

Playbook Module

A-5: Basic Drone Flight Control

Level: Beginner

Pre-requisites: A-1: Build Your First Drone, A-2: Essential Drone Knowledge, A-3 Introduction to the Drone Flight Controller, A-4 Introduction to the BSA Raptor Academy App

Learning Objectives:

- Learn & demonstrate basic drone flight control
- Hovering, landing maintaining controlled altitude, simple routes, slow turns
- This can be done individually, as a group event, or even as a competition event (although the Beginners Race is the same set of maneuvers).

Materials Needed:

- a. Operational Drone, controller and BSA Raptor App on a phone
- b. 4 items to mark the box corners (simple safety pylons work great)
- c. Something to mark a 5-foot diameter circle (a 16-foot long bright colored rope works well)
- d. A tape measure capable of measuring at least 20 feet (a 50-foot tape measure is even more helpful)
- e. Something to mark the pilot's position (a piece of cardboard is good)

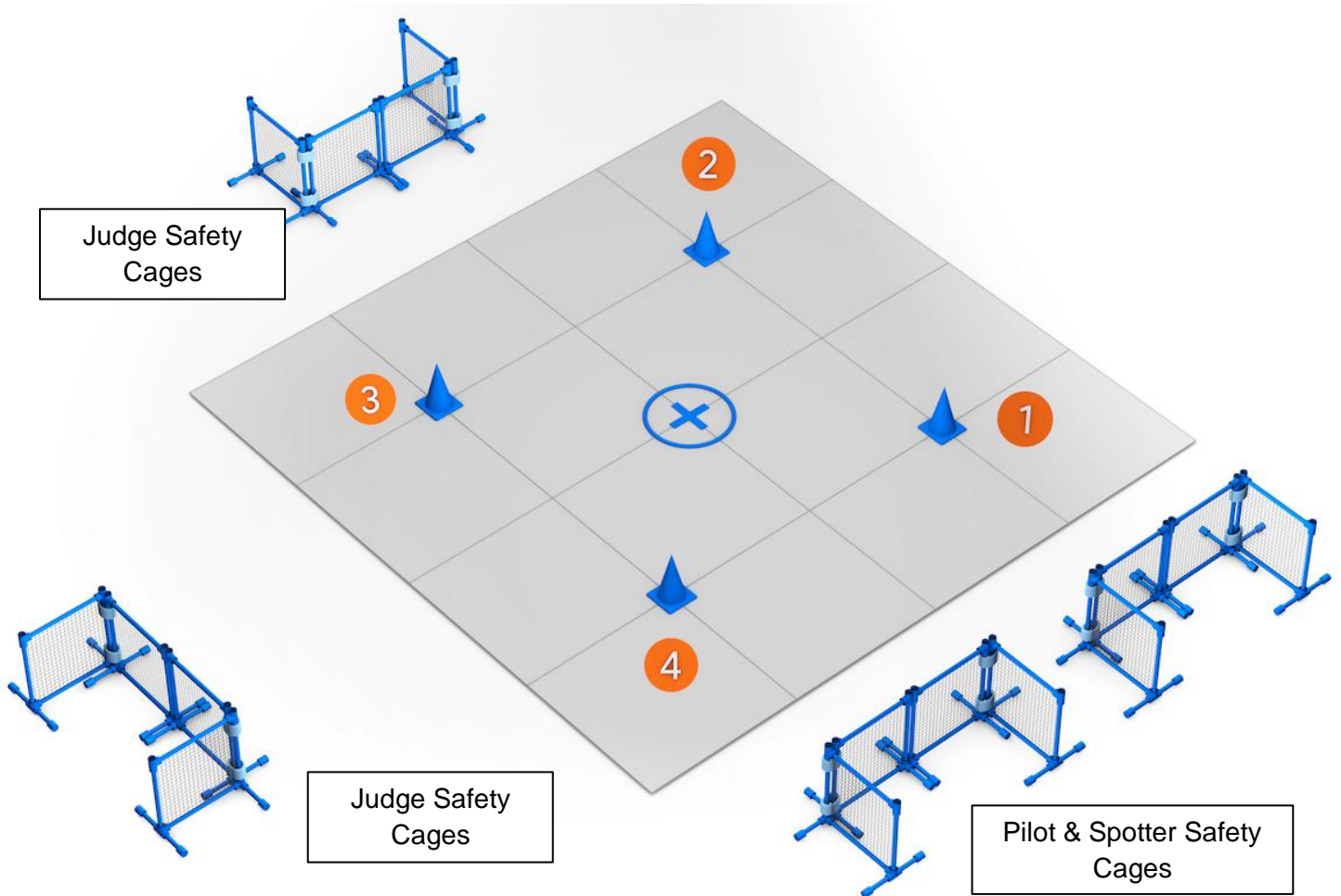
Space Needed: 20x30 foot clear area

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Prepare the Course

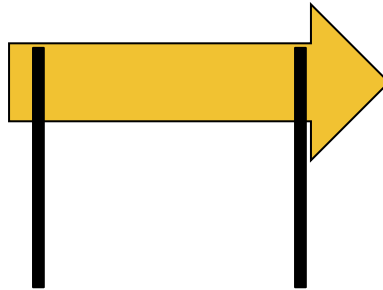
- 1) Check out the Events & Competitions Handbook for course information
- 2) Refer to the figure below as you mark your reference points.



- a) Mark a 5-foot diameter circle.
- b) Place the four pylons to make a 20 x 20 foot box centered on the circle.
