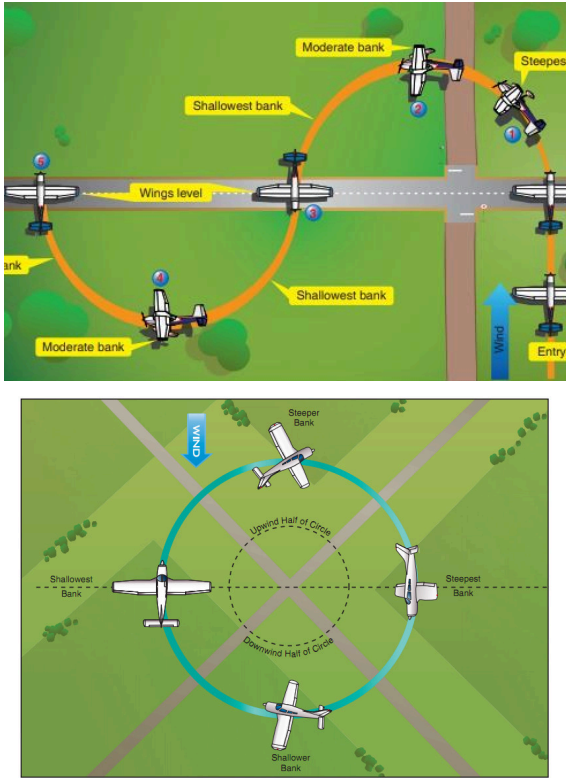


## Ground Reference Maneuvers

<p><b>Objective</b></p> <p>To ensure the applicant learns the purpose of and can exhibit a clear understanding of the three required Private Pilot ground reference maneuvers and how to perform the maneuvers properly.</p>	
<p><b>Purpose</b></p> <p>The rectangular course maneuver simulates the pattern that we will fly when landing at an airport. It introduces the concept of the airport traffic pattern, traffic pattern entry, and demonstrates the effect of wind on the airplane's ground track, as well as corrections necessary to counteract the wind. The S-Turns and Turns Around a Point maneuvers are more advanced ground reference maneuvers, demonstrating how wind greatly affects turn radius, and requiring the pilot to vary bank angle to maintain a desired ground track as the relative wind direction changes. They also build skills related to aircraft coordination through a wide range of bank angles.</p>	<p><b>Equipment</b></p>
<p><b>Schedule</b></p> <ul style="list-style-type: none"> <li>● <b>Ground Lesson:</b> 30 minutes</li> <li>● Initial <ul style="list-style-type: none"> <li>■ <b>Flight 1:</b> 60 minutes - <i>Introduction to Maneuvers</i></li> <li>■ <b>Flight 2:</b> 60 minutes - <i>Improve Proficiency (Dual)</i></li> </ul> </li> <li>● Solo <ul style="list-style-type: none"> <li>■ <b>Flight 3:</b> 40 minutes - <i>Improve Proficiency</i></li> </ul> </li> <li>● Pre-Checkride <ul style="list-style-type: none"> <li>■ <b>Flight 4:</b> 30 minutes - <i>Demonstrate Proficiency</i></li> </ul> </li> <li>● <b>Debrief:</b> 10 minutes (<i>per flight</i>)</li> </ul>	<ul style="list-style-type: none"> <li>● n/a</li> </ul>
<p><b>Student Actions</b></p> <ul style="list-style-type: none"> <li>● Ask any questions, receive study material for the next lesson.</li> <li>● Watch linked videos.</li> <li>● Review listed references.</li> </ul>	<p><b>Instructor Actions</b></p> <ul style="list-style-type: none"> <li>● Deliver the ground lesson (below).</li> <li>● Demonstrate the maneuver in flight.</li> <li>● Debrief after each flight.</li> </ul>
<p><b>Completion Standards</b></p> <ul style="list-style-type: none"> <li>● <b>Ground:</b> Student can explain the purpose of the maneuvers and how to execute them properly.</li> <li>● <b>Flight:</b> Student can perform the maneuvers to the applicable ACS standards. <ul style="list-style-type: none"> <li>● See expanded Completion Standards below.</li> </ul> </li> </ul>	

## References

- ERAUSpecialVFR - “Traffic Patterns”
  - YouTube - [https://www.youtube.com/watch?v=w\\_Bbs4K7L5U](https://www.youtube.com/watch?v=w_Bbs4K7L5U)
- ERAUSpecialVFR - “S Turns”
  - YouTube - <https://www.youtube.com/watch?v=JEVKxX3CVK4>
- ERAUSpecialVFR - “Turns Around a Point”
  - YouTube - [https://www.youtube.com/watch?v=YzNSBTxH\\_Cs](https://www.youtube.com/watch?v=YzNSBTxH_Cs)
- AIM-2024-03-21 (Aeronautical Information Manual) - Page 187-189 [Traffic Patterns, Entry]
- FAA-H-8083-3C (Airplane Flying Handbook) - Chapter 7, Page 5-7 [Rectangular Course Maneuver Description], Chapter 7, Page 8-10 [S-Turns Maneuver Description], Chapter 7, Page 7-8 [Turns Around A Point Maneuver Description]
- FAA-S-ACS-6C (Private Pilot ACS) - Area V Task B
- FAA-S-ACS-25 (CFI ACS) - Area IX Task E

