

VORs - Ground Lesson

Attention

You are coming back to Kennesaw from north Alabama. You are VFR on top of a heavy blanket of clouds. You forgot to charge your iPad yesterday and it is almost out of power. Now your Garmin 430W is having some sort of issue. Can you find your way home?

Objective

To gain knowledge of all the elements of VORs and why they are still useful. To be able to know where you are at between VORs, to be able to fly to one, and to be able to track yourself away from one.

Schedule

Ground instruction – 30 minutes

Air instruction – 60 minutes

Reference Material

wikipedia.org

cflessonplans.flightinstructorguide.com

What

VHF Omni Directional Radio Range (VOR) is a type of short-range radio navigation system for aircraft, enabling aircraft with a receiving unit to determine their position and stay on course by receiving radio signals transmitted by a network of fixed ground radio beacons. It uses frequencies in the very high frequency (VHF).

A VOR ground station sends out an omnidirectional master signal, and a highly directional second signal is propagated by a phased antenna array and rotates clockwise in space 30 times a second. This line of position is called the "radial" from the VOR. The intersection of radials from two different VOR stations can be used to fix the position of the aircraft, as in earlier radio direction finding (RDF) systems.



Figure 1 Side view of a VOR



Figure 2 Side view of another VOR

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Animation of how the radio signals work:

https://en.wikipedia.org/wiki/VHF_omnidirectional_range#/media/File:VOR_principle.gif

Why

Before all planes flew mostly by GPS...before GPS was in any plane...there was a system of VORs set up all over America. Planes of any size could fly along the Victor airways in VFR or IFR conditions. Developed in the United States beginning in 1937 and deployed by 1946, VOR is the standard air navigational system in the world, used by both commercial and general aviation.

Elements

Radials

TO vs FROM

Tracking and intercepting a radial

Material

VOR stations are fairly short range: the signals are line of sight between transmitter and receiver and are useful for up to 200 miles. Each station broadcasts a VHF radio composite signal including the navigation signal, station's identifier and voice, if so equipped. The navigation signal allows the airborne receiving equipment to determine a bearing from the station to the aircraft (direction from the VOR station in relation to Magnetic North). The station's identifier is typically a three-letter string in Morse code. The voice signal, if used, is usually the station name, in-flight recorded advisories, or live flight service broadcasts. At some locations, this voice signal is a continuous recorded broadcast of Hazardous Inflight Weather Advisory Service or HIWAS.

The radials

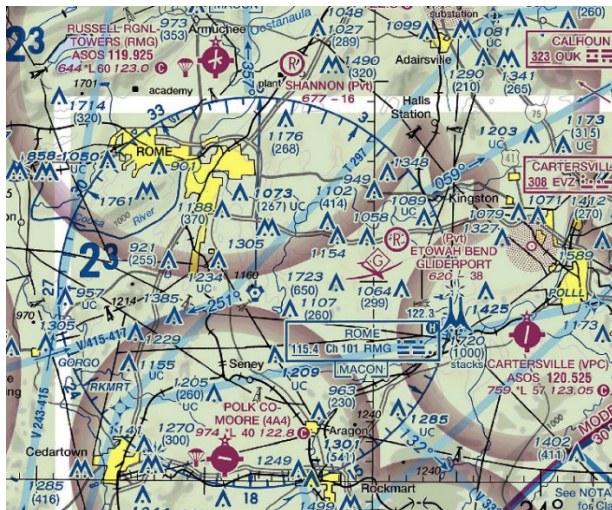


Figure 3 RMG VOR

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VORs have 360 radials...one each for each degree on a compass

R0 = Radial pointing north...aligned to magnetic north

R90 = east

R180 = south

R270 = west

FROM = on a particular radial

TO = FROM radial + 180

FROM R90 = TO R270

Testing

According to §91.171, VOR receivers must be checked within 30 days. If you are using a single VOR receiver in the air it must be +/- 6°. If you are using dual (one vs other) VOR receivers in the air it must be +/- 4°. Log location, error, and date then sign.

