

Private Pilot (ASEL) Ground School Course

Lesson 22 | Electronic and Visual Navigation

Chester County
Aviation



Lesson Overview

Lesson Objectives:

- Develop knowledge and operational understanding of VOR's.

Lesson Completion Standards:

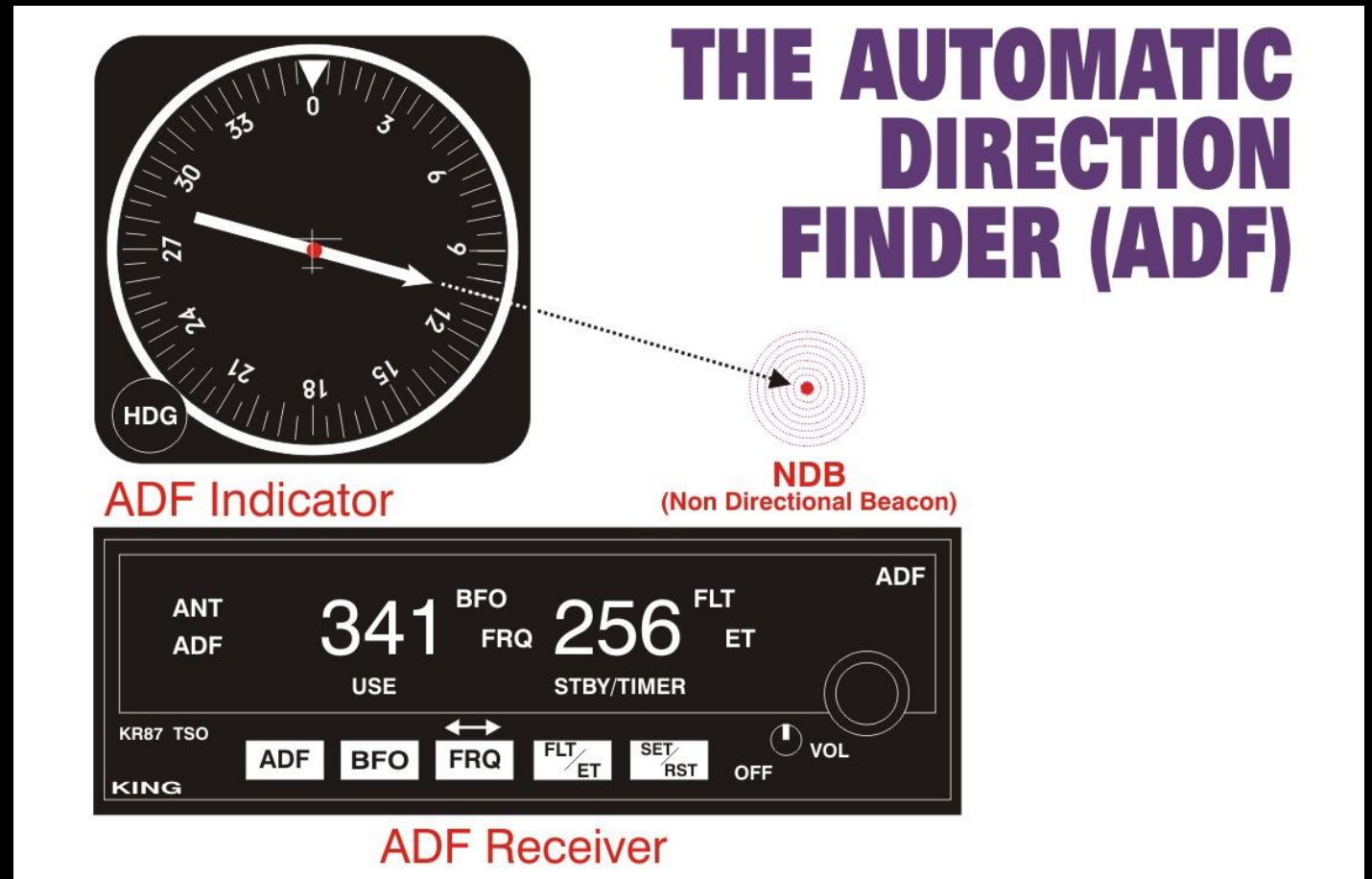
- •Student demonstrates satisfactory knowledge of electronic and visual navigation by answering questions and actively participating in classroom discussions.
- Students can describe how to recover from being lost while navigating through a classroom discussion.

NDB/ADF

Electronic and Visual Navigation

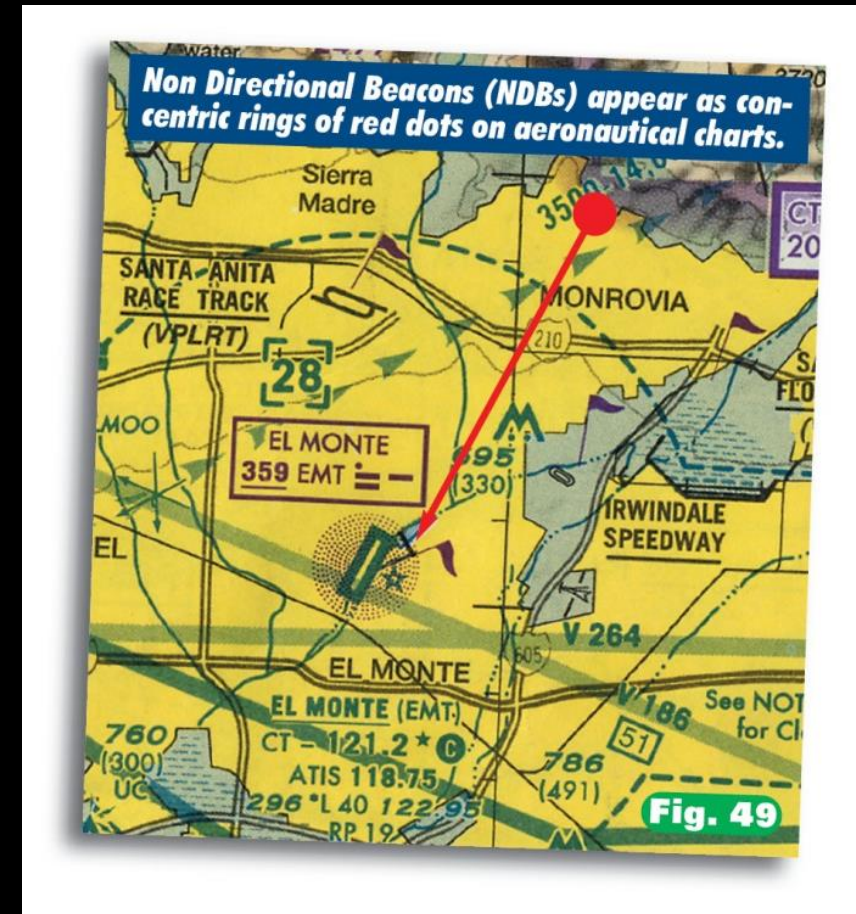
Automatic Direction Finder

- Points to L/MF Non-Directional Beacons (NDB)
- Was used for NDB navigation and approaches



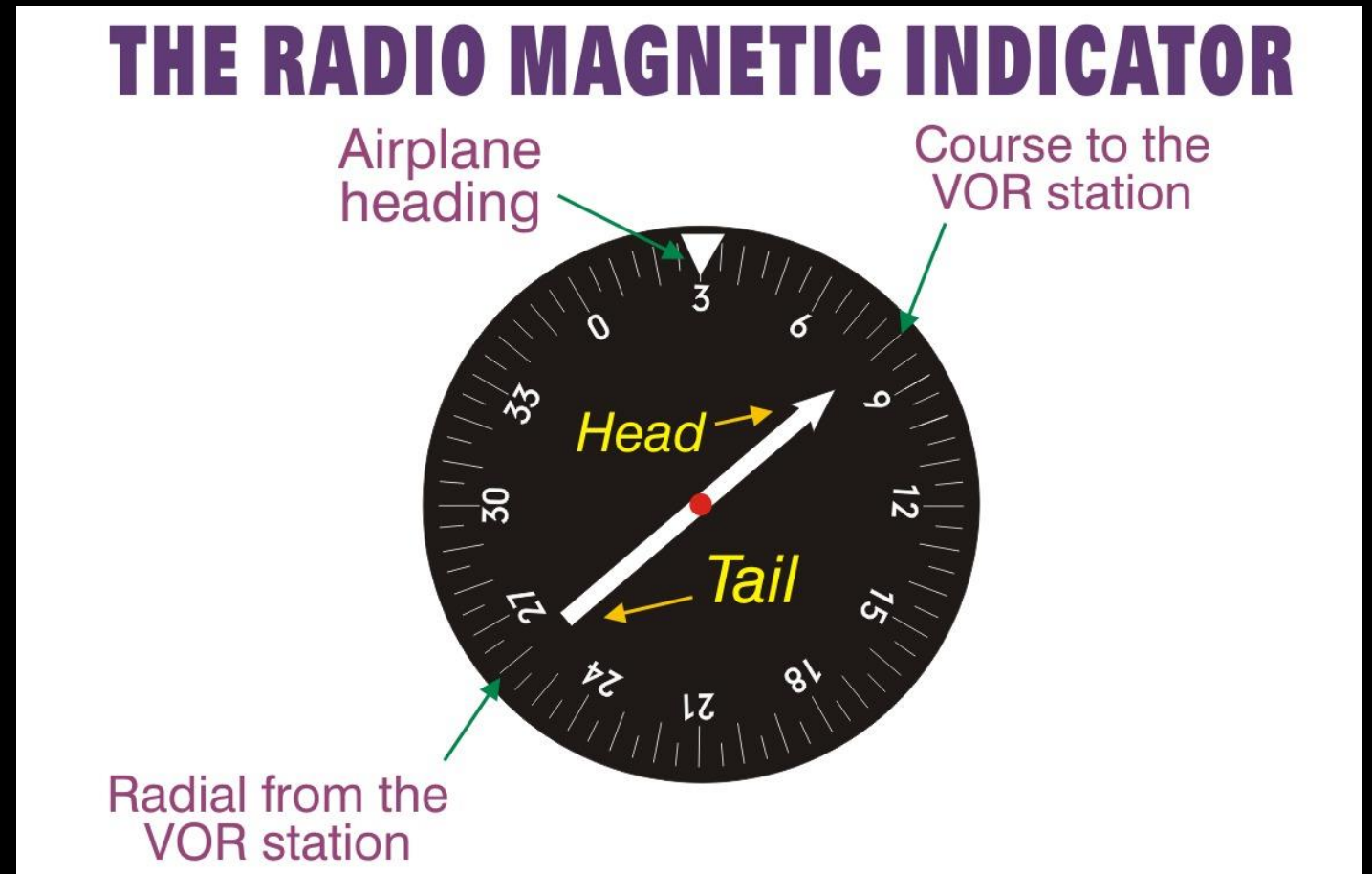
Non-Directional Beacons (NDBs)

- Concentric rings of red dots on sectional chart



Radio Magnetic Indicator (RMI)

- Gyro slaved heading
- Head points to VOR station or NDB
- Tail indicates VOR radial you are on
- Can be used for ADF and VOR



VHF Omnirange (VOR)

Electronic and Visual Navigation

VHF
Omnidirectional
Range
Ground Station

- In use since the late 1940's
- Emits a signal that is received and displayed in the cockpit
- Enables pilots to navigate to or from any of the hundreds of VOR stations
- Paths between VOR stations are electronic highways called Victor Airways

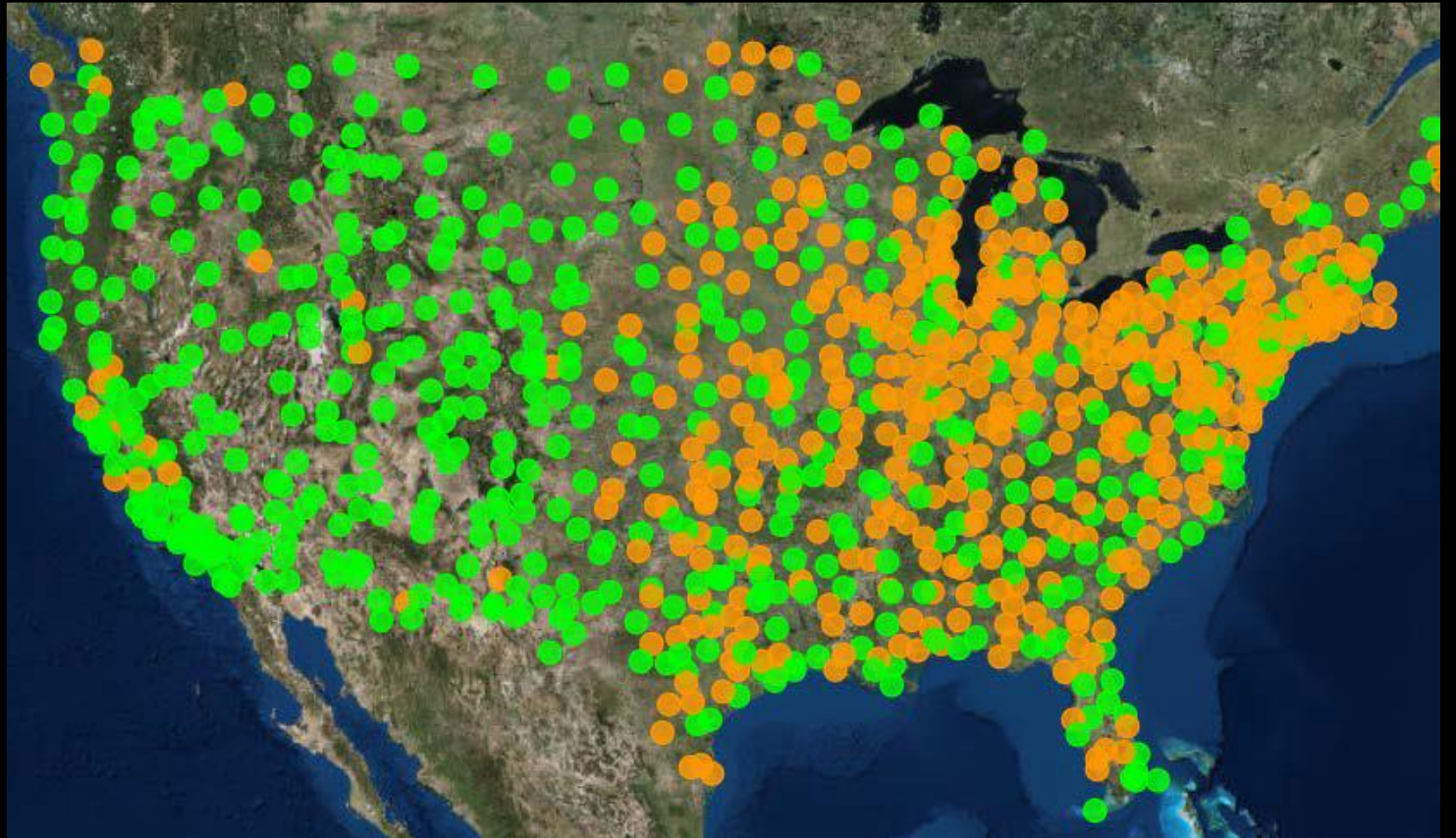


VOR Navigation

- In spite of the widespread use of GPS, much of the IFR enroute environment is based on airways defined by VOR facilities
- Even if VOR facilities are eventually replaced as the primary tool of instrument navigation, the displays you use to track a course will continue to look and work much like VOR indicators

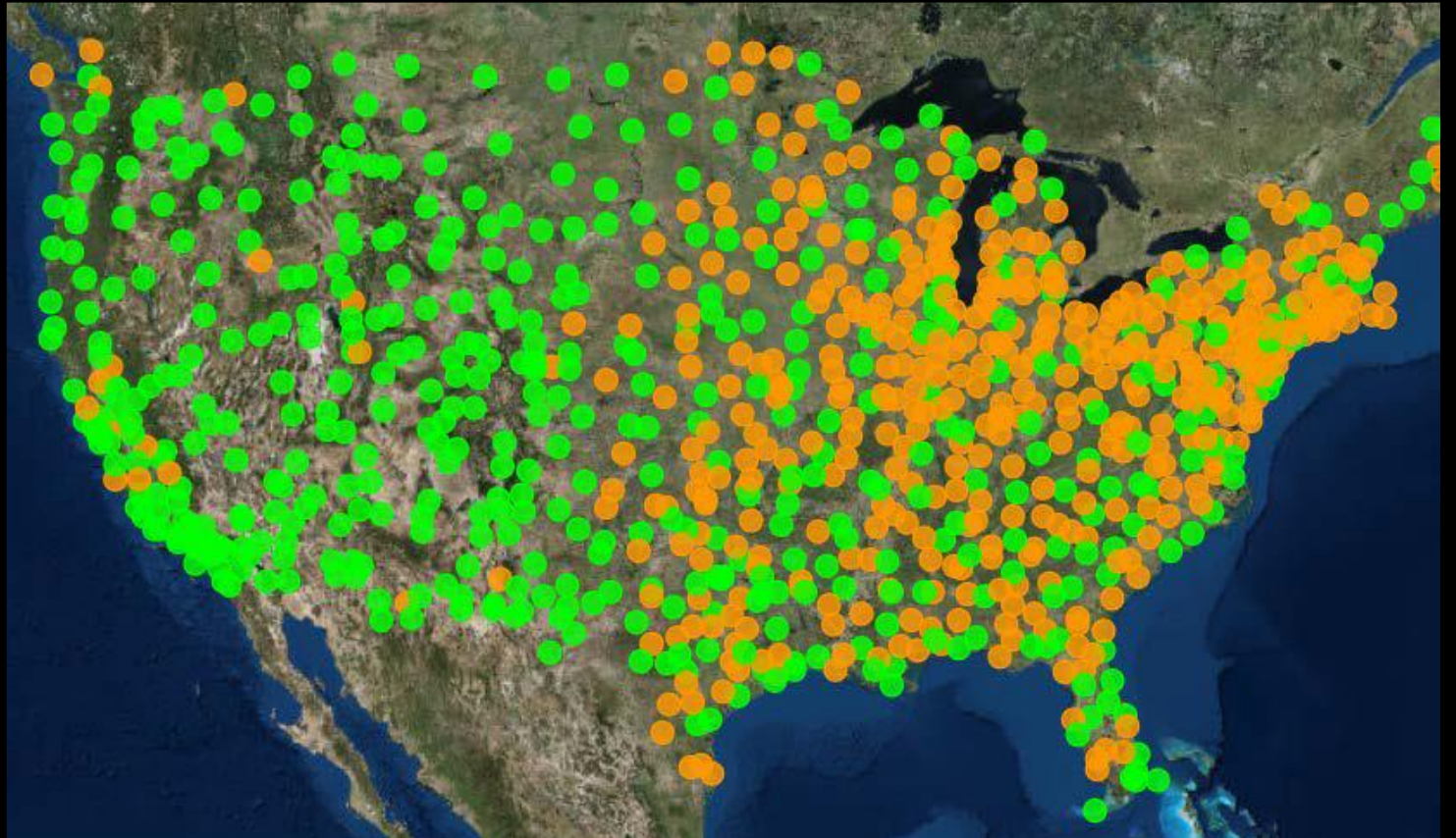
VOR Minimum Operational Network (MON)

- GPS is the preferred mode of navigation
- VOR navigation is a backup in case the GPS fails
- VOR system is being reduced in size via a program known as MON or Minimum Operational Network



VOR Minimum Operational Network (MON)

- Provides a conventional navigation backup service in the event of a loss of GPS signals
- Includes the minimum number of geographically situated VORs in the contiguous US necessary to provide coverage at and above 5,000 feet AGL



VOR Navigation

- *Requires two things:*
- 1. A ground transmitting station
- 2. Airborne VOR equipment

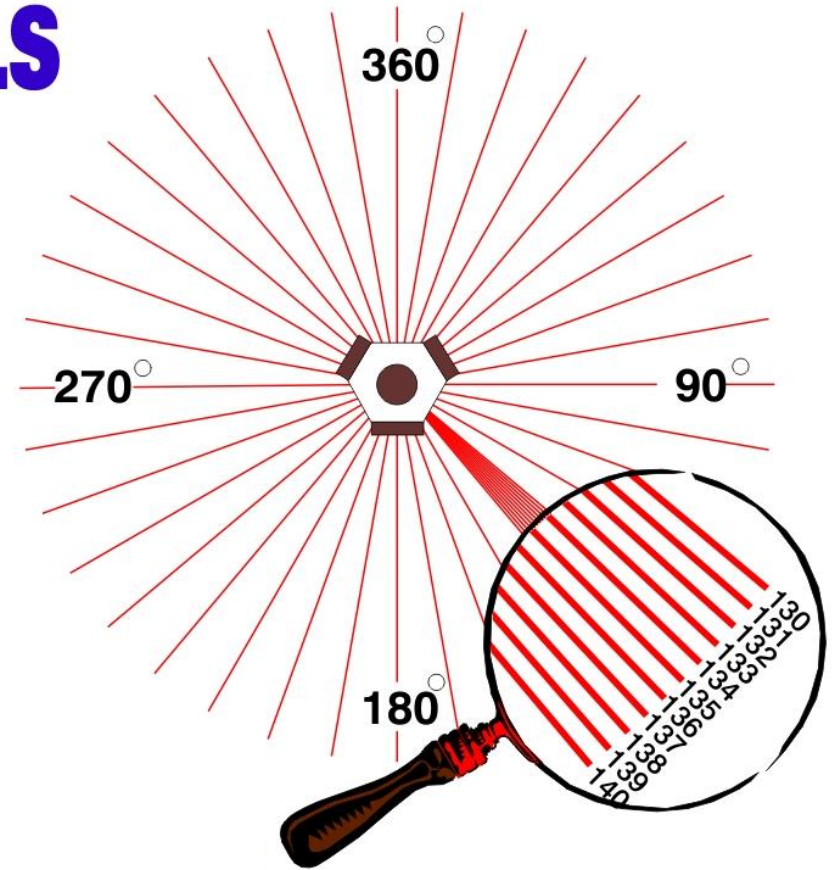


VOR Radials

- Ground transmitter radiates 360 electronic spokes *from* its center called radials
- Since there are 360° degrees in the compass rose, there are 360 specific signals radiating from the station
- Each radial (away from the station) represents one degree on the compass, with 0° due north from the station
- Pilots can navigate either directly *to* or *from* a VOR station on any of its 360 radials

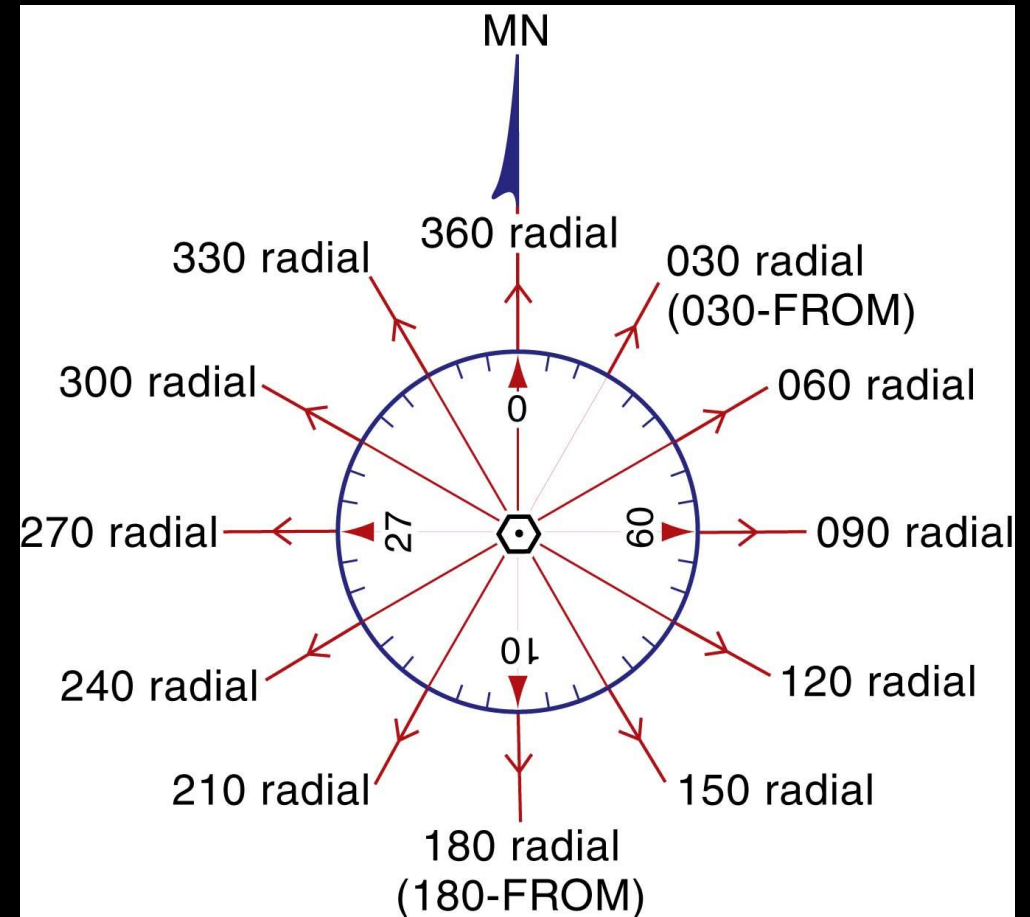
VOR RADIALS

Think of the VOR as a transmitter that radiates 360 individual radials from its center. These radials are oriented to the magnetic north pole. You may navigate to or from the station on any of these radials via your airborne VOR equipment.



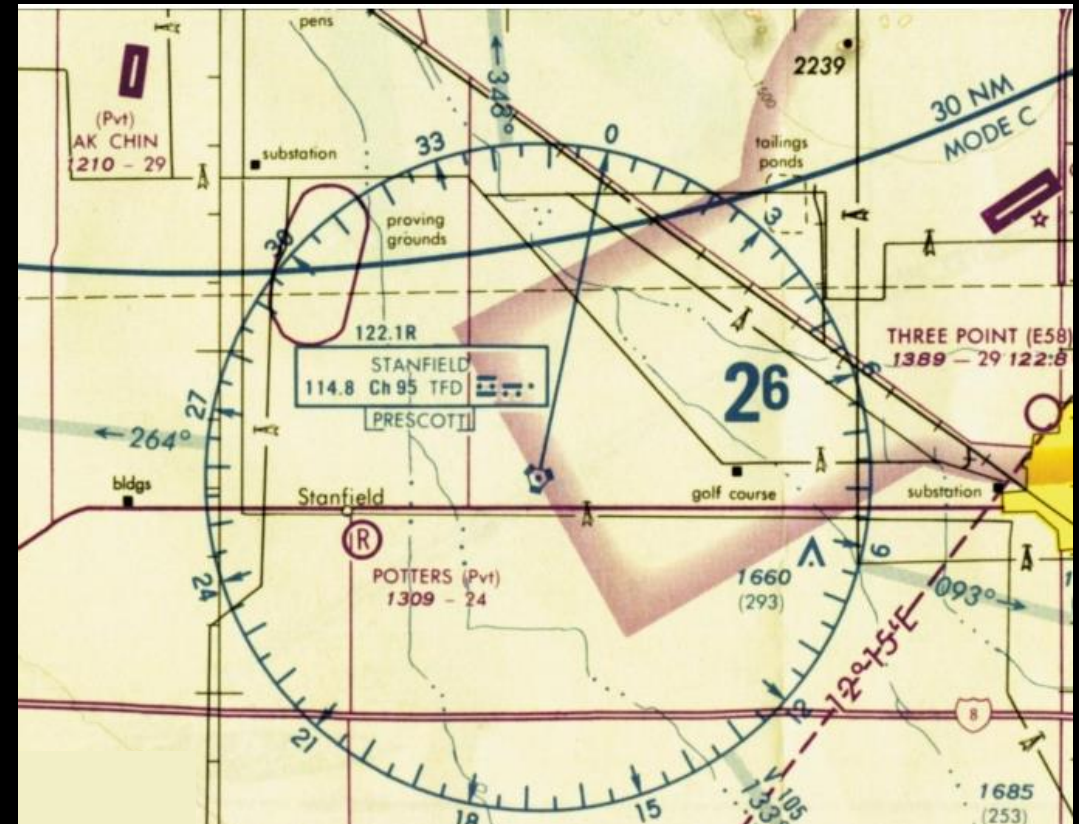
Radials Radiate FROM a VOR Ground Station

- Ground station transmits specific directional signals for every degree of the compass *from* the station
- VOR radials are referenced from Magnetic North



VOR Station on Sectional Chart

- VOR compass rose on a sectional chart
- VOR station is in the middle of the surrounding compass rose
- VOR name, frequency, and its Morse code identifier are shown in the box
 - Each VOR station transmits its signals on frequencies ranging from 108.0 to 117.95 MHz
 - These frequencies are just below the VHF frequencies used for aircraft communications (118.0 to 135.975 MHz)

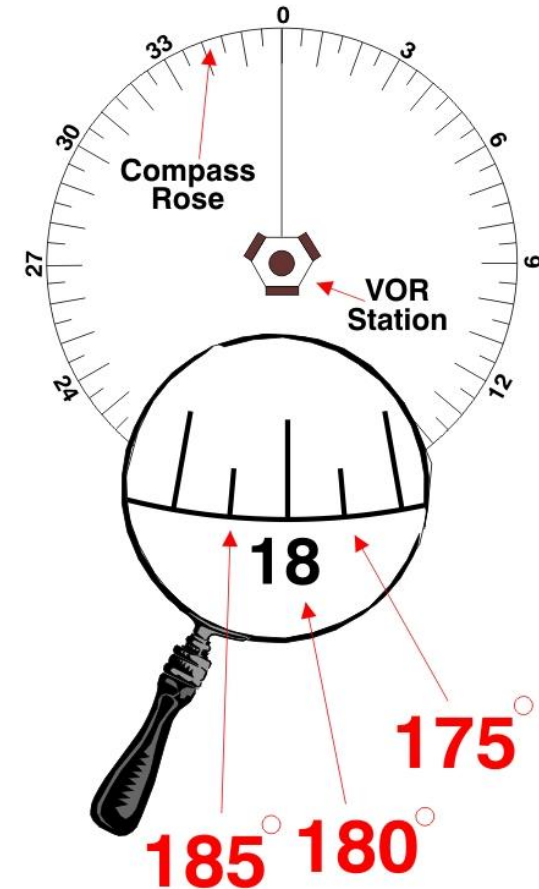


VOR Compass Rose

- Individual radials aren't shown on charts
- Can be approximated by using the outer ring of the compass rose
- Rose has a marking every 5°, a larger marking every 10°, and numbers every 30°

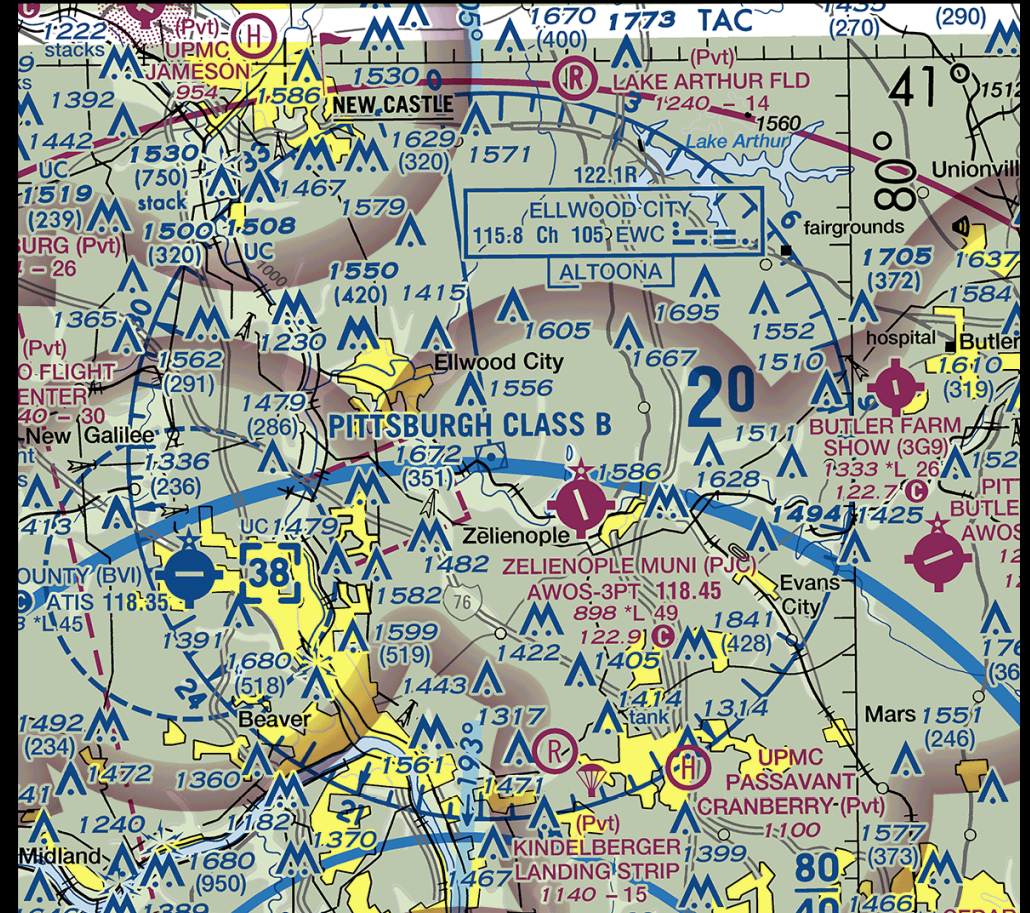
VOR COMPASS ROSE

The VOR compass rose has markings every 5 degrees, with larger markings at 10 degree increments. Additionally, the compass rose is numbered at 30 degree increments.