## Ground Lesson Outline

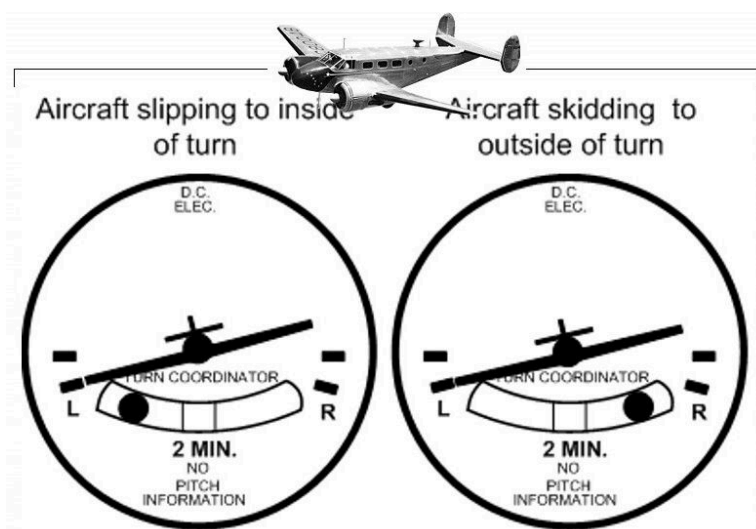
- Ground Reference Maneuvers
  - Selecting the ground references
  - Coordination
  - Safety considerations
    - Use of checklists
    - Emergency Landing Area
    - Visual traffic scanning
- The Rectangular Course
  - Heading vs. Course
  - Wind Correction Angle
  - Airport Traffic Patterns
    - Upwind, Crosswind, Downwind, Base, Final
  - Maneuver Descriptions - step-by-step and Expanded Completion Standards
- S-Turns
  - Two Loops - Downwind and Upwind, Groundspeed and Bank Angle vs. Rate/Radius of Turn
  - Maneuver Descriptions - step-by-step and Expanded Completion Standards
- Turns Around A Point
  - Two Halves - Upwind and Downwind, Groundspeed and Bank Angle vs. Rate/Radius of Turn
  - Maneuver Descriptions - step-by-step and Expanded Completion Standards

## Common Errors

- Failure to adequately clear the area above, below, and on either side of the airplane for safety hazards, initially and throughout the maneuver.
- Selection of a ground reference where there is no suitable emergency landing area within gliding distance.
- **Failure to properly assess wind direction.**
- Failure to establish a constant, level altitude prior to entering the maneuver.
- **Failure to maintain altitude or airspeed during the maneuver.**
- Failure to manipulate the flight controls in a smooth and continuous manner.
- **Failure to properly divide attention between controlling the airplane and maintaining proper orientation with the ground references.**
- Failure to execute turns with accurate timing.
- **Uncoordinated use of flight controls.**
- **Improper correction for wind drift.**

## Ground Lesson Content

- **Ground Reference Maneuvers** - These maneuvers are **ground reference maneuvers**, meaning they are performed by reference to prominent features on the ground.
  - **Selecting a Ground Reference** - It is crucial to select easy to identify ground features which are in an unpopulated area and clear of hazards on the ground. Do not choose things like houses or other occupied structures as references, as this could cause a nuisance. *Because these maneuvers are performed so close to the ground (below 1,000ft AGL), make sure that the chosen ground references are near a suitable emergency landing area, as gliding distance will be almost zero.*
  - **Coordination** - Because these maneuvers are flown close to the ground and involve turning, it is important to pay close attention to flying with proper coordination. As the airplane rolls into and out of turns, the rudder must be used to keep 'the ball' in the center. This avoids *slips* and *skids*, which create the risk of a stall or spin. The turn coordinate is shown below:

