# VOR TRACKING & INTERCEPTING

## What is a VOR?

VOR stands for 'very high frequency omni-directional radio range'. It operates on VHF between 108.00 & 117.95MHz. Basically, a VOR allows a pilot to identify where they are in relation to a beacon, or what track to follow in order to go to/from the beacon. They are often coupled with DME (distance measuring equipment), and the combination of the two can give an accurate position fix. Because they are VHF, the range is determined by line of sight. The higher we fly, the greater the range of the beacon. Range will however be discussed later. VOR's are primarily used for en-route navigation, as they often determine airways, but they are also used for instrument approaches.

## Considerations

- VOR cockpit instrumentation.
- Actions prior to using a VOR.
- Position fixing using a VOR.
- VOR tracking.
- Intercepting VOR radials.
- Using the HSI indicator & RMI pointer.
- Turning over a VOR waypoint.

## VOR cockpit instrumentation

In the cockpit we have two parts to the VOR:

1. The VOR display itself.
2. The NAV section on our radio equipment.

*Figure 1*

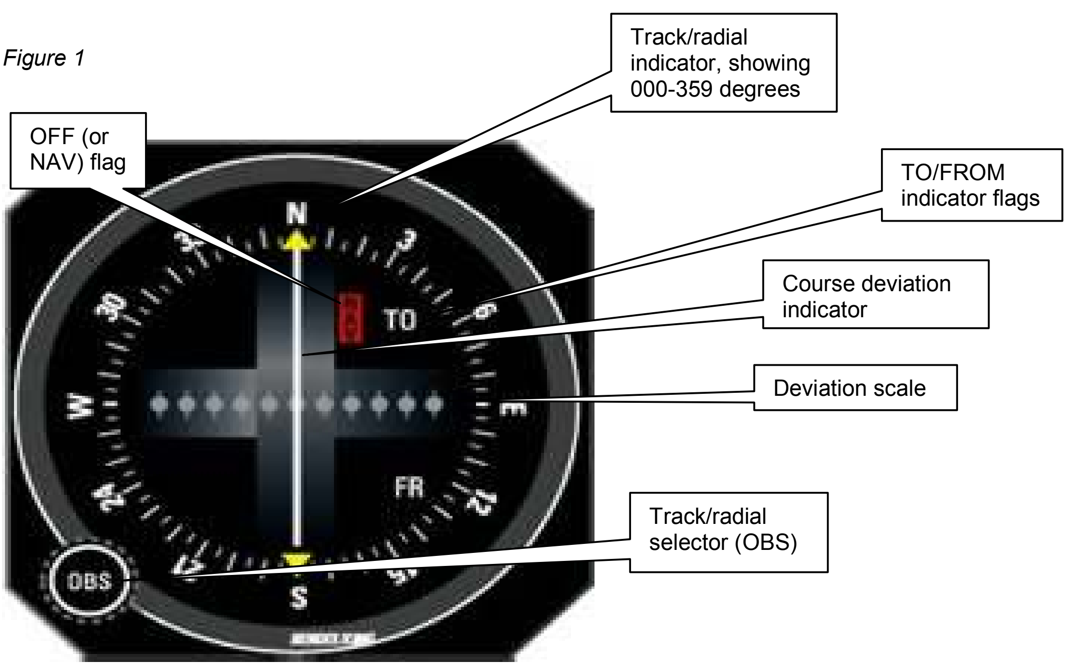


Figure 1 shows the VOR display. The key features are identified, with further explanation below:

1. **OFF/NAV flag** – if showing the instrument is not picking up a signal.
2. **Track/radial indicator** – shows the chosen track (if a TO flag is showing) or radial (if a FROM flag is showing). The display is a rotatable card showing degrees from 000-359. It is moved by the **track/radial selector**.
3. **TO/FROM flags** – show whether the selected indication is relative to a TRACK TO THE BEACON, or a POSITION FROM THE BEACON.
4. **Course deviation indicator** – shows the aircraft position relative to the selected track radial on the **deviation scale**. Each dot represents 2 degrees deviation on a VOR, with a full-scale deflection being 10 degrees or more. An inner circle is often used to depict the first dot.

