is essentially a closed obstacle base connected by four 8-foot pipes. It fits on the closed obstacle base, or can be attached to the ground outdoors with rebar sections.

The top is the gate, so you should mark the sides with criss-crossed tape of flag cloth to indicate pilots are not to fly through the sides of the launch gate.

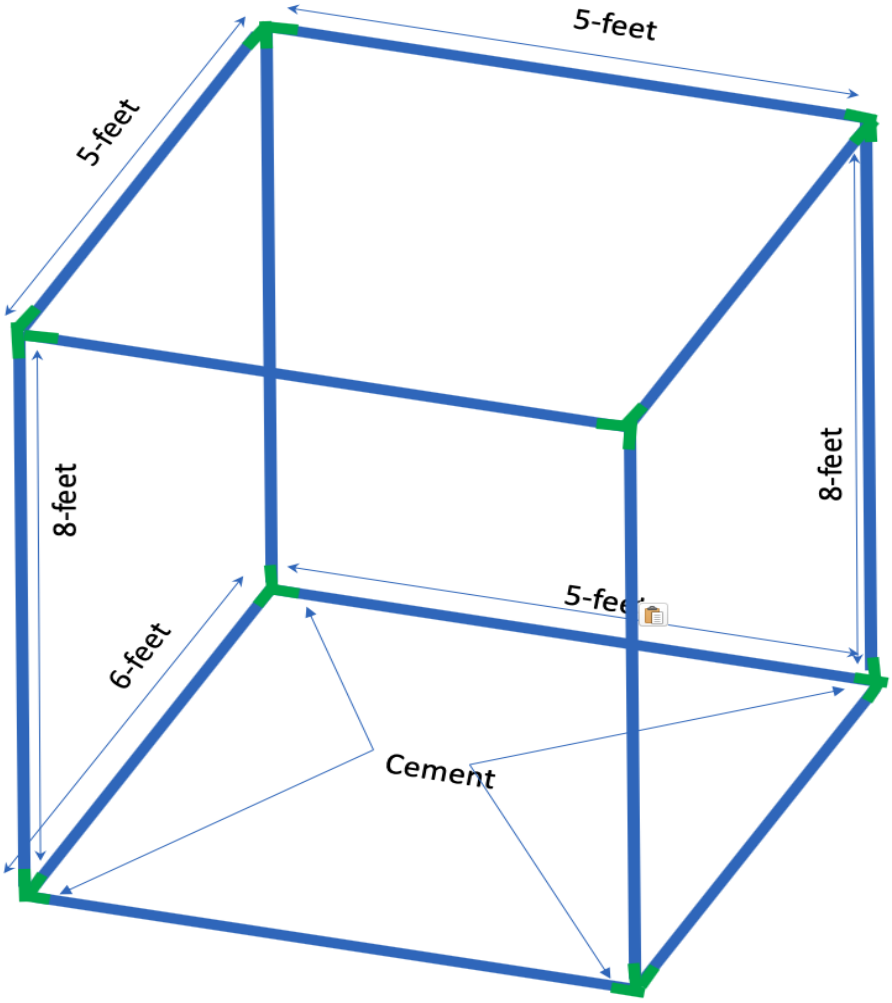
The gate is 5x5 feet, and is 8-feet high.

Bill of Materials:

- 2 each ¾ inch closed bases
- 4 each 8-foot, ¾ inch PVC Pipe segments

Assembly

1. Attach the 4 8-foot pipes to the four side outlet elbows of two closed bases and do not cement them.



10.4.7 Dive Gate

A dive gate is similar to a launch gate, except that one side of the top gate is 3-feet lower than the other side. It uses two ¾-inch closed bases – the same base & top used on the launch gate. They are intended for pilots to dive down into the dive gate, and quickly fly out the bottom opposite side without crashing into the ground. It fits on the closed obstacle base or can be attached to the ground outdoors with rebar sections.