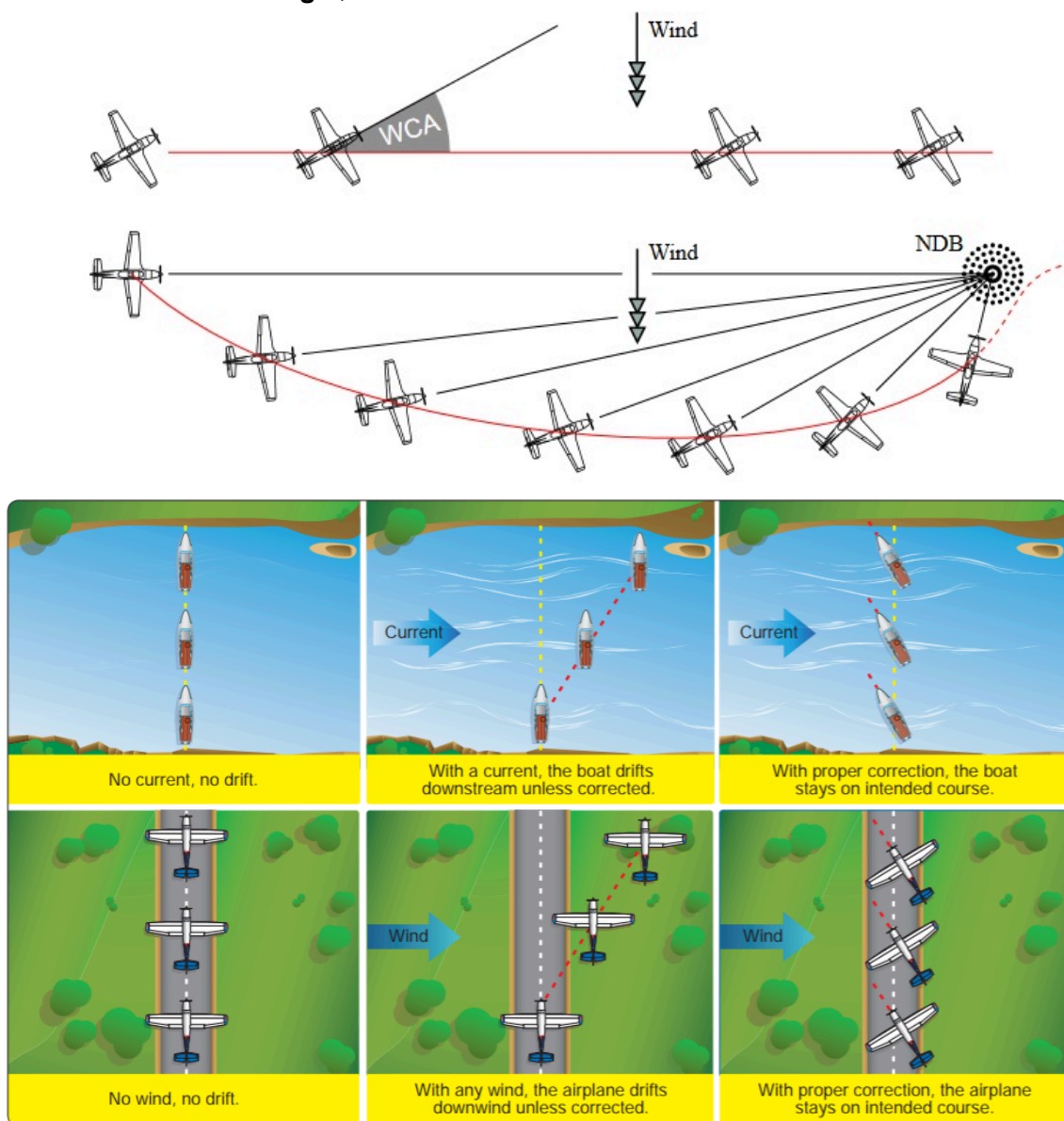


- **Safety Considerations**
  - **Checklists** - Pilots should complete a pre-maneuver checklist before beginning the maneuver.
  - **Emergency Landing Area** - Due to the risks involved with maneuvering at low altitude, pilots should select a suitable emergency landing area.
  - **Visual Traffic Scanning** - Pilots must remember to keep up their traffic scan throughout the maneuver.

## Rectangular Course

- **The Rectangular Course** - The rectangular course ground reference maneuver is a basic building block of a pilot's skillset. It is nothing more than it sounds: flying a rectangular course over the ground. The challenge of this maneuver, however, is that airplanes fly within the air, which is nearly always moving. Simply pointing at a ground landmark and flying 'towards' it will result in the airplane flying a longer, curved path. As an airplane flies through the air, in order to track a straight line, called a *course*

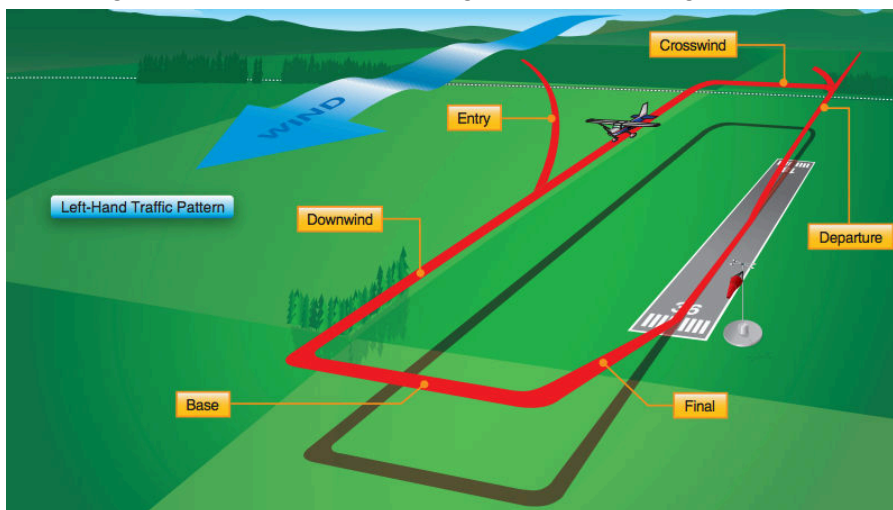
line, they must fly at an angle relative to the line which counteracts the effects of the wind. This is called a **wind correction angle**, or WCA.