The second part of the VOR instrumentation is the NAV section of our radio. This is tuned in the same way as the COMM box. There is also an IDENT switch, which enables us to listen to the Morse code identifier for the beacon.

**Actions prior to using a VOR**

Prior to use, the following actions must be taken:

1. **SELECT** the frequency of the VOR. This is given on maps/approach plates, or in the AIP (en-route or aerodrome sections).
2. **IDENTIFY** the beacon by listening to the Morse code identifier. This consists of the three-letter identifier for the beacon, transmitted as Morse code. The beacon must be within range for this to happen. All beacons have a DOC (designated operational coverage), which is listed in the AIP. Theoretical range is covered during ATPL ground studies, so will not be covered here. As pilots we are interested in whether we are within the published range, and whether a positive ident can be heard.
3. Ensure the **DISPLAY** is set up correctly for the information required. If we wish to find out where we are from a beacon, or track from a beacon, then the deviation bar should be centered with a FROM flag showing. To track to a beacon, then a TO flag should be visible, again with the deviation bar central. If the NAV flag is showing, then the instrument is not picking up a signal.
4. If the instrument is to be used with a co-joined DME, then the DME must be independently SELECTED, IDENTIFIED & DISPLAY checked.

## Position fixing using a VOR

If we centralise the deviation bar, with a FROM flag showing, the indication given is our position from the beacon (ie which radial we are on). **It must be understood that this bears no relation whatsoever to the aircraft heading**.

*Figure 2*

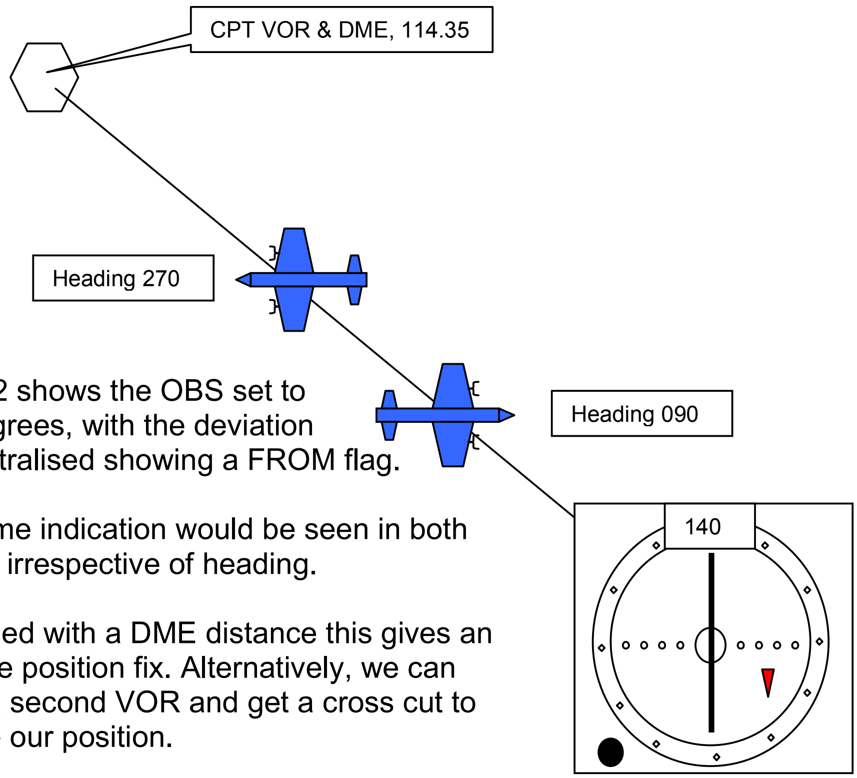



Figure 2 shows the OBS set to 140 degrees, with the deviation bar centralised showing a FROM flag.

The same indication would be seen in both aircraft, irrespective of heading.

Combined with a DME distance this gives an accurate position fix. Alternatively, we can select a second VOR and get a cross cut to indicate our position.