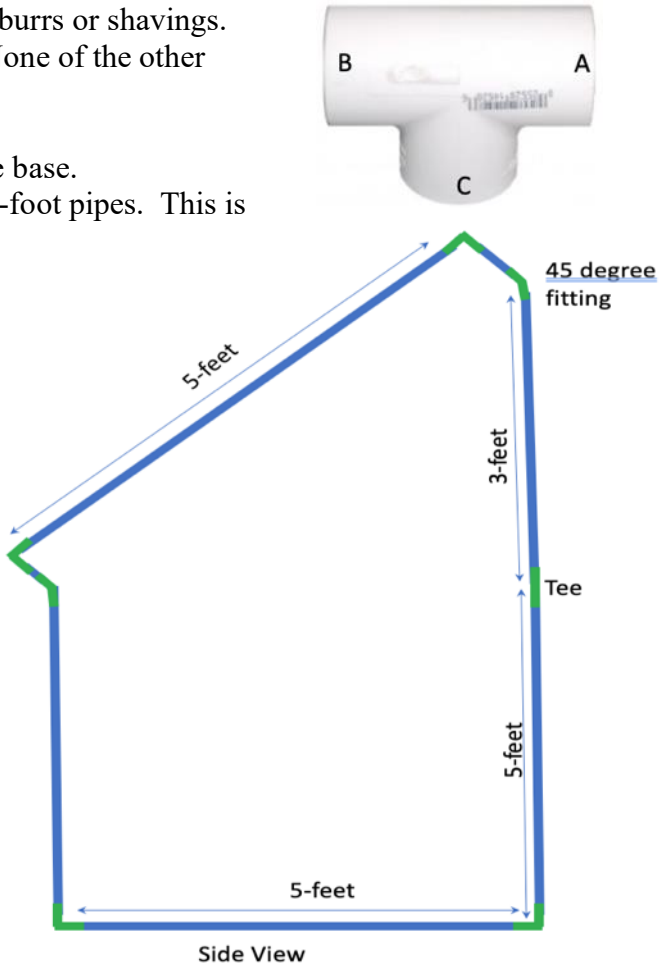
Mark the top of the angled gate as the entrance, and the bottom of the opposite side as the exit gate. Block off the other sides and the top section of the back to indicate to pilots not to fly in those parts.

Bill of Materials:

- 5 each 5-foot, ¾-inch PVC pipe segments
- 2 each 3-foot, ¾-inch PVC pipe segments
- 2 each 2.5-inch ¾-inch PVC Pipe segments
- 2 each 6-inch ¾-inch PVC pipe segments
- 4 each 45-degree ¾-inch fittings.
- 2 each ¾ inch Tee fittings
- 2 each ¾-inch closed bases

Assembly

1. Cut the PVC pipe sections, clean the ends of any burrs or shavings.
2. The bases are the only parts that are cemented. None of the other pieces are cemented.
3. Setup one base on the ground.
4. Put four of the 5-foot pipes into the fittings on the base.
5. Put two Tee fittings (hole "A") on two adjacent 5-foot pipes. This is the back of the gate. Then put the last 5-foot pipe into holes "C" to make a cross-brace. This is the top of the exit gate.
6. Take the two 6-inch pipes and attach two of the 45-degree fittings to one end of each pipe. Put the other end of the 45-degree fitting on one end of each of the 3-foot pipes
7. Put the other ends of the 6-inch pipes into two adjacent fittings on the second closed base.
8. Take two 45-degree fittings and put them on one end of each 2.5-inch pipe. Put the other end of the 2.5-inch pipe into the other two fittings of the second closed base.
9. Turn this second base over, and attach the 3-foot pipes to the Tees and the 45-degree fittings on the 2.5-inch pipes on the other 5-foot legs.



10.5 Other Obstacles

10.5.1 Full/Half Hurdle

Hurdles are great for slowing down racers and forcing some more technicality in their piloting. Hurdles are often used with gates to create quick up and down sequences that both slow down and challenge the pilot.