- Every time an airplane lands, you can see this at work... the aircraft below must fly at an angle in order to fly directly down the runway:

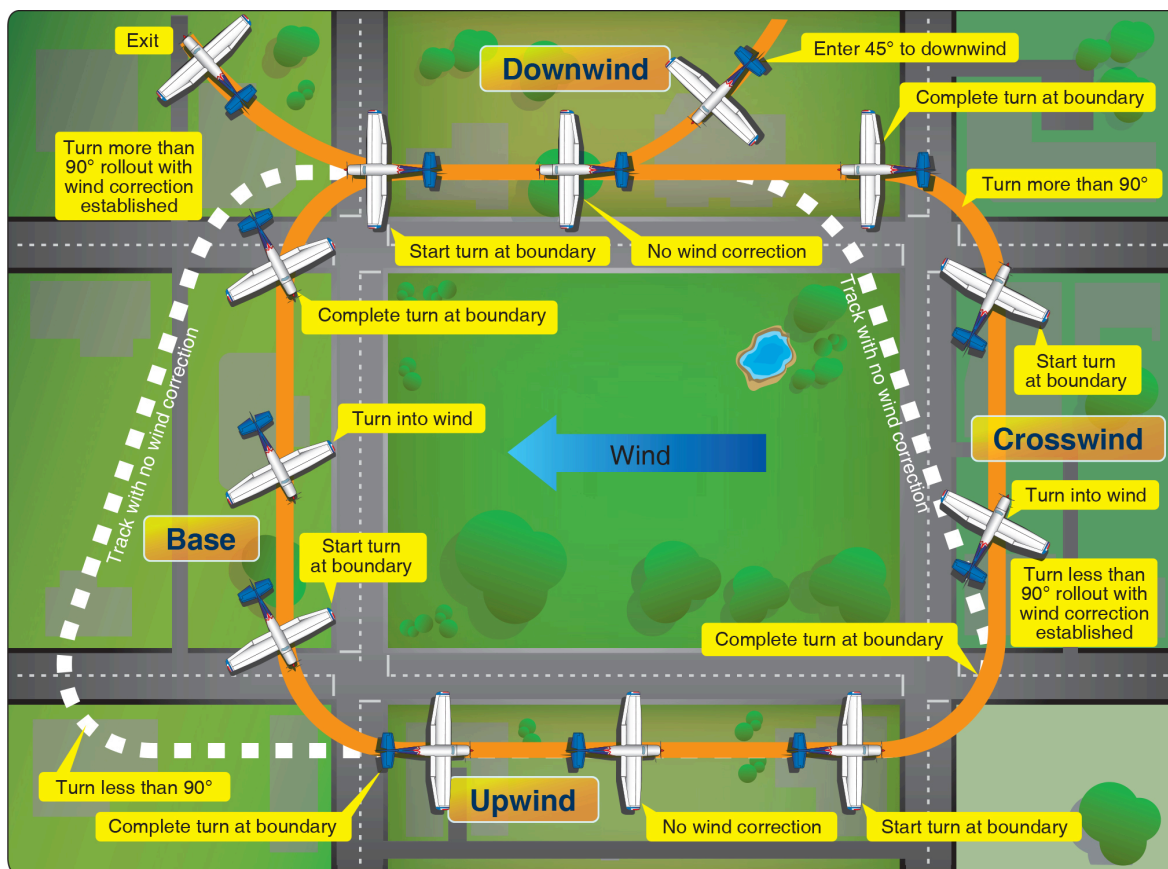


- **Airport Traffic Patterns** - The rectangular course maneuver is related to takeoff and landing. It aims to simulate the shape of something called an **airport traffic pattern**. An airport traffic pattern is simply a rectangle, with one of the long segments aligned with the runway. Imagine an airplane that would take off from a runway, and 'circle back' to land again on the same runway. Doing so would be called 'flying a pattern'. A traffic pattern is used to organize the flow of traffic taking off and landing on the same runway, and has 5 'legs':
  - **Upwind/Departure** - As the airplane takes off, the first portion of the flight, in the same direction as the runway, is called the 'upwind' or 'departure' leg. It is called this because normally airplanes choose to take off on a runway which faces into the wind.
  - **Crosswind** - As the airplane climbs, usually once it has reached 700 ft above the ground, it turns left. This is called 'crosswind', as the leg is *across* the wind.
  - **Downwind** - As the airplane continues in the pattern, it turns left again, now facing opposite of how it began. This is usually *with* the wind, meaning the wind is blowing from behind, and this is called 'downwind'.
  - **Base** - As the airplane prepares to land, it begins to descend and turns left again, once it is far enough from the landing runway. This is called the 'base' leg, because this leg is the basis for, and determines how the next, final approach leg, will be started.
  - **Final** - The airplane turns left once more to align with the runway. This is essentially the same as the 'Upwind' leg, but the airplane is landing instead of taking off.





- Because the rectangular course maneuver is flown without descending, *the Upwind and Final legs can be considered the same*. The maneuver is generally flown as a simplified form of practice for flying actual traffic patterns for takeoff and landing at an airport.
- As a simulation for an airport traffic pattern, this maneuver should be flown in a configuration similar to how one would normally fly the 'downwind' leg of a pattern: in a clean configuration, and at a moderate airspeed, usually less than cruise.
- **Fly by Reference to the Ground!** - The maneuver is a **ground reference maneuver**, meaning it is performed by reference to a prominent feature on the ground. In the case of this maneuver, this can be any large, rectangular area, in a suitable location, away from populated areas and within gliding distance of an emergency landing site.
- The maneuver is flown with the airplane remaining  $\frac{1}{2}$  to  $\frac{3}{4}$  miles *outside* of the rectangular area. The turns should be timed so that they can be completed without flying beyond the desired rectangle course.



- **Wind Correction** - The main challenge of this maneuver is determining the wind correction angle. This takes some practice, but the main task is determining the direction of the wind itself (look for smoke, flags, etc), and then visually estimating how different wind correction angles affect the ground track of the airplane by trial and error.