## VOR tracking

Once we have established the aircraft's position, we can then use the instrument to track to or from the beacon. As an example we will look at an aircraft tracking to a beacon from the west, flying overhead the beacon, and then tracking from the beacon to the east.

*Figure 3*

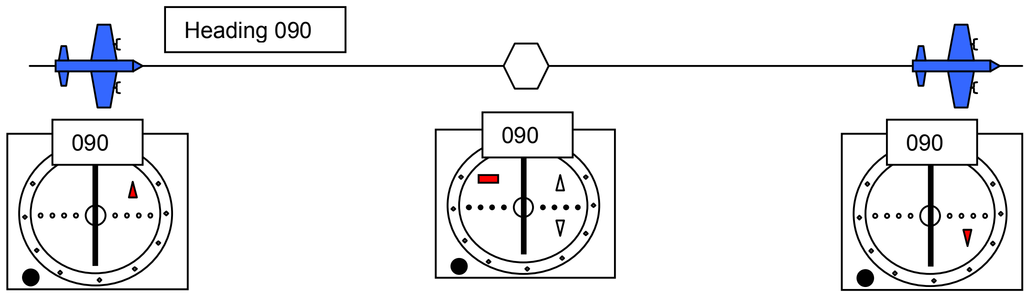


Figure 3 shows the situation in zero wind conditions. The VOR is set up with a track of 090 at the top of the rotatable dial. The heading is also 090 due to no drift, and the aircraft is on track, so the deviation bar is central. The TO flag on the VOR indicates the aircraft tracking to the beacon. As the aircraft flies overhead the beacon, it enters the 'cone of confusion' (the VOR does not radiate a signal in it's overhead), so the NAV flag appears. In this area the heading should be flown. On passing the beacon, the FROM flag appears, indicating tracking away from the beacon (on the 090 radial). Again, if the aircraft is on track, the deviation bar is central.

Track error corrections:

*Figure 4*

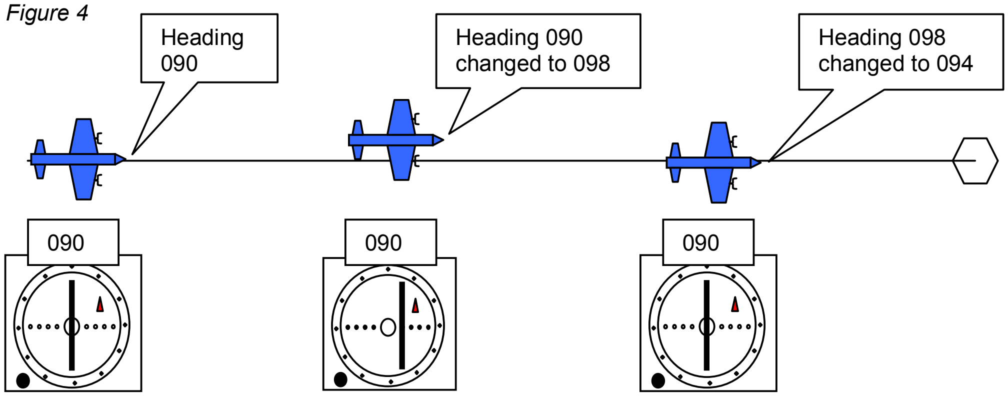



Figure 4 shows the situation when tracking to a beacon with an unplanned wind, in this case from the south of track. As the wind moves the aircraft off track, the deviation bar moves to **indicate where the track lies in relation to the aircraft**. In the example the bar shows 2 dots 'fly right', which equates to 4 degrees track error. **To correct error the pilot should apply double the difference towards track**, giving a new heading of 098. When the deviation bar centralises once more, returning to 090 would cause the same error to occur once more, so a compromise heading should be selected, in this case 094.