- c) Mark the pilot's position 30 feet from the circle (10 feet from the edge of the box) and set a safety cage. Optionally, set a spotter's cage next to the pilot's cage.
- d) Mark Judge positions and set safety cages

Prepare your drone

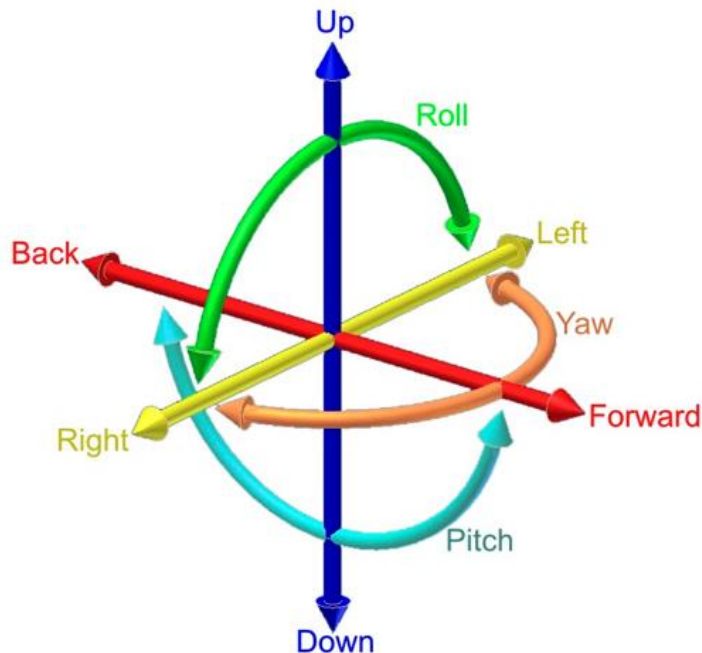
- 1) **Verify Drone Registration:** Verify that your drone has your FAA registration number clearly marked on the outside of the drone and is registered with the BSA Drone system
- 2) **Review Flight Plan:** Review your flight plan and safety rules before flying.
- 3) You will be flying this set of maneuvers in Line-of-Sight mode. That means the camera feed should be turned off and no First Person View (or FPV for short) goggles are allowed. For beginners, line of sight is the best way to start learning how to control a drone. Once you get good at line of sight control, transitioning to FPV is easier and you'll have better control over your drone. For example, when flying FPV, it is easy to lose track of your altitude and attitude (aircraft 3-D orientation).
- 4) Pro TIP!: If you are having problems seeing the orientation of your drone, you can make a simple visual aid. Using lightweight cardboard or foam board, make a large arrow and glue two straws or small diameter dowels to it. Attach it to the top of your drone with the arrow pointing to the nose. It would look something like this. You can also attach some brightly colored tape to the front and a different color on the back of the drone to make it easier to keep track of your drone's orientation as you fly these maneuvers.