VOT (VOR Test) check +/- 4°. A VOT differs from a VOR in that it replaces the variable directional signal with another omnidirectional signal, in a sense transmitting a 360° radial (FROM 360 / TO 180) in all directions. Remember: "They are all from the north"

Record the date, place, bearing error, and sign the aircraft log or other record. No signature req.

Tracking a radial



Figure 4 CDI set for the 270 radial

You always fly towards the needle. In Figure 4, if are set to the 270 radial and you are flying from the VOR you would need to turn the plane more to the right to get back on course.

Each dot on a CDI or HSI represents 2°. A 'full deflection' is 5 dots = 10°. Anything worse than 10° off will still show as 5 dots. One dot is 2NM off course @ 60NM distance from the VOR.

Example:

3 dots off, 30 NM from VOR

$(200 \text{ ft} * 3 \text{ dots} * 30 \text{ NM}) / 6076 = 3 \text{ NM}$

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Using two+ VORs you can find your current location or where you need to go.
For example KRYY is on R108 of RMG, R346 of ATL, R304 of PDK.

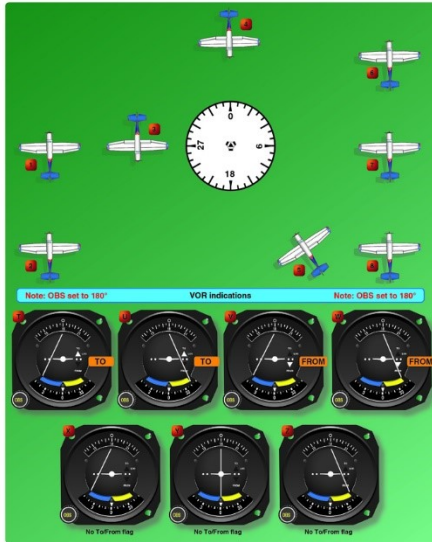


Figure 5

1 = X 2 = V 3 = X 4 = not shown 5 = W 6 = U 7 = Z 8 = W

The course selector is an azimuth dial that is rotated to select a radial or to determine the Radial. In addition, the magnetic course TO or FROM the station can be determined. When the OBS is rotated, the CDI moves to show the position of the radial relative to the Plane. If the flag displays "TO," the course on the course selector must be flown to the Station. If "FROM" is displayed and the course shown followed, the plane flies away from the Station.

So if your GPS/radios do not have a way to quickly show you what radial you are on, you can turn till the needle is centered and it indicates FROM.

CDI Examples

Go to http://www.luizmonteiro.com/Learning_VOR_Sim_1.aspx to demonstrate to yourself. These same concepts will apply to tracking GPS intersections.

Note that I never mention what the current heading is. It simply makes no difference at all except whether you will get back on track or end up lost.

I also do not mention distance. The only time that is important is if you are so far from the VOR you can not get a signal any more.

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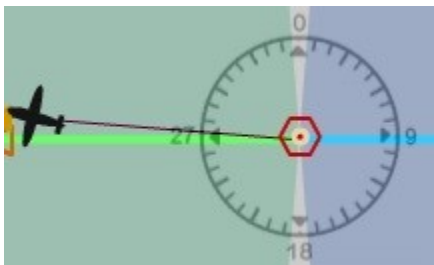
CDI set for 270, showing FROM, needle deflected to the right.



You are on R264. You need to fly to the right to get back on course.



CDI set for 270, showing FROM, needle deflected to the left.

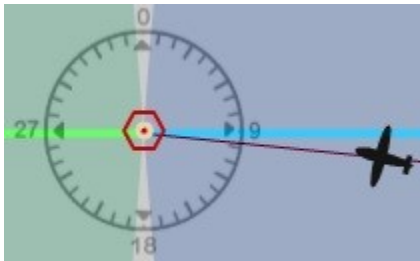


You are on R275. You need to fly to the left to get back on course.