Note: the earlier the error is picked up, the smaller the corrections will be. Also, using the 1 in 60 rule, it can be seen that 1 degree error at 60 miles from a beacon represents 1 mile off track, whereas at 10 miles it represents 1/6$^{th}$ of a mile track error. This is important for two reasons:

1. The needle will become more sensitive as the aircraft approaches the beacon, so a good heading must be established early on the track, otherwise more and more corrections will be used as the aircraft approaches.
2. The time taken to correct any degrees track error will be greater the further the aircraft is from the beacon, as the distance to be covered is greater. The rate at which the needle moves will also therefore be slower at greater distance from the beacon (and can move very quickly when close to the beacon!).
3. If a heading has been good until the aircraft gets close to the beacon (within a couple of miles), then the heading should be flown despite

any movement of the deviation bar, otherwise unwanted corrections may be made as the needle moves full scale deflection as the aircraft passes over the beacon.

Wind considerations:

When tracking a beacon a wind correction angle will usually be required. This should be applied into wind as usual. The aircraft heading and track selected will therefore differ by this wind correction angle.

Other notes:

- When tracking more than one beacon, the master instrument should be switched between the two beacons at a sensible point (usually half way). Remember to use SID (select, identify, display) when using any new navaids.
- Going overhead a beacon (or a point determined by a beacon) is the same as going over a visual waypoint, and should be recorded on the plog. The actions can be remembered by TTTTP – note the TIME, TURN onto the new heading, TWIST the OBS to the new track, TALK to ATC if required, update the PLOG (ATA/ETA's/fuel).

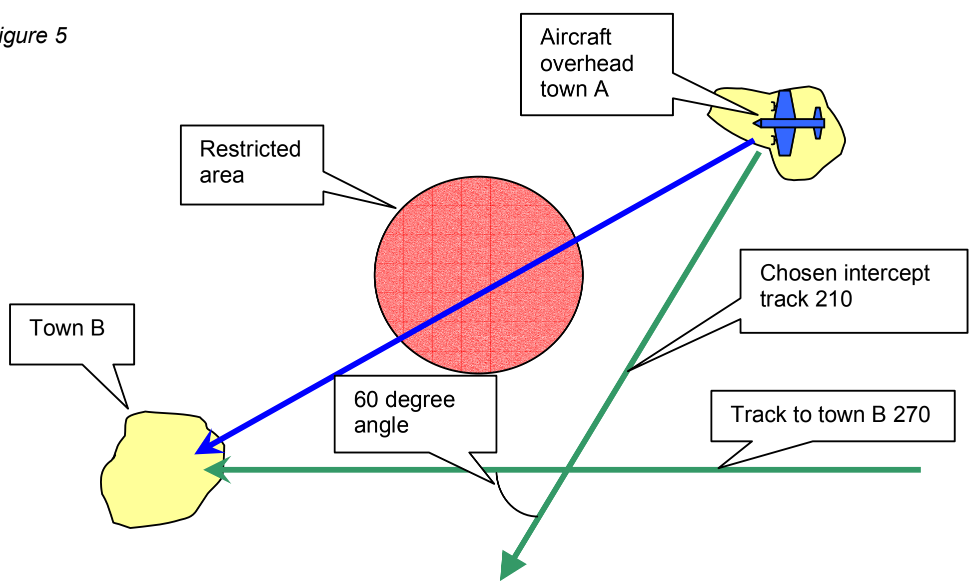
**Intercepting VOR radials**

Clearly we will not always be on the exact radial we require, so we also need to consider intercepting radials from a different position. This can be achieved by using three steps:

1. **Where am I?**
2. **Where do I want to go to?**
3. **How am I going to get there?**

In order to understand how to do this, let us first consider an example doing the same thing, but flying visually.