- 5) Alternately, get or make a small doll and attach it on top of your drone with the doll facing the nose of the drone - pretend that this is you, the pilot!

Drone Coordinates and movements

- 1) Throughout this module, we will refer to the different axes of movement of the drone, using the coordinate axes and terminology shown here.



Imagine that this little drawing is centered on your drone.

- 2) “Forward” is straight out the nose (where the camera is). “Down” is to the ground. This coordinate system is locked to your drone and moves with it. If the drone is upside down (not recommended), then “up” is towards the ground.
- 3) “Roll” controls the left and right movement of your drone. Quite simply, if you move the right joystick to the right, your drone will move to the right and if you move your right joystick to the left your drone will move left.

It’s important that you perfect your rolls; in the early days try and spend plenty of time getting them right. Accidents often happen if you fly your drone too far to the right or left, so take time to properly learn.

- 4) “Pitch” controls the forward and reverse movement of your UAV. So, if you push your right joystick forward then the drone will move forward, and if you push the right joystick back your drone will move backward. Simple as that!

Similarly to roll, it’s important you give plenty of time to learn and perfect your pitch movement.

- 5) Yaw: Yaw is incredibly useful for when you’re looking to adjust your drones position. When you move your left joystick to the left your drone will spin in a counterclockwise direction. When you move your left joystick to the right it will spin in a clockwise direction.

6) Throttle: The throttle is what gets your drone off the ground. If you push your left joystick up your drone will ascend, and if you push the joystick down your drone will descend.

The throttle is the only control that remains engaged in the air. The moment you let go of the throttle the drone will lose power and begin to fall from the air. It's important to learn how to give your drone just enough throttle to enable it to maintain its aerial position (hover).

7) Altitude: Altitude is your drone's height. Pilots talk about altitude above mean sea level (MSL) and above ground level (AGL). Mean sea level (MSL) altitude refers to the average of the height of the oceans around the world and how high you are above that imaginary plane. Altitude above ground level (AGL) refers to the height between your drone and the ground. As the ground changes its altitude above MSL, keeping track of how high your drone is above the ground is important!

Different sensors can give you different types of altitude measurements. A barometric altimeter always tells you the altitude above mean sea level and is a measurement of the pressure of the air. A GPS (Global Positioning Satellite) sensor also tells you the altitude above MSL, and is based on a constellation of satellites around the world. It is a much more precise sensor than a barometric altimeter. Although GPS can tell you the altitude above your take off point, it cannot tell if the ground level has changed. Often, pilots will add an optical flow or some sort of ranging sensor that measures the altitude above ground and couples to the barometric or GPS altimeter.

8) Attitude: Attitude refers to the orientation of the drone coordinate system to a similar coordinate system linked to the horizon. If your drone is flying straight & level, then it's roll and pitch are zero with respect to the horizon.