## Rectangular Course Maneuver Description

- **Select a Rectangular Ground Reference** - Select a prominent rectangular area, which is ideally at least  $\frac{1}{2}$  mile wide and 1 mile long, and is easy to identify. It should be in an unpopulated area with good emergency landing options and clear of hazards on the ground. Rectangular fields which are

easy to distinguish, or bounded by roads on all sides are ideal. The goal is to replicate an airport traffic pattern, and so the rectangular course should be large enough to realistically simulate this.

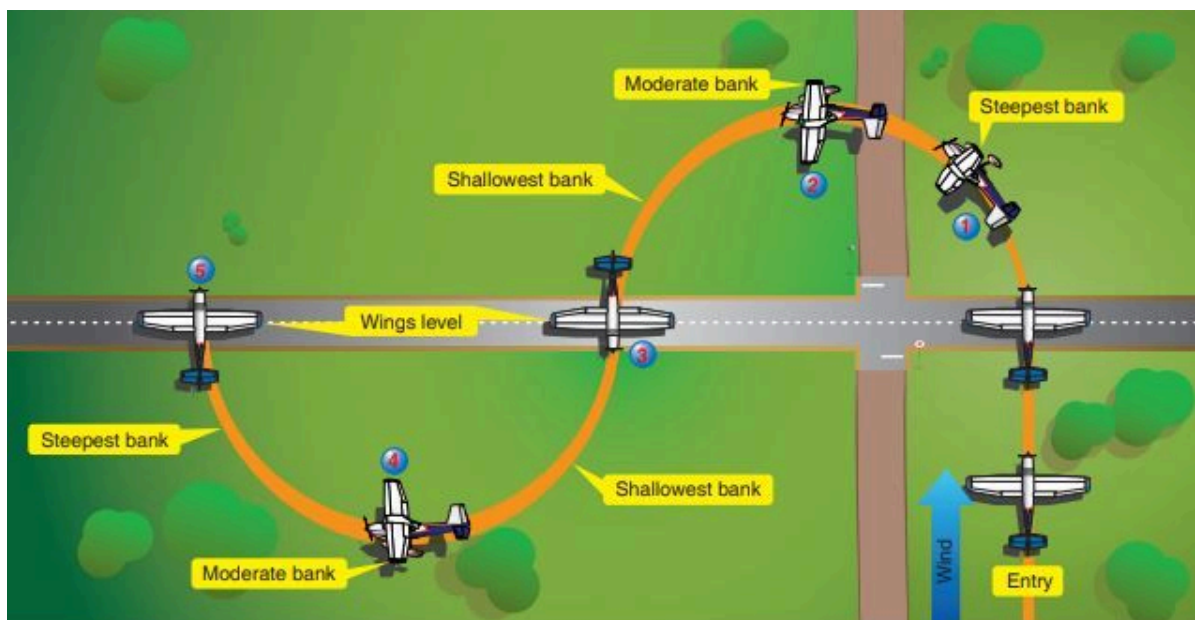
- **Entry Position and Heading** - First, the wind direction should be identified. Look for smoke, flags, or other signs of surface wind direction. If none are available, the ATIS or METAR of a local airport can be used to estimate. Plan to enter the *downwind* leg at a 45 degree angle, and when  $\frac{1}{2}$  to  $\frac{3}{4}$  of a mile from the field boundary marking the downwind, turn to join the leg.
- **Altitude** - This maneuver should be performed at **600 to 1,000ft AGL**.
- **Bank** - Since this maneuver simulates an airport traffic pattern and involves maneuvering at low altitude, the bank angle should be *less than 30 degrees*.
- **Course** - Apply wind-drift correction and track the rectangular area, **remaining  $\frac{1}{2}$  to  $\frac{3}{4}$  of a mile outside the field boundary**.
- **Airspeed** - The maneuver must be started at less than **V<sub>a</sub>** (maneuvering speed). Choose a normal level cruise flight airspeed and power setting, at least 5-10 knots below V<sub>a</sub>. Ideally, perform this at a normal traffic pattern airspeed.
- **Coordination** - The entire maneuver should be flown in coordinated flight. Attention should be given to proper rudder input during turns.
- **Recovery** - Recover to straight and level flight after making one full circuit of the rectangular area, unless specified by the instructor.
- **This is a visual maneuver!** Eyes should remain outside the cockpit as much as possible to scan for traffic and ensure proper tracking of the ground references. *In particular, this is a very low altitude maneuver. Keep a careful watch for obstructions or other ground hazards.*