EWC VOR Box on Sectional Chart

- Name: Ellwood City
- Frequency: 115.8
- Identifier: EWC
- Morse code shown for EWC



Morse Code Identifier

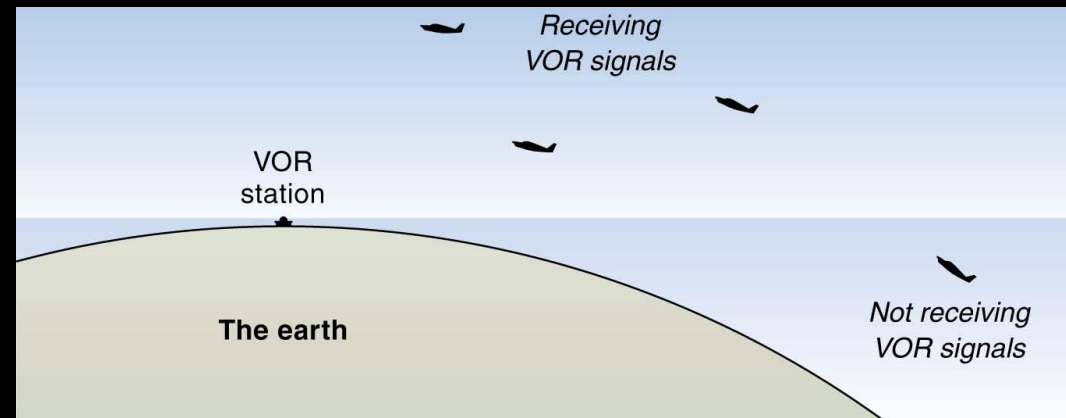
- Allows you to positively confirm the station identification
- Just because a frequency is tuned in and showing on the display does not absolutely guarantee you are receiving that frequency
- Listen on the VOR receiver to match the dots and dashes you hear with those on the chart
- Some VOR stations also have a repetitive voice identification along with the Morse Code

Morse Code Identifier

- Stations sometimes malfunction, or taken off the air for maintenance
- Absence of a Morse identifier, or the broadcast of a TEST code indicates the VOR is not reliable for navigation
- *Never use a VOR for navigation unless it has been positively identified*

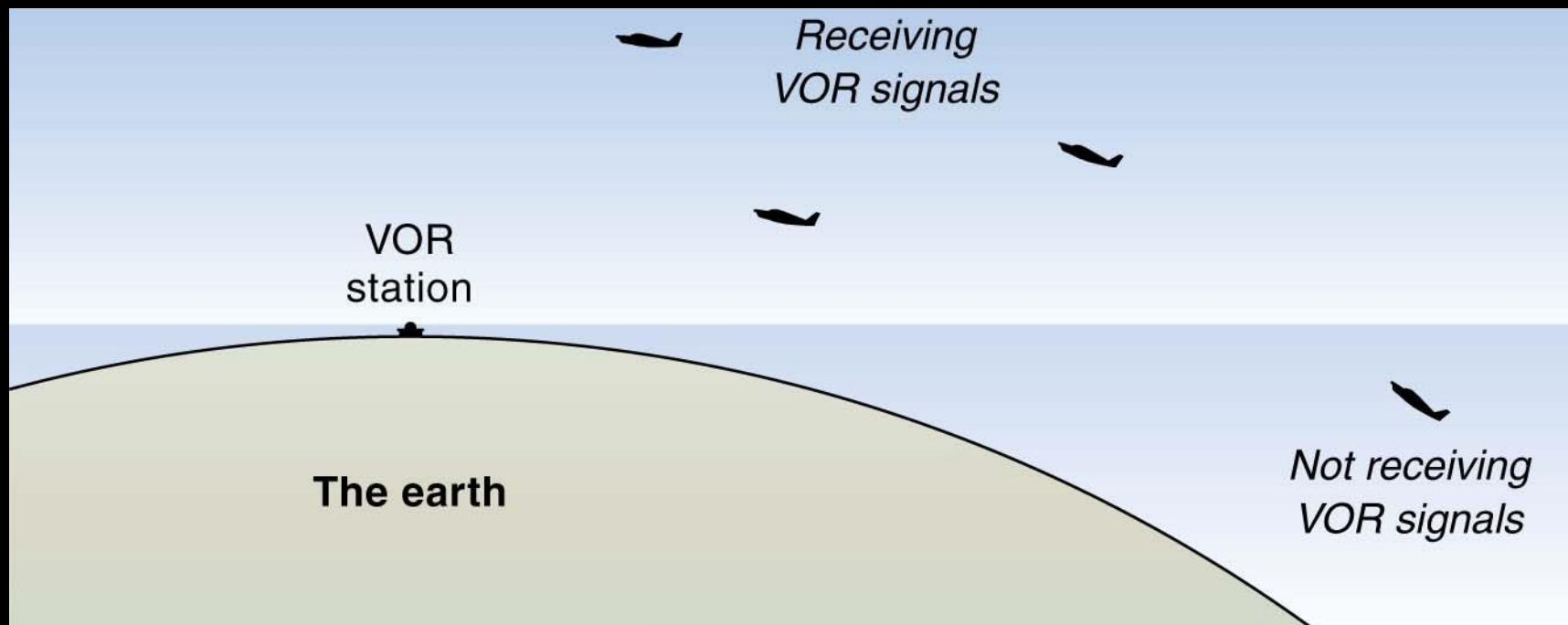
Operational Considerations

- VORs operate on VHF frequencies which do not bend or curve around obstacles
- Signal depends on line of sight
- If there isn't a clear path from transmitter to receiver, the signal can't get through
- Signal can be lost if mountains, hills, or even buildings are between you and the VOR station



Operational Considerations

- The onboard VOR equipment's OFF flag will be activated
- Adequate reception is only assured when you hear the audio identification with no OFF flag visible



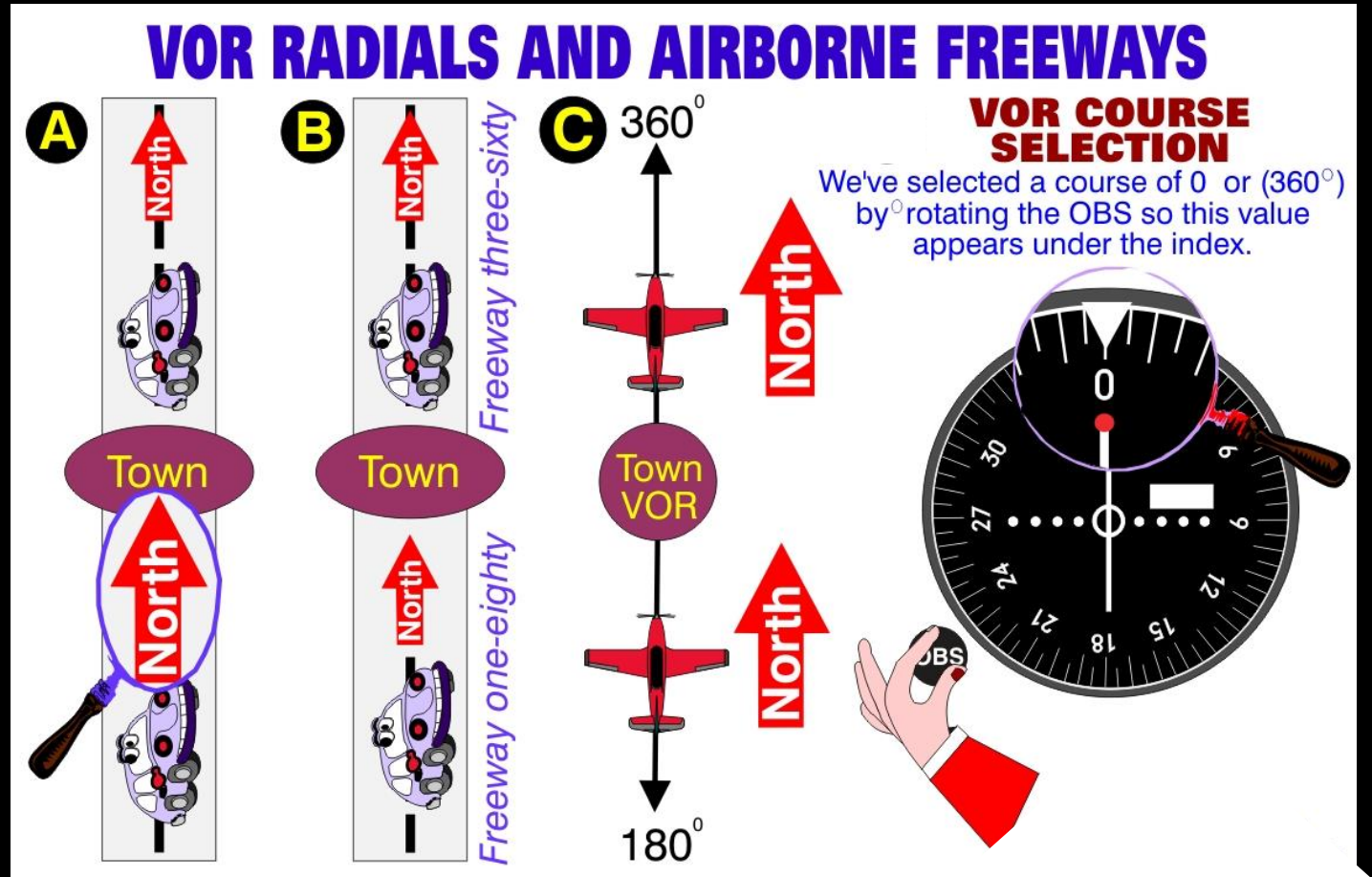
VOR Receiver With Indicator

- Airplanes usually have one or more VOR receivers on board
- Usually, a combination of a navigation receiver and a communications transmitter receiver in one package
- Referred to as the navcomm
- The VOR receiver is connected to the VOR indicator



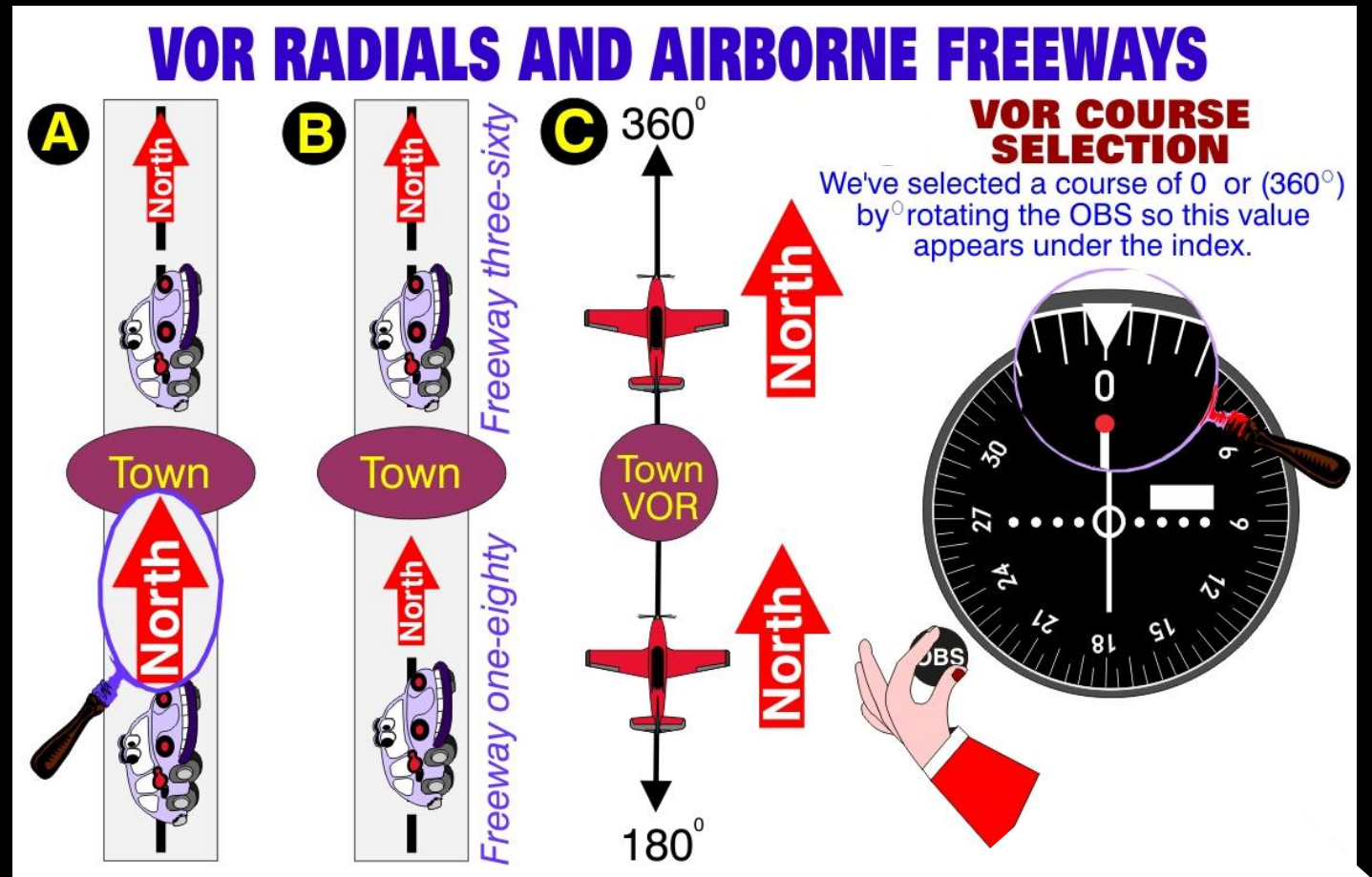
Airborne Freeways

- The freeway is pointed due north as it passes straight through town
- While entering and leaving town the car points north (360°) in the same direction as the freeway



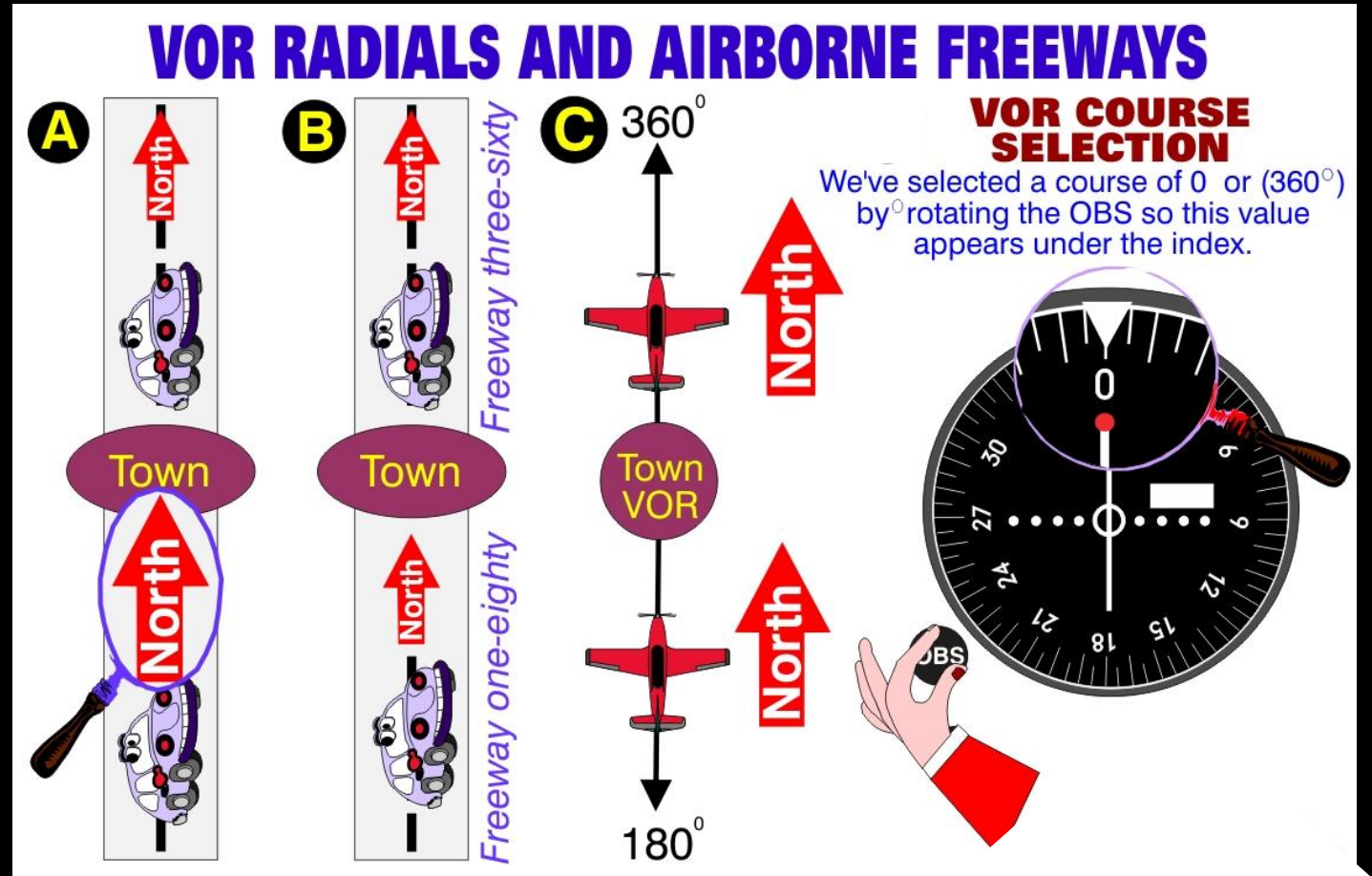
Airborne Freeways

- Name the portion of the freeway exiting the town to the south Freeway 180
- Name the portion exiting to the north Freeway 360
- Car entered town on Freeway 180 and exited town on Freeway 360
- The cars direction never changed despite giving the freeway different names



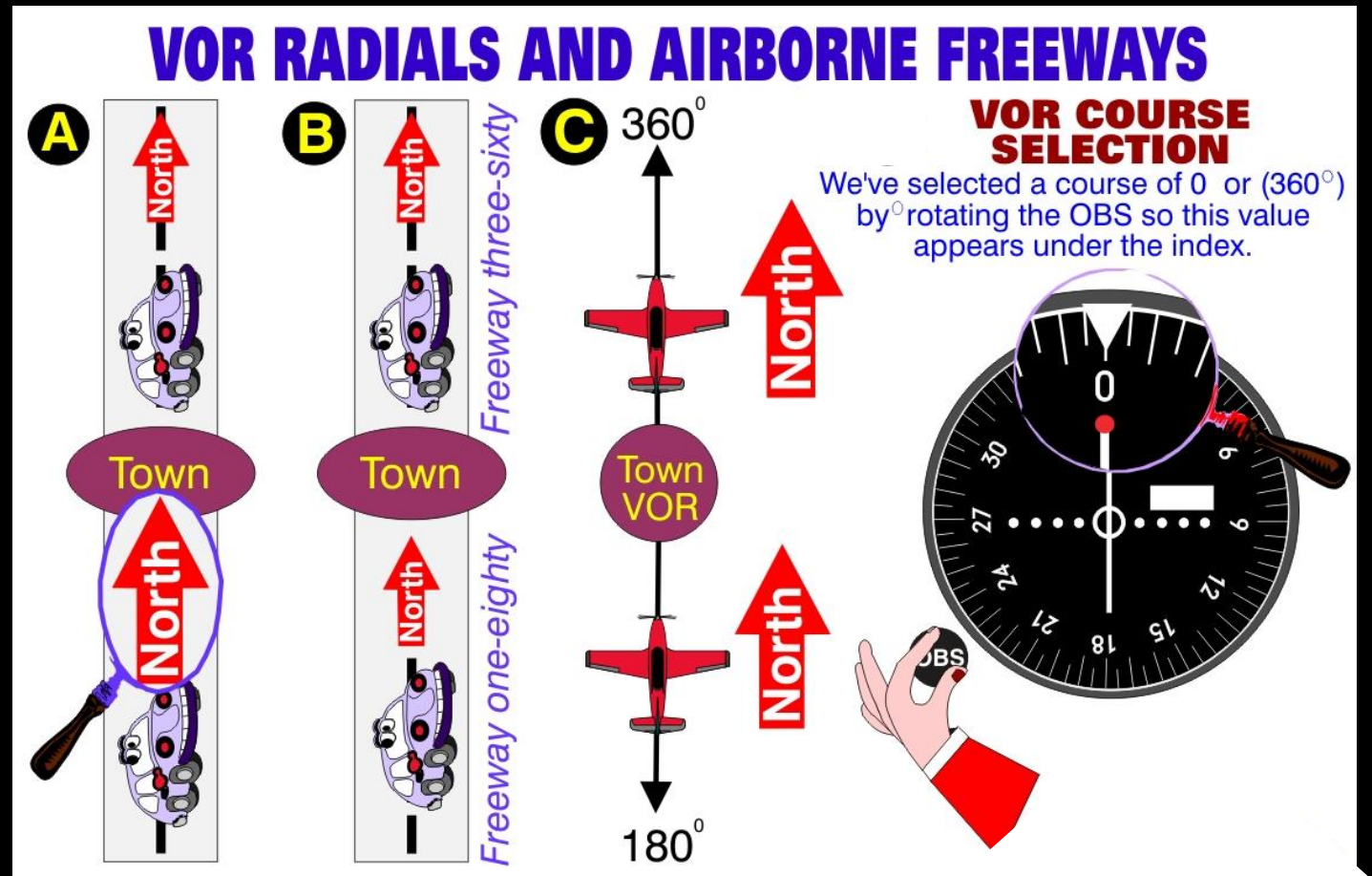
Airborne Freeways

- Navigation by VOR is the same
- If headed northbound to the Town VOR, we travel inbound on the 180° radial and outbound on the 360° radial
- The airborne freeway points in a direction of 360°



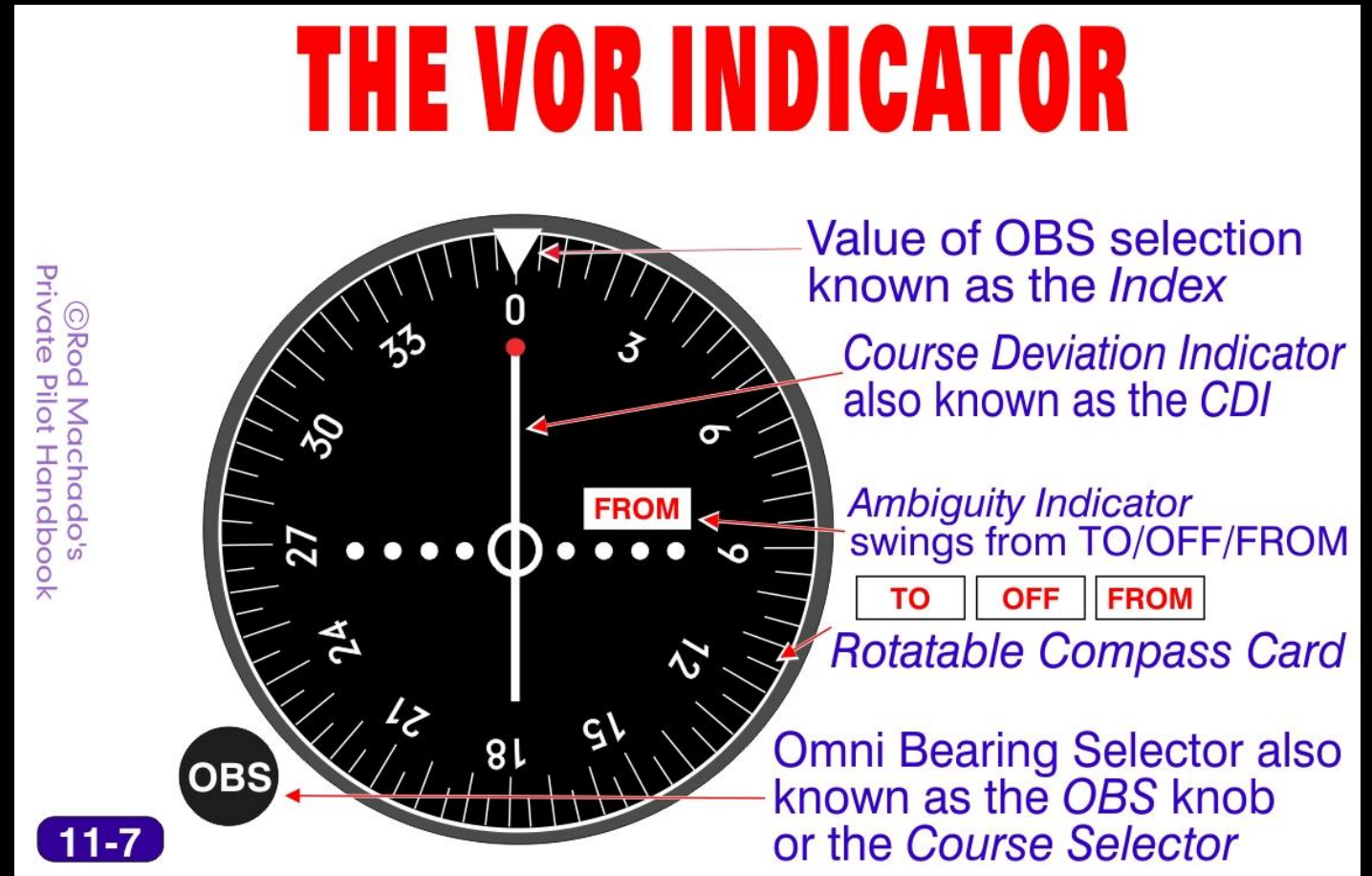
Airborne Freeways

- Refer to the freeways as courses
- The course is the direction the airborne freeway points (360°)



VOR Indicator

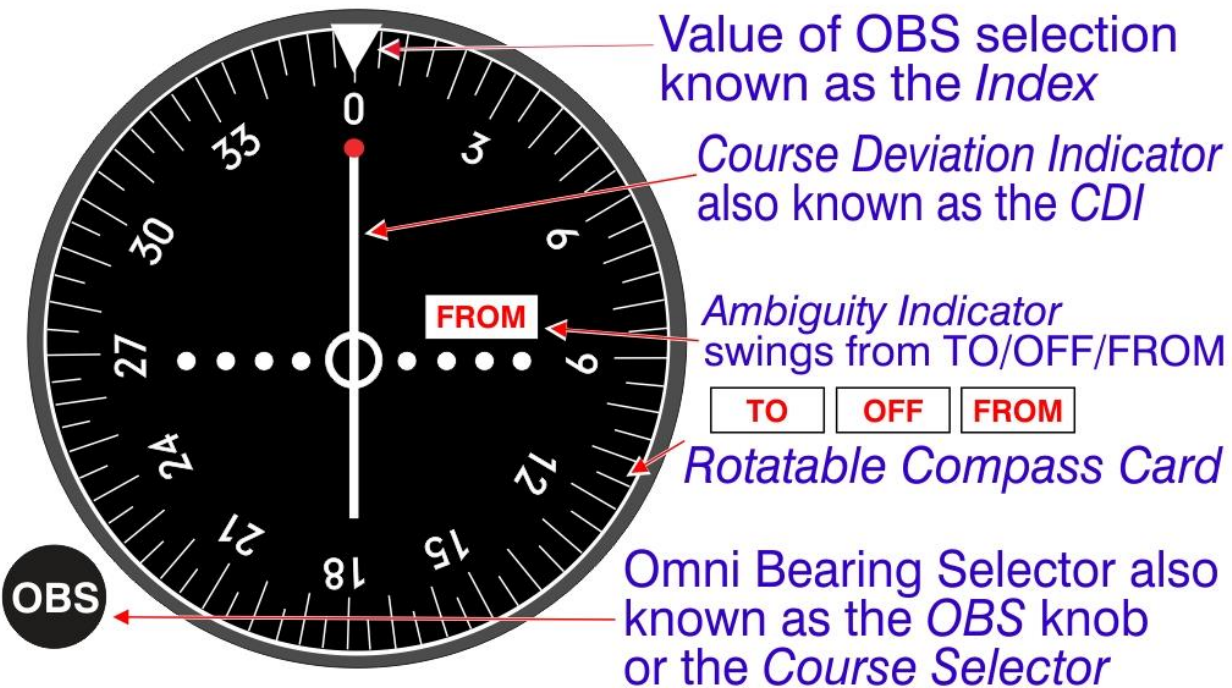
- Display is a graphic representation of what the radio receiver is receiving
- *Consists of:*
- Vertical needle (course deviation indicator, or CDI) that swings right or left
- Flag (ambiguity indicator) with three possible indications: TO, FROM or OFF
- Omni bearing selector (OBS knob)



VOR Indicator

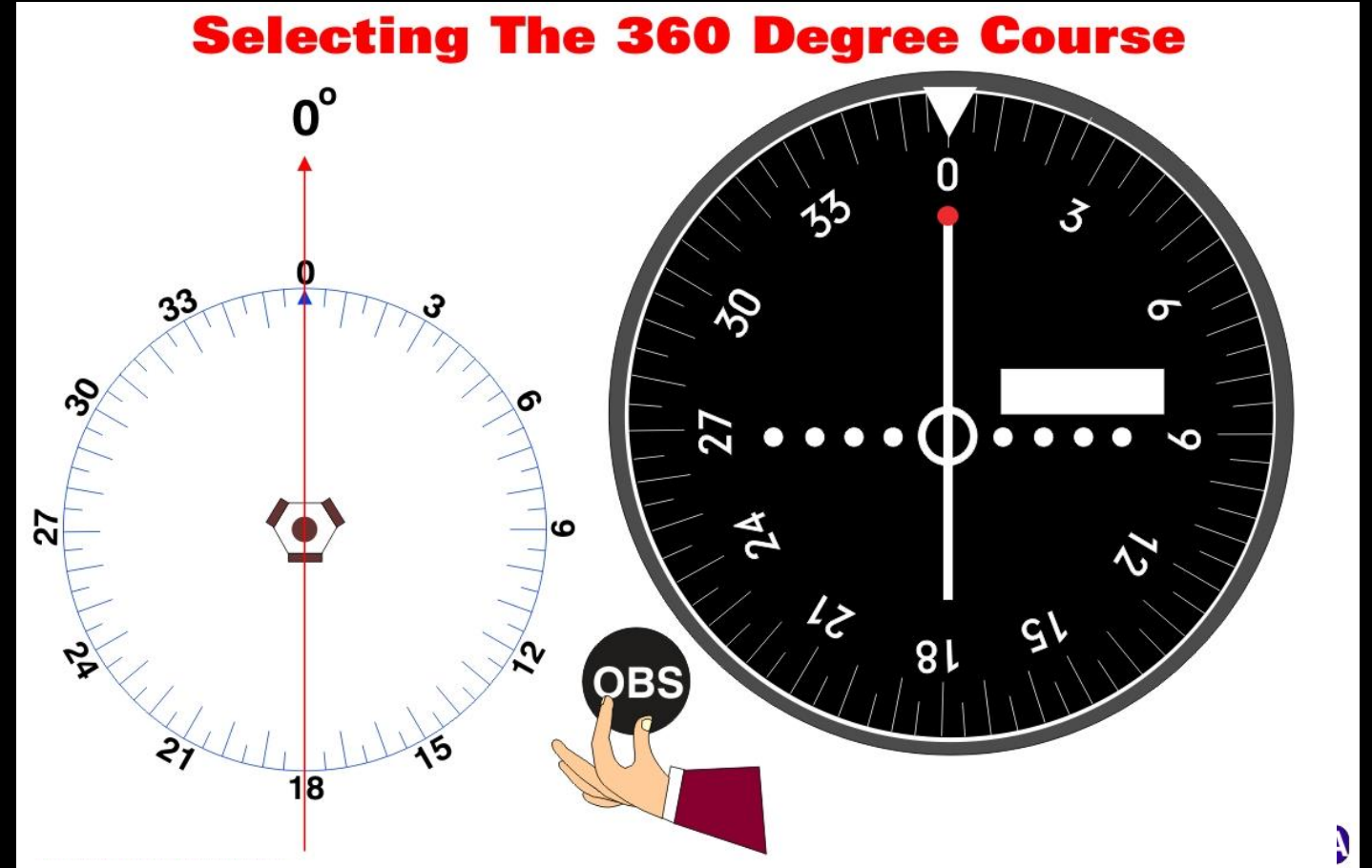
- Circular, moveable compass rose controlled by the OBS
- Rotating the OBS knob causes a different compass value to move under the index at the top of the instrument

THE VOR INDICATOR



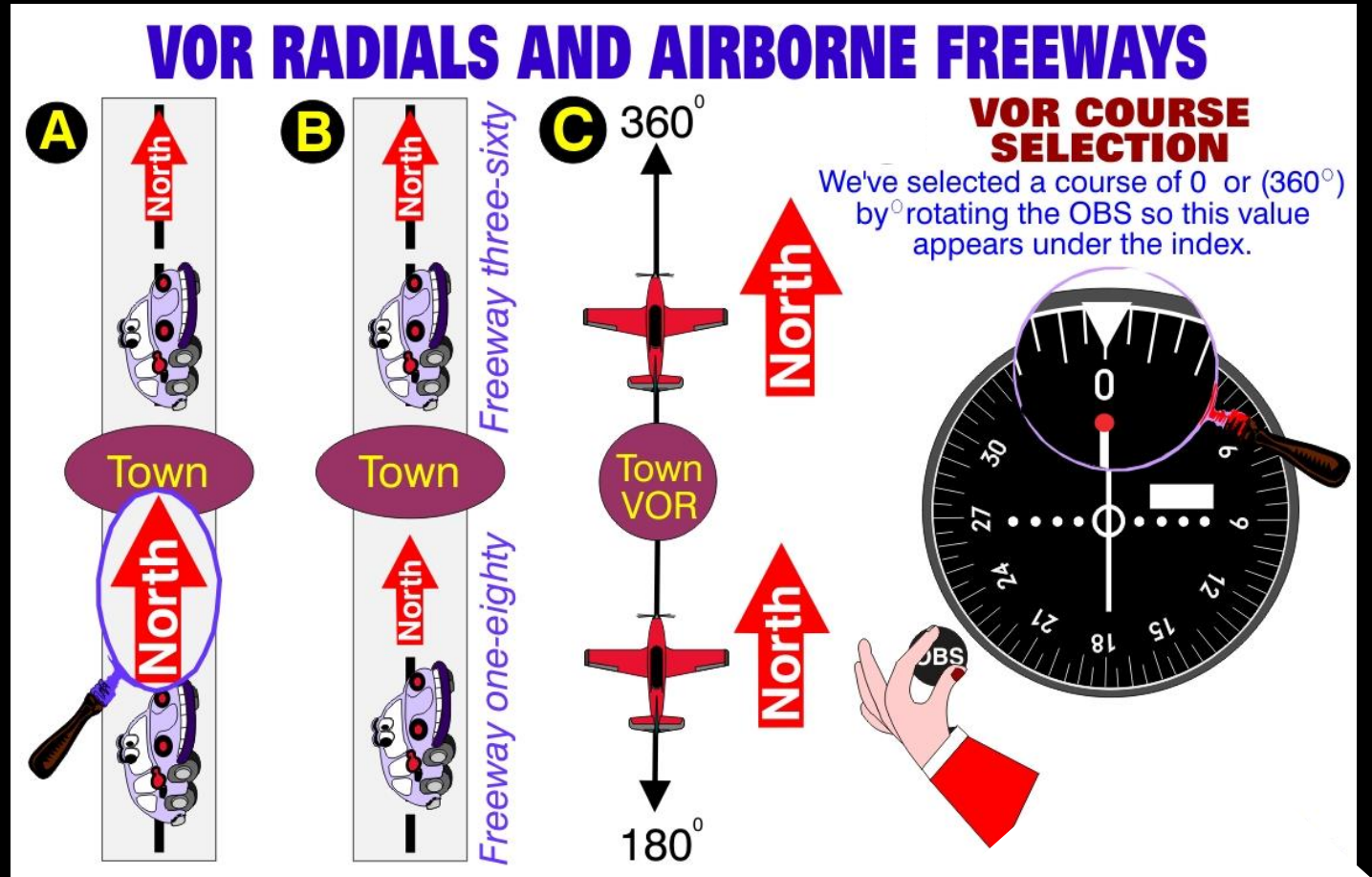
Navigate With VOR

- Tune and identify the VOR station
- Rotating the OBS to a specific number allows you to select any one of the VOR's 360 flyable courses
- Select 360° (0°) with the OBS
- VOR automatically orients itself to tell you where the 360° course is located
- The 360° course runs completely through the VOR in a direction of 360°



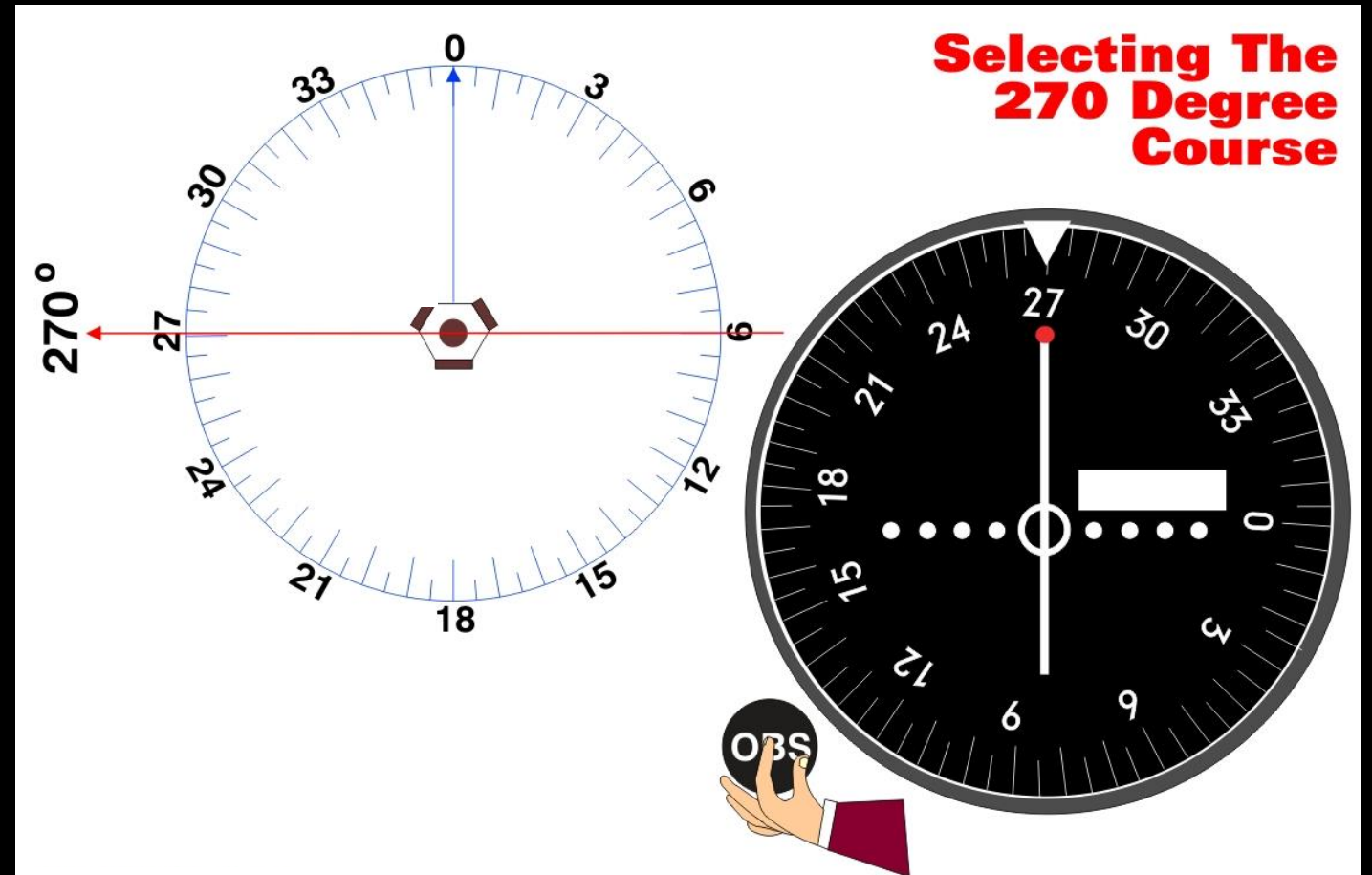
Airborne Freeways

- The 360° course runs completely through the Town VOR in a direction of 360° just like the freeway running through town