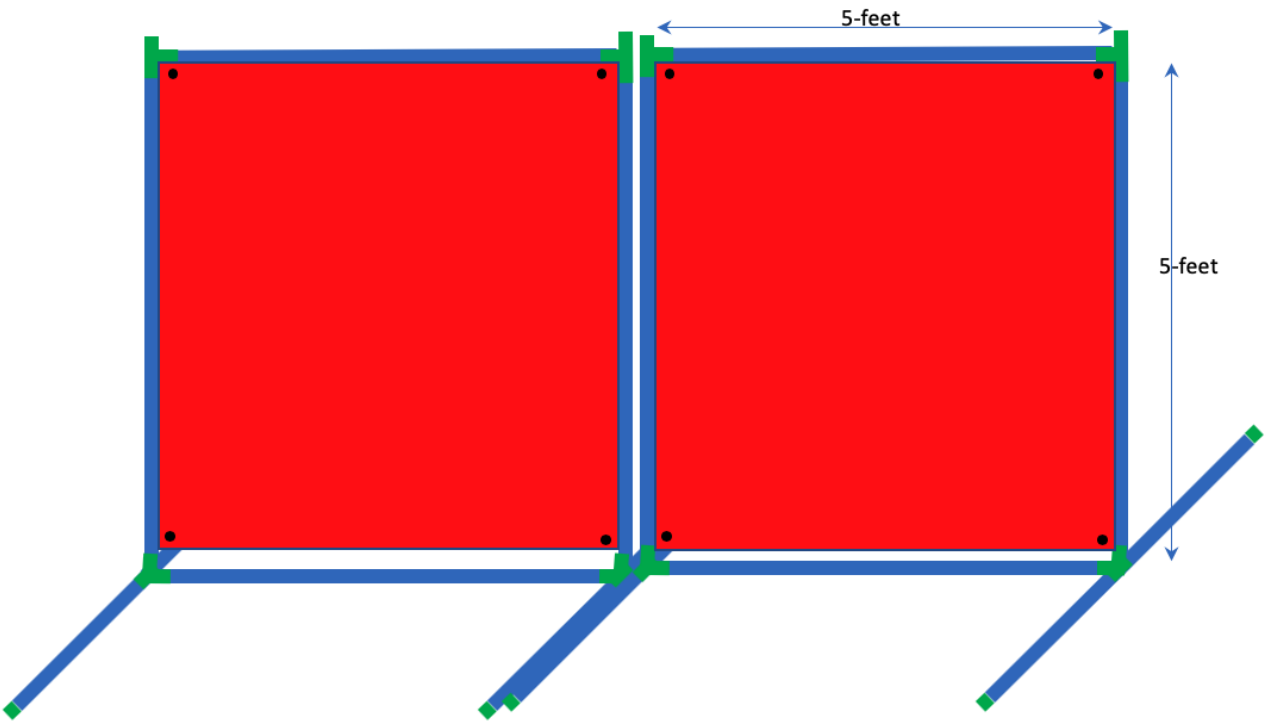
A full hurdle is a 5-feet high by 10-feet wide barrier. These are two standard ½-inch gates that are placed end to end and tied together. They have a 5-foot mini-flag on either end to force the pilot to fly over the hurdle. They can each fit onto the standard open obstacle bases, or they can be attached to the ground outdoors with rebar sections.

Bill of Materials:

- 2 each standard ½-inch gates (1 each for a half hurdle)
- 2 each 5 x 4 foot pieces of brightly colored cloth, or use left over bird netting from the Safety Net segments with 4 grommets, one per corner. *NOTE: If you use bird netting then these hurdles can be used as safety cages.* (1 each for a half hurdle)
- 2 each ½" open bases (1 each for a half hurdle)
- 2 each ½" 5-foot flags

Assembly

1. Build the two gates.
2. Cut two pieces of brightly colored cloth measuring 5 feet by 4 feet. Put grommets into the four corners of the cloth.
3. Using twine or zip ties, attach the top grommets to the top corners of the gate.
4. At the event site, place the gates into standard ½-inch bases and using twine or zip ties, secure the gates together to form a 10-foot long hurdle. Put the mini flags into the top of the hurdle at either end
5. Attach the grommets at the bottom of the cloth to the foot junctions of the gate base.



10.5.2 Flag

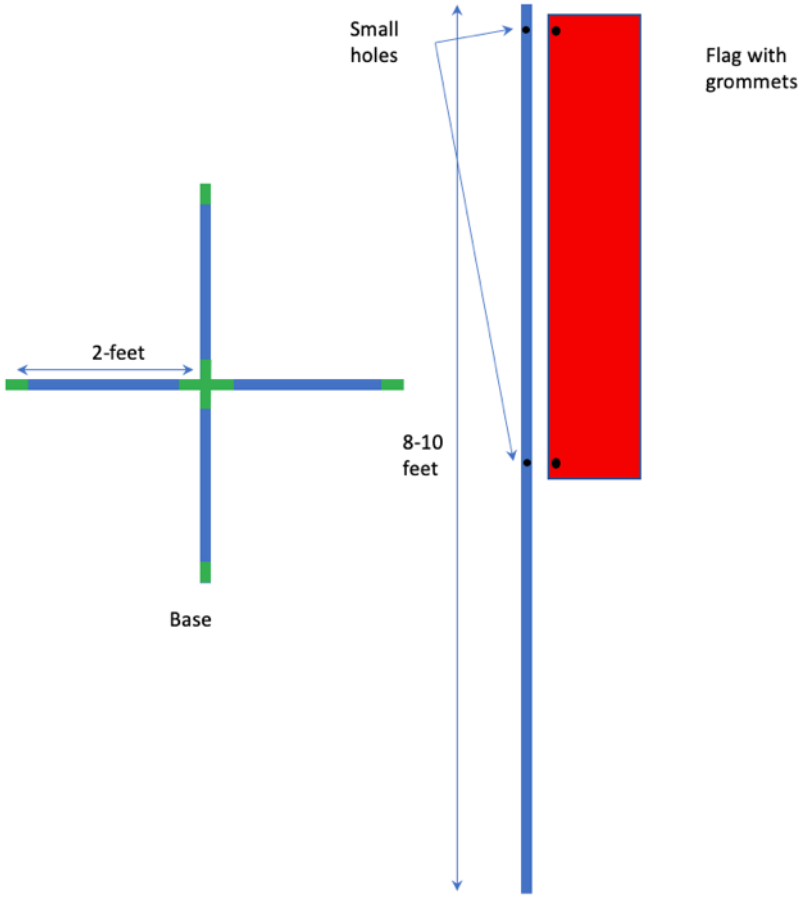
A flag is similar to what is commonly called a marketing feather flag. It is a tall pole with a strip of fabric attached to the length of the pole to make it highly visible. Bright colored lightweight fabric makes these very easy to see from outside of the course area. Flags are used to mark areas, provide an object to fly around, etc. A flag uses its own base. A mini flag is used on the ends of hurdles. It has no base, and is just a 5-foot pipe with cloth attached.