## Rectangular Course Expanded Completion Standards

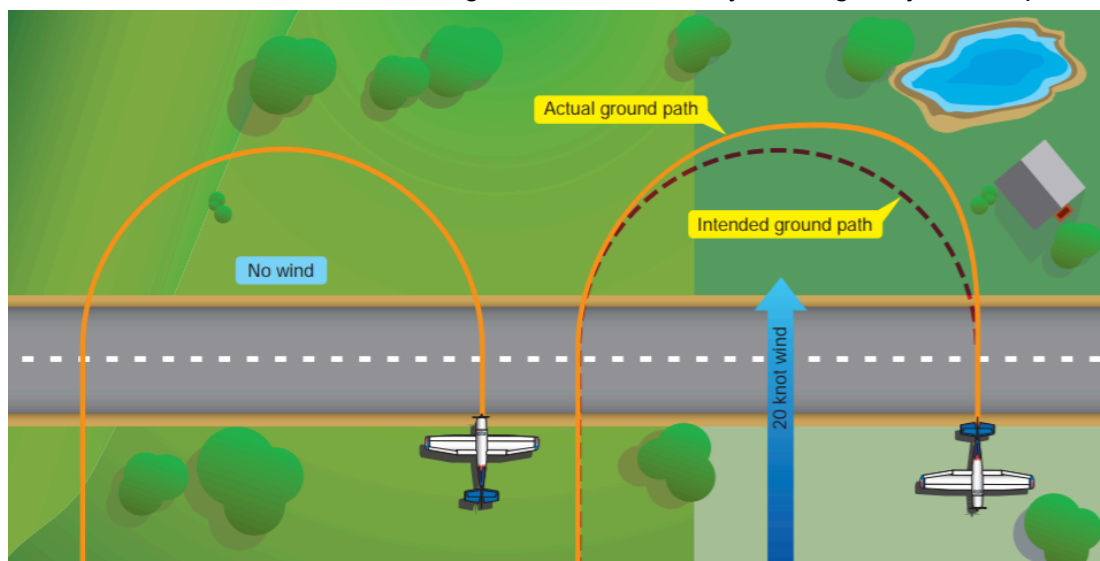
- The pilot can explain the purpose of the Rectangular Course ground reference maneuver and how the various factors affect the performance of the maneuver.
- The pilot can perform the maneuver to the following standards:
  - Pilot clears the area, performs a pre-maneuver checklist, establishes a speed *below V<sub>a</sub>*, and selects an appropriate altitude for maneuver entry, **between 600 and 1,000 feet AGL**.
  - Pilot selects a suitable ground reference area, with landmarks approximating a rectangular area.
  - Pilot enters the maneuver on a 45 degree segment to the downwind leg.
  - Pilot applies proper wind correction to maintain straight legs and flies a rectangular pattern around the ground references.
  - Pilot maintains altitude +/- 100 feet, maintains airspeed +/- 10 knots
  - Pilot divides attention between accurate, *coordinated airplane control* and outside visual references.

## S-Turns

- **S-Turns Across a Road** - The S-Turns Across a Road maneuver is a more advanced ground reference maneuver that mainly demonstrates that correcting for wind in turns requires adjusting the *bank angle*. The object of the maneuver is to fly two semicircles or 'loops' of constant radius, crossing a reference line (road, canal, etc.) with the wings level exactly at the end of each loop, and then performing a loop in the opposite direction.



- **Wind, Bank, and Rate of Turn** - During straight-and-level flight, an airplane can correct for the wind by flying at a *wind correction angle*, however during turning flight, this tactic doesn't work. Instead, the **rate of turn**, and therefore the bank angle, is used to keep the airplane flying on the desired ground track.
- As the airplane flies into the wind, or **upwind**, it flies slower over the ground, and therefore needs *less* rate of turn. As the airplane flies with the wind, or **downwind**, it needs *more* rate of turn. An airplane which does not correct for the wind during turns will instead fly an irregularly curved path:



- **Fly by Reference to the Ground!** - The maneuver is a **ground reference maneuver**, meaning it is performed by reference to a prominent line on the ground. For this maneuver, any prominent line on the ground can be chosen, as long as it is in a relatively unpopulated area. Because the maneuver will be flown close to the ground, it should be chosen within gliding distance of an emergency landing site.
- Before the maneuver can be started, the wind direction needs to be determined. Look for smoke, flags, or other indications of wind on the ground. The maneuver is started on the *downwind* portion, meaning the airplane is flying *with* the wind.



- The airplane should begin far enough away from the line so that it can be flying straight and level, directly downwind, and cross perpendicular to the line.
- **Two Loops** - The maneuver can be broken into *two loops*:
  - **Downwind** loop - Start a turn in the desired direction. Initially a **steep bank angle** is required, with the bank angle gradually reducing as the airplane approaches the 180 degree point, heading back upwind to cross the reference line again.
  - **Upwind** loop - Start a turn in the *opposite* direction. Initially a very **shallow bank angle** is required, with the bank angle gradually increasing as the airplane returns to the downwind portion, completing the loop and crossing the reference line again.
- **Symmetry** - The progress of the turn should be monitored visually, continuously glancing between the reference line to judge the symmetry of the loops and the flight instruments. The goal is to maintain the symmetric loops by continually changing the bank angle, and to maintain the same altitude and airspeed as at the beginning of the maneuver. The airplane should cross the reference line perpendicular each time.
- Any normal cruise airspeed below *maneuvering speed* ( $V_a$ ) can be chosen, and the maneuver is normally flown in the clean configuration.

## S-Turns Maneuver Description

- **Selecting a Ground Reference** - Select a prominent line feature on the ground, which is easy to identify. It should be in an unpopulated area and clear of hazards on the ground and with good emergency landing options. A long, straight road is usually a good choice.
- **Entry Position and Heading** - First, the wind direction should be identified. Look for smoke, flags, or other signs of surface wind direction. If none are available, the ATIS or METAR of a local airport can be used to estimate. Plan to enter the *downwind* portion of the maneuver, perpendicular to the reference line.
- **Altitude** - This maneuver should be performed at **600 to 1,000ft AGL**.
- **Bank** - Since this maneuver involves maneuvering at low altitude, the bank angle should be *less than 45 degrees*. It will be necessary to bank more when heading downwind, and less when heading upwind. Maintain a constant radius semicircle and cross perpendicular to the reference line again upwind. Repeat in the opposite direction.
- **Airspeed** - The maneuver must be started at less than  **$V_a$**  (maneuvering speed). Choose a normal level cruise flight airspeed and power setting, at least 5-10 knots below  $V_a$ .
- **Coordination** - The entire maneuver should be flown in coordinated flight. The varying bank angle will require more or less rudder throughout the maneuver. Attention should be given to proper rudder input during turns.
- **Recovery** - After making the number of turns requested, recover to straight and level flight.
- **This is a visual maneuver!** Eyes should remain outside the cockpit as much as possible to scan for traffic and ensure proper tracking of the ground references. *In particular, this is a very low altitude maneuver. Keep a careful watch for obstructions or other ground hazards.*