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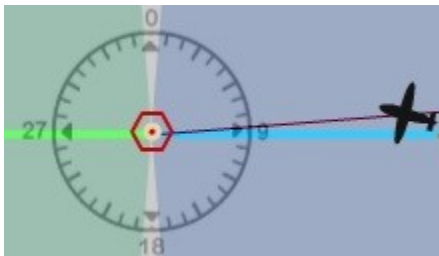
CDI set for 270, showing TO, needle deflected to the right.



You are on R96. You need to fly to the right to get back on course.



CDI set for 270, showing TO, needle deflected to the left.



You are on R85. You need to fly to the left to get back on course.

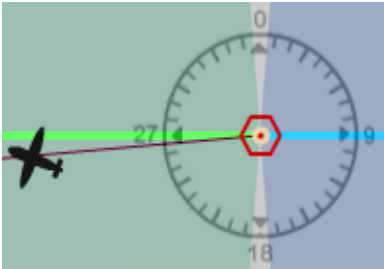
HSI Examples

Go to http://www.luizmonteiro.com/Learning_HSI_Sim_1.aspx to demonstrate for yourself. These same concepts will apply to tracking GPS intersections.

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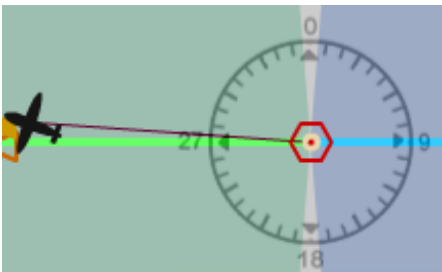
HSI set for 270, showing FROM, needle deflected to the right.



You are on R265. You need to fly to the right to get back on course.



CDI set for 270, showing FROM, needle deflected to the left.

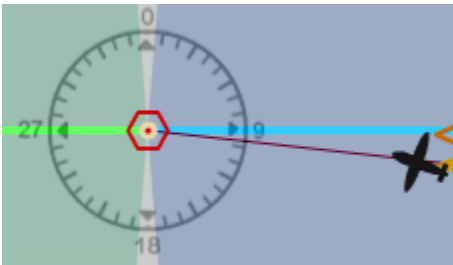


You are on R274. You need to fly to the left to get back on course.

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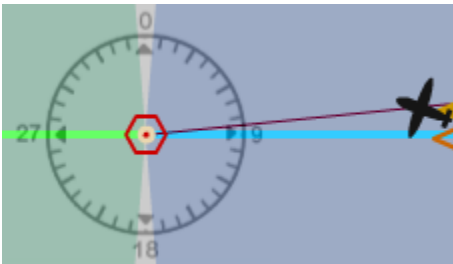
HSI set for 270, showing TO, needle deflected to the right.



You are on R96. You need to fly to the right to get back on course.



HSI set for 270, showing TO, needle deflected to the left.



You are on R84. You need to fly to the left to get back on course.

Quick Math

FROM R -, FROM L +, TO R +, TO L -

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What does this mean?



TO/FROM = FROM

Needle is to the right (R)

Since it is set for 270 and it is deflected two dots then $\rightarrow 270-4 = 264$

You are on R264

Why should I care?

I can follow the magenta line on my GPS or my tablet...

1.

I had a GPS failure on my private pilot test. This was after I did everything and just had to get back to the airport. Also understand the examiner was based out of KFGU Collegedale TN where the airport is situated in a valley. He said I will not tell you how to get there if you find your way then you pass. He was impressed I used two VORs and a paper map in about a minute.

2.

I still fly some old planes with some historic looking GPS that do not even have a map. If you do not know how to use a CDI you better not leave the pattern.

3.

You might fly in an area that is having GPS inconsistencies.

4.

Tablets alone are not legal for IFR flying although some people mumble they do it.