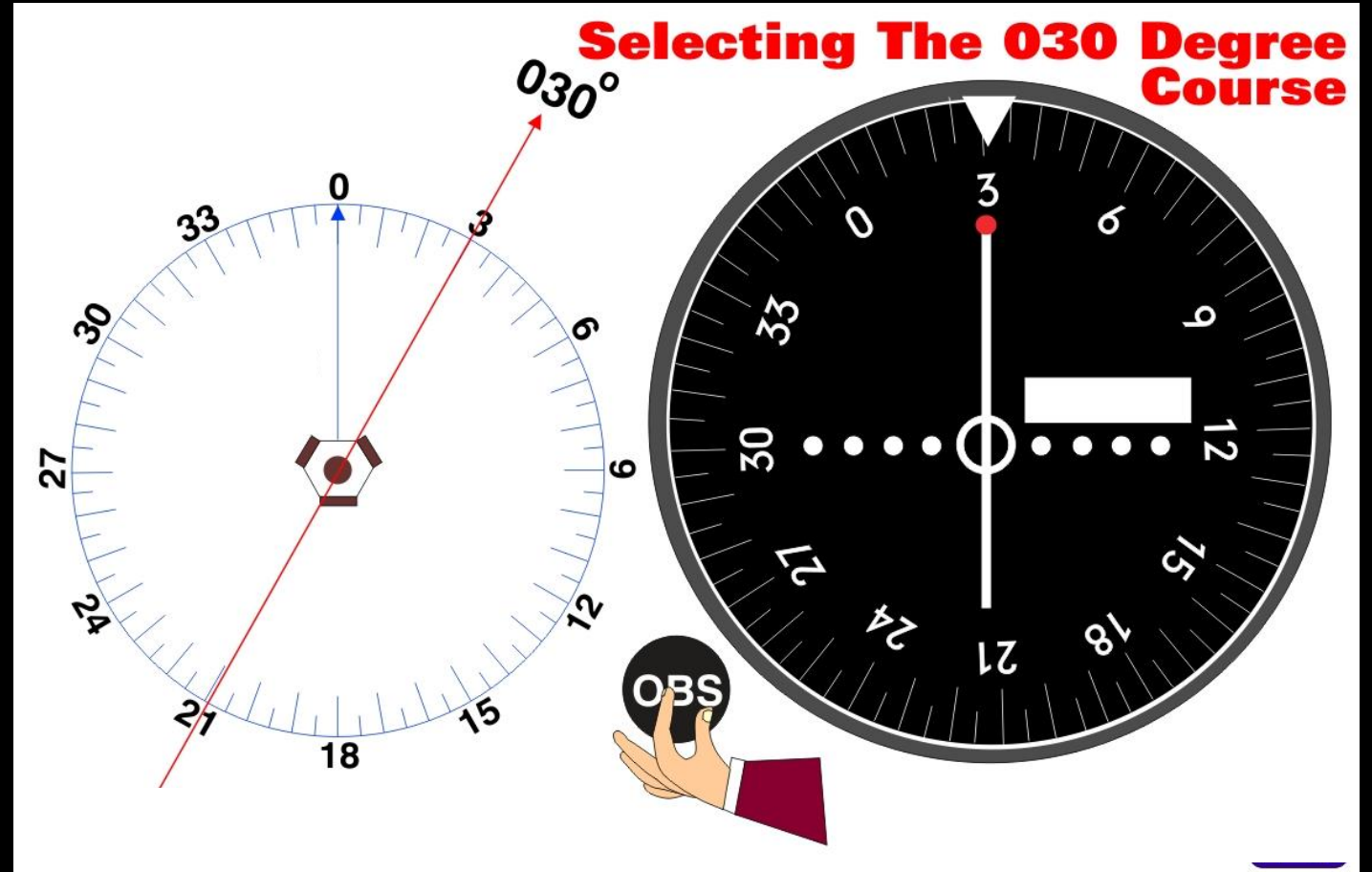
Rotate OBS to 270° Course

- VOR equipment orients itself to the 270° course



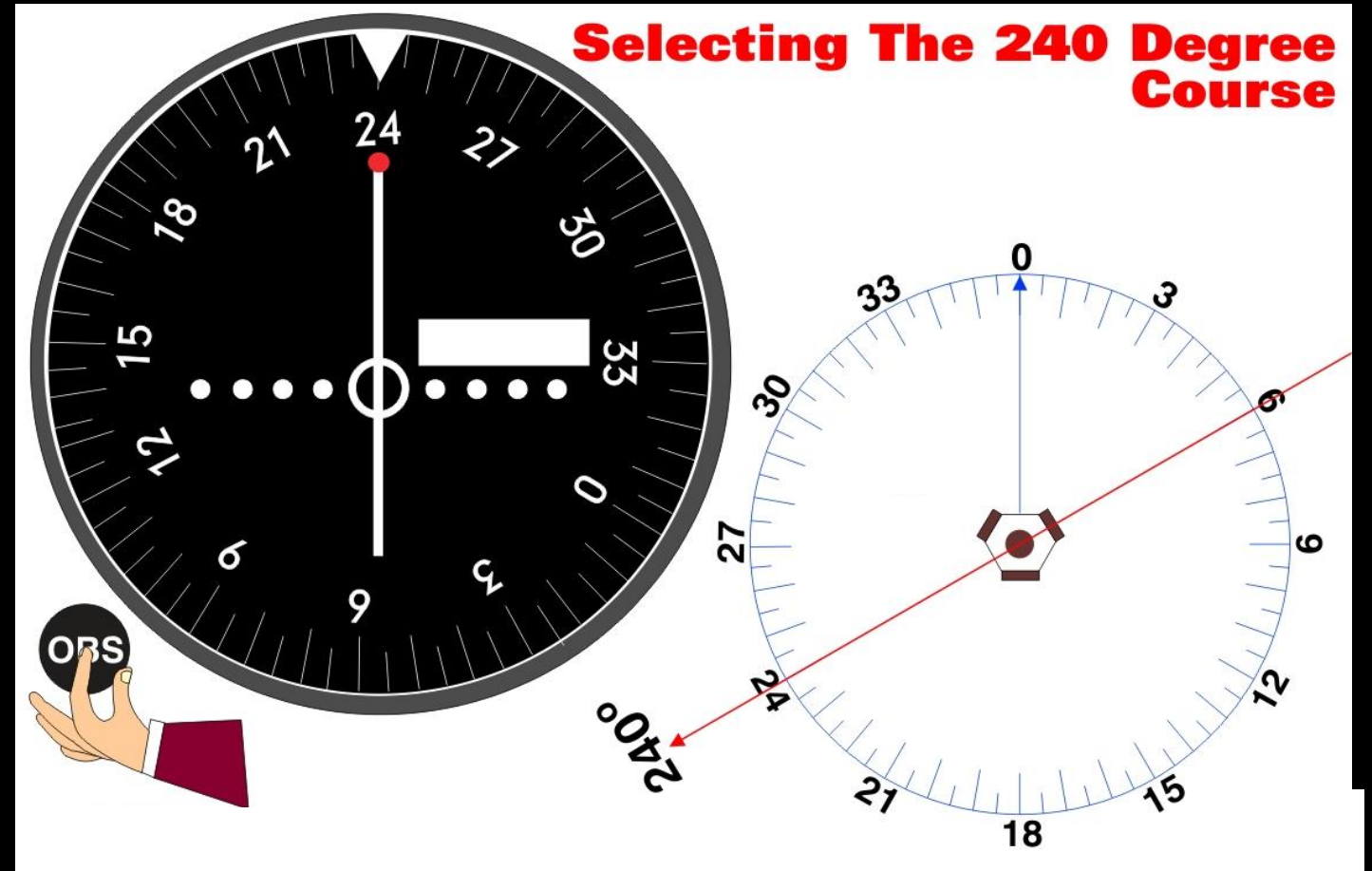
Rotate OBS to 030° Course

- VOR equipment orients itself to the 030° course



Rotate OBS to 240° Course

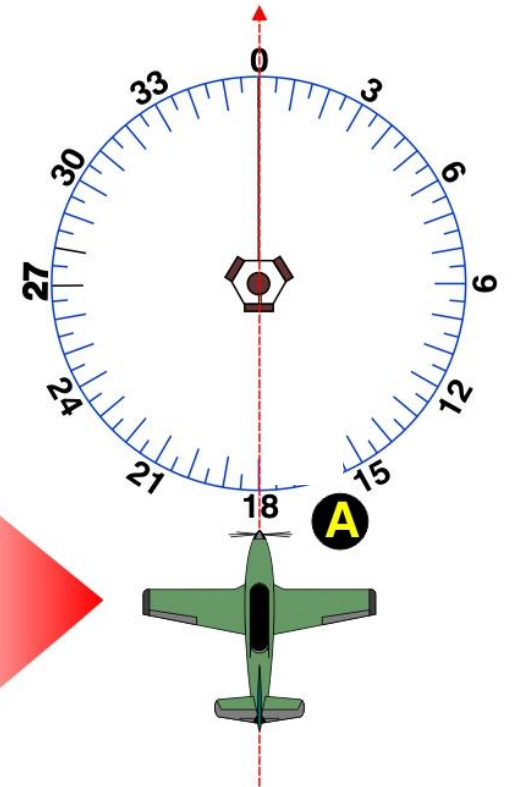
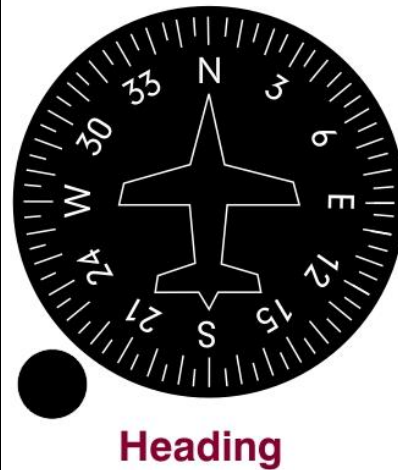
- VOR equipment orients itself to the 240° course



Flying 360° Course

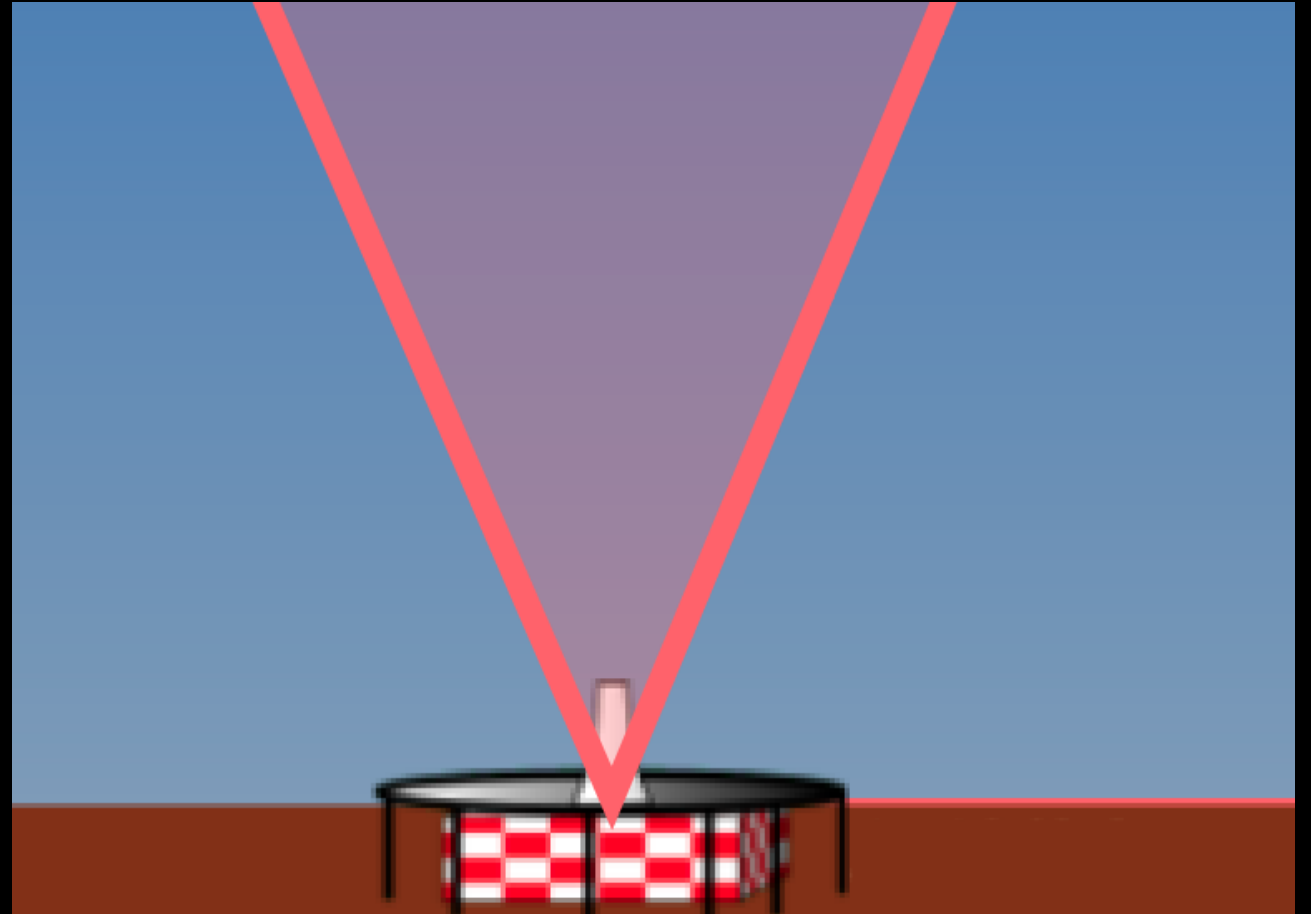
- 360° course selected with the OBS
- To fly this course, you head your airplane in a magnetic direction of 360° on the heading indicator
- The VOR indicator shows a centered needle with a TO flag indication

**SELECTING 0° (360°)
WITH THE OBS
AND FLYING A
HEADING OF 360°**



Station Passage

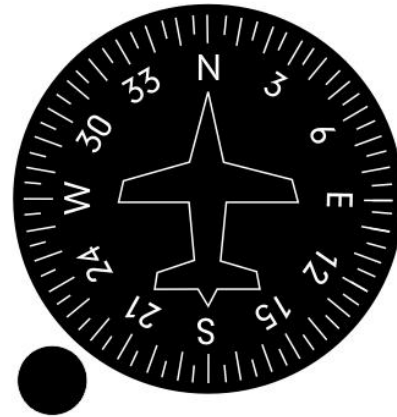
- As you get close to a station in an area called the *Cone of Confusion* the CDI and TO/FROM indicators fluctuate
- Station passage is indicated by the first positive, complete reversal of the TO/FROM indicator



Flying 360° Course

- When directly over the station the flag reads OFF
- This indicates a position of ambiguity
- You're neither going to nor from the VOR at the time

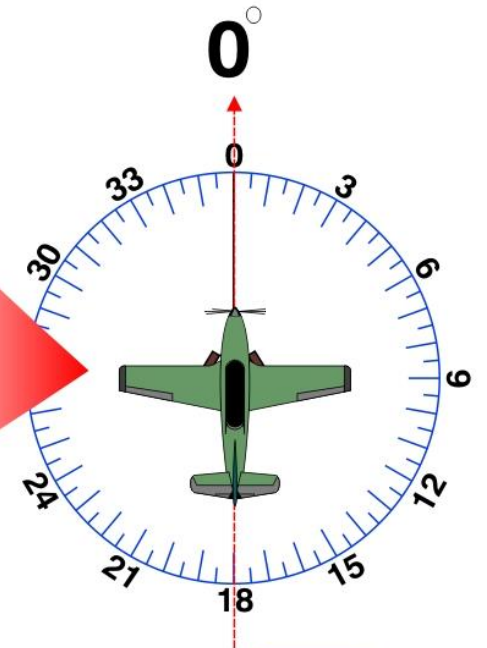
**SELECTING 0° (360°)
WITH THE OBS
AND FLYING A
HEADING OF 360°**



Heading



VOR

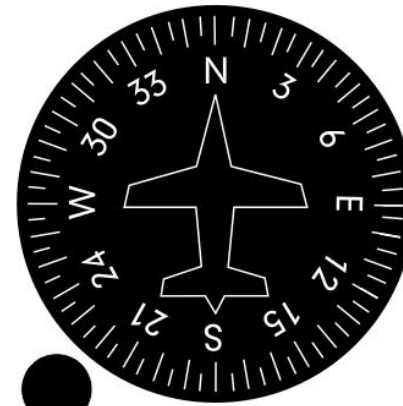


11-10B

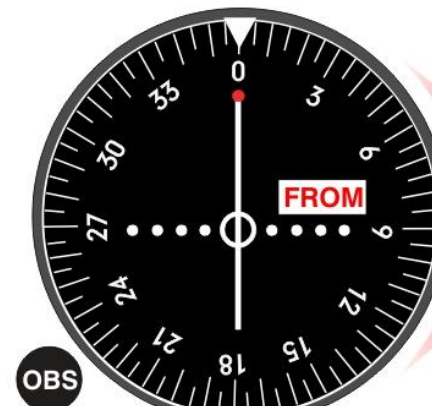
©Rod Machado's
Private Pilot Handbook

Flying 360° Course

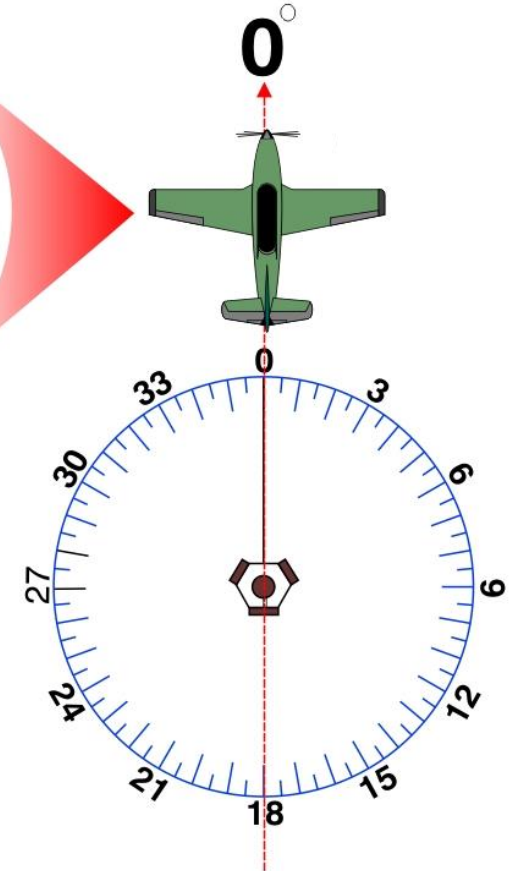
- As you fly along the selected 360° course, the TO flag automatically changes to a FROM flag on the other side of the station
- The TO or FROM flag lets you know whether you're going to or from the VOR station if you point in the direction of the course set into the OBS while keeping the needle centered



Heading



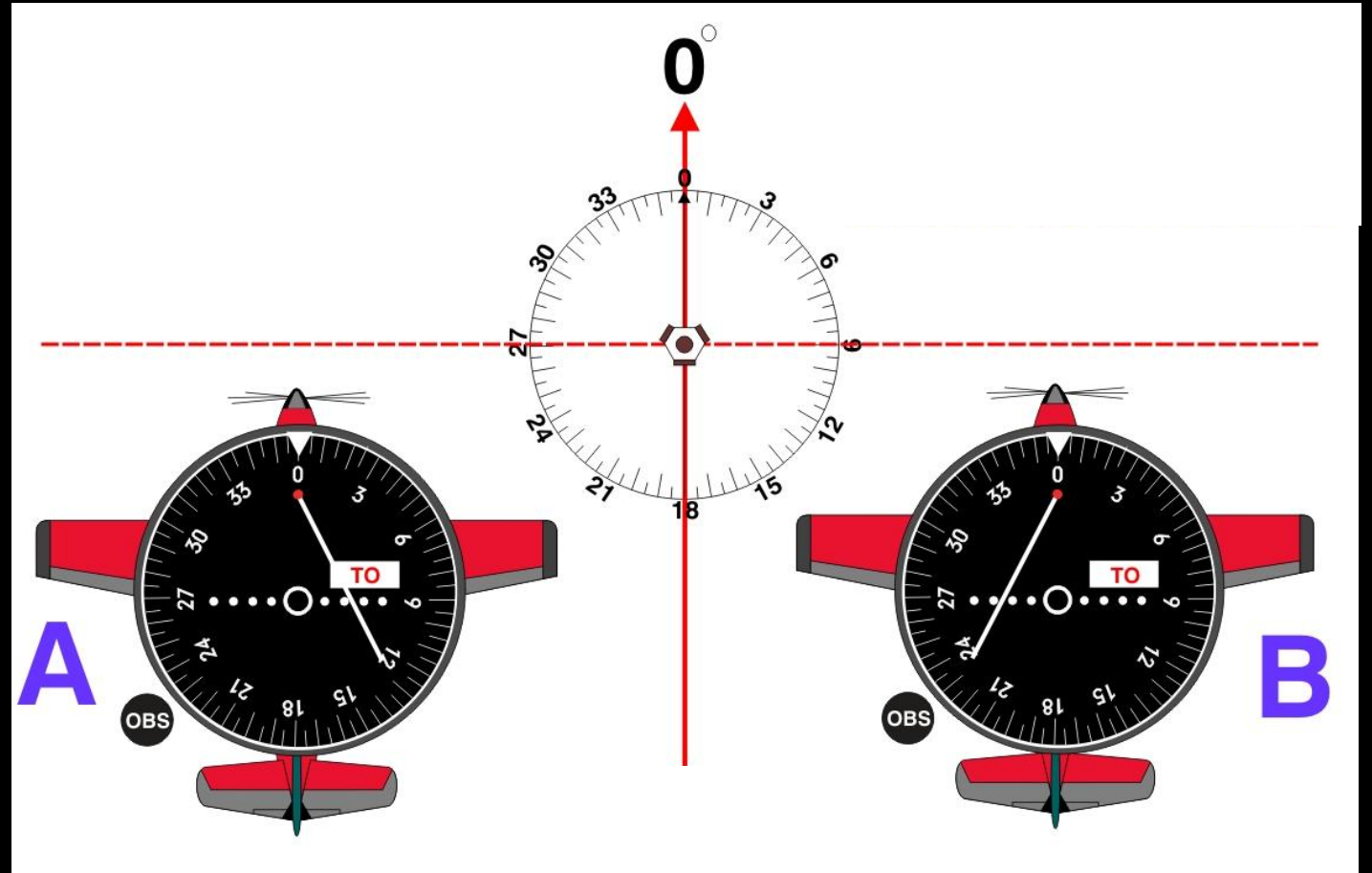
VOR



**SELECTING 0° (360°)
WITH THE OBS
AND FLYING A
HEADING OF 360°**

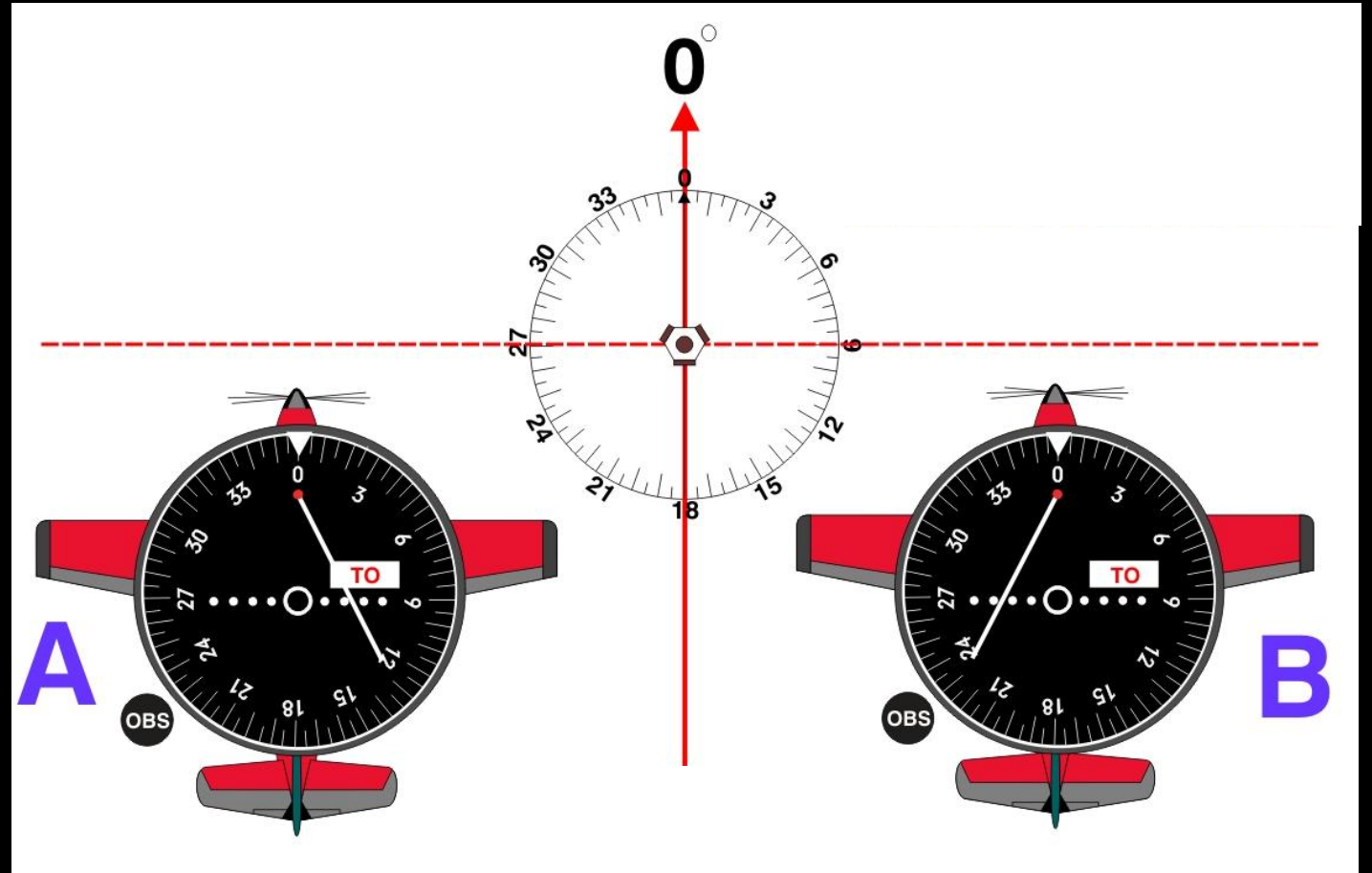
VOR Needle Indications

- Airplane A is heading 360° (direction of the selected course)
- VOR indicator shows a right needle with a TO indication
- The selected course is to the right



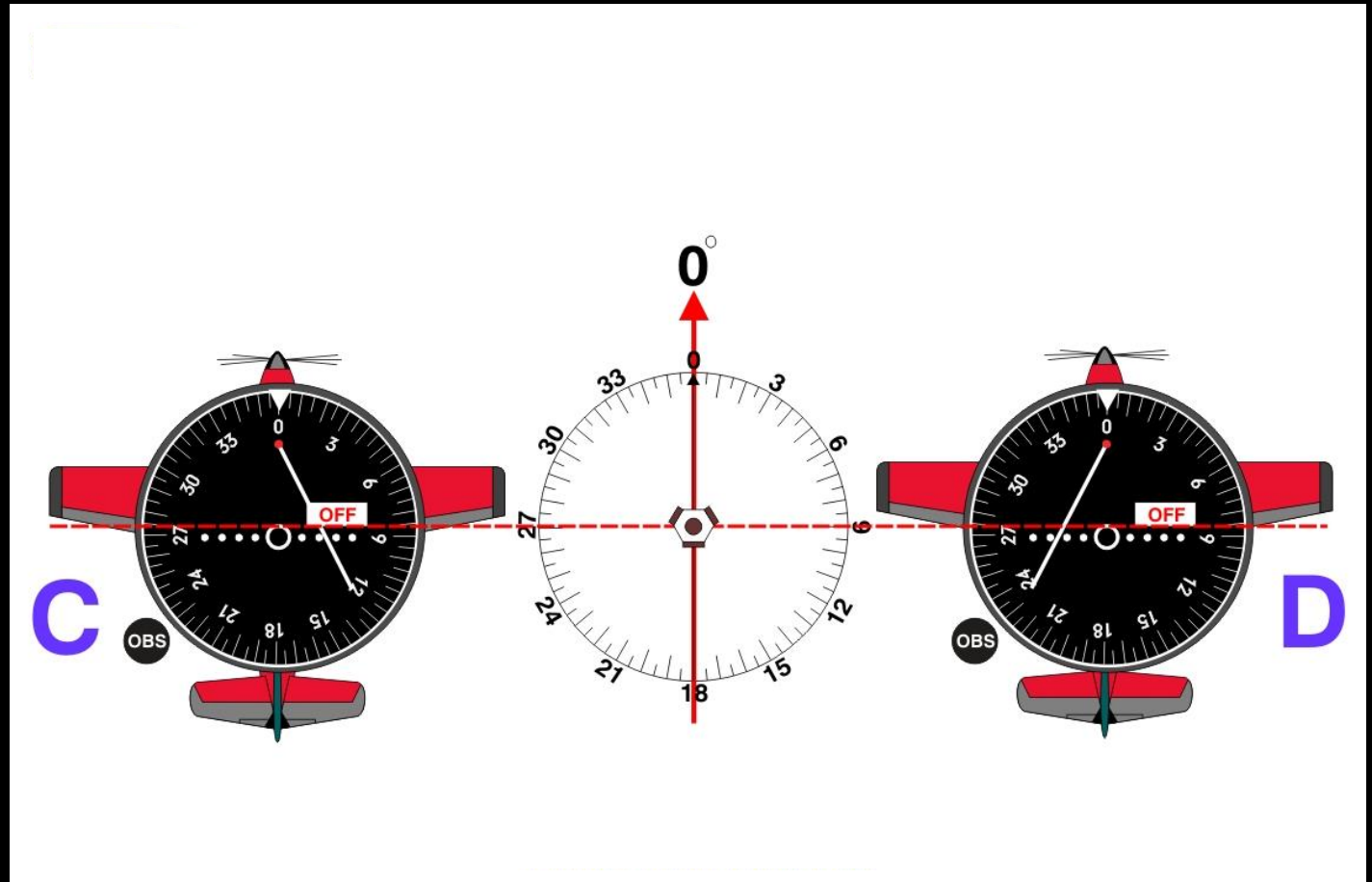
VOR Needle Indications

- If Airplane A was on the course, it would be headed to the station
- Must turn right to intercept the selected course
- Airplane B must turn left to intercept the selected course



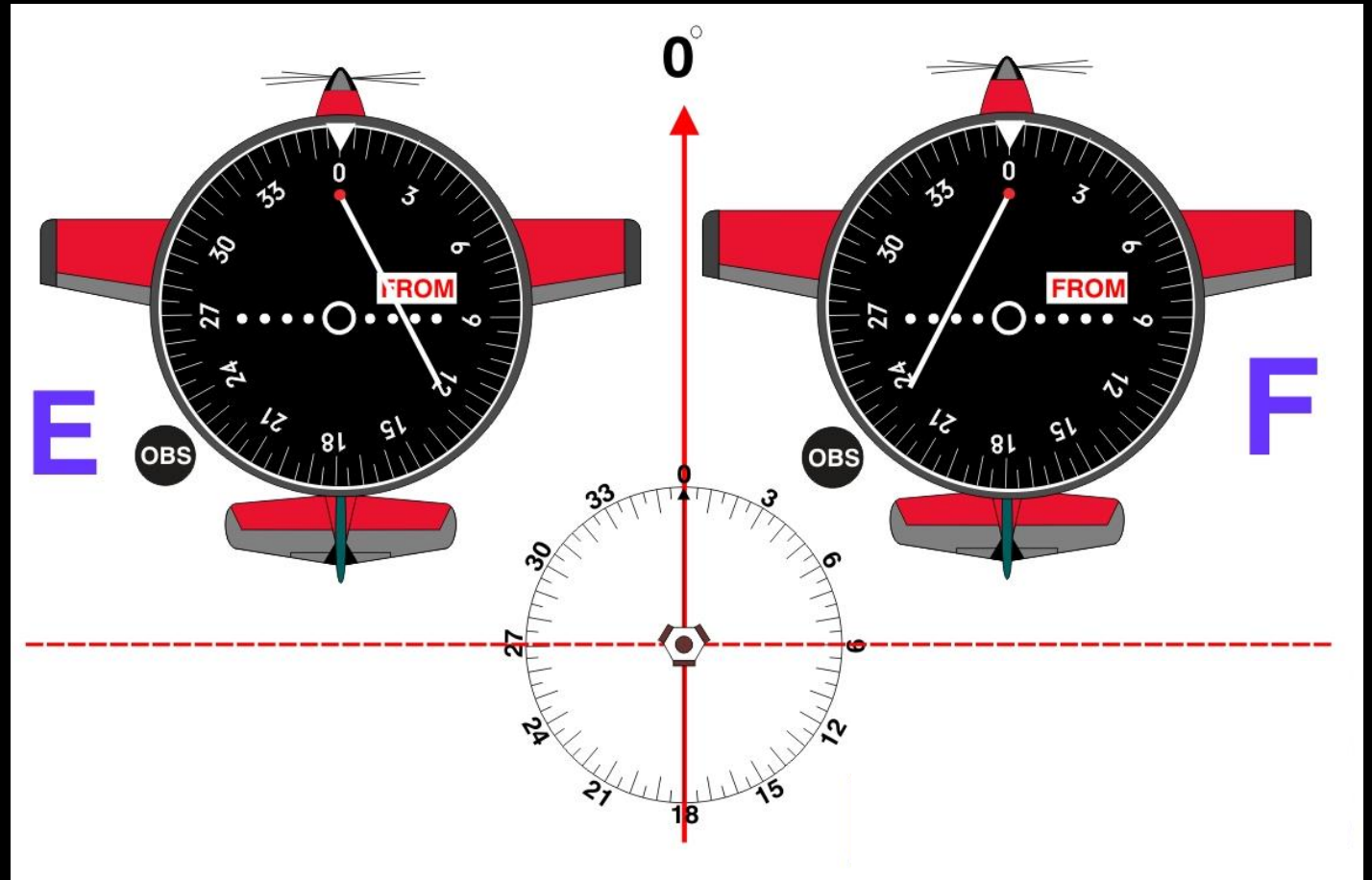
VOR Needle Indications

- When you are abeam (90° to the side of) the station, the ambiguity indicator shows OFF
- You are in the zone of ambiguity and are going neither to nor from the station
- Airplane C must turn right to intercept the selected course
- Airplane D must turn left to intercept the selected course