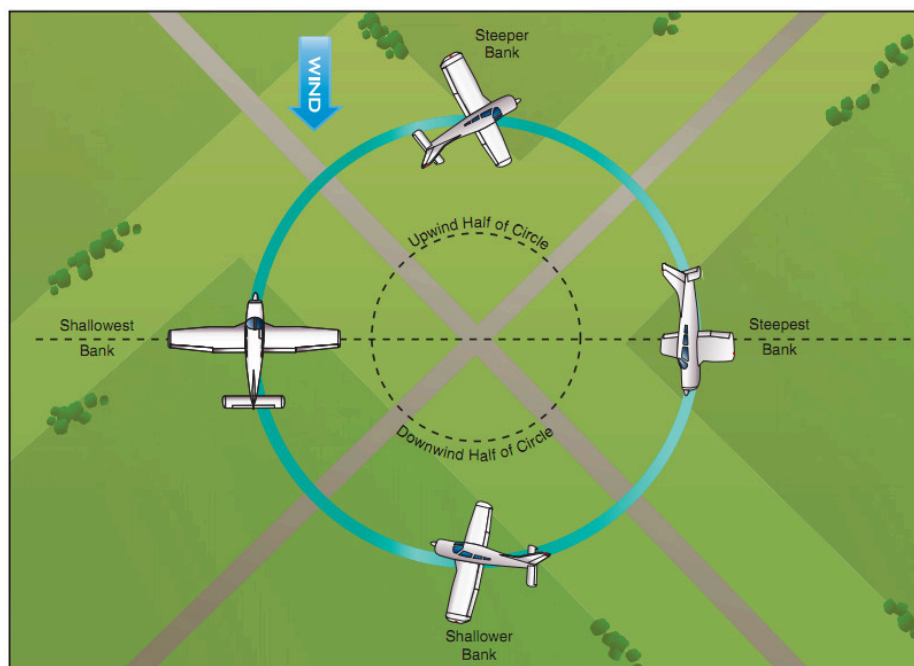
## S-Turns Expanded Completion Standards

- The pilot can explain the purpose of the S-Turns across a Road ground reference maneuver and how the various factors affect the performance of the maneuver.

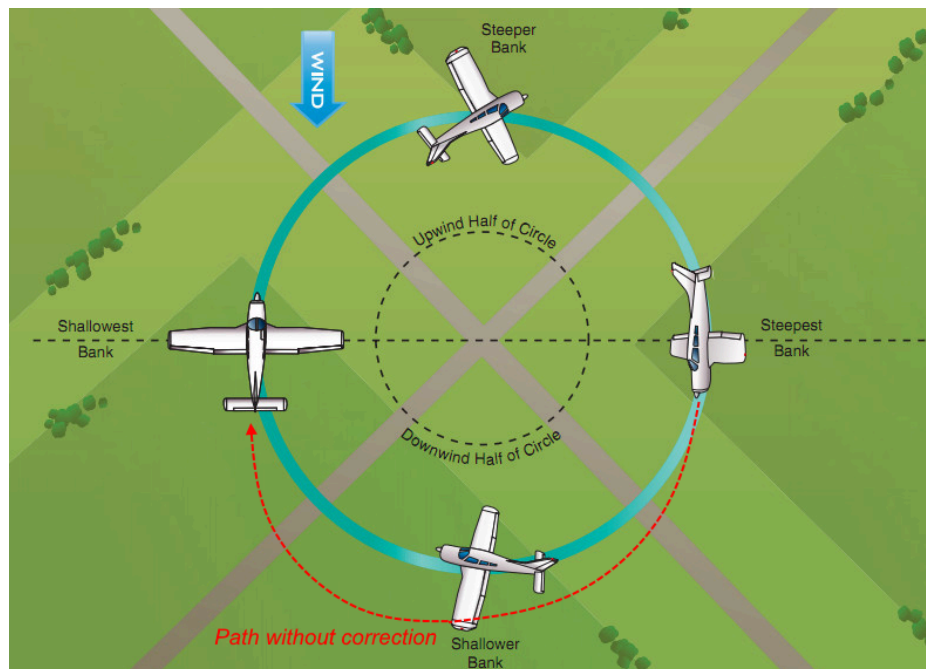
- The pilot can perform the maneuver to the following standards:
  - Pilot clears the area, performs a pre-maneuver checklist, establishes a speed *below*  $V_a$ , and selects an appropriate altitude for maneuver entry, **between 600 and 1,000 feet AGL**.
  - Pilot selects a suitable ground reference line, free from any ground hazards.
  - Pilot enters the maneuver perpendicular to the reference line.
  - Pilot applies proper wind correction by continuously adjusting the bank angle to maintain symmetrical loops and reverses turn direction directly over the reference line.
  - Pilot maintains altitude +/- 100 feet, maintains airspeed +/- 10 knots
  - Pilot divides attention between accurate, *coordinated airplane control* and outside visual references.