Basic flight maneuvers

- 1) **Prep:** Put your drone in the center of the circle, with the nose pointing away from the pilot's position and turn it on. Move to the pilot's position and face your drone. Make sure you are in beginner flight mode.
- 2) **Now, go through the pre-flight checklist in the App.**
- 3) **1) Taking off & Landing:** Gently increase power until the drone lifts off the ground. Lift straight up to about head level, then stop ascending. Gently lower the drone back to land it. Once you've landed, cut the throttle to zero to stop the propellers. Repeat this several times until you can do it smoothly (you don't want the drone to bounce on the landing) and your drone lands within a 1-foot radius of the original take off spot.
- 4) **2) Let's practice the hover:** Start up your drone and gently increase power to take off and climb to head height. Now hover in place for a period of time. Start with 10 seconds, then increase to 15 seconds, 30 seconds, then 1 minute. After each hover, land again. Practice this till you can keep the drone within the 5-foot circle zone and within 1 foot of the same altitude the entire time. ****Pro TIP: use very small movements of the controls until you get used to them.****
- 5) **3) Square Dance Maneuvers:** The Square Dance maneuvers help you to learn how to control forward, backward and side-to-side, level flight from different orientations. For all of these maneuvers, your drone is facing with its nose pointed away from you. There is no yaw used, just forward, sideways and backward movements of the drone.
 - a) **3a Forward Facing Square Dance:**
 - i) Take off and lift to head level.
 - ii) Keeping the drone facing straight away from you, fly slowly sideways till your drone is lined up with the left-side pylons. Then, fly forward to pylon #1.
 - iii) Stop and hover at Pylon 1 for 10-20 seconds.
 - iv) Next, fly horizontally left, keeping your drone facing away from you and at head height until you reach Pylon #2.
 - v) Stop and hover at Pylon 2 for 10-20 seconds.
 - vi) Fly backwards, keeping your drone facing away from you and at head height until you reach Pylon #3.
 - vii) Stop and hover at Pylon 3 for 10-20 seconds.
 - viii) Fly horizontally right, keeping your drone facing away from you and at head height until you reach Pylon #4.
 - ix) Stop and hover at Pylon 4 for 10-20 seconds.
 - x) Fly forward until you are back over Pylon #1.
 - xi) Repeat flying horizontally from Pylons 1, 2, 3, & 4, until you can fly this smoothly while keeping the drone at head height and facing away from you.
 - xii) Return to the circle and land gently when you are done.
 - b) **3b Left Facing Square Dance:**
 - i) Turn to face to your left, with the box on your right and the drone's nose facing the same direction it was in for the forward facing Square Dance.
 - ii) Looking to your right, while keeping your body facing to the left, repeat the box pattern until you can comfortably and smoothly fly it.
 - c) **3c Rear Facing Square Dance:**

- i) Turn to face away from the box, with the box now behind you and the drone's nose facing the same direction it was in for the forward facing Square Dance.
 - ii) Looking over your shoulder, while keeping your body facing away from the box, repeat the box pattern until you can comfortably and smoothly fly it.
- d) **3d Forward Facing Square Dance-Diagonals:**
- i) Instead of making a square pattern, we are going to fly diagonally from corner to corner.
 - ii) Turn back to face the box again, with the drone's nose facing the same direction it was in previously (forward).
 - iii) This time, when you take off, you will fly a straight line to Pylon #1, while the drone continues facing the far side of the box (forward), so that you are flying at a 45-degree angle. Hover over Pylon 1 for 10-20 seconds.
 - iv) Now, fly directly to Pylon #3 and hover for 10-20 seconds.
 - v) Fly to the right to pylon #4 and hover for 10-20 seconds.
 - vi) Fly diagonally directly to Pylon #2.
 - vii) Be sure to keep your drone facing the far side of the box (forward) the entire time.
 - viii) Repeat this pattern until you can fly it comfortably and smoothly.
 - ix) Mix in flying sideways, forward and backward, and flying the diagonals.
 - x) Return to the circle and land when you are complete.
- e) **4) 360 degree Yaw:** Take off and rise to a hover. Then, using your yaw control, slowly rotate the drone 360 degrees clockwise while trying to stay in the center hover position and within the hover zone. Land gently. Repeat this maneuver rotating counterclockwise. Now, repeat this maneuver working to reduce sideways drift until you can rotate the drone completely within a space that is no more than 2x the drones diameter approximately 4 feet
- f) **5) Walking the dog hover:** Time to bring all these maneuvers together! Let's try maintaining a stable hover, while changing directions and moving.
- i) Start anywhere and take off to a hover about head height.
 - ii) Once you have a good, stable hover, start walking around, keeping your drone hovering and pointing away from you. Be sure to keep the drone about 5-10 feet in front of you as you walk. First, walk straight, then turn and eventually walk back to your starting point. Pretend your drone is on a leash and you are walking it around the area, just like a dog!