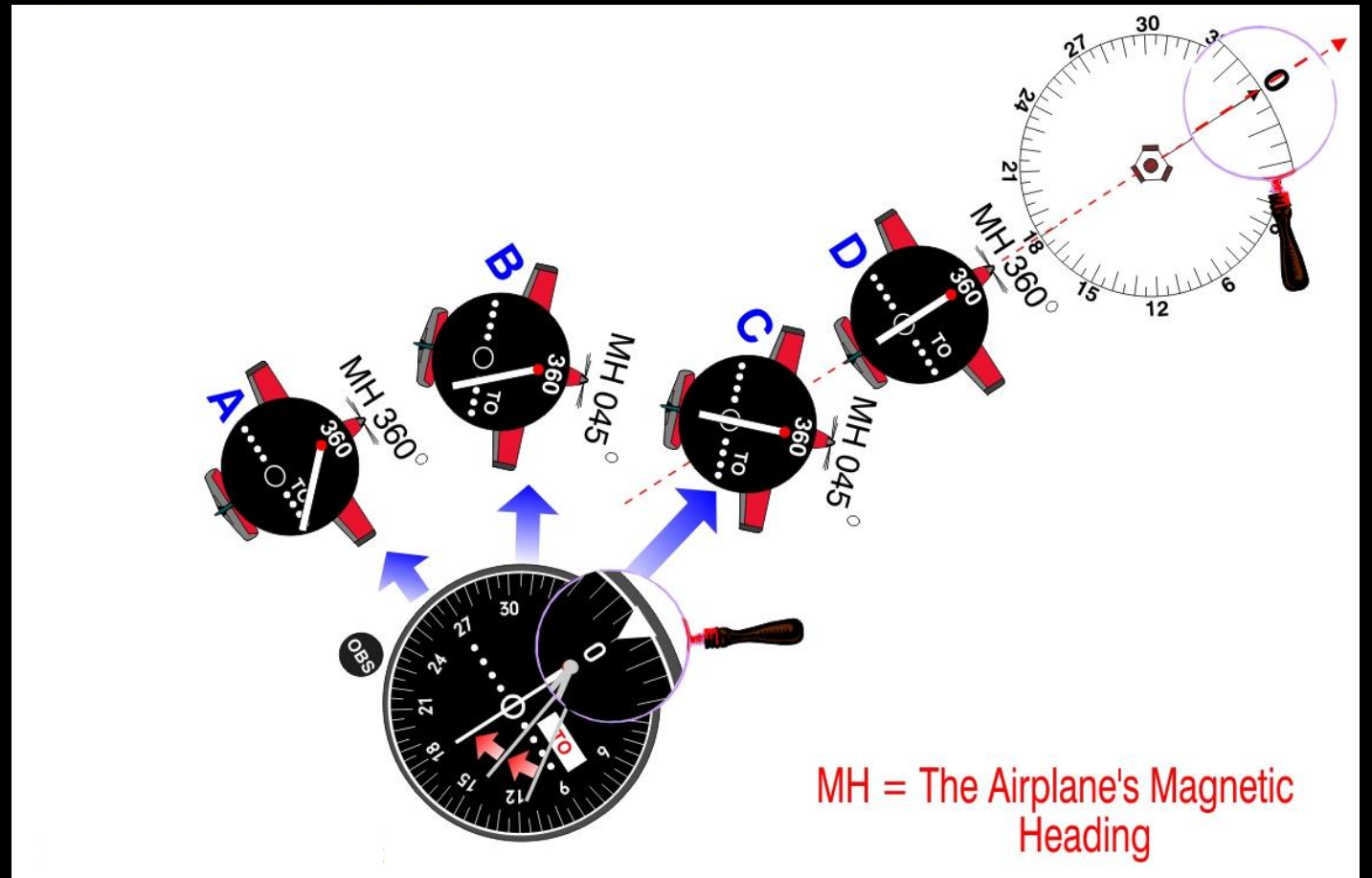
VOR Needle Indications

- Ambiguity indicator shows FROM indication
- Airplane E must turn right to intercept the selected course
- Airplane F must turn left to intercept the selected course



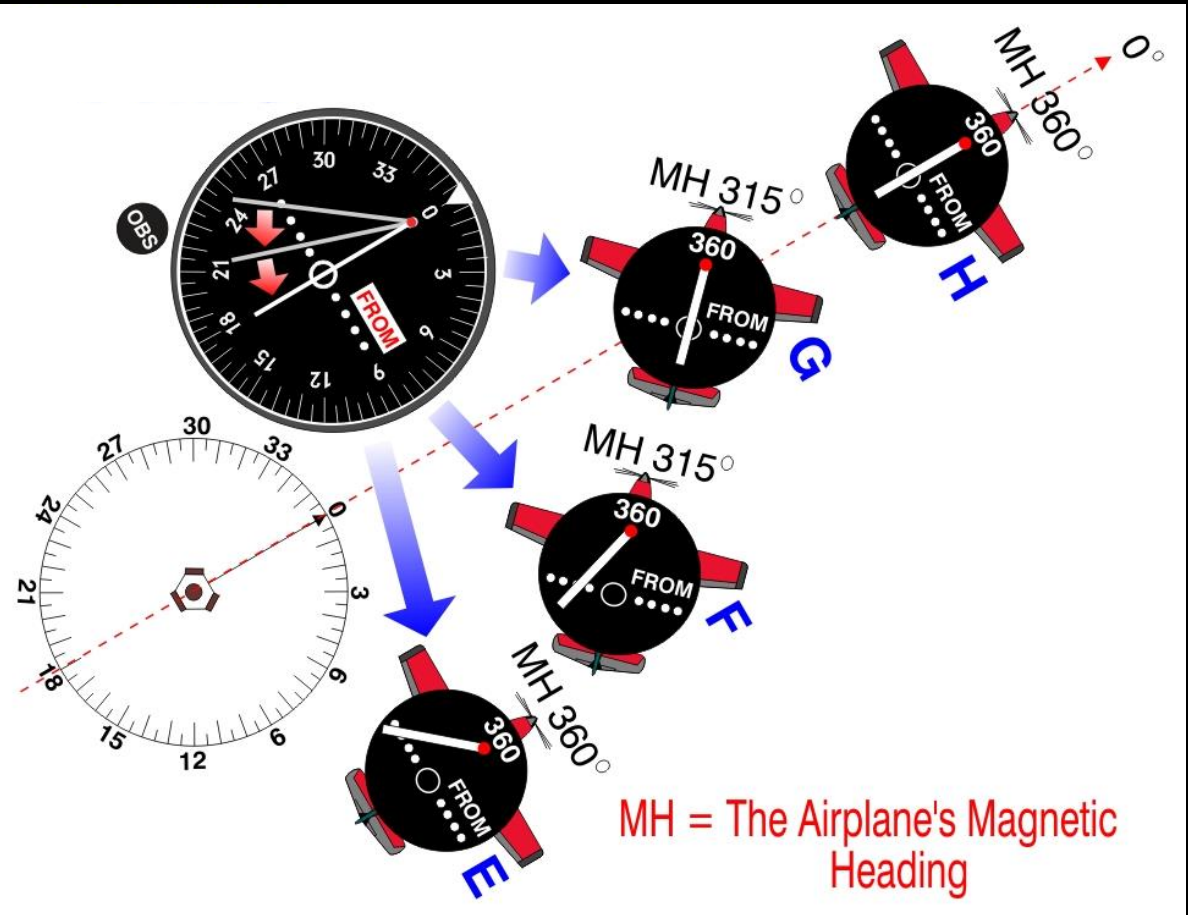
Intercepting the 360° Course TO VOR

- Airplane A in turns right to a heading of 045° to intercept the 360° course TO the VOR
- As it approaches the course, the VOR needle begins to center (B & C)
- Once the needle is centered, the airplane should be heading 360° to fly the selected course to the station



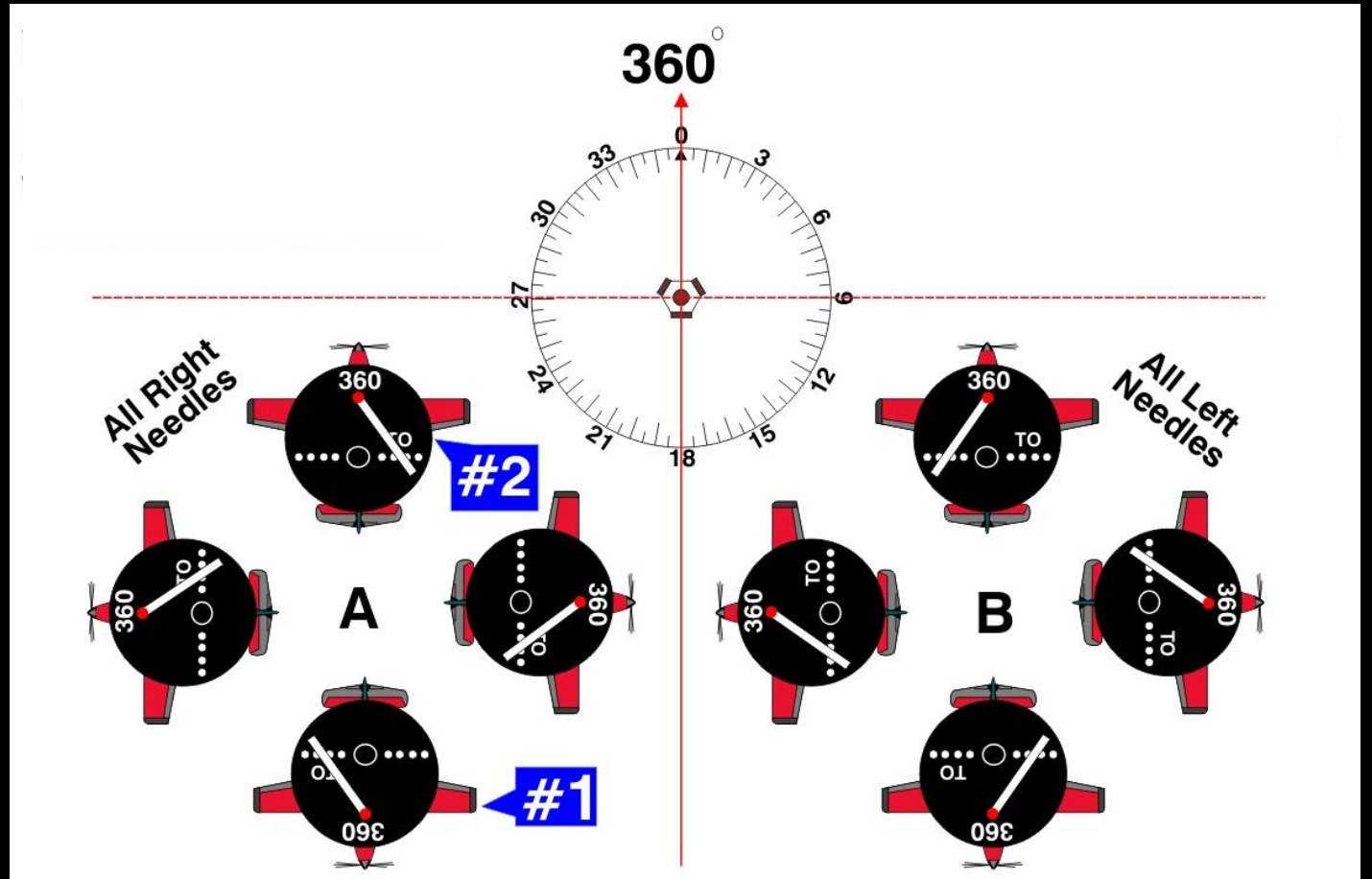
Intercepting the 360° Course FROM VOR

- Airplanes E, F, G and H intercept 360° course with a FROM indication
- Airplanes F & G intercept the 360° course at a 45° angle (an intercept heading of 315° is 45° to the left of 360°)



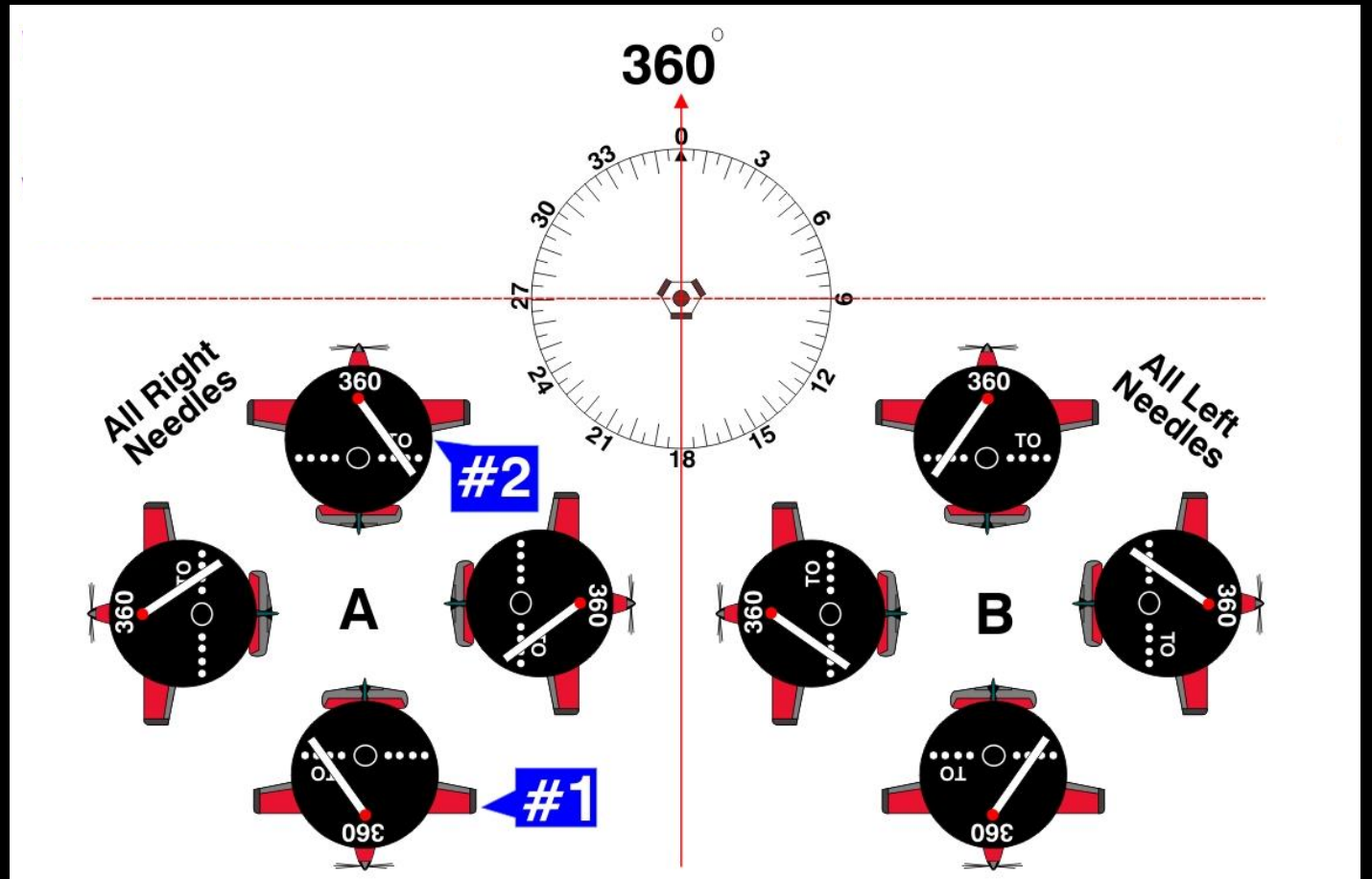
VOR Indications Independent of Heading

- A right or left needle indication doesn't tell you on what side of the airplane the selected course is located
- You must physically point the airplane in the direction set into the OBS (or imagine yourself pointed in this direction)
- *The VOR needle and flag indications are completely independent of the airplane's heading*



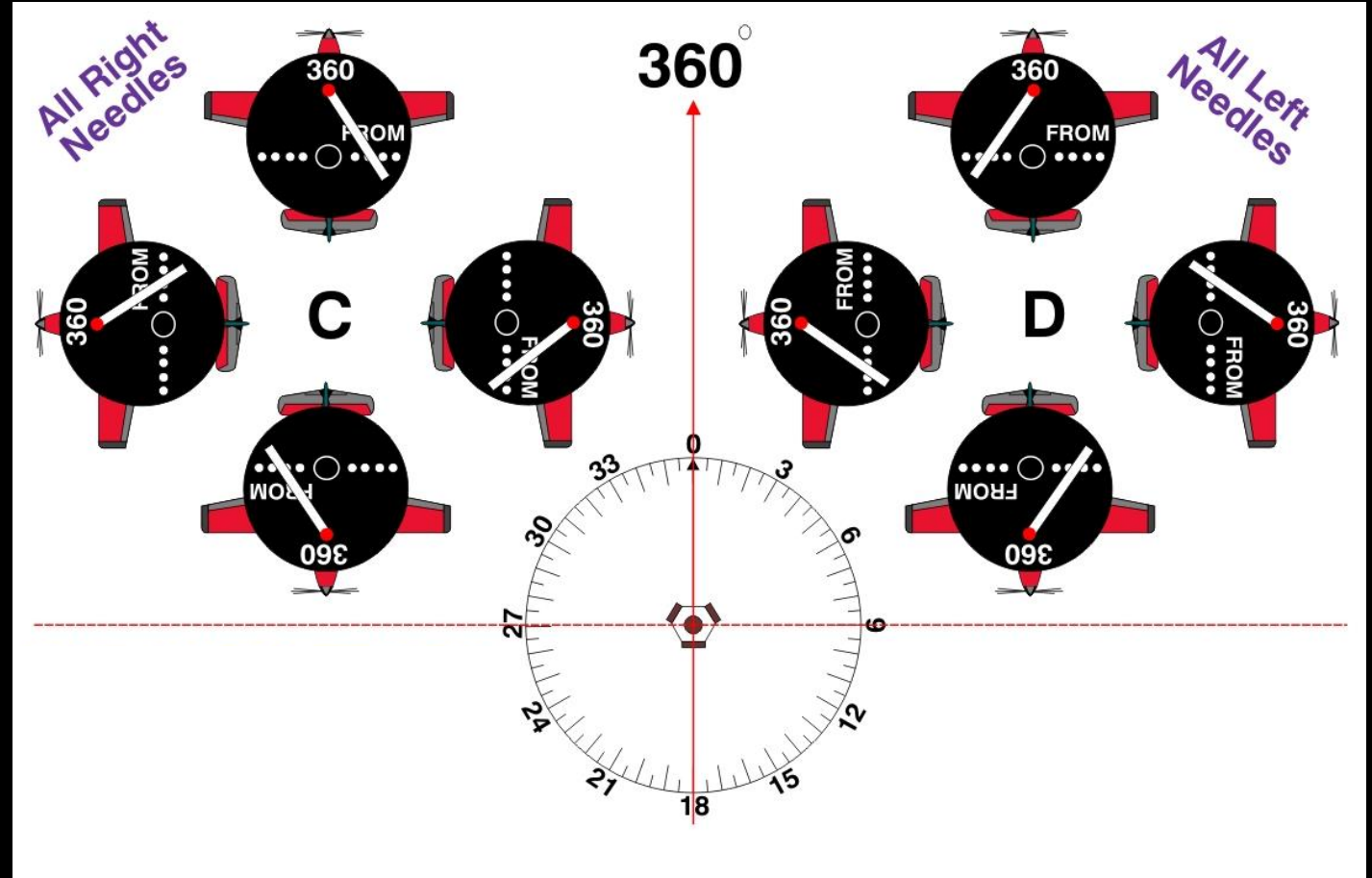
VOR Indications Independent of Heading

- OBS set to 360°
- The VOR indication on the airplanes in A all show a right needle with a TO indication
- Airplanes in B all show a left needle with a TO indication, regardless of airplane's heading



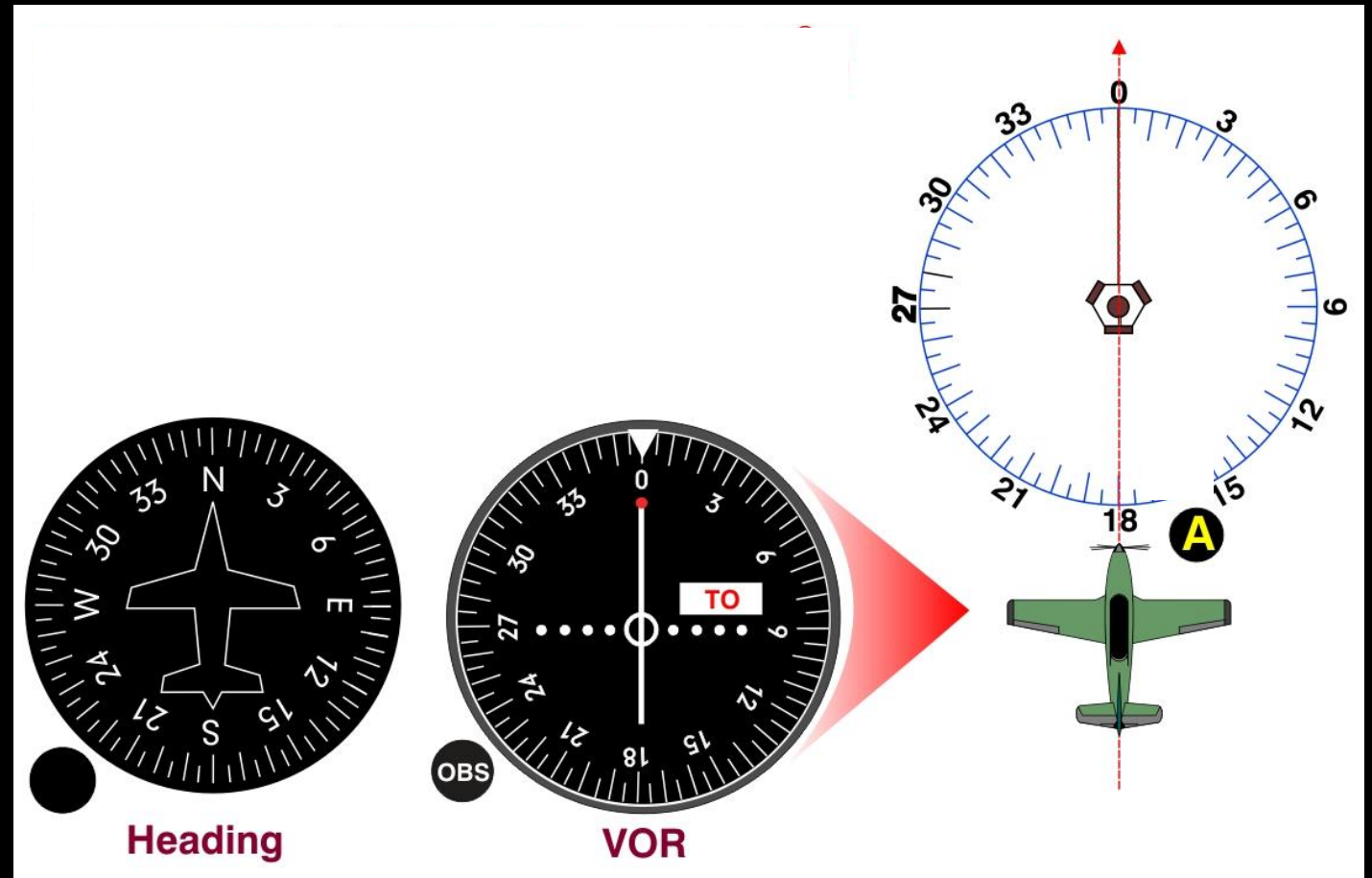
VOR Indications Independent of Heading

- Airplanes in C all show a right needle with a FROM indication
- Airplanes in D show a left needle with a FROM indication



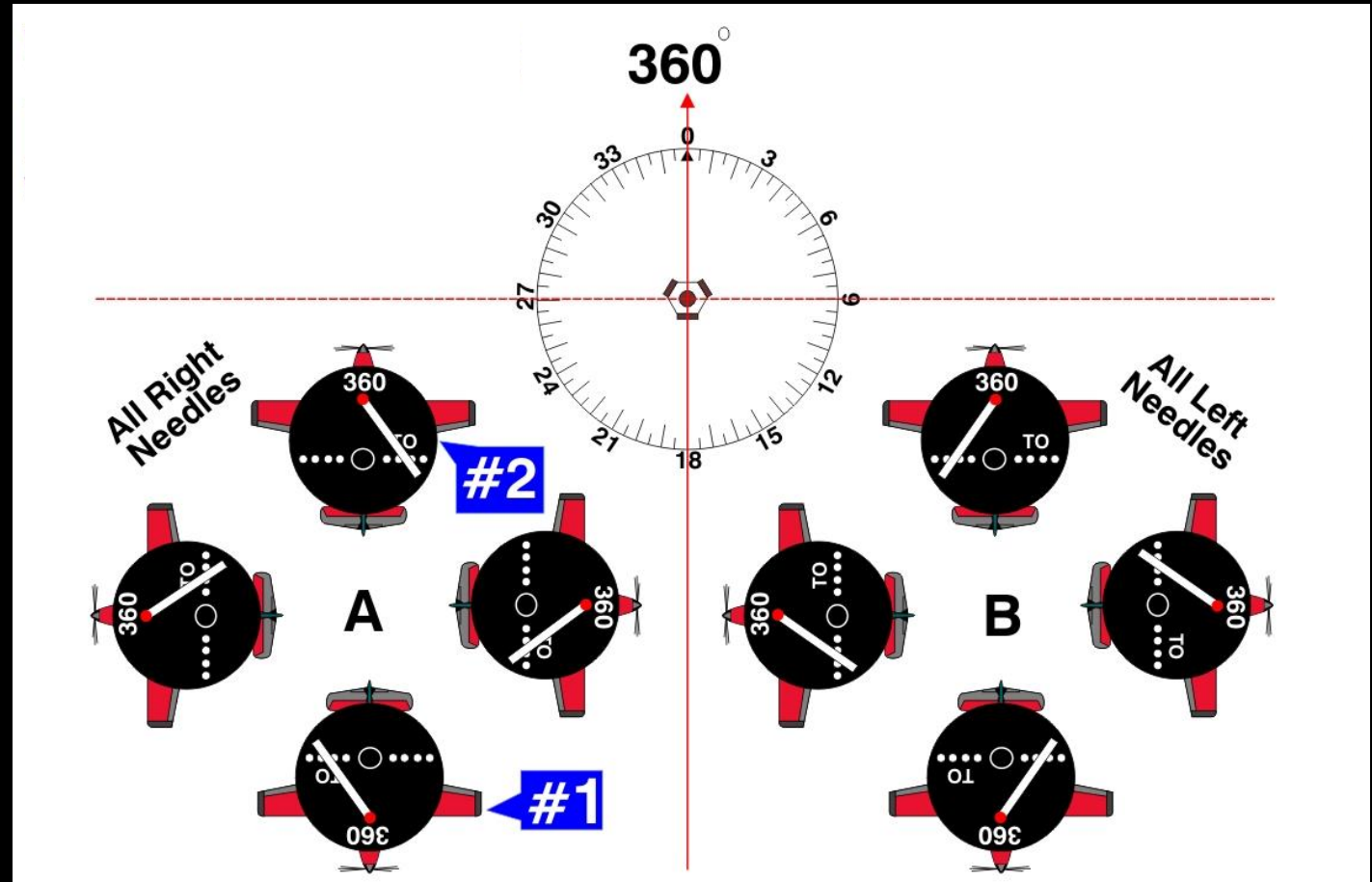
VOR Indications Independent of Heading

- A left or right needle deflection and a TO or FROM flag indication only have meaning if you are pointed (physically or mentally) in the direction of the selected course
- VOR only shows if it's to the right or left of a selected course and if the selected course takes it to or from the station



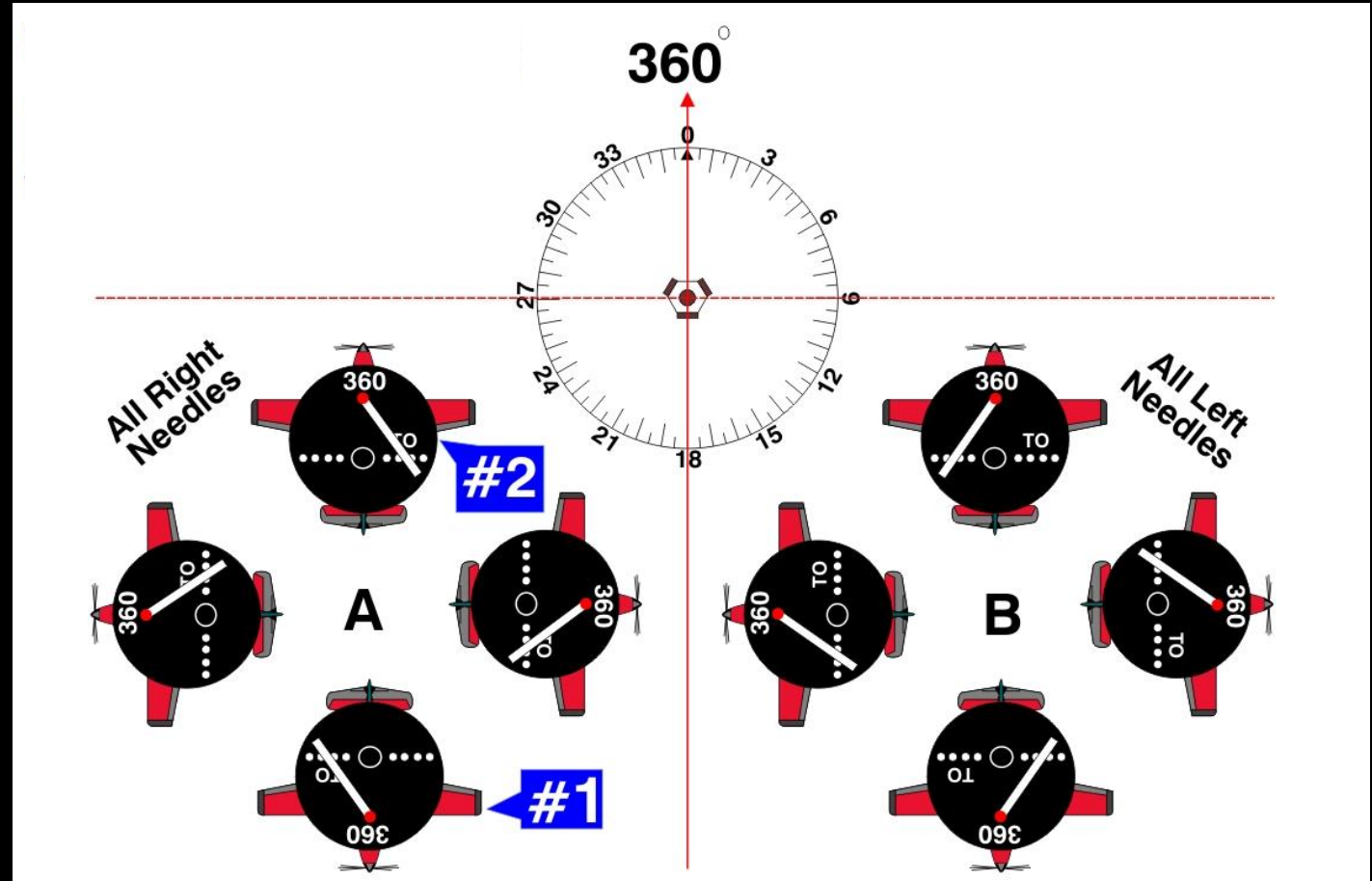
VOR Indications Independent of Heading

- If the airplane also physically points in the same direction as the selected course a right or left needle means the selected course is to your right or left



VOR Indications Independent of Heading

- Airplane 1 shows a right needle and TO flag indication
- The selected course isn't located off the right wing
- If the pilot turns (or imagines) the airplane to 360° (Airplane 2) the needle reflects the side of the airplane on which the course is located (the right side)



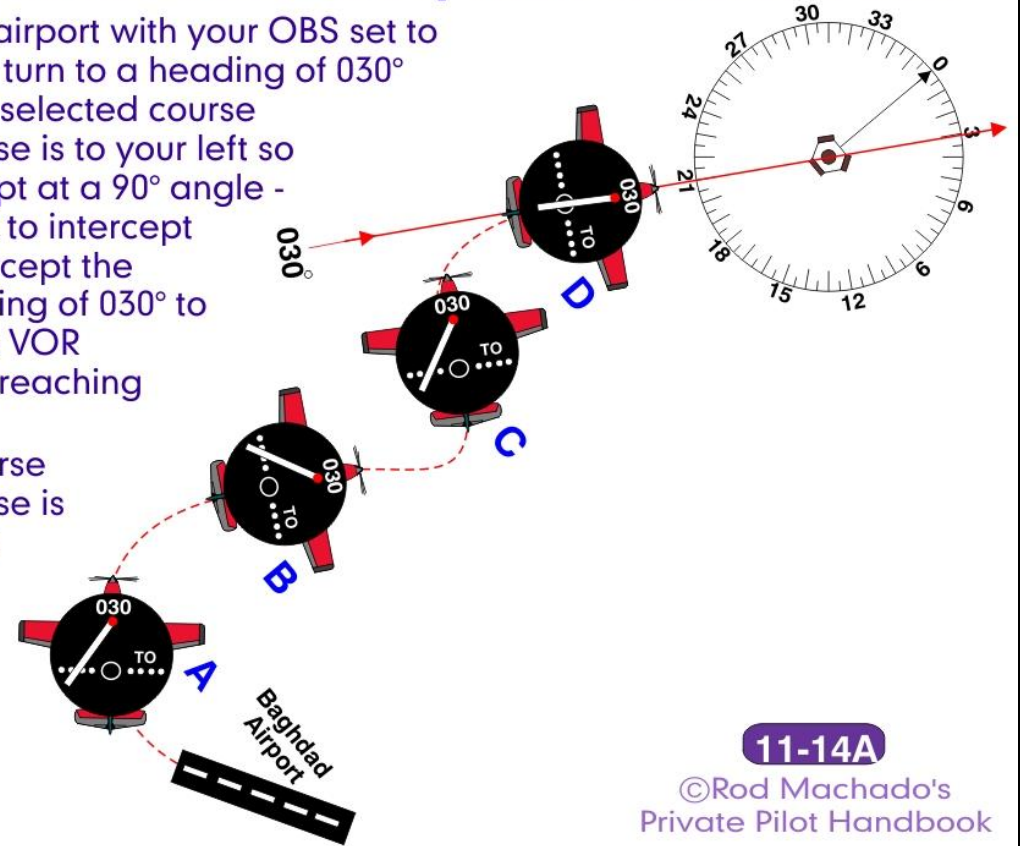
Flying Course TO VOR

- Depart Baghdad airport and fly the 030° course to and beyond the VOR
- Set the OBS to 030° and depart Baghdad A
- The VOR face in A shows a left needle with a TO indication
- The 030° course is not to the left of A

FLYING A SELECTED COURSE TO, THEN FROM THE VOR

You depart Baghdad airport with your OBS set to 030° (Airplane A). You turn to a heading of 030° and fly parallel to the selected course (Airplane B). The course is to your left so you turn left to intercept at a 90° angle - the shortest distance to intercept (Airplane C). You intercept the course and fly a heading of 030° to the VOR then from the VOR (Airplane D & E), until reaching Yazoo airport.

parallel to the selected course (Airplane B). The course is to your left so you turn left to intercept at a 90° angle -- the shortest distance to intercept (Airplane C).