*Figure 5*



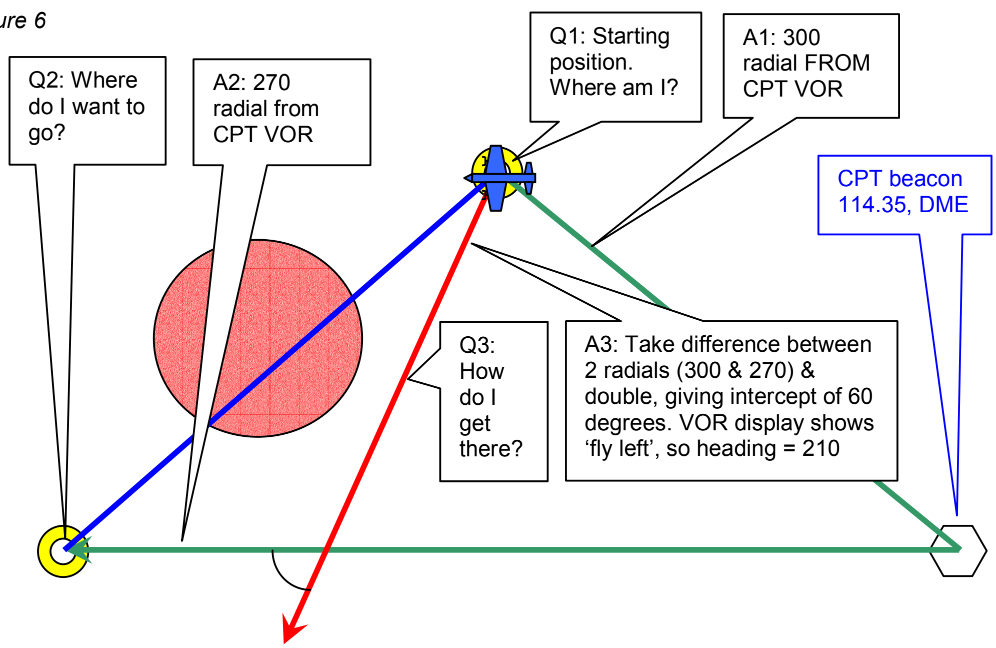
From overhead town A, we wish to fly to town B, but there is a restricted area on the direct track, which we cannot overfly. We must therefore fly around, and in order to do so we decide to fly inbound to town B, with a 60 degree intercept of that track from our current position. This clearly involves an initial track of 210 to achieve this intercept. In doing this we have answered all three of the above questions: where am I; where do I want to go; how do I get there.

The important things to consider however, when looking at the same scenario using a VOR, are:

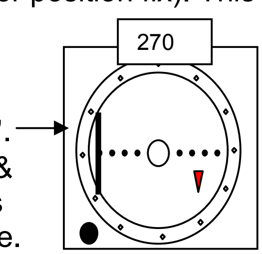
- Where am I **(location <u>rather than</u> heading)** is relevant in determining a sensible intercept angle for the new desired track.
- Where do I want to go is also relevant in determining the intercept angle. **The intercept angle is also applied to this desired track, <u>not</u> current track or heading**.
- **The aircraft heading is not relevant at any time in relation to the above** two questions. It only becomes relevant when turning onto the intercept heading (how do I get there), as the initial heading versus new heading will determine the direction of the turn.

Now let's look at the same example using a VOR.

*Figure 6*




- In order to answer the first question (where am I), rotate the OBS until the deviation bar is central with a FROM flag (as for position fix). This shows the 300 radial.
- Next consider where you want to go, in this case the 270 radial FROM the beacon. Dial this up on the display. **The deviation bar shows 'fly left'**.
- Double the difference between the 2 radials (300 & 270) **UP TO A MAXIMUM OF 90 DEGREES**. This gives the intercept angle of 60 degrees in this case.



- **Apply the intercept angle to the desired track in the correct sense** (in this case to the left, so 270 **–** 60 = 210).
- Turn from current heading to new heading of 210 using the shortest direction turn.
- In the example shown the aircraft is heading 270, so would turn left 60 degrees to 210. However if the aircraft had been heading in any direction the result would be the same (because heading is not relevant to the calculation) – a required heading of 210. If our initial heading had been 090 this would mean a right turn of 120 degrees onto 210.

<u>Wind considerations:</u>

When strong wind conditions exist it may be necessary to increase or decrease the intercept angle if a large crosswind component exists.

**Using the HSI indicator & RMI pointer**

The HSI (horizontal situation indicator) provides information regarding heading and tracking on one instrument. It also rotates automatically to show heading at the top, as it is linked to a flux gate compass, so there is no need to manually adjust the instrument against the magnetic compass (although slaving checks should be carried out prior to and during use).