## Turns Around A Point

- **Turns Around A Point** - The Turns around a Point maneuver is a more advanced ground reference maneuver that mainly demonstrates that correcting for wind in turns requires adjusting the *bank angle*. The object of the maneuver is to fly a circle of constant radius, essentially just a 'perfect circle' around some prominent point on the ground.



- **Wind, Bank, and Rate of Turn** - During straight-and-level flight, an airplane can correct for the wind by flying at a *wind correction angle*, however during turning flight, this tactic doesn't work. Instead, the **rate of turn**, and therefore the bank angle, is used to keep the airplane flying on the desired ground track.
- As the airplane flies into the wind, or **upwind**, it flies slower over the ground, and therefore needs *less* rate of turn. As the airplane flies with the wind, or **downwind**, it needs *more* rate of turn. An airplane which does not correct for the wind during turns will instead fly a spiral:



- **Fly by Reference to the Ground!** - The maneuver is a **ground reference maneuver**, meaning it is performed by reference to a prominent point on the ground. For this maneuver, any prominent point on the ground can be chosen, as long as it is in a relatively unpopulated area. Because the maneuver will be flown close to the ground, it should be chosen within gliding distance of an emergency landing site.
- Before the maneuver can be started, the wind direction needs to be determined. Look for smoke, flags, or other indications of wind on the ground. The maneuver is started on the *downwind* portion, meaning the airplane is flying *with* the wind.
- The airplane should begin far enough away from the point so that it can be flying straight and level, directly downwind, and will pass approximately  $\frac{1}{4}$  mile away from the point. The point will be to the right for a right-turning circle, and to the left for a left turning circle.
- **Two Halves** - The maneuver can be broken into *two halves*:
  - **Downwind** half - Initially a **steep bank angle** is required, with the bank angle gradually reducing as the airplane approaches the 180 degree point, heading back upwind.
  - **Upwind** half - Initially a very **shallow bank angle** is required, with the bank angle gradually increasing as the airplane returns to the downwind portion, completing the circle.
- **Symmetry** - The progress of the turn should be monitored visually, continuously glancing between the reference point and the flight instruments. The goal is to maintain the  $\frac{1}{4}$  mile distance from the point (making a symmetrical circle) by continually changing the bank angle, and to maintain the same altitude and airspeed as at the beginning of the maneuver.
- Any normal cruise airspeed below *maneuvering speed* ( $V_a$ ) can be chosen, and the maneuver is normally flown in the clean configuration.

## Turns Around A Point Maneuver Description

- **Selecting a Ground Reference** - Select a prominent point, which is easy to identify. It should be in an unpopulated area and clear of hazards on the ground. A road intersection is usually a good choice. Do not choose things like houses or other structures as references, as this could cause a nuisance. *Because this maneuver is performed so close to the ground (below 1,000ft AGL), make sure that the*

*chosen ground reference is near a suitable emergency landing area, as gliding distance will be almost zero.*

- **Entry Position and Heading** - First, the wind direction should be identified. Look for smoke, flags, or other signs of surface wind direction. If none are available, the ATIS or METAR of a local airport can be used to estimate. Plan to enter the *downwind* portion of the circle, about ¼ mile abeam the point.
- **Altitude** - This maneuver should be performed at **600 to 1,000ft AGL**.
- **Bank** - Since this maneuver involves maneuvering at low altitude, the bank angle should be *less than 45 degrees*. It will be necessary to bank more when heading downwind, and less when heading upwind. Maintain a constant radius circle over the point.
- **Airspeed** - The maneuver must be started at less than **V<sub>a</sub>** (maneuvering speed). Choose a normal level cruise flight airspeed and power setting, at least 5-10 knots below V<sub>a</sub>.
- **Coordination** - The entire maneuver should be flown in coordinated flight. The varying bank angle will require more or less rudder throughout the maneuver. Attention should be given to proper rudder input during turns.
- **Recovery** - After completing the maneuver, usually at least 2 circles, recover to straight and level flight.
- **This is a visual maneuver!** Eyes should remain outside the cockpit as much as possible to scan for traffic and ensure proper tracking of the ground references. *In particular, this is a very low altitude maneuver. Keep a careful watch for obstructions or other ground hazards.*

## Turns Around A Point Expanded Completion Standards

- The pilot can explain the purpose of the Turns Around a Point ground reference maneuver and how the various factors affect the performance of the maneuver.
- The pilot can perform the maneuver to the following standards:
  - Pilot clears the area, performs a pre-maneuver checklist, establishes a speed *below V<sub>a</sub>*, and selects an appropriate altitude for maneuver entry, **between 600 and 1,000 feet AGL**.
  - Pilot selects a suitable ground reference point, free from any ground hazards.
  - Pilot enters the maneuver approximately ¼ mile from the reference point.
  - Pilot applies proper wind correction by continuously adjusting the bank angle to maintain a constant radius circle directly around the reference point.
  - Pilot flies two circles around the point.
  - Pilot maintains altitude +/- 100 feet, maintains airspeed +/- 10 knots
  - Pilot divides attention between accurate, *coordinated airplane control* and outside visual references.