11-14A

©Rod Machado's
Private Pilot Handbook

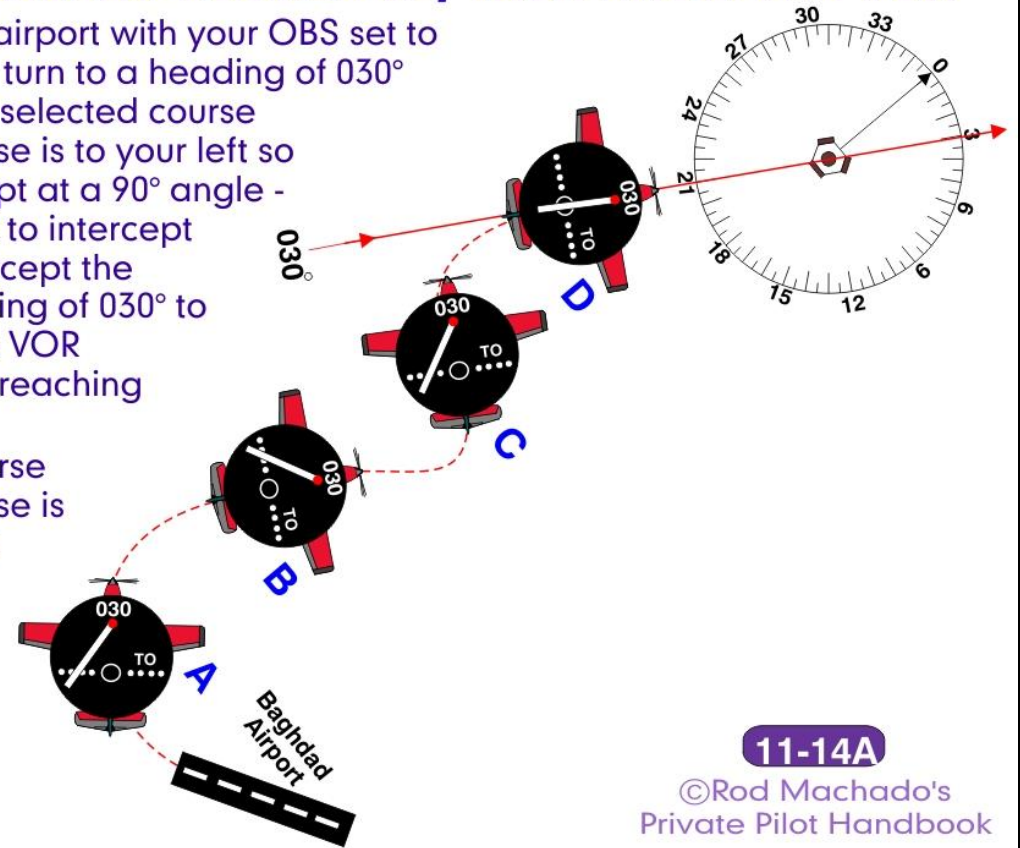
Flying Course TO VOR

- If we turn the airplane to the direction of the selected course (030°) the needle and flag will properly orient us to that course B
- Needle shows the selected course is physically to the left of the airplane
- TO/FROM flag shows once on the course and heading 030° we'll be going directly TO the VOR station (assuming no wind)

FLYING A SELECTED COURSE TO, THEN FROM THE VOR

You depart Baghdad airport with your OBS set to 030° (Airplane A). You turn to a heading of 030° and fly parallel to the selected course (Airplane B). The course is to your left so you turn left to intercept at a 90° angle - the shortest distance to intercept (Airplane C). You intercept the course and fly a heading of 030° to the VOR then from the VOR (Airplane D & E), until reaching Yazoo airport.

Let's say you are flying parallel to the selected course (Airplane B). The course is to your left so you turn left to intercept at a 90° angle -- the shortest distance to intercept (Airplane C).



11-14A

©Rod Machado's
Private Pilot Handbook

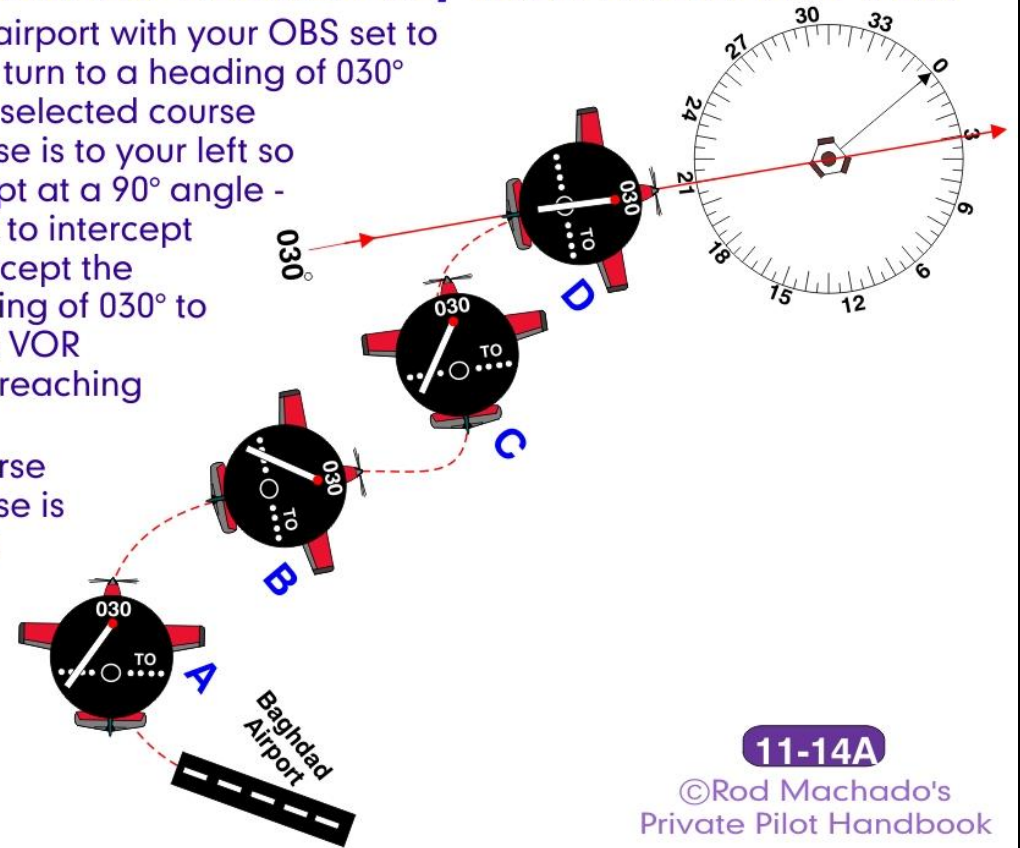
Flying Course TO VOR

- To intercept the 030° course B must be turned to the left
- More than 0° and less than 90° of intercept, depending on how fast you want to intercept
- Flying a heading perpendicular to the selected course (300°) results in the shortest intercept time

FLYING A SELECTED COURSE TO, THEN FROM THE VOR

You depart Baghdad airport with your OBS set to 030° (Airplane A). You turn to a heading of 030° and fly parallel to the selected course (Airplane B). The course is to your left so you turn left to intercept at a 90° angle - the shortest distance to intercept (Airplane C). You intercept the course and fly a heading of 030° to the VOR then from the VOR (Airplane D & E), until reaching Yazoo airport.

parallel to the selected course (Airplane B). The course is to your left so you turn left to intercept at a 90° angle -- the shortest distance to intercept (Airplane C).



11-14A

©Rod Machado's
Private Pilot Handbook

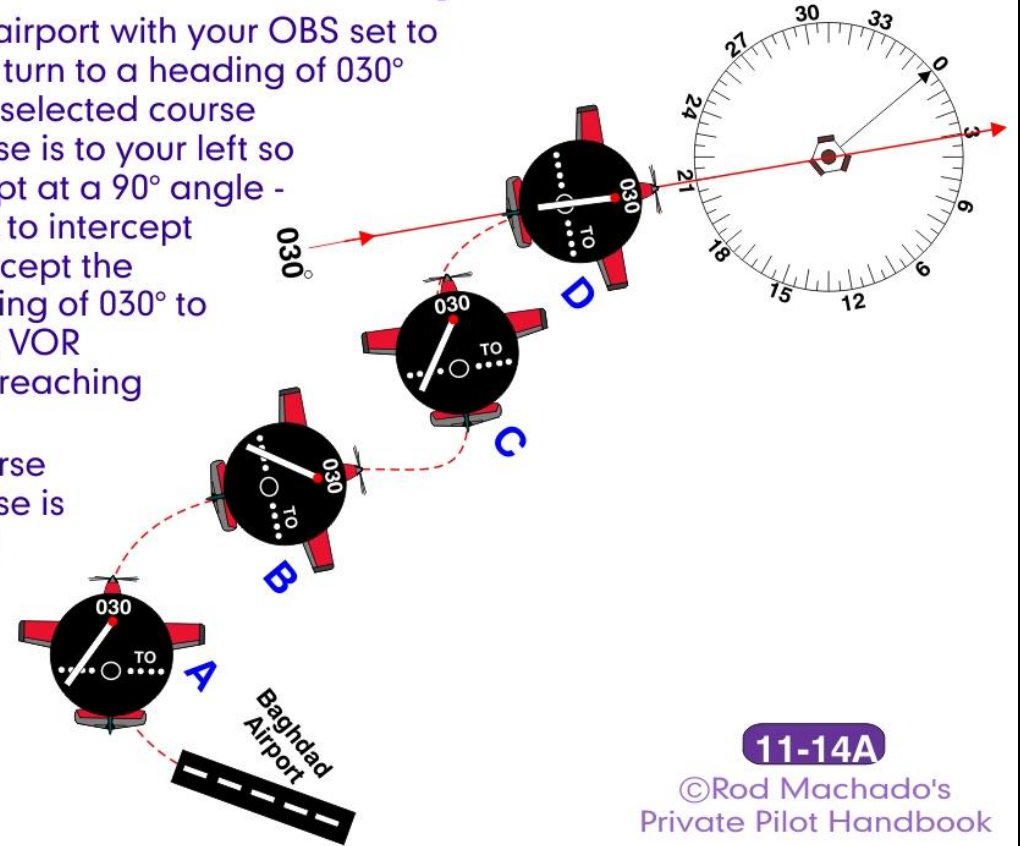
Flying Course TO VOR

- Airplane C turns in the direction of the selected course as the radial is intercepted
- A precisely completed interception and turn is shown by Airplane D
- The VOR needle of Airplane D centers as the airplane heads 030° (selected course direction)

FLYING A SELECTED COURSE TO, THEN FROM THE VOR

You depart Baghdad airport with your OBS set to 030° (Airplane A). You turn to a heading of 030° and fly parallel to the selected course (Airplane B). The course is to your left so you turn left to intercept at a 90° angle - the shortest distance to intercept (Airplane C). You intercept the course and fly a heading of 030° to the VOR then from the VOR (Airplane D & E), until reaching Yazoo airport.

parallel to the selected course (Airplane B). The course is to your left so you turn left to intercept at a 90° angle -- the shortest distance to intercept (Airplane C).



11-14A

©Rod Machado's
Private Pilot Handbook

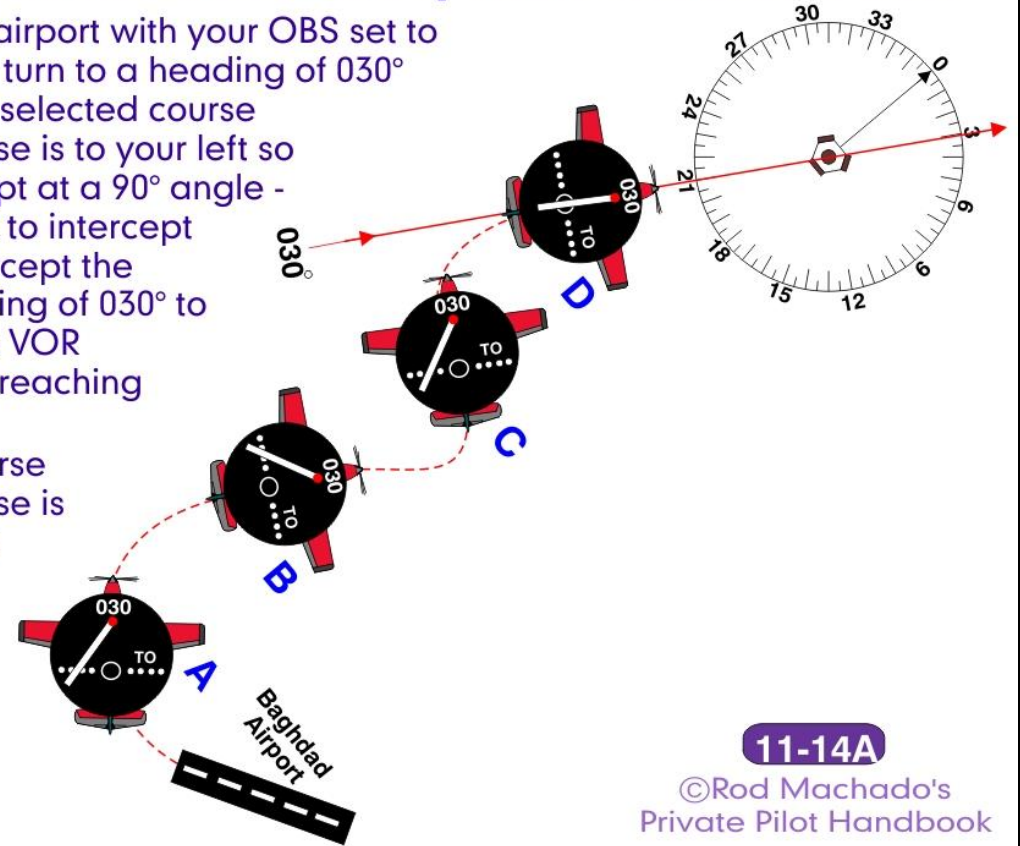
Flying Course TO VOR

- How quickly the needle centers is a function of how close you are to the station
- With experience you estimate the rate at which the needle approaches the center and how much (before centering) to begin your turn to the on-course heading

FLYING A SELECTED COURSE TO, THEN FROM THE VOR

You depart Baghdad airport with your OBS set to 030° (Airplane A). You turn to a heading of 030° and fly parallel to the selected course (Airplane B). The course is to your left so you turn left to intercept at a 90° angle - the shortest distance to intercept (Airplane C). You intercept the course and fly a heading of 030° to the VOR then from the VOR (Airplane D & E), until reaching Yazoo airport.

parallel to the selected course (Airplane B). The course is to your left so you turn left to intercept at a 90° angle -- the shortest distance to intercept (Airplane C).



11-14A

©Rod Machado's
Private Pilot Handbook

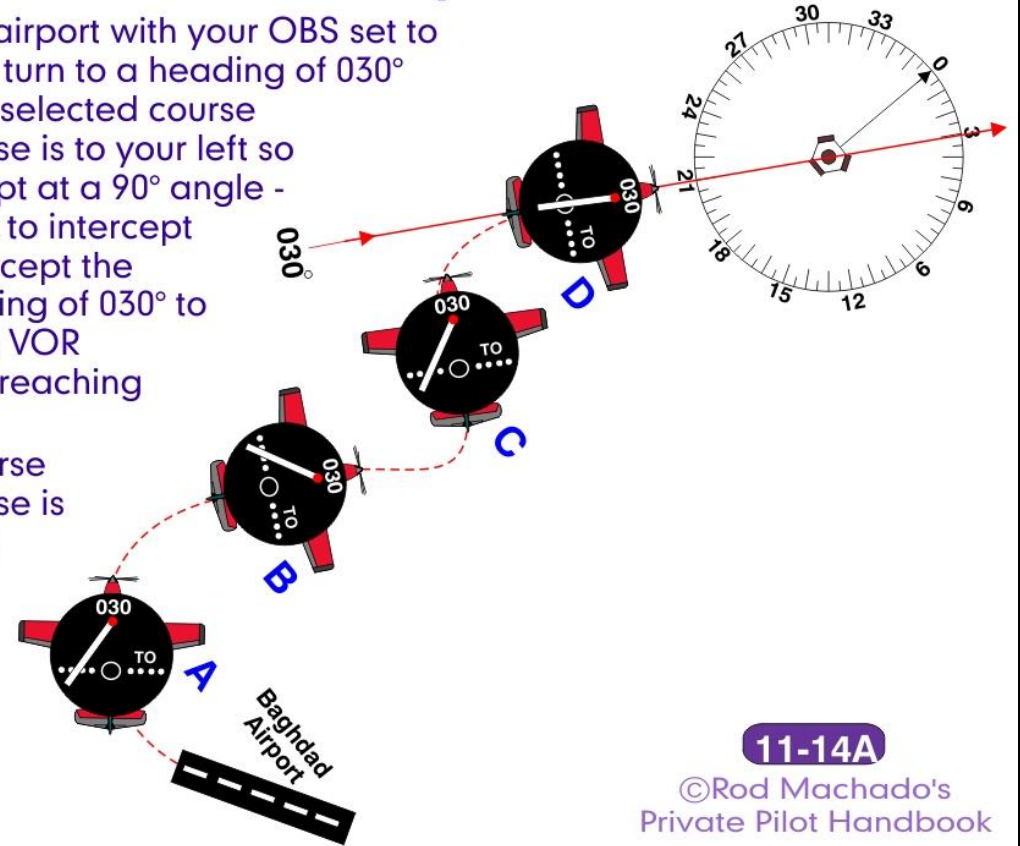
Flying Course TO VOR

- Airplane D will eventually pass over the VOR and its VOR flag will automatically switch from TO, to OFF, and then to FROM

FLYING A SELECTED COURSE TO, THEN FROM THE VOR

You depart Baghdad airport with your OBS set to 030° (Airplane A). You turn to a heading of 030° and fly parallel to the selected course (Airplane B). The course is to your left so you turn left to intercept at a 90° angle - the shortest distance to intercept (Airplane C). You intercept the course and fly a heading of 030° to the VOR then from the VOR (Airplane D & E), until reaching Yazoo airport.

parallel to the selected course (Airplane B). The course is to your left so you turn left to intercept at a 90° angle -- the shortest distance to intercept (Airplane C).



11-14A

©Rod Machado's
Private Pilot Handbook

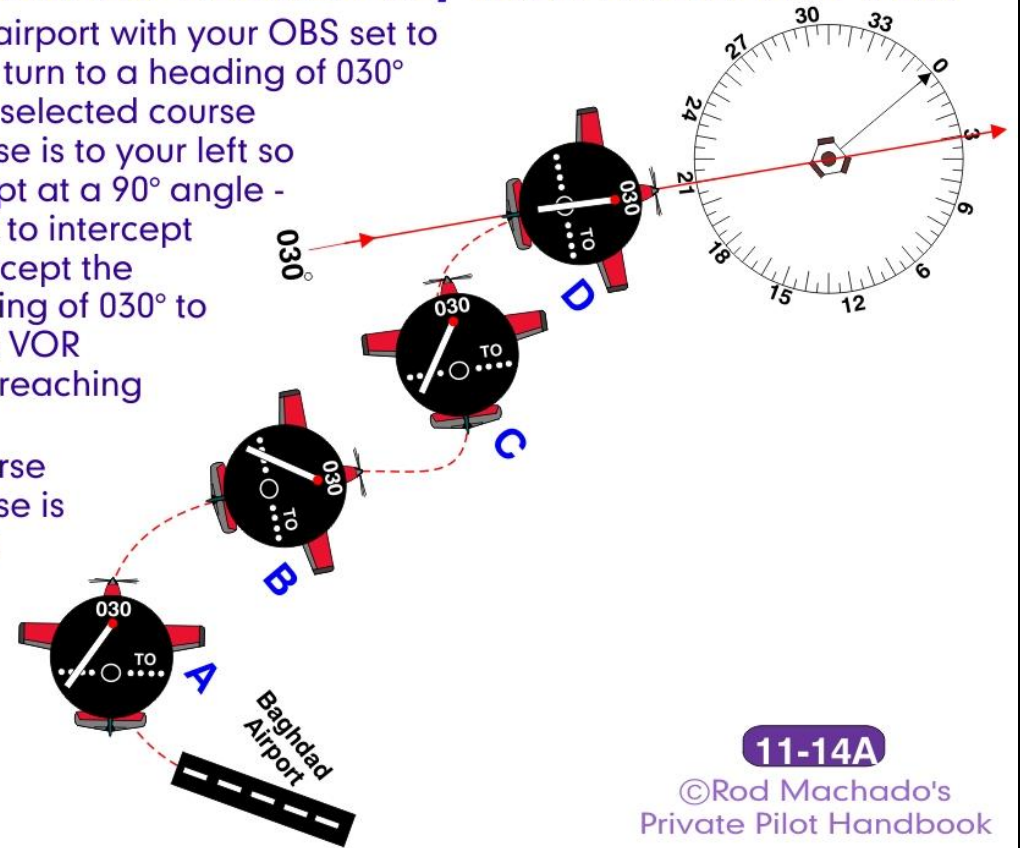
Flying Course TO VOR

- The airplane is now on the 030° course from the station
- Keeping the needle centered will eventually put Airplane F directly over Yazoo airport

FLYING A SELECTED COURSE TO, THEN FROM THE VOR

You depart Baghdad airport with your OBS set to 030° (Airplane A). You turn to a heading of 030° and fly parallel to the selected course (Airplane B). The course is to your left so you turn left to intercept at a 90° angle - the shortest distance to intercept (Airplane C). You intercept the course and fly a heading of 030° to the VOR then from the VOR (Airplane D & E), until reaching Yazoo airport.

parallel to the selected course (Airplane B). The course is to your left so you turn left to intercept at a 90° angle -- the shortest distance to intercept (Airplane C).



11-14A

©Rod Machado's
Private Pilot Handbook

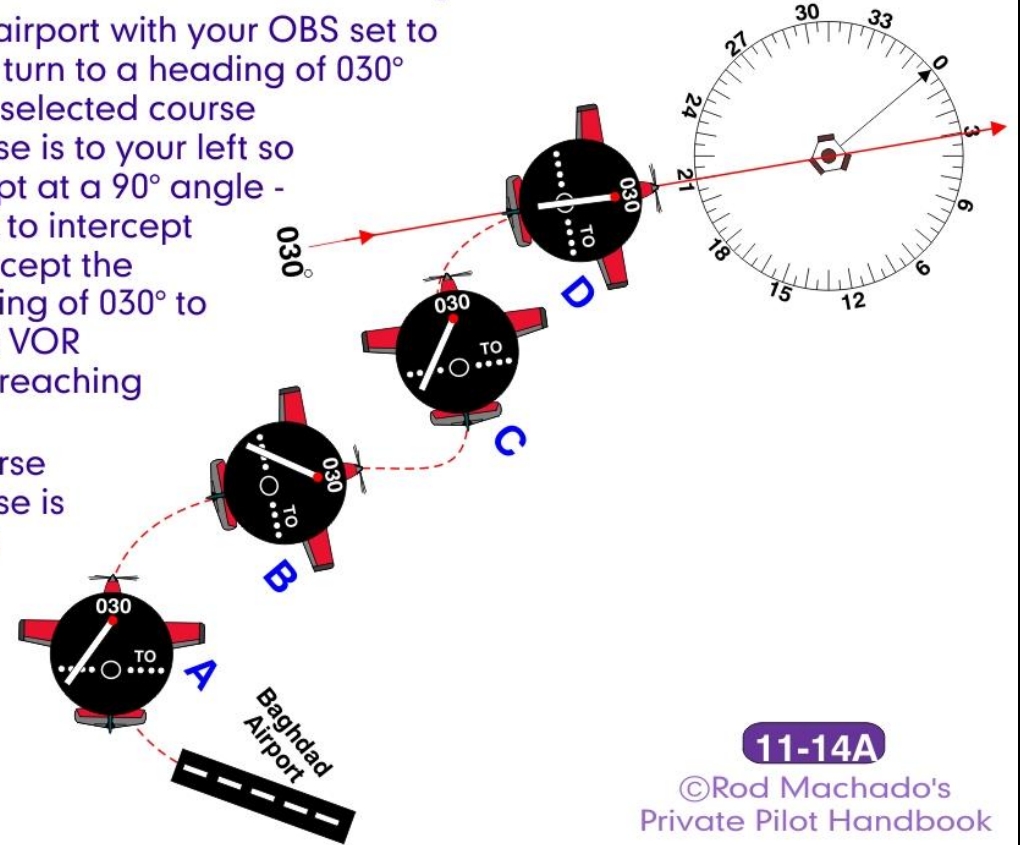
Flying Course TO VOR

- Some VORs have distance measuring equipment (DME)
- A receiver in the airplane converts the DME signals into a distance readout from the VOR station
- If you know Yazoo's distance from the VOR and fly the selected course until that distance shows on the DME, you'll be directly over the airport

FLYING A SELECTED COURSE TO, THEN FROM THE VOR

You depart Baghdad airport with your OBS set to 030° (Airplane A). You turn to a heading of 030° and fly parallel to the selected course (Airplane B). The course is to your left so you turn left to intercept at a 90° angle - the shortest distance to intercept (Airplane C). You intercept the course and fly a heading of 030° to the VOR then from the VOR (Airplane D & E), until reaching Yazoo airport.

parallel to the selected course (Airplane B). The course is to your left so you turn left to intercept at a 90° angle -- the shortest distance to intercept (Airplane C).



11-14A

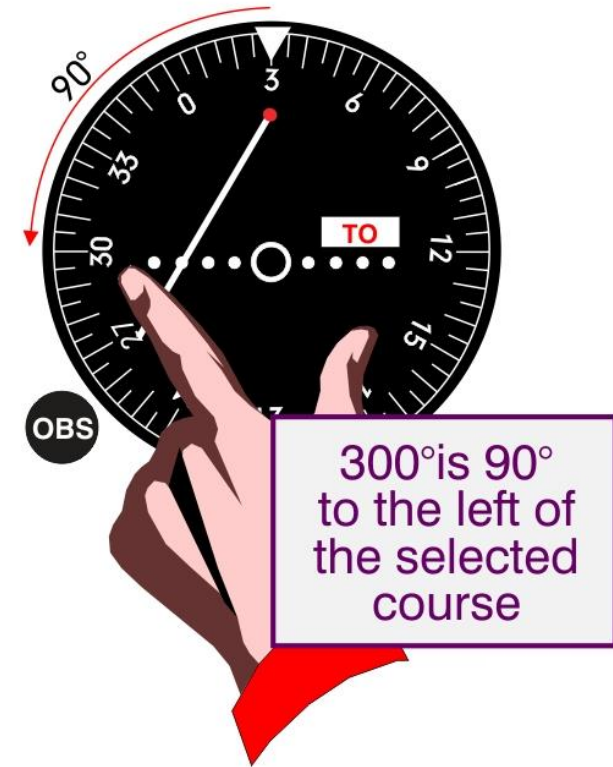
©Rod Machado's
Private Pilot Handbook

VOR Course Intercept Angle

- To get on the course as soon as possible, intercept at a 90° angle
- Turning left to a heading of 300° perpendicular to the selected course (030°) results in the shortest intercept time

VOR COURSE INTERCEPT ANGLE

To find an angle to intercept the selected VOR course, look to the left or right of the present course selection on the VOR's compass rose. A heading of 300° provides the shortest distance to intercept the 030° course.

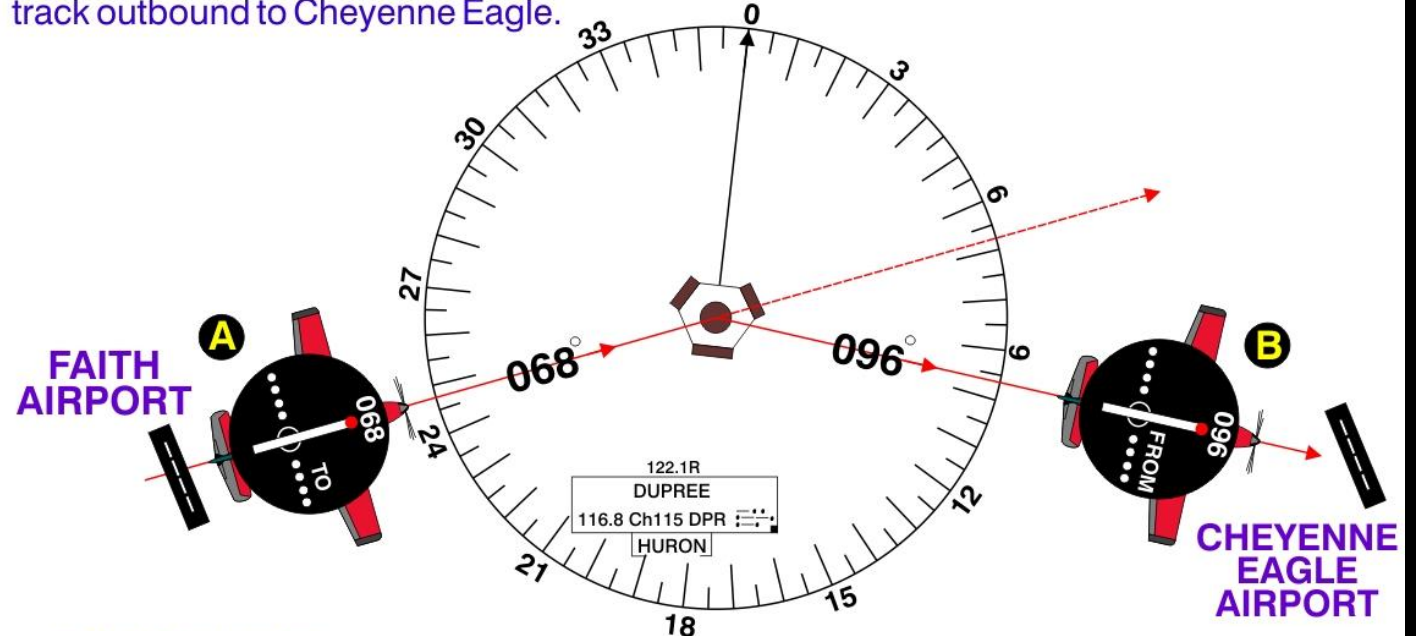


VOR Navigation

- Depart Faith airport and fly directly to the Dupree VOR, then fly outbound on the 096 course to Cheyenne Eagle
- Using the VOR compass rose determine what route runs directly from the center of Faith airport to the Dupree VOR
- Draw line from the center of Faith airport through center of the Dupree VOR, and out the side of the compass rose (068)

VOR NAVIGATION FROM FAITH TO CHEYENNE EAGLE

Tuning your OBS to 068° takes you direct to the Dupree VOR from Faith airport. To fly to Cheyenne Eagle airport, select the 096° course on your OBS when over the VOR, then track outbound to Cheyenne Eagle.

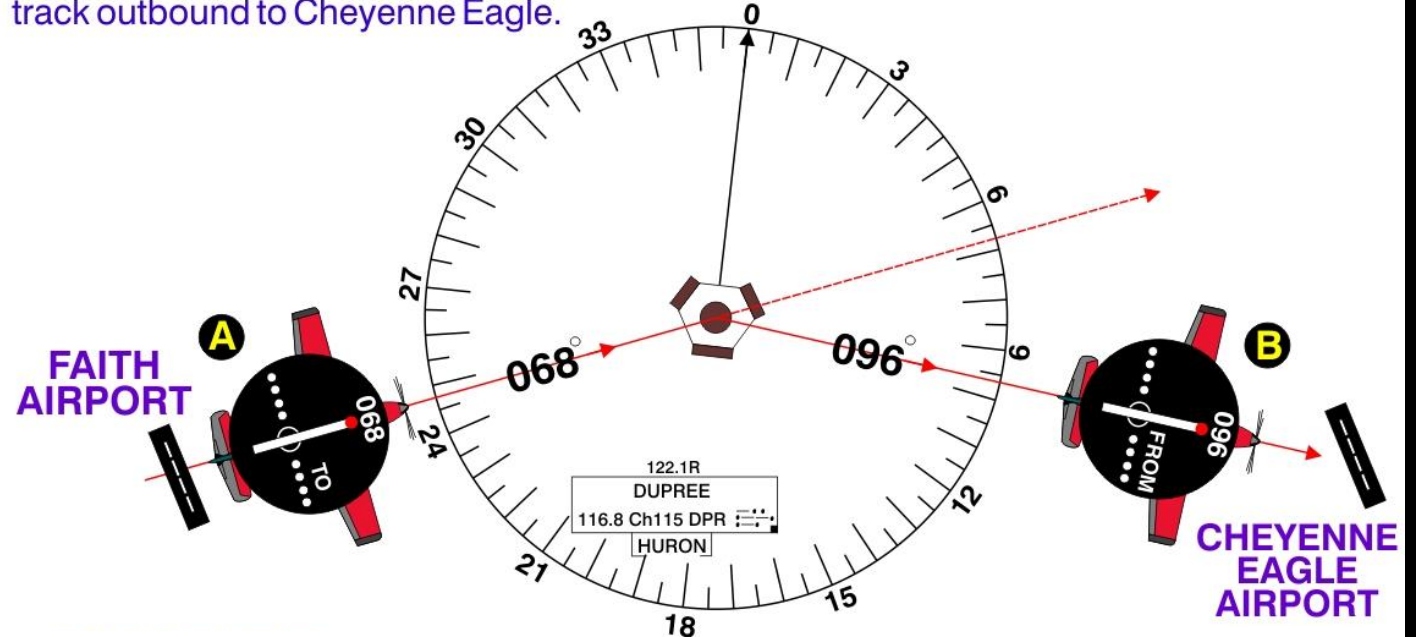


VOR Navigation

- Rotate the OBS to 068 and fly this course to the VOR after departure
- Over the VOR, when the flag switches from TO to OFF, turn right to a heading of 096, then rotate OBS to 096
- Track this new route FROM the VOR to Cheyenne Eagle

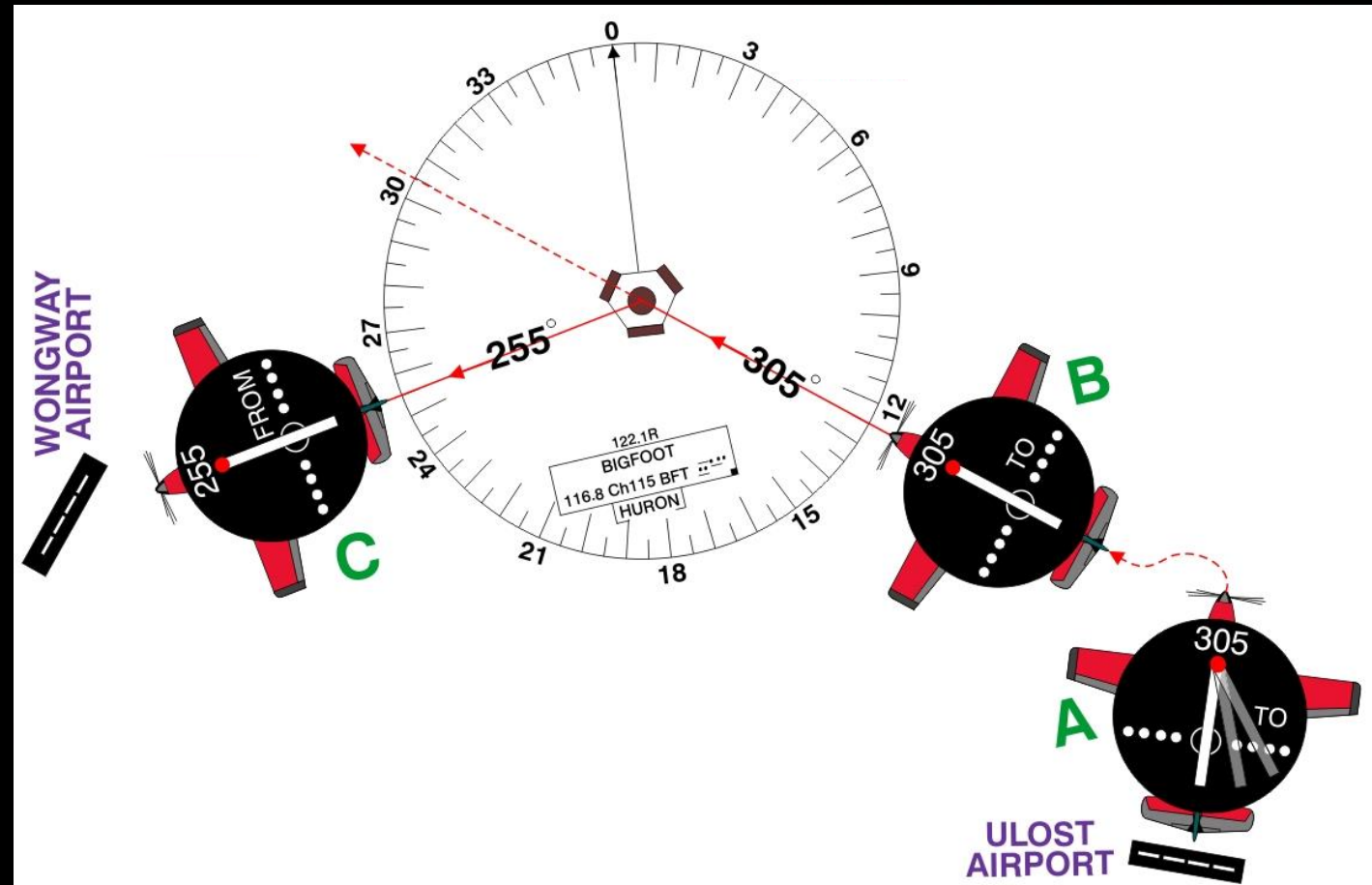
VOR NAVIGATION FROM FAITH TO CHEYENNE EAGLE

Tuning your OBS to 068° takes you direct to the Dupree VOR from Faith airport. To fly to Cheyenne Eagle airport, select the 096° course on your OBS when over the VOR, then track outbound to Cheyenne Eagle.