*Figure 7 - HSI*


The principals of using the instrument are the same as for a standard VOR indicator. Required track is established by turning the track needle so that the arrow points to the desired track. The deviation bar shows degrees off track as normal. The TO and FROM flags should be read in relation to the head of the needle. In figure 7 the track is set to 080, with a TO flag showing. The desired track is 6 degrees to the right of the aircraft, and the aircraft is heading 097 degrees, providing a 17 degree intercept angle. Once on track the aircraft will be on the 260 radial.

If the aircraft is fitted with an RMI (remote magnetic indicator), it may also have a VOR needle. This is simply a pointer, which shows magnetic track to the beacon from current position, and consequently the current radial on the tail of the needle. These instruments will also have an NDB pointer. The VOR is green, and the NDB yellow.

*Figure 8 – RMI*

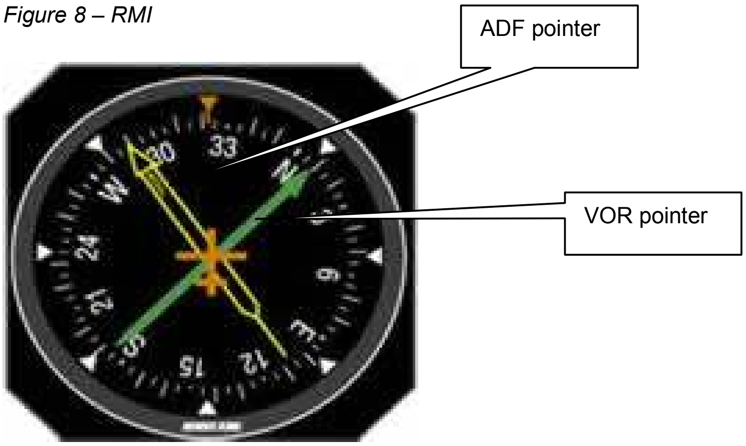
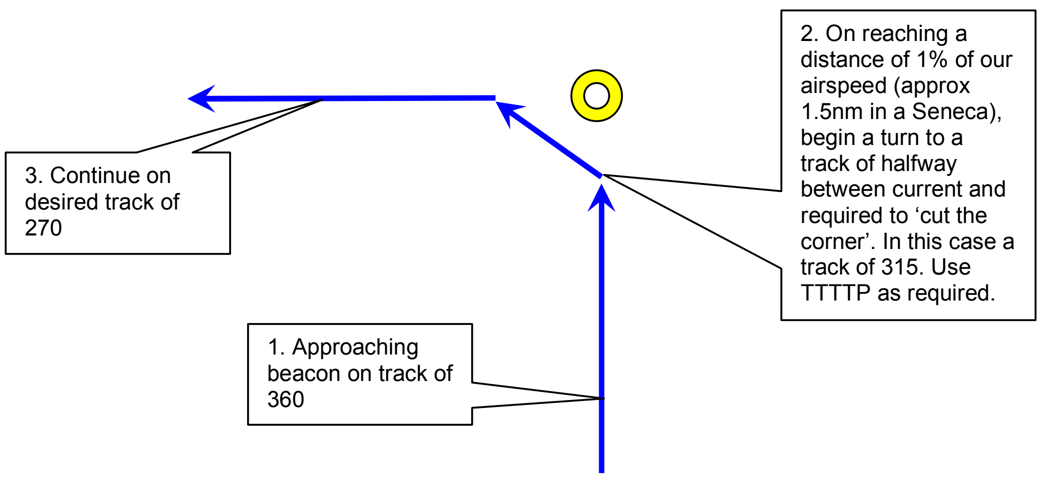



Figure 8 shows a typical RMI. Again, slaving should be checked prior to and during use. The example shows the aircraft with a track of 010 to the VOR, on the 190 radial. The NDB needle (ADF) shows a QDM (magnetic bearing to) of 290, and a QDR (magnetic bearing from) of 110.

## Turning over a VOR waypoint (and other waypoints)

*Figure 8 – commercial turn*




A commercial turn means that we do not actually fly directly over a waypoint, but anticipate arriving and turn onto a track to intercept our new required track, as shown in figure 8.