Postflight checklist

Pull up your postflight checklist and go through it.

Optional practice.

- 1) Once you are comfortable flying these maneuvers outside, you can try them inside a building. When flying outdoors, the GPS receiver does a lot of the work for you to stabilize the drone's flight. It compensates for wind and drift. When flying indoors, most buildings have lots of metal in their roofs, which prevent the GPS from getting good reception from the GPS Satellites. That means you have to manually keep adjusting the drone's position. While you don't have wind to worry about indoors, the biggest change you will see is in what happens when you let go of the joysticks. With GPS assist, the drone stops moving and hovers in place until you move the joysticks again. Without GPS assist, the drone keeps moving and you have to stop it yourself.

Let's calculate your Proficiency Points!

Note: to receive proficiency points, a designated adult must monitor and verify/score the flight maneuvers. These points can only be awarded once - no matter how many times they have been practiced. It is best to practice these maneuvers until they are mastered, then ask for an adult (not your parent/guardian) to verify/score the skills.

- 1) Basic flight maneuvers: (Up to 50 points)
- 2) Take off & Landing: (5 points)
 - a) ___ Smoothness of takeoff - did not shoot up high in the air, gentle takeoff
 - b) ___ Land near the takeoff point.
 - c) ___ Smoothness of landing - no bouncing, land upright, did not flip over
- 3) Hover: (5 points)
 - a) ___ Smoothness of takeoff - did not shoot up high in the air, gentle takeoff
 - b) ___ Stay in the hover circle.
 - c) ___ Maintain altitude while hovering.
 - d) ___ Land near the takeoff point.
 - e) ___ Smoothness of landing - no bouncing, land upright, did not flip over
- 4) Square Dance Maneuvers (20 points)
 - a) Forward facing Square Dance (5 points)
 - i) ___ Smoothness of flight
 - ii) ___ Flying over all 4 pylons
 - iii) ___ Maintain altitude and forward orientation.
 - b) Left facing Square Dance (5 points)
 - i) ___ Smoothness of flight
 - ii) ___ Flying over all 4 pylons
 - iii) ___ Maintain altitude and forward orientation.
 - c) Backward facing Square Dance (5 points)
 - i) ___ Smoothness of flight
 - ii) ___ Flying over all 4 pylons
 - iii) ___ Maintain altitude and forward orientation.
 - d) Forward facing Diagonals (5 points)
 - i) ___ Smoothness of flight
 - ii) ___ Flying straight line between diagonal pylons
 - iii) ___ Maintain altitude and forward orientation.
- 5) 360 degree Yaw: (10 points)
 - a) ___ Smoothness of takeoff - did not shoot up high in the air, gentle takeoff
 - b) ___ Drone stayed in the 10-foot circle.
 - c) ___ Good altitude control while flying.
 - d) ___ Tightness of circle. (spin around axis, vs meandering around)
 - e) ___ Landing close to the takeoff point.
 - f) ___ Smoothness of landing - no bouncing, land upright, did not flip over

6) Walking the Dog Hover: (10 points)

- a) ___ Smoothness of takeoff - did not shoot up high in the air, gentle takeoff
- b) ___ Drone stays 5-10 feet in front of them with the nose pointing away from them.
- c) ___ Good altitude control while flying.
- d) ___ Land near the takeoff point.
- e) ___ Smoothness of landing - no bouncing, land upright, did not flip over