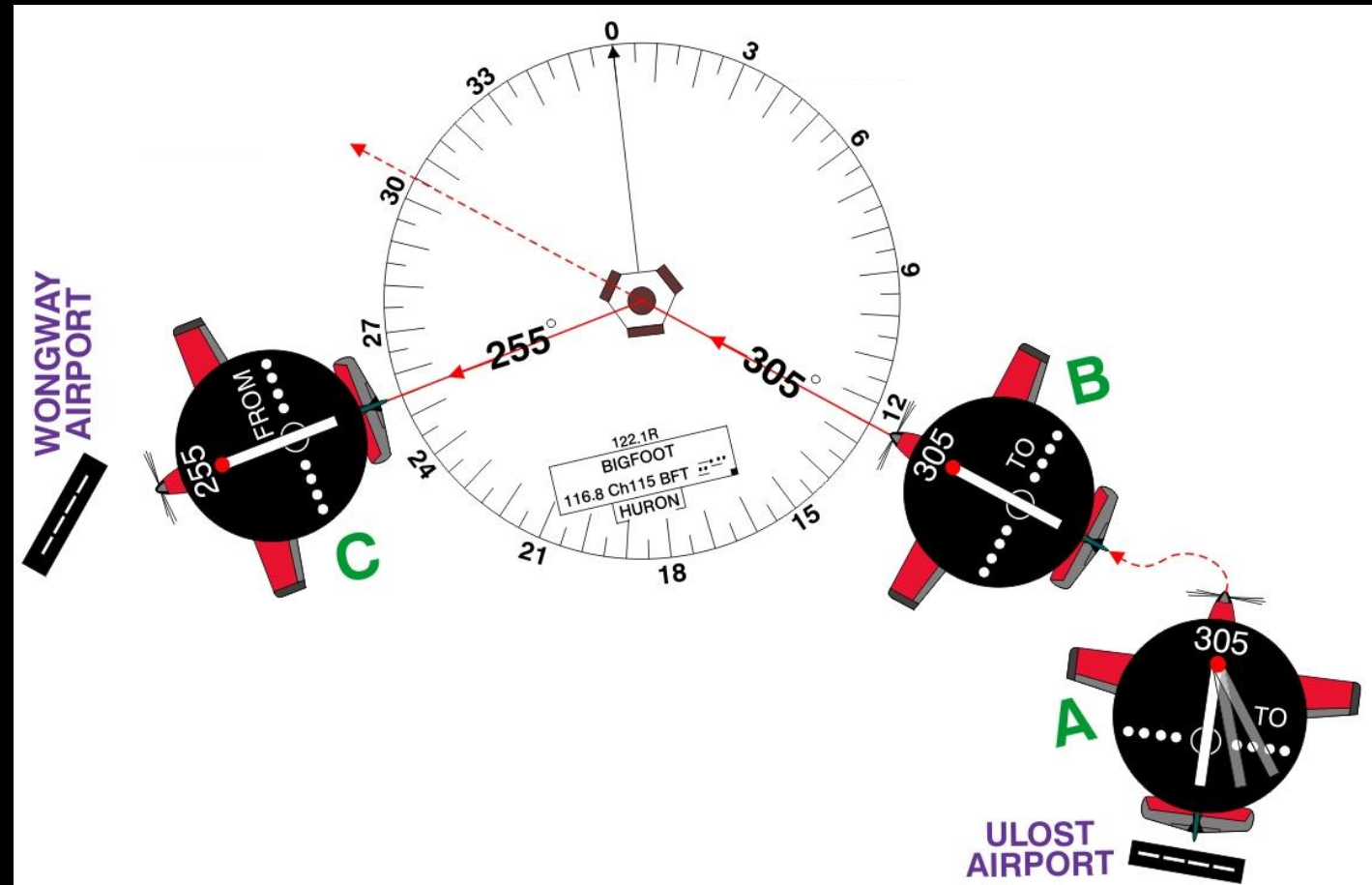
Shortest Route to VOR

- Suppose you're in the vicinity of Ulost airport and want to fly to Wongway airport
- Since you're not exactly sure of your position, what's the best way to get to the Bigfoot VOR?
- You are always on some course going to the VOR
- How do you know which course it is?



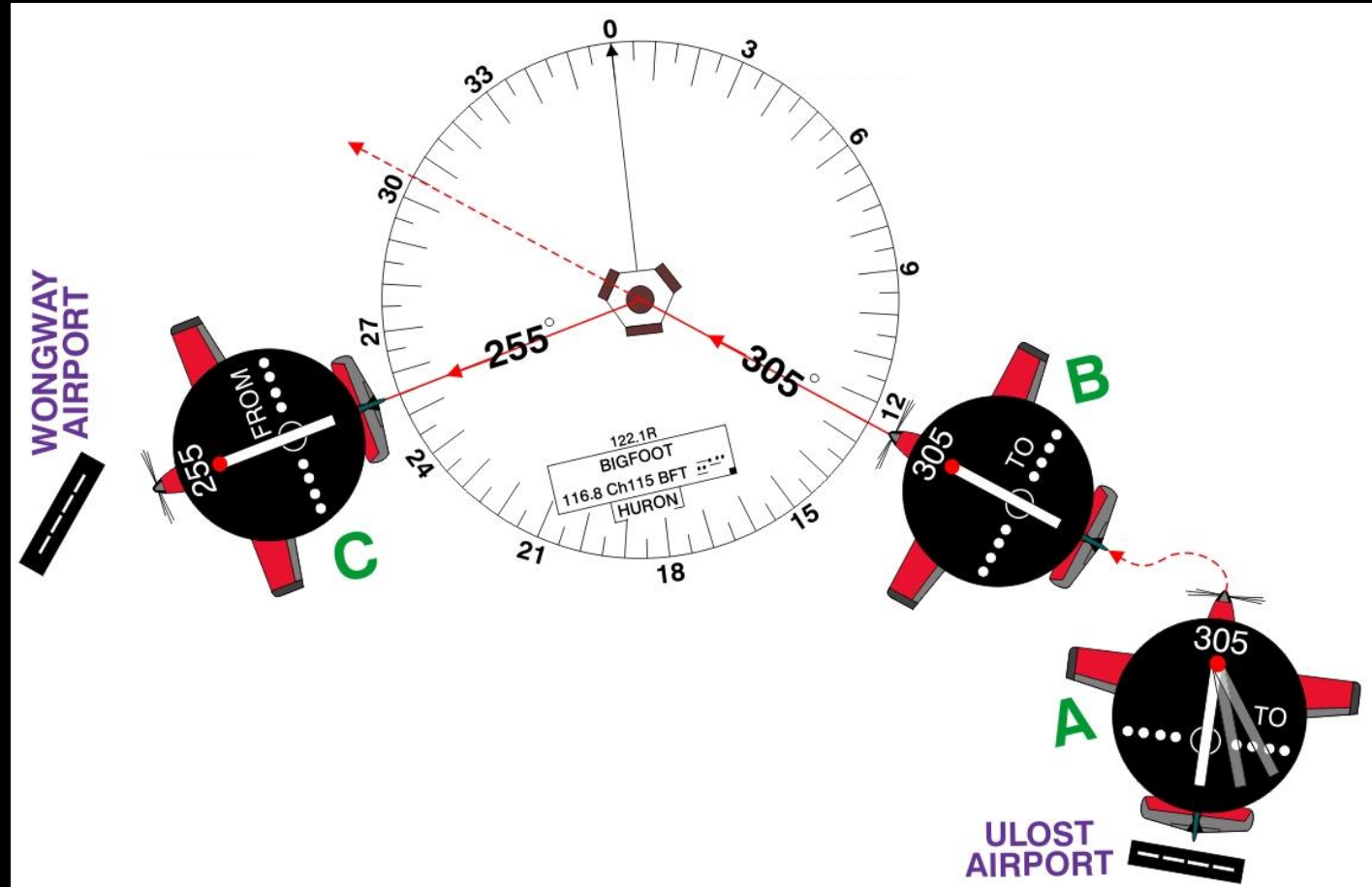
Shortest Route to VOR

- Tune in the Bigfoot VOR frequency on the navigational radio and ID the station
- Rotate the OBS until you get a TO flag indication and the needle centers
- Look up at the index to see what the course is



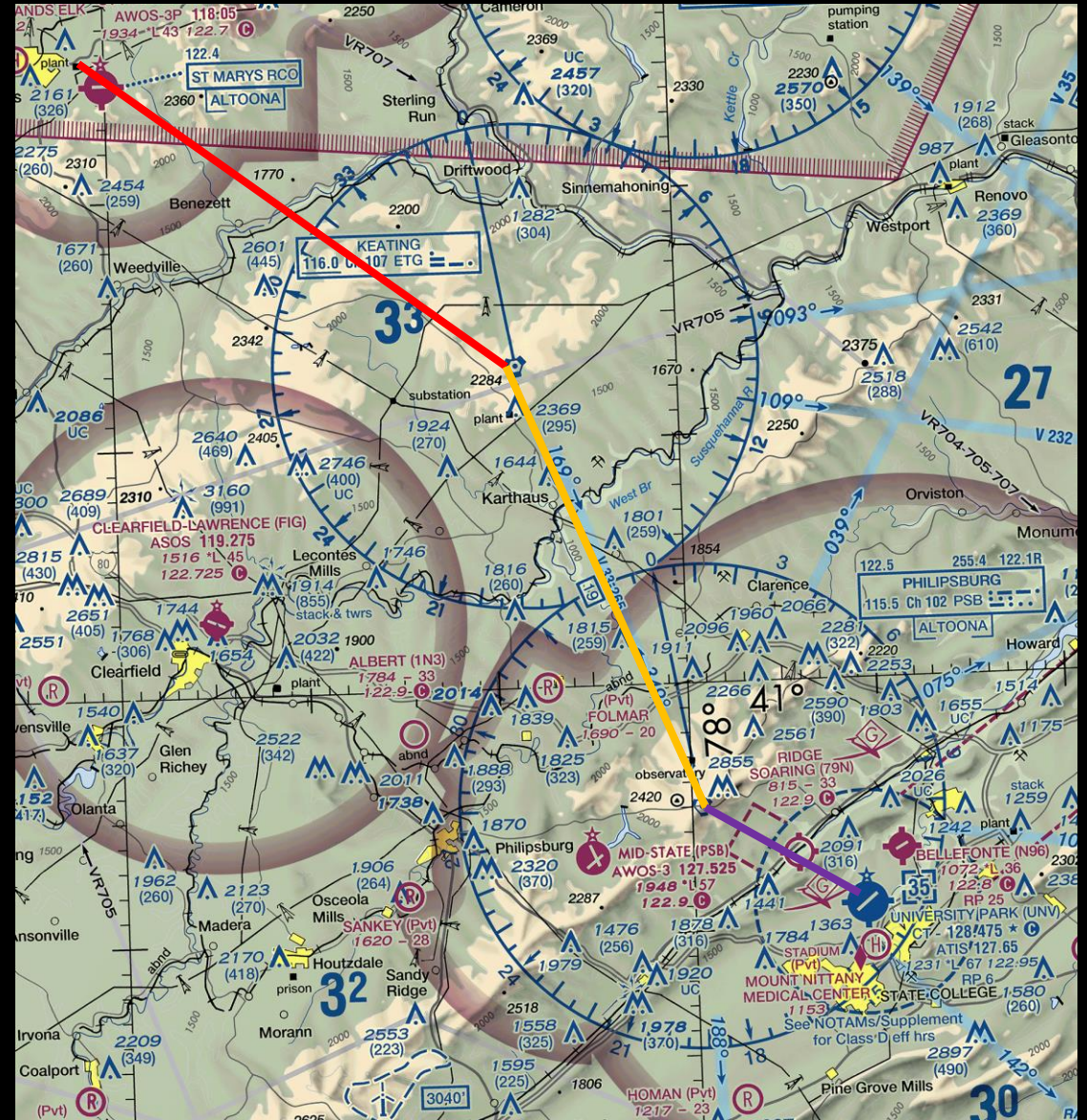
Shortest Route to VOR

- Index shows 305° course to the Bigfoot VOR
- Turn to a heading of 305° on your heading indicator and fly that course to the VOR
- When over the station, fly outbound FROM the VOR on 255° course to Wongway airport



VOR Navigation KOYM - KUNV

- KOYM direct ETG (136° course)
- ETC 170° course to PSB
170° course
- PSB 132° course to KUNV

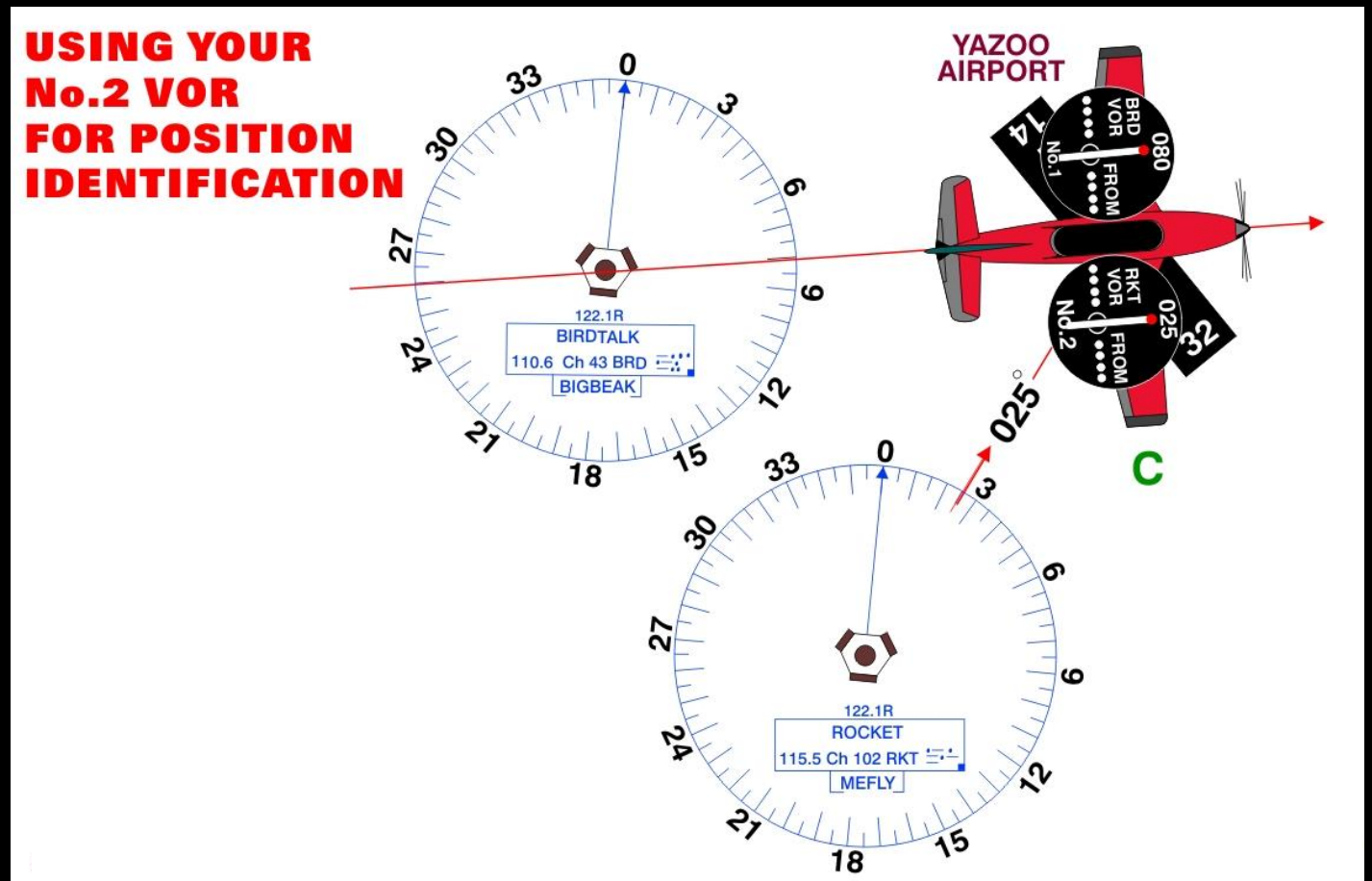


Victor Airways



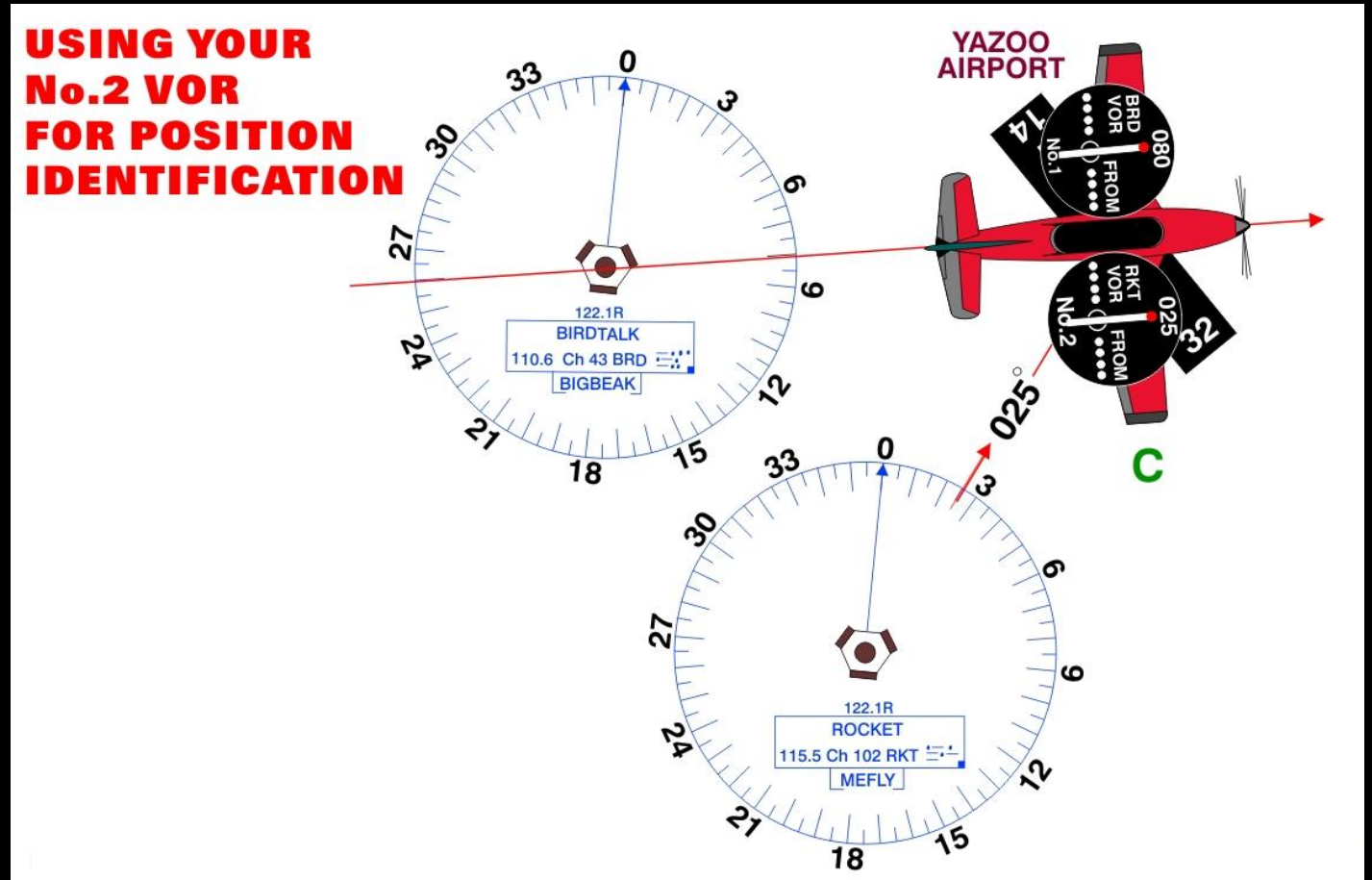
Dual VORs for Position Fixing

- If #1 VOR is set to navigate from the BRD VOR to Yazoo, could the #2 VOR receiver be used to inform you when you're over Yazoo?
- Find another station in the vicinity of Yazoo by checking the sectional chart
- RKT VOR is nearby
- Draw a line from the center of RKT VOR through the center of Yazoo airport



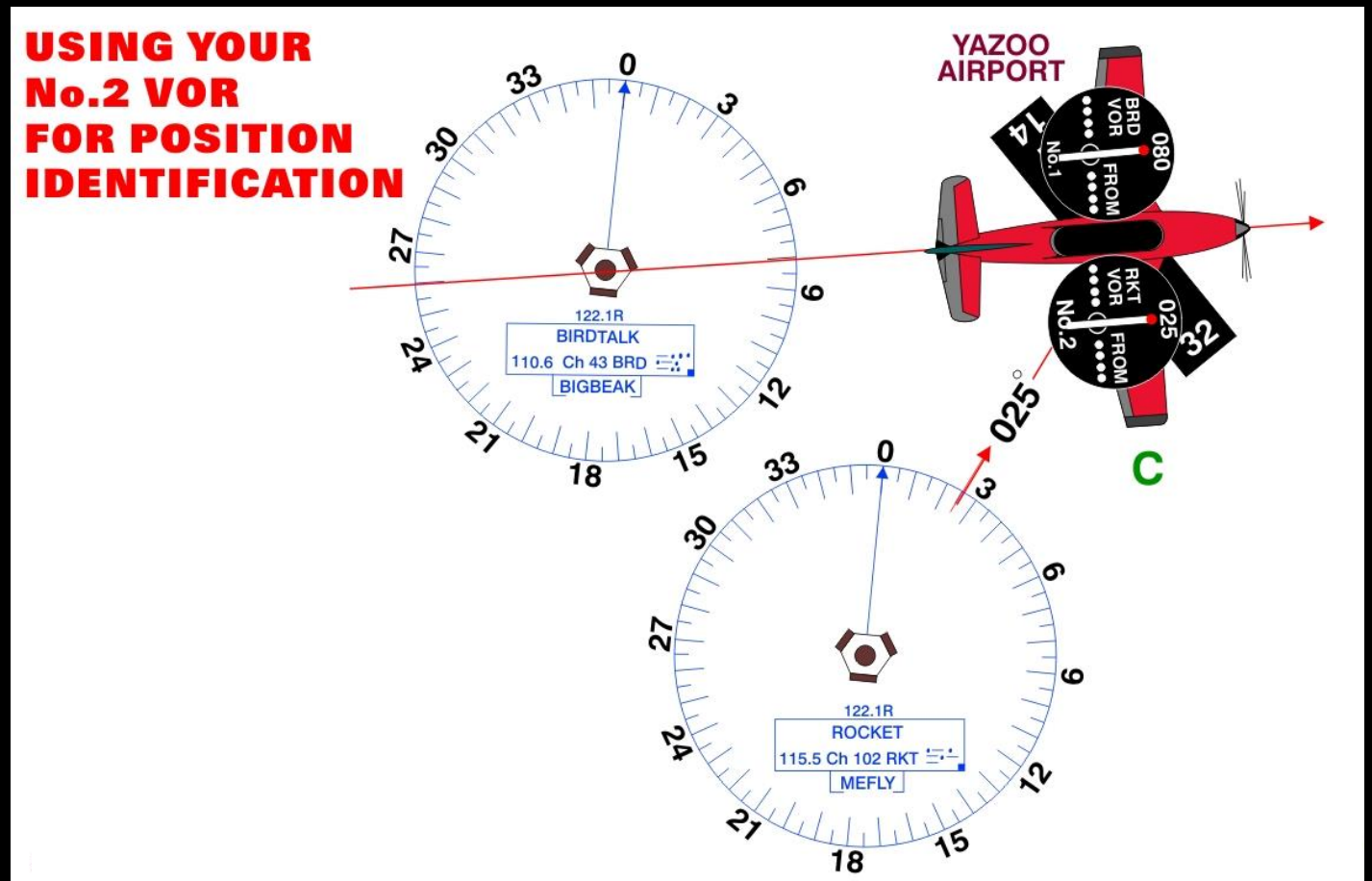
Dual VORs for Position Fixing

- Compass rose around RKT VOR shows the 025° course from the station to Yazoo
- *Note: Always use FROM courses to cross check positions*
- Set 025° into the #2 VOR receiver and tune to RKT VOR
- Outbound from BRD VOR prior to Yazoo airport #2 VOR will show a right needle with a FROM indication



Dual VORs for Position Fixing

- Approaching Yazoo airport, the needle in #2 VOR moves toward the center of the instrument
- When the needle centers, you are over Yazoo airport



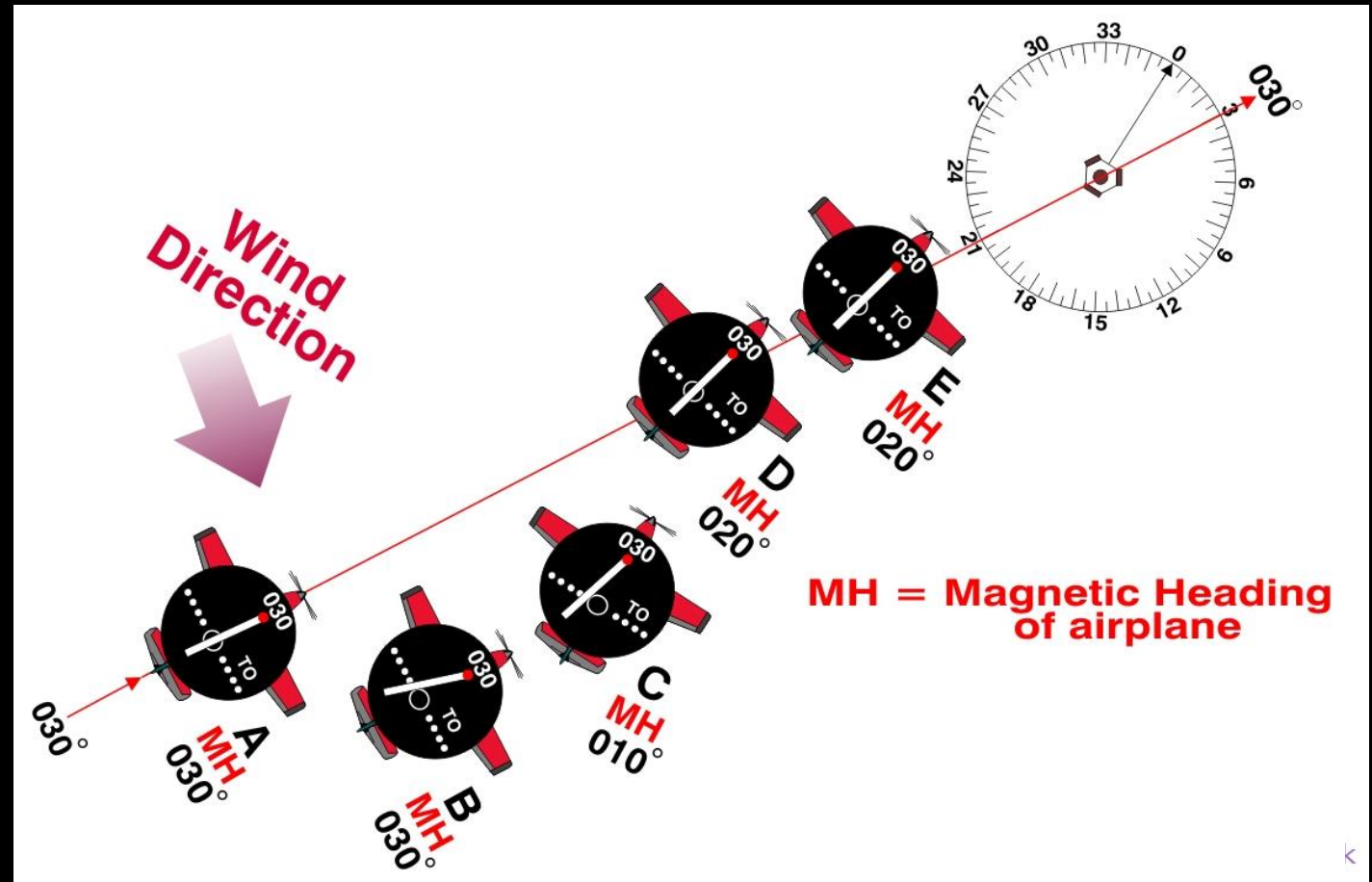
Tracking a Selected VOR Course

Wind correction is broken down into four components:

- *1. Identifying the effect of wind on the airplane*
- *2. Re-intercepting the course*
- *3. Applying a wind correction*
- *4. Adjusting the correction*

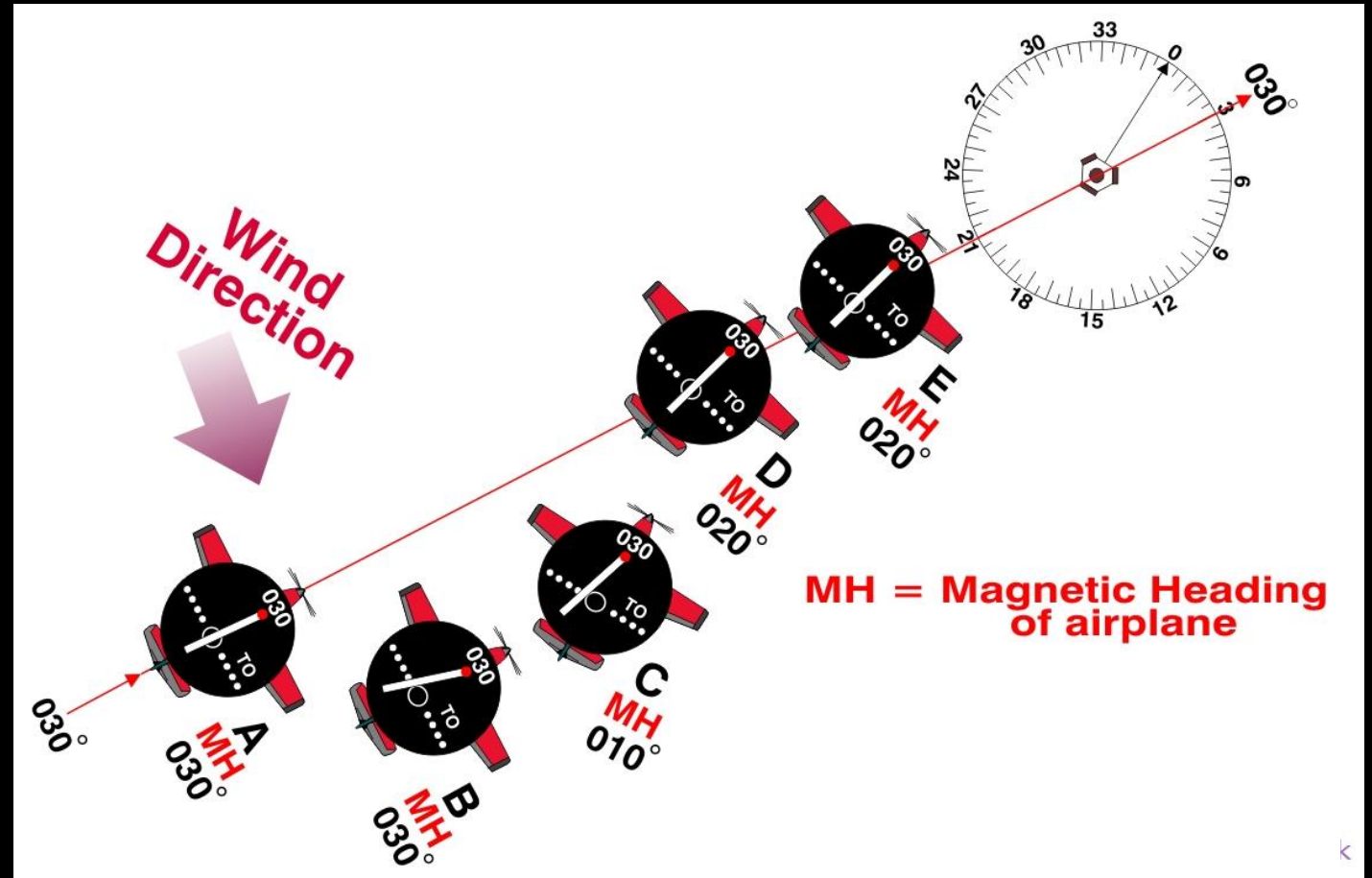
Wind Correction When Tracking VOR Course

- Airplane A just intercepted the 030° course to the VOR
- Under a no-wind condition, A could hold a 030 heading and fly to the VOR with a centered needle
- With wind the airplane will drift off course.
- Determining wind direction and making the proper correction is paramount to successful navigation