Bill of Materials:

- 4 each 2-foot, ½" PVC pipe segments
- 1 each 8-10-foot, ½" PVC Pipe segment
- 1 each, ½" 5-way fitting
- 4 each, ½" end caps
- 1 each 5-feet by 1.5-2 feet bright, lightweight fabric

Assembly

1. Cut the PVC pipe sections, clean the ends of any burrs or shavings.
2. Prime and cement the end caps on one end of each 2-foot leg segment. Prime and cement the other ends of the leg segments into holes A, & B of the 5-way fitting. (Leave the legs that go into holes C & D uncemented.)
3. Put grommets into the ends of the long edge of the flag to attach it to the pipe. The 5-foot flag should be attached to the top 5-feet of the pole.
4. Do not cement the 10-foot pipe into hole E of the 5-way fitting to make it easier to transport.



10.6 Safety Netting

There are two ways to protect the pilots, judges and spectators from a fast flying drone running out of the course area and potentially hitting someone. The recommended approach is to provide Safety Cages for the pilot, spotters and judges, and then locate the spectators behind the pilot and 75 feet behind the flight line, and use participant safety rules for avoiding accidents.

A variation on that is to provide a row of safety netting segments 3 feet in front of the participant area, in which case, the participant area can move up to 156-20 feet behind the flight line.

The other method is to enclose the flight area in Safety Netting. This allows much more freedom of movement to the pilots, spotters and Judges, but can present some issues. The large number of safety netting segments to enclose an entire course can be in the range of $300-$500. In addition, you still have the issue of drones flying over the 10-foot high safety netting segments - and you need to consider covering the entire fight course with some form of safety netting.

We provide plans for 10-foot tall safety netting segments, which can protect spectators or an entire course, and plans for Safety Cages for pilots, spotters and judges.

10.6.1 Safety Cages

A standard Safety Cage consists of 4-each 5-foot standard gates covered with bird netting. If you use bird netting for your hurdles, then those segments can double as Safety Cages.

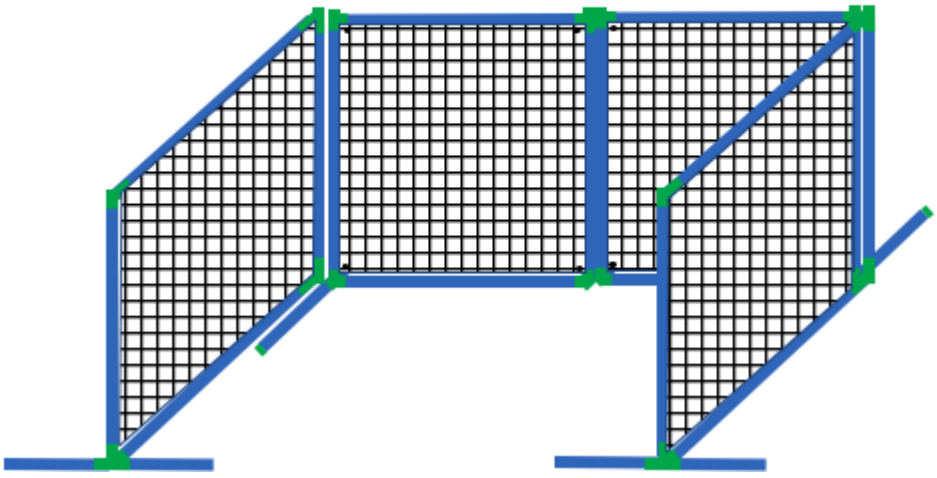
Bill of Materials:

- 4 each standard ½-inch gates
- 4 each 5 x 5 foot pieces of bird netting with 4 (optional) grommets, one per corner.
- 4 each ½" open bases

Assembly

1. Build the four standard gates as described earlier.
2. Cut 4 5x5 foot pieces of bird netting.
3. (Optional) place one grommet in each corner of the safety netting - you should put small 2x2-inch squares of fabric (or duct tape) on the netting to reinforce the grommets.
4. Using zip ties, attach the bird netting to the standard gate.
5. Tie 2 standard gates together with zip ties or twine, or other fastening method as shown below to make the long "front" of the safety cage.
6. Remove the feet from one end of the remaining two gates and fasten that end to both ends of the front part built in the prior step. You now have the basic shape built.
7. Lastly, you can optionally remove the two feet that are in the inside, middle of the front so that the person in the cage does not trip over them.
8. The person inside the cage should stay about 3 feet behind the front (long side) of the cage to allow for some penetration and bounce of a drone crashing in, and to provide them room enough to duck below the top of the cage. A couple of pieces of string, or caution tape running from side to side at the point where the front legs stop can provide that distance reminder.

Safety Cage



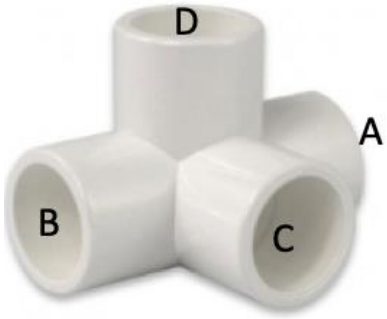
10.6.2 Safety Netting Segment

These are built and tied together to protect a larger group of people, such as an audience, or can even be built all the way around an event course. A standard safety netting segment is a 10-foot x 10-foot square opening, with stabilizing legs, and with lightweight bird netting covering the upper 7-8 feet. These segments are designed to connect to each other to provide any size safety net area around a course. are made such that they can be stacked to make ladders in various configurations.

Bill of Materials:

- 4 each 10-foot, 1" PVC pipe segment
- 4 each 2-foot. 1" PVC pipe segment cut from a 10-foot pipe
- 1 each 2-inch, 31" PVC pipe segments from the 10-foot pipe leftover piece.
- 2 each Tee, 1" fittings
- 2 each 4-way 1" fitting
- 4 each 1" end caps
- 10x7 feet bird netting

Assembly



9. Cut the PVC pipe sections, clean the ends of any burrs or shavings.
10. Prime 4 end caps and one end of the four 2-foot pipe segments and then cement one end cap on each pipe segment. These are the stabilizing "feet" of the base.
11. Put two each of the 2-foot pipe segments into holes "A" and "B" two 4-way furniture fittings. DO NOT CEMENT these so that it is easier to transport.
12. Prime both ends of the 10-foot pipe segment and hole "C" of the 4-way fittings. Put some cement on one pipe segment end and insert it into the 4-way fitting.
13. Lay this assembly flat on the ground with hole "D" facing up.
14. Cement the other end of the 10-foot pipe segment to the other foot, making sure that all four feet are flat on the ground.
15. Your safety netting base is now complete.
16. Now, to make the top of the net segment, Prime hole "A" of the two Tee fittings, and both ends of a 10-foot pipe. Cement these, making sure that the two hole "C"s are lined up. One way to do this is to put the two vertical 10-foot pipes into hole "C" and lay it all flat on the ground before you cement the top cross bar to the Tee fittings.

17. Let the cement dry, then put the 2-inch pipe segment into the outside of one of the Tee fittings.
18. With the top bar and the two side bars connected, cut a 10-foot piece of netting, lay it on the frame, starting at the top, and use either duct tape, twine, or tie warps to attach the netting to the frame.
19. With a helper, lift the top of the net segment and slip the two vertical pipes into the base. The net segment is complete.
20. Make as many of these segments as you need for each side. Couple the pieces together at the top with the 2-inch pipe segments and use either duct tape, twine or tie wraps to tie the bottom of the verticals together to make the netting wall sturdy,

21. When you get to the corners, you can either just tie segments together at a 90-degree angle with tape, twine or tie wraps, or build a special top bar using a side out elbow on either end in place of the Tees.