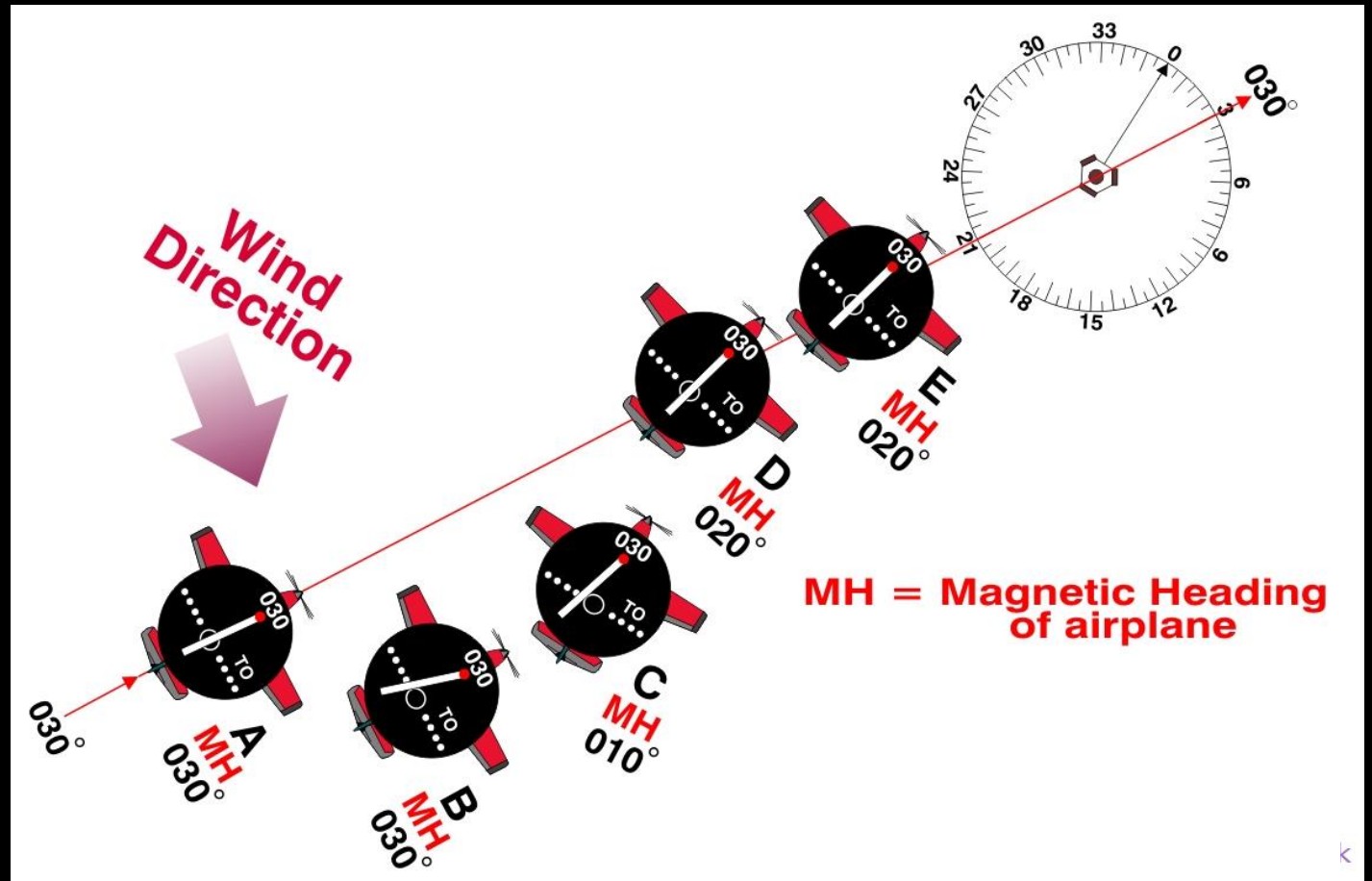
Wind Correction When Tracking VOR Course

- To determine wind effect, fly the heading set by the OBS (030°) and wait
- If there is no wind the needle will stay centered
- If a crosswind exists, the needle will show a deflection B
- Let the needle move just a little (end of the circle in the center) before making a correction



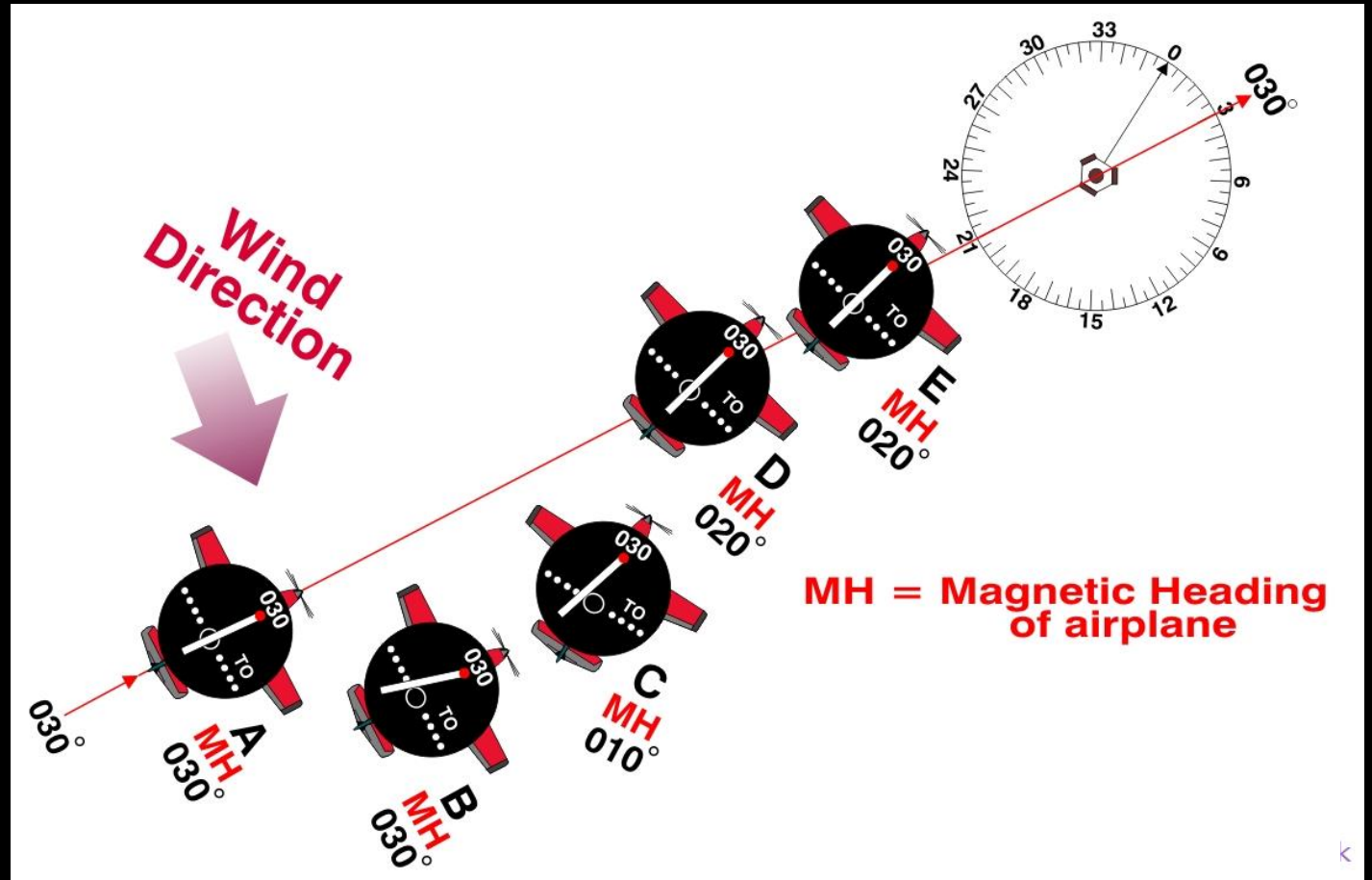
Wind Correction When Tracking VOR Course

- Since needle moves left, the selected course is to the left B
- Airplane has been blown to the right of course (crosswind is from the left)
- Next step is to get back on course before applying a wind correction



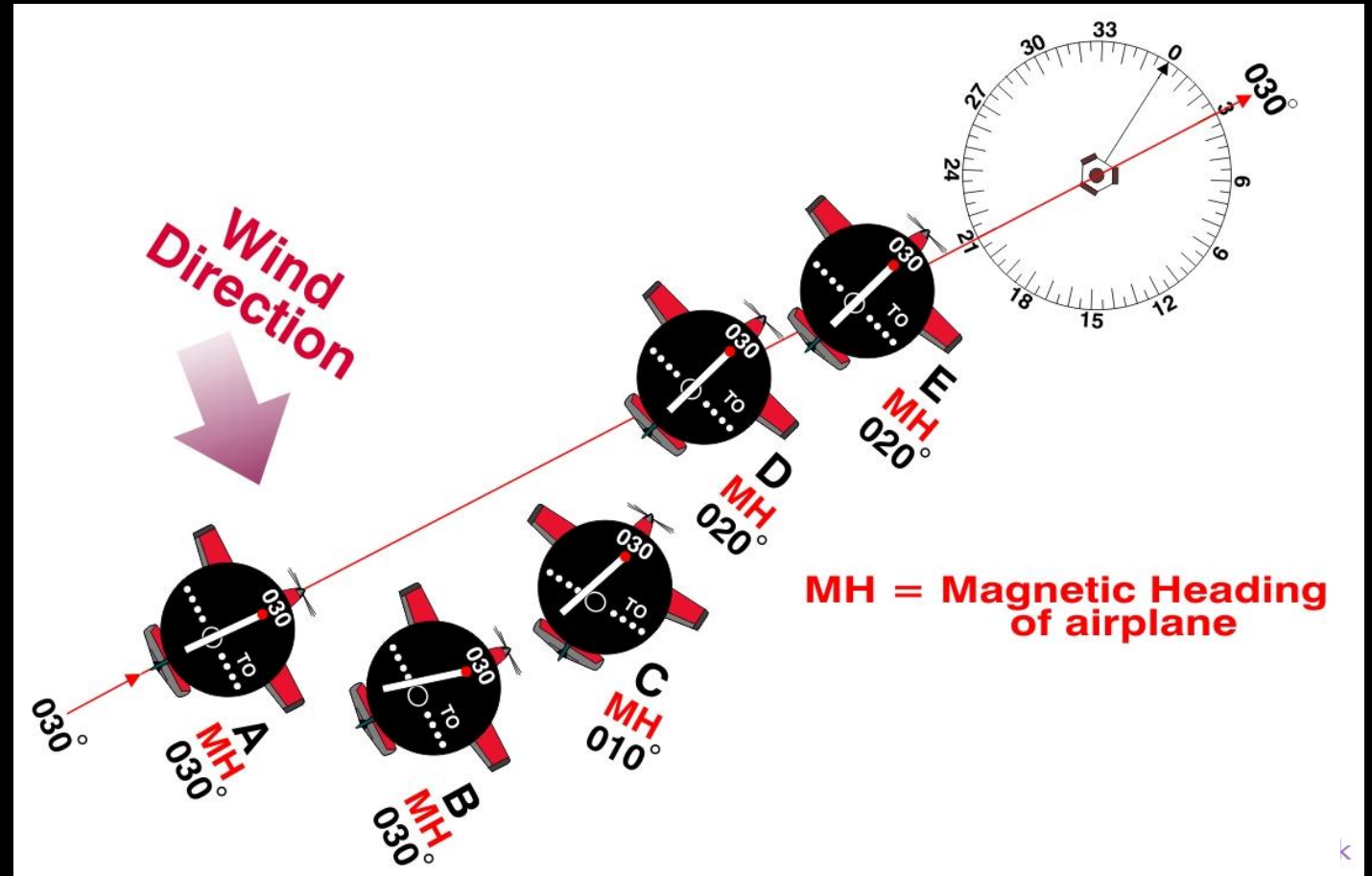
Wind Correction When Tracking VOR Course

- Once reestablished on course, the third step in tracking is to apply a wind correction
- The airplane must be angled (turned) by some amount into the wind
- The angle depends on the wind speed, wind angle, and your airspeed



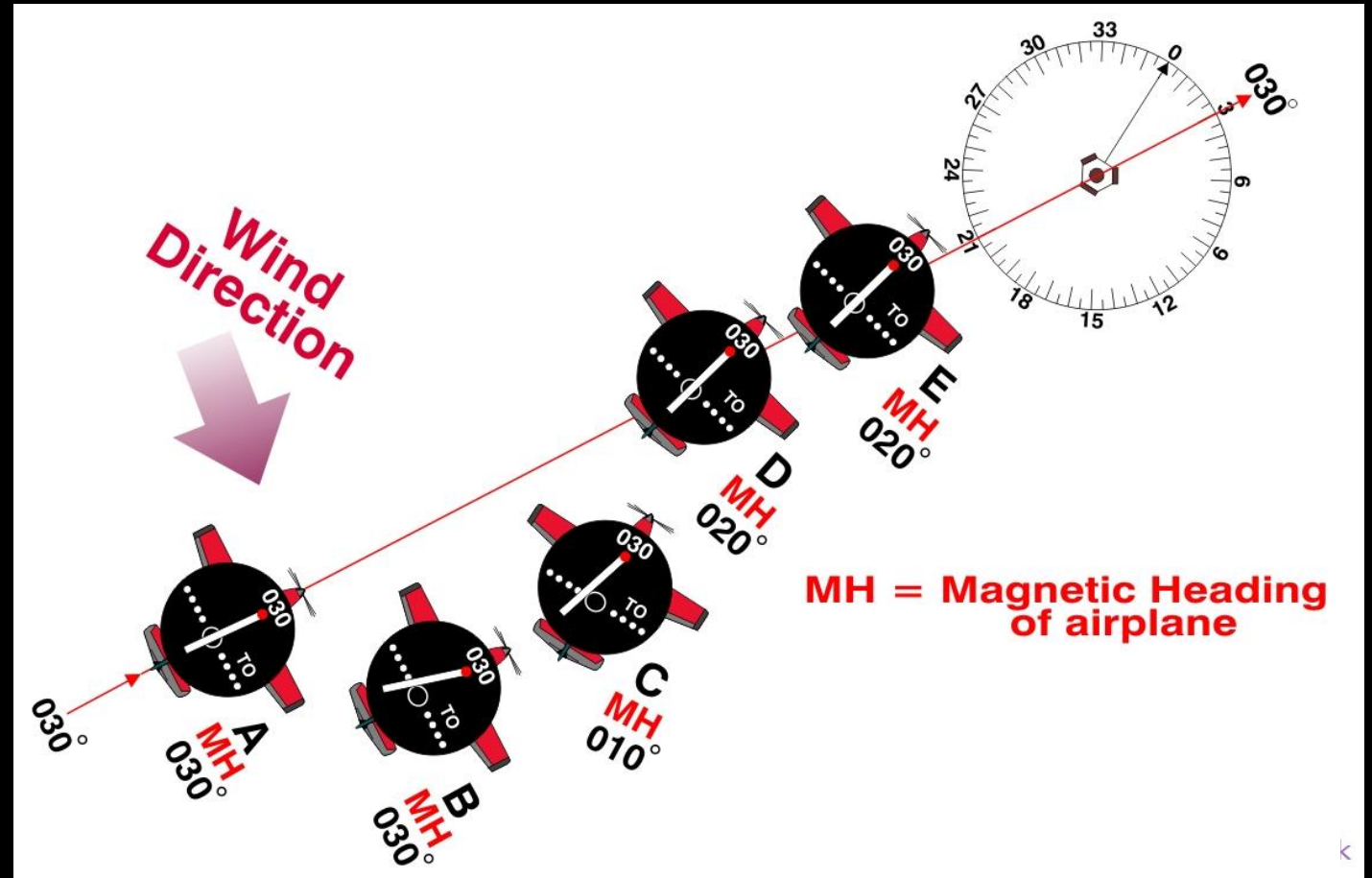
Wind Correction When Tracking VOR Course

- Use 1/2 of your intercept angle (10 in this case) and see if it works
- Once back on course, turn the airplane 10° the right (heading 020°) D, and wait to see what happens
- D has a wind correction angle of 10° left while heading 020°
- D and E are tracking directly to the VOR station on the 030 course



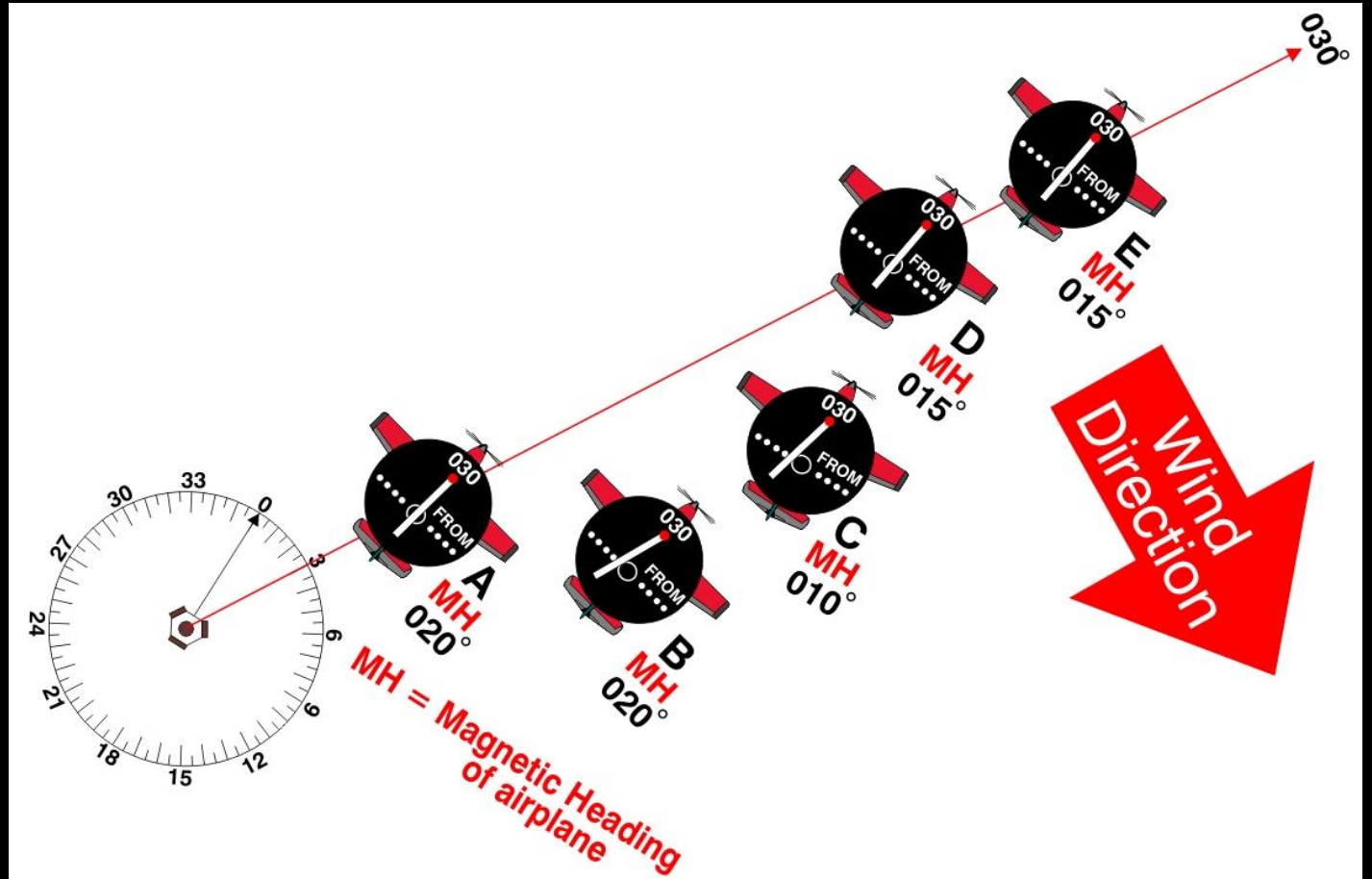
Wind Correction When Tracking VOR Course

- Realistically, you will probably make a minimum of two attempts at determining a WCA before you find the right one



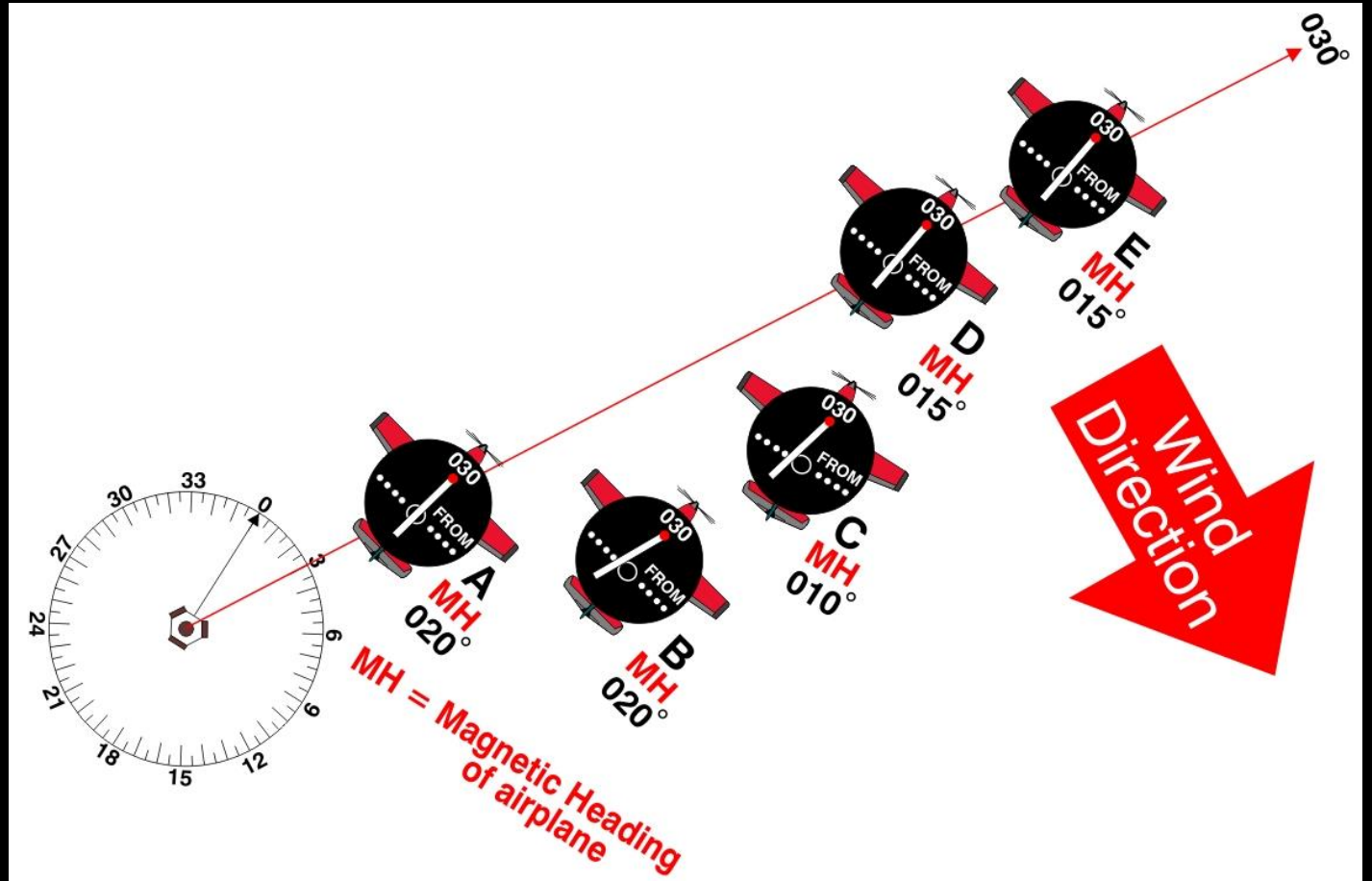
Wind Correction When Tracking VOR Course

- Airplane A is tracking from VOR station using a 10° WCA left
- Airplane begins to drift so WCA must be changed B
- Return to 010° and re-intercept the course C
- Since a heading of 020° (10° WCA left) didn't keep you on course, increase the WCA by 5° to 15° left



Wind Correction When Tracking VOR Course

- Realistically, the wind varies, and the entire flight consists of constantly changing the WCA
- Apply small corrections to stop the needle from moving before it ever gets away from the center

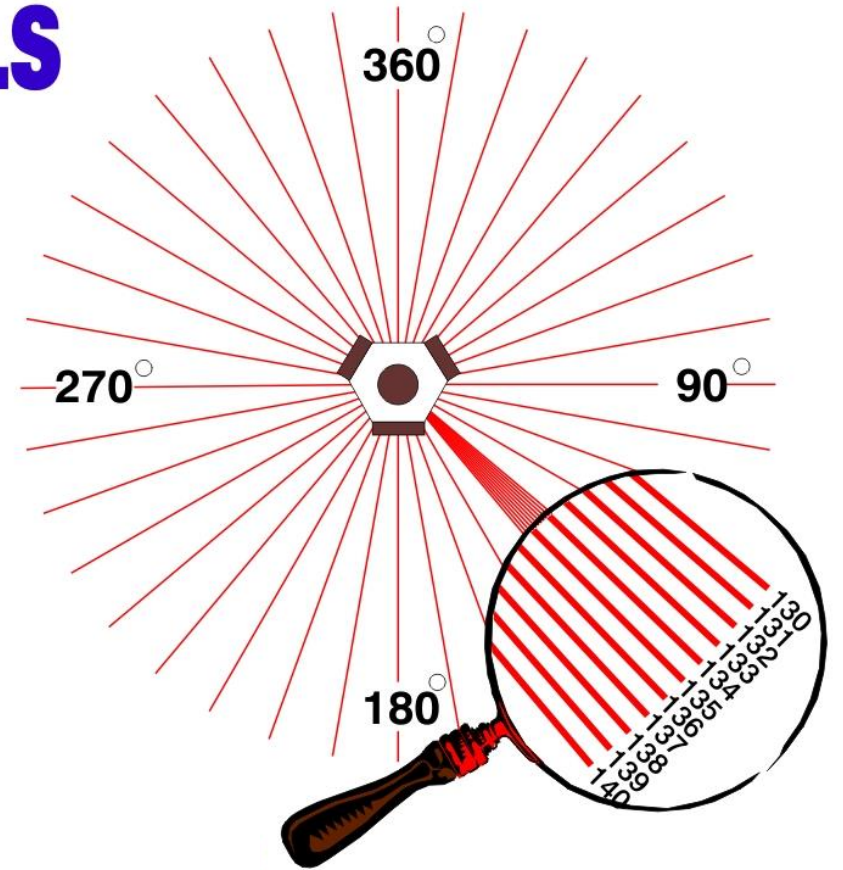


Chasing the Needle

- Patience with the VOR needle will solve most tracking problems
- Needle becomes quite sensitive when closing in on VOR station
- Rapid needle movements occur within 1/2 mile of a VOR transmitter
- When close to the station, settle on a heading and fly it until station passage

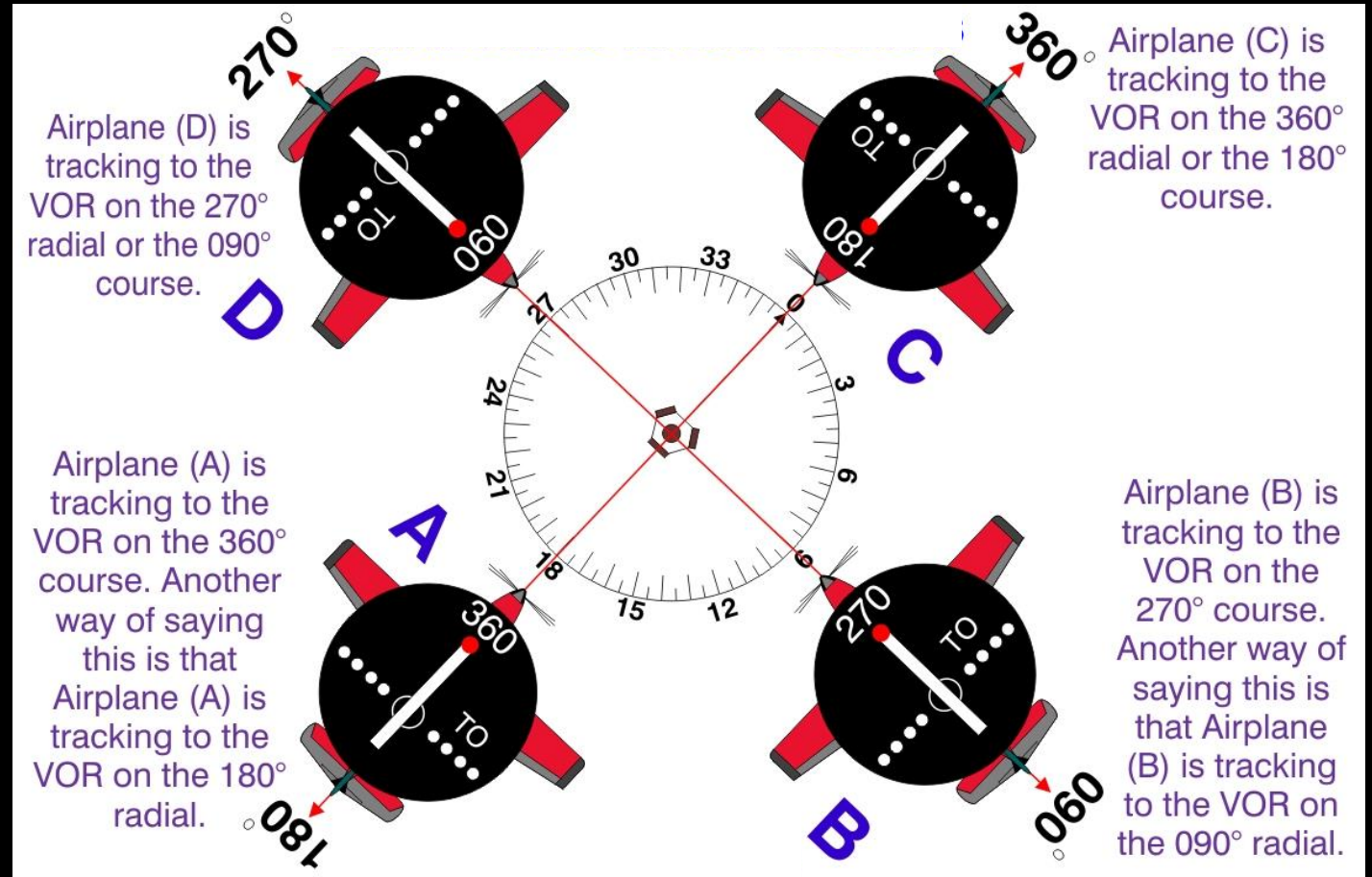
VOR RADIALS

Think of the VOR as a transmitter that radiates 360 individual radials from its center. These radials are oriented to the magnetic north pole. You may navigate to or from the station on any of these radials via your airborne VOR equipment.



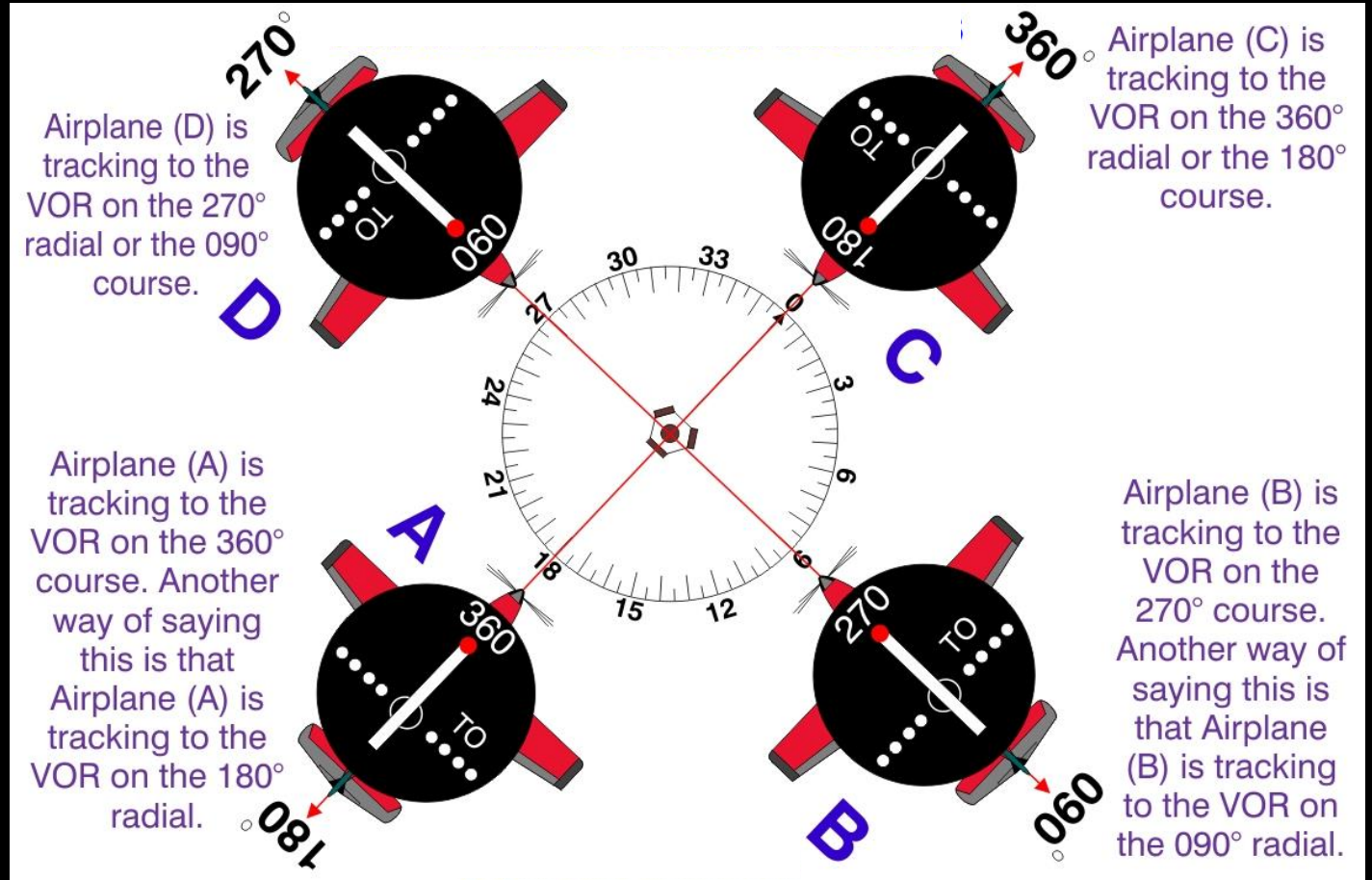
VOR Radials vs. Courses

- VORs transmit 360 individual directional signals spaced one degree apart
- Since they radiate from the station, they're called radials
- VOR courses are selected with the OBS
- Those courses are either to or from the VOR



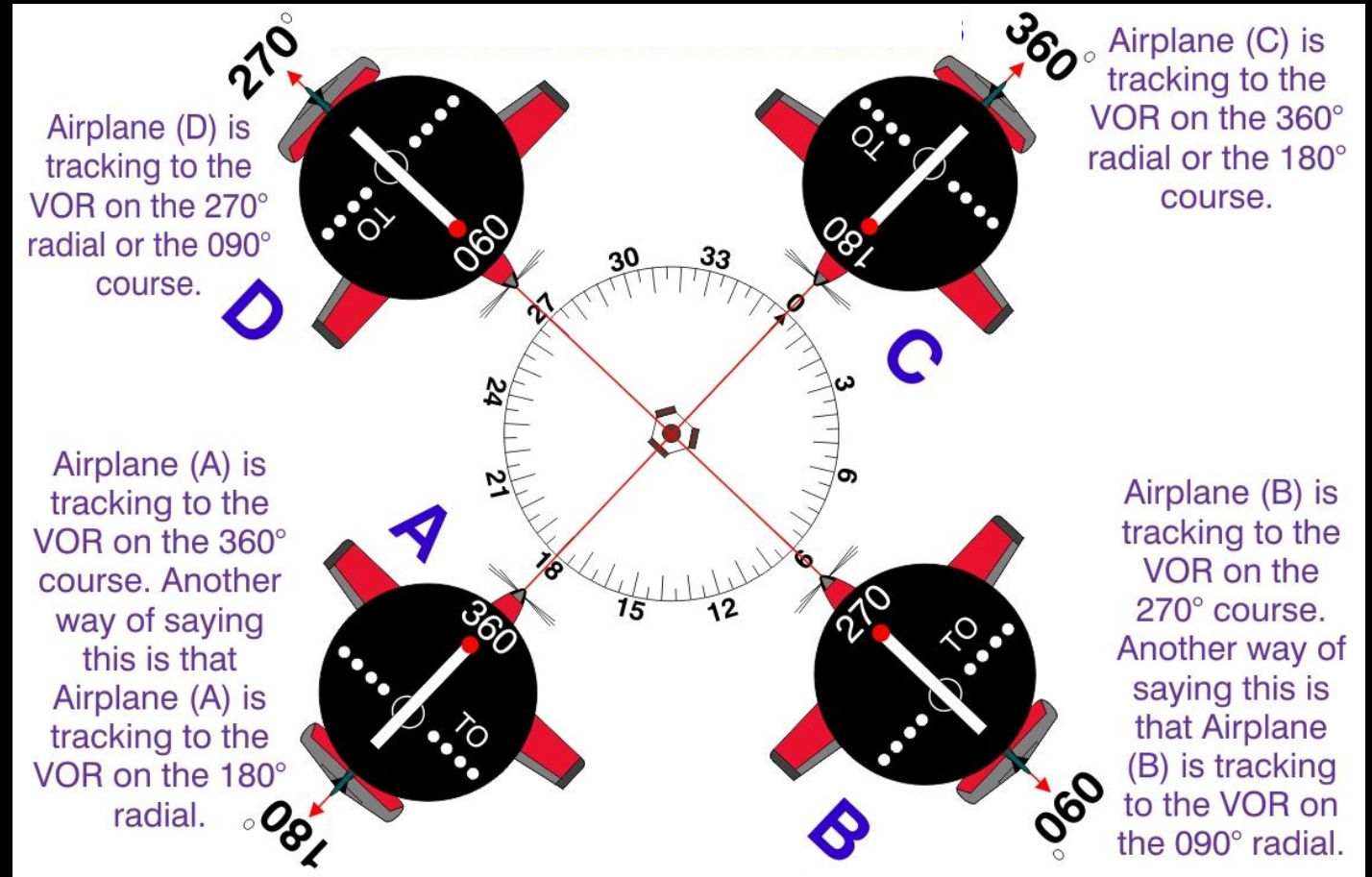
VOR Radials vs. Courses

- To track FROM a station on a specific radial, set the OBS to that radial
- Radials radiate from the station, and this is the same direction you would fly them
- To track TO a VOR on a radial, set the OBS to the reciprocal (add or subtract 180°) of that radial



VOR Radials vs. Courses

- All the airplanes are flying TO the VOR on specific radials
- Each OBS is selected to the reciprocal of the radial it's on



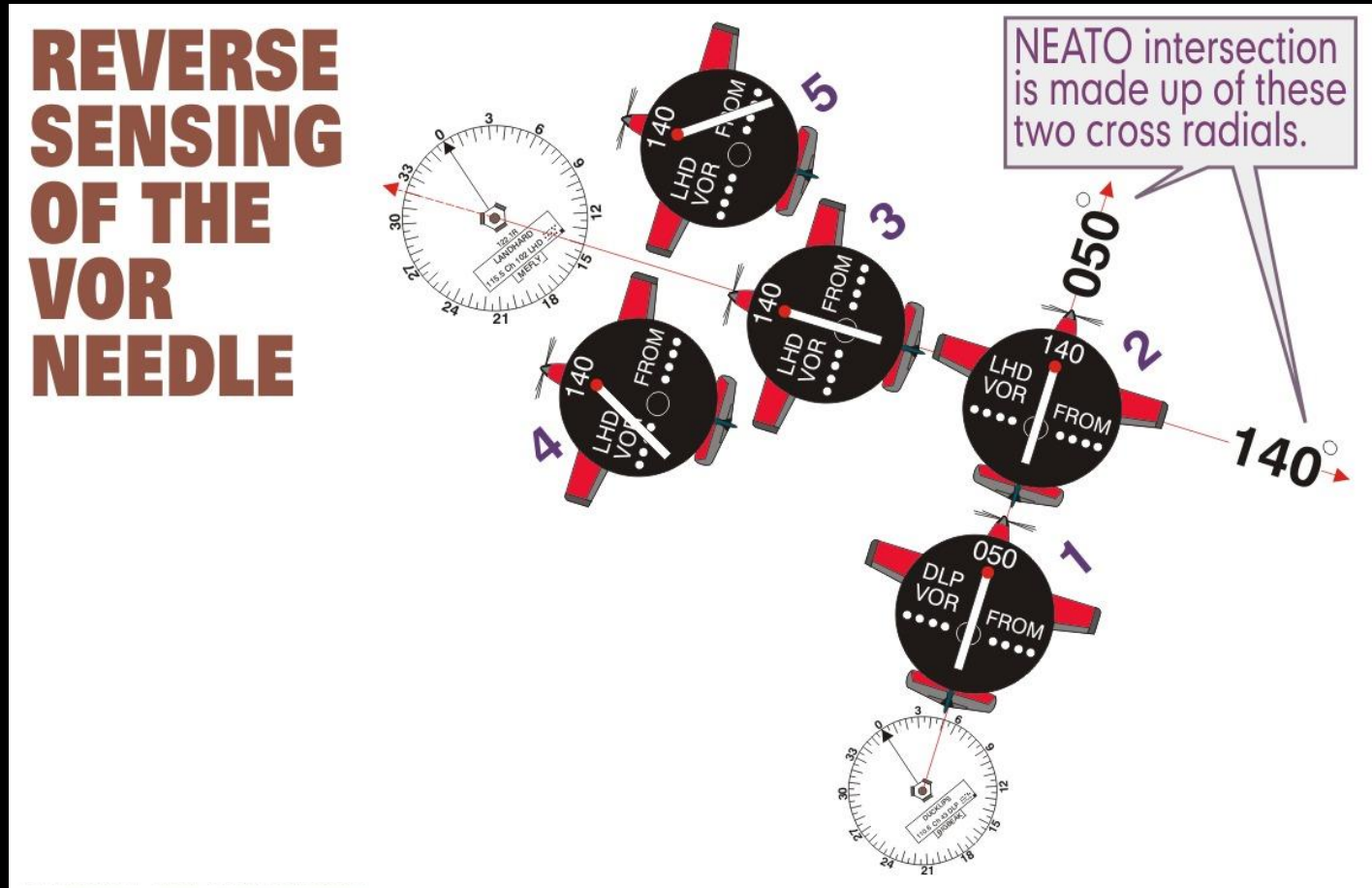
Finding Reciprocals

- If course is 180° or less:
add 200, then subtract 20
 - *Reciprocal of 120° :*
 $120 + 200 - 20 = 300^\circ$
- If course is greater than 180° :
subtract 200, then add 20
 - *Reciprocal of 300° :*
 $300 - 200 + 20 = 120^\circ$



VOR Needle Reverse Sensing

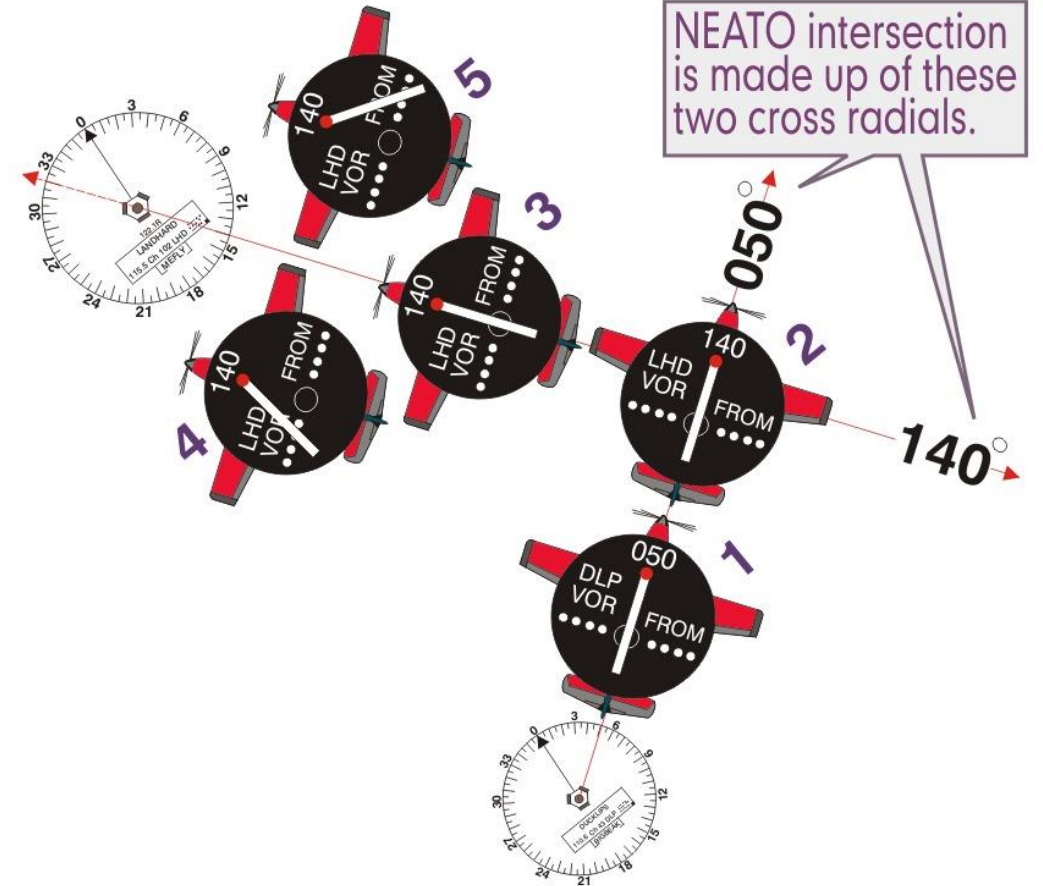
- One trap of VOR navigation occurs when pilots attempt to travel *to* a VOR with a FROM flag showing on the instrument (or the other way around)
- The VOR needle will show your selected course in reverse of its actual position



VOR Needle Reverse Sensing

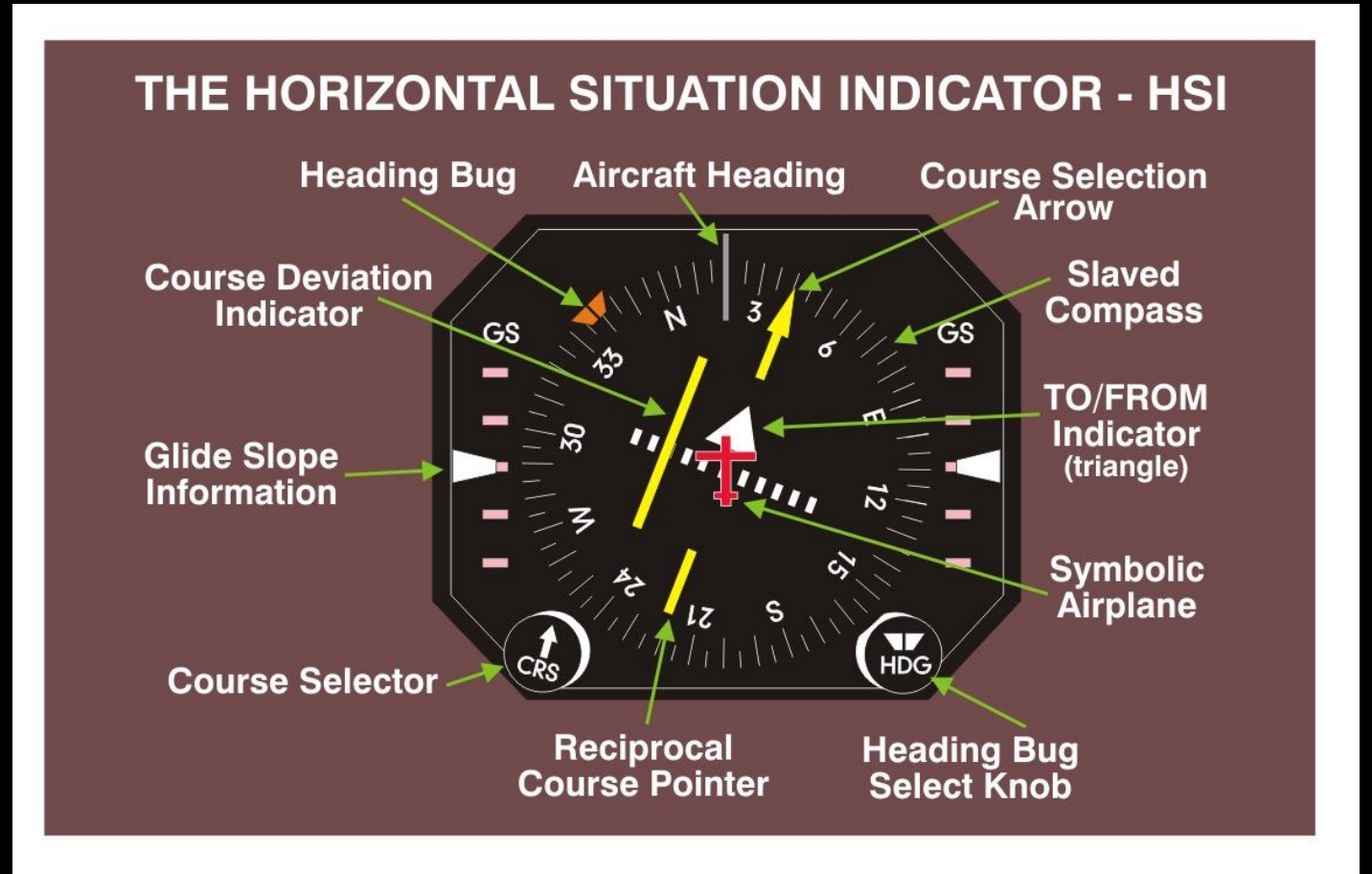
- Don't try to navigate or orient yourself *to* a VOR station unless a TO flag is showing
- Don't try to navigate or orient yourself *from* a VOR station unless a FROM flag shows in the window.

REVERSE SENSING OF THE VOR NEEDLE

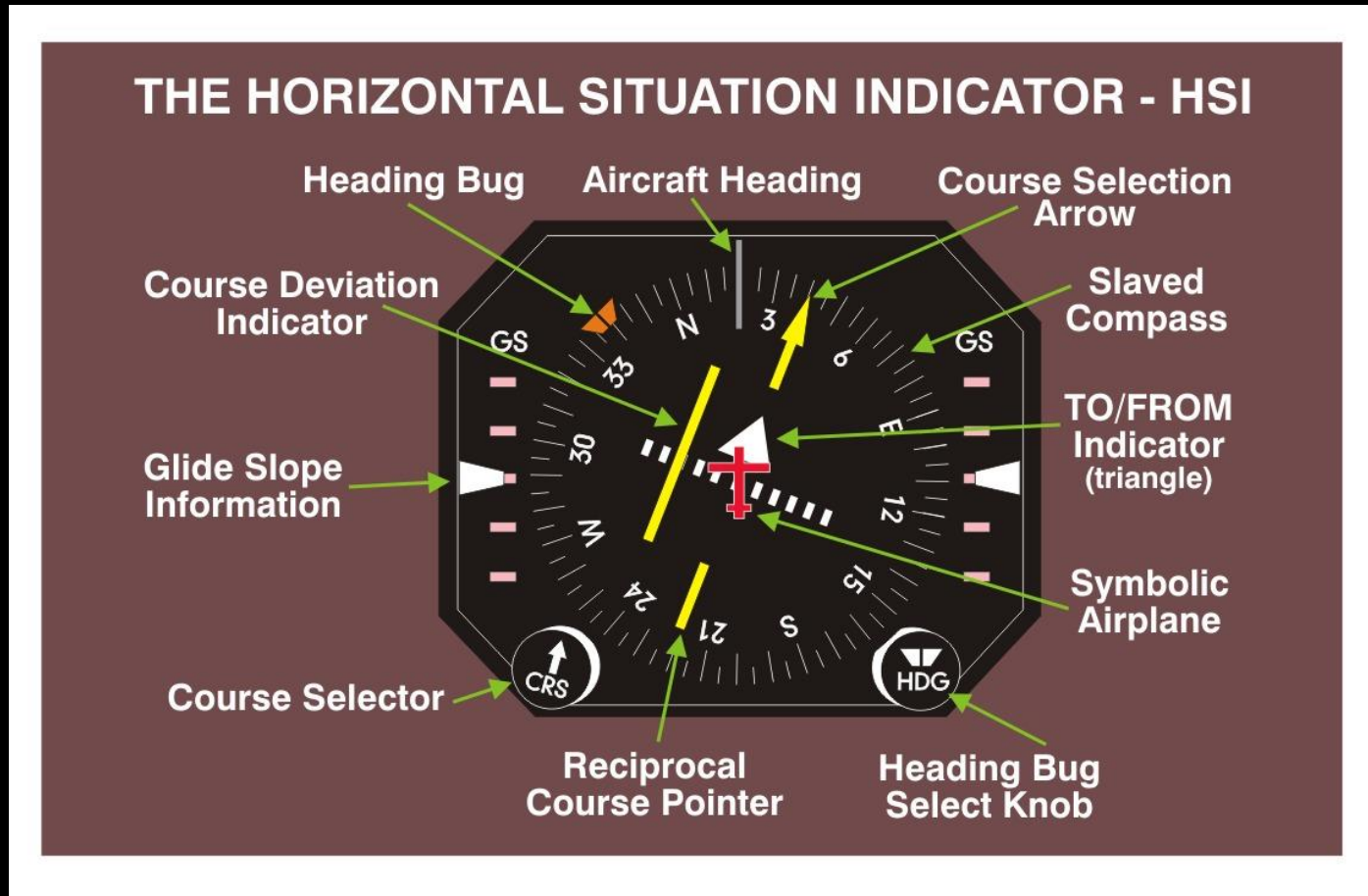


Horizontal Situation Indicator

- VOR unit combined with a heading indicator (electrically slaved to a compass)
- Instead of a needle that swings, its CDI slides sideways, away from the course selection arrow, to indicate the direction and amount of course deviation



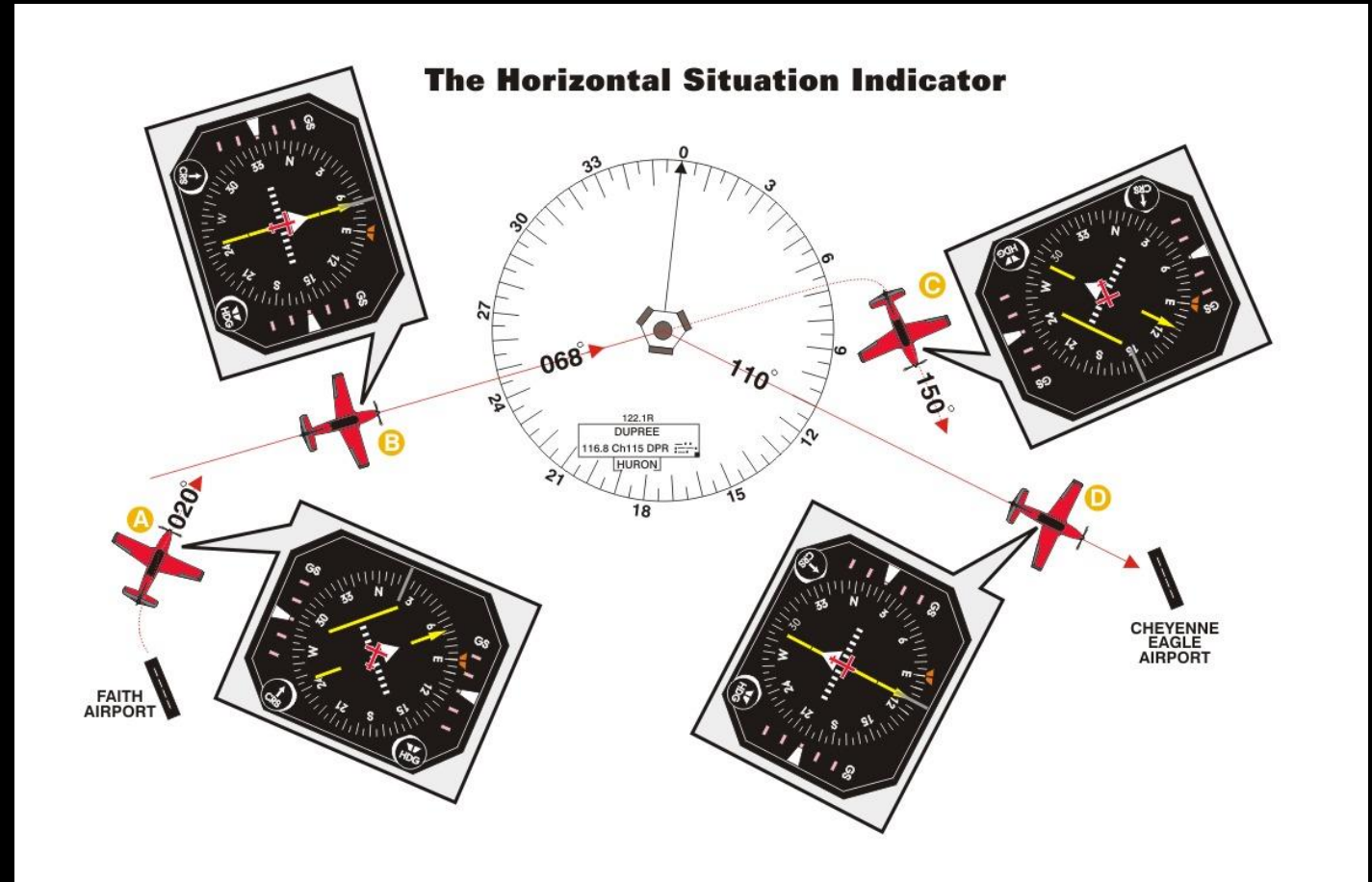
Horizontal Situation Indicator



- The TO/FROM indicator is a single white triangle that flips toward the head or tail of the course selection arrow, depending on whether the selected course takes you to or from the station
- The heading bug is a heading reminder that can be set on any heading value

Horizontal Situation Indicator

- Symbolic airplane always points straight ahead, in the direction the airplane is headed
- For course interception turn until the symbolic airplane is pointed toward the horizontally displaced CDI
- HSI provides a picture of your airplane, relative to the selected course



VOT - VOR Test Facility

- Allows you to check the VOR's accuracy
- Only broadcasts a signal for the 360 radial
- Selecting 360° on OBS should result in a centered needle and a FROM indication
- Selecting 180° should give you a centered needle with a TO indication
- Rule doesn't apply to VFR pilots

VOR TEST FACILITIES (VOT)

| Facility Name (Airport Name) | Freq. | Type, VOT Facility | Remarks |
|---|-------|--------------------|---------|
| Phoenix Sky Harbor Intl | 109.0 | G | |
| Prescott (Prescott Rgnl-Ernest A. Love Fld) | 110.0 | G | |

CALIFORNIA VOR RECEIVER CHECKPOINTS


| Facility Name (Airport Name) | Freq/Ident | Type Check Pt. Gnd. AB/ALT | Azimuth from Fac. Mag. | Dist. from Fac. N.M. | Checkpoint Description |
|------------------------------|------------|----------------------------|------------------------|----------------------|--------------------------------|
| Arcata (Arcata) | 110.2/ACV | G | 148 | 0.8 | At apch end Rwy 32 runup area. |

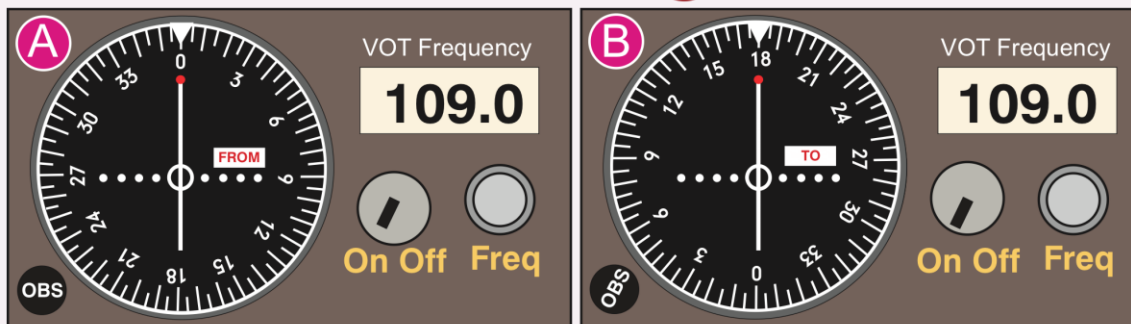
(A) VOT Frequency: 109.0. OBS knob set to 360°. Needle is centered. FROM indication.

(B) VOT Frequency: 109.0. OBS knob set to 180°. Needle is centered. TO indication.

Step 2: Select the VOT frequency and rotate OBS knob to 360° (A). Look for a FROM indication and a centered needle. Now rotate the OBS knob to 180° (B). Look for a TO

VOT - VOR Test Facility

| VOR TEST FACILITIES (VOT) | | | | | |
|---|------------|----------------------------|---|----------------------|--------------------------------|
| Facility Name (Airport Name) | Freq. | Type, VOT Facility | Remarks | | |
| Phoenix Sky Harbor Intl | 109.0 | G |  | | |
| Prescott (Prescott Rgnl-Ernest A. Love Fld) | 110.0 | G | | | |
| CALIFORNIA | | | | | |
| VOR RECEIVER CHECKPOINTS | | | | | |
| Facility Name (Airport Name) | Freq/Ident | Type Check Pt. Gnd. AB/ALT | Azimuth from Fac. Mag. | Dist. from Fac. N.M. | Checkpoint Description |
| Arcata (Arcata) | 110.2/ACV | G | 148 | 0.8 | At apch end Rwy 32 runup area. |



Step 2: Select the VOT frequency and rotate OBS knob to 360° (A). Look for a FROM indication and a centered needle. Now rotate the OBS knob to 180° (B). Look for a TO

- Check the CS for the VOT frequency at PHX
- Select the VOT frequency and rotate OBS knob to 360°
- Look for a FROM indication and a centered needle
- Then rotate the OBS knob to 180°
- Look for a TO indication and a centered needle

VOT - VOR Test Facility

- If the needle isn't centered on either of these values:
- Rotate the OBS knob +/- 4° to center the needle
- If the needle can't be centered within this range, the accuracy of the VOR equipment is in question

| VOR TEST FACILITIES (VOT) | | | | | |
|---|-------|--------------------|---------|--|--|
| Facility Name (Airport Name) | Freq. | Type, VOT Facility | Remarks | | |
| Phoenix Sky Harbor Intl | 109.0 | G | Z | | |
| Prescott (Prescott Rgnl-Ernest A. Love Fld) | 110.0 | G | | | |

| CALIFORNIA VOR RECEIVER CHECKPOINTS | | | | | |
|--|------------|----------------------------|------------------------|----------------------|--------------------------------|
| Facility Name (Airport Name) | Freq/Ident | Type Check Pt. Gnd. AB/ALT | Azimuth from Fac. Mag. | Dist. from Fac. N.M. | Checkpoint Description |
| Arcata (Arcata) | 110.2/ACV | G | 148 | 0.8 | At apch end Rwy 32 runup area. |

A

VOT Frequency
109.0

On Off Freq

B


VOT Frequency
109.0


On Off Freq

Step 2: Select the VOT frequency and rotate OBS knob to 360° (A). Look for a FROM indication and a centered needle. Now rotate the OBS knob to 180° (B). Look for a TO

VOR Ground Test Signals

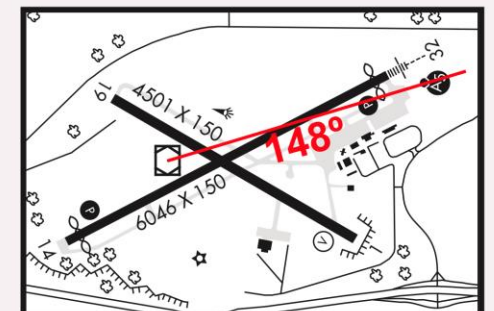
- If there is no VOT source, you can test the accuracy of VOR equipment another way
- Some airports have approved VOR ground check points identified in the CS
- The letter "G" indicates that there is a ground checkpoint on the field at Arcata airport

| VOR TEST FACILITIES (VOT) | | | | |
|---|-------|---|---------|--|
| Facility Name (Airport Name) | Freq. | Type, VOT Facility | Remarks | |
| Phoenix Sky Harbor Intl | 109.0 | G  | | |
| Prescott (Prescott Rgnl-Ernest A. Love Fld) | 110.0 | G | | |

| CALIFORNIA VOR RECEIVER CHECKPOINTS | | | | | |
|--|------------|---|------------------------|----------------------|--------------------------------|
| Facility Name (Airport Name) | Freq/Ident | Type Check Pt. Gnd. AB/ALT | Azimuth from Fac. Mag. | Dist. from Fac. N.M. | Checkpoint Description |
| Arcata (Arcata) | 110.2/ACV | G  | 148 | 0.8 | At apch end Rwy 32 runup area. |


VOR Ground Test Signals


If there is no VOT source nearby you can test the accuracy of your VOR equipment another way. Some airport have an approved VOR ground check points as identified in the *Chart Supplement* (position Z). The letter "G" indicates that there is a ground checkpoint on the field at Arcata airport (position X, above). You'll want to taxi to that spot, tune your VOR to 110.2 MHz and set the course selector to 148°. The allowable error for a VOR ground check is +/- 4 degrees. In other words, you should be able to center the CDI by rotating the course selector 4 degrees either side of the depicted radial (148° degrees in this case) defining that checkpoint.



VOR Ground Test Signals

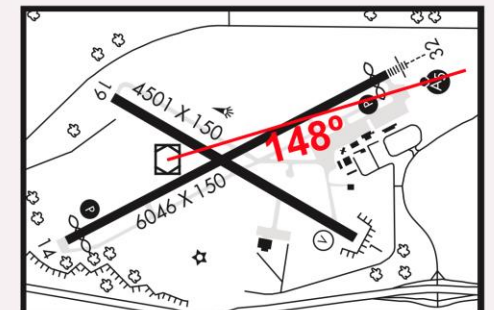
- Taxi to that spot, tune VOR to 110.2 MHz, and set the OBS to 148°
- The allowable error for a VOR ground check is +/- 4°
- You should be able to center the CDI by rotating the course selector 4° either side of the depicted radial (144° to 152°) defining that checkpoint

| VOR TEST FACILITIES (VOT) | | | | |
|---|-------|---|---------|--|
| Facility Name (Airport Name) | Freq. | Type, VOT Facility | Remarks | |
| Phoenix Sky Harbor Intl | 109.0 | G  | | |
| Prescott (Prescott Rgnl-Ernest A. Love Fld) | 110.0 | G | | |

| CALIFORNIA VOR RECEIVER CHECKPOINTS | | | | | |
|--|------------|---|------------------------|----------------------|-------------------------------|
| Facility Name (Airport Name) | Freq/Ident | Type Check Pt. Gnd. AB/ALT | Azimuth from Fac. Mag. | Dist. from Fac. N.M. | Checkpoint Description |
| Arcata (Arcata) | 110.2/ACV | G  | 148 | 0.8 | At apch end Rwy 32 unop area. |

VOR Ground Test Signals

If there is no VOT source nearby you can test the accuracy of your VOR equipment another way. Some airports have approved VOR ground check points as identified in the *Chart Supplement* (position Z). The letter "G" indicates that there is a ground checkpoint on the field at Arcata airport (position X, above). You'll want to taxi to that spot, tune your VOR to 110.2 MHz and set the course selector to 148°. The allowable error for a VOR ground check is +/- 4 degrees. In other words, you should be able to center the CDI by rotating the course selector 4 degrees either side of the depicted radial (144° degrees in this case) defining that checkpoint.



Distance Measuring Equipment

- DME provides nautical mile distances from many VOR stations
- DME tunes the same way as a VOR receiver
- Usually displays groundspeed as well



VOR Symbology

- Not every VOR has a DME station associated with it
- VOR station symbology depicts the presence of DME
- **A: VOR station without DME**
- **B: Symbol for a VORTAC (VOR station and a military TACAN which includes DME capability**
- **C: Depicts a combination VOR and DME station**

VOR SYMBOLOGY

The chart displays several VOR stations with their respective symbology:

- A:** VOR station without DME (represented by a hexagon with a black dot).
- B:** VORTAC (represented by a hexagon with a black dot and a white circle).
- C:** VOR-DME (represented by a hexagon with a black dot and a white circle).

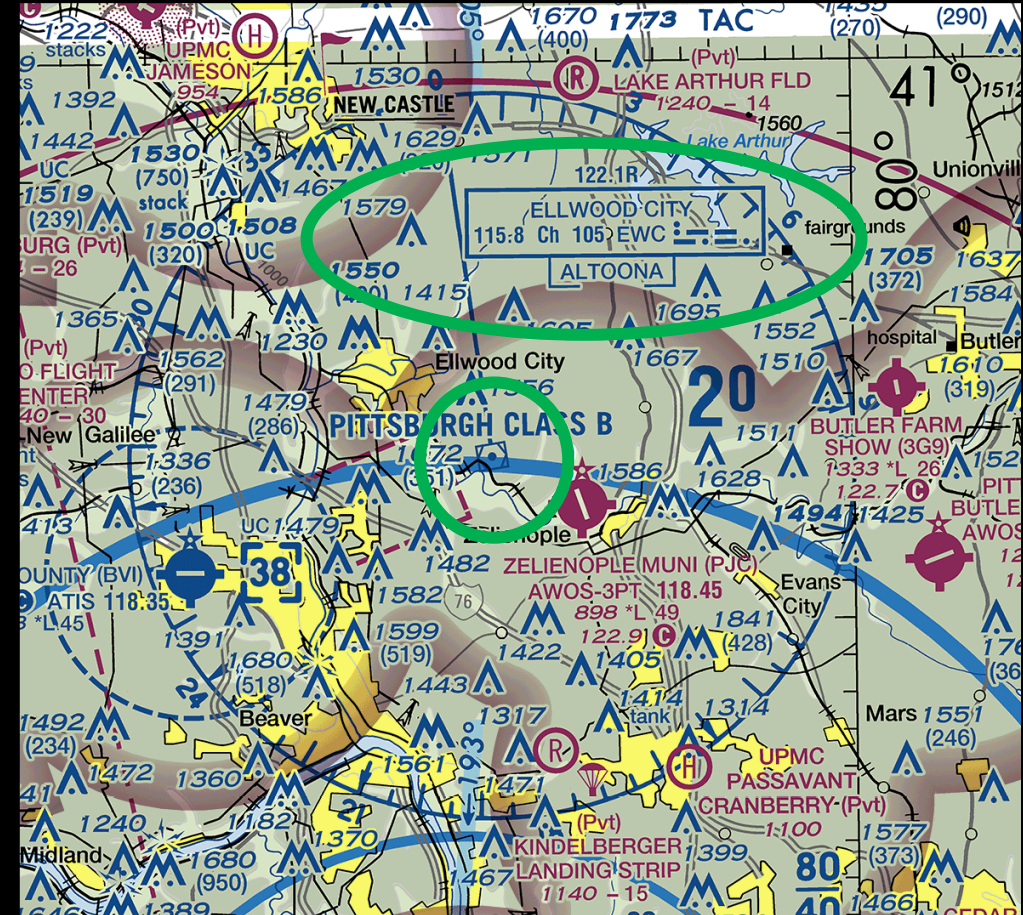
Key locations and routes shown on the chart include Los Angeles, Hawthorne, Redondo Beach, and various routes like the 100 SFC and 50 SFC.

©Rod Machado's Private Pilot Handbook

11-24/25

EWC VOR/DME

- VOR frequency box for the Ellwood City VOR/DME
- To the right of 115.8 MHz is Ch 105 (only used by military)
- This implies the VOR station has DME capability



DME Slant Range

DME SLANT RANGE MILEAGE

DME measures slant range mileage. At 6,000' AGL directly over the station, Airplane (B's) DME reads 1 mile (1 nm = appx. 6,000'). The greatest DME error occurs directly over the station. At greater distances from the station this slant range error diminishes. Airplane (A's) DME readout is Appx. 10 nm.



Knowledge Check

A VOR has how many radials?

- A. 1
- B. 180
- C. 270
- D. 360

Knowledge Check

A VOR has how many radials?

~~A. 1~~

~~B. 180~~

~~C. 270~~

D. 360

Knowledge Check

VFR pilots are not allowed to fly on Federal Victor Airways?

- A. True
- B. False

Knowledge Check

VFR pilots are not allowed to fly on Federal Victor Airways?

- A. ~~True~~
- B. False

Knowledge Check

How can you identify a VOR is operational?

- A. Verify NOTAMs say the VOR is in service
- B. Use the morse code ID
- C. Use a GPS to verify the waypoint matches a sectional chart
- D. All of the above

Knowledge Check

How can you identify a VOR is operational?

- ~~A. Verify NOTAMs say the VOR is in service~~
- B. Use the morse code ID**
- ~~C. Use a GPS to verify the waypoint matches a sectional chart~~
- ~~D. All of the above~~

Knowledge Check

Wind correction is required to track a VOR radial?

- A. True
- B. False

Knowledge Check

Wind correction is required to track a VOR radial?

- A. True
- ~~B. False~~