

Aviation Navigation

Tutorial

3. Radio Navigation

Radio navigation provides the pilot with position information from ground stations located worldwide. There are several systems offering various levels of capability with features such as course correction information, automatic direction finder and distance measuring.

Most aircraft now are equipped with some type of radio navigation equipment. Almost all flights whether cross-country or "around the patch" use radio navigation equipment in some way as a primary or secondary navigation aid.

Automatic Direction Finder (ADF)

ADF is the oldest radio navigation system still in use. ADF uses Non-Directional Beacons (NDBs) that are simply AM-radio transmitters operating in the Low and Middle Frequency (L/MF) Band from 190 to 535 kHz. These frequencies are below the standard broadcast band. All ADFs can also home in on AM broadcast stations. Pilots can listen to the radio and navigate also. The ADF indicator has a compass rose and an indicating needle. The needle automatically points to the station. "Homing" means following the needle. "Crabbing" to track to the station is more efficient. Crabbing is a method of flying in which the horizontal axis of the airplane is not parallel to the flight path. ADFs have a "HDG" knob where the pilot can dial in the aircraft heading.



Very High Frequency Omni-directional Range (VOR)



The VOR station transmits two signals, one is constant in all directions, and the other varies the phase relative to the first signal. The VOR receiver senses the phase difference between the two frequencies and the difference identifies 360 different directions or "radials" from the VOR. The aircraft is on one, and only one, radial from the station. The system does not provide distance information.

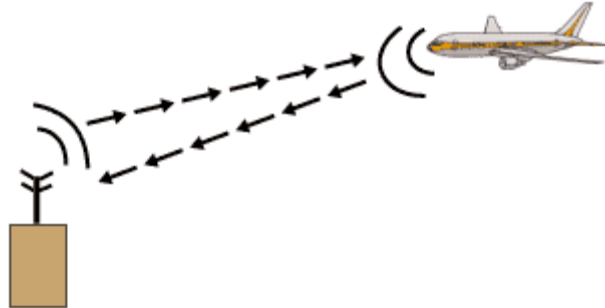
When the appropriate VOR frequency is entered into a navigation radio, the VOR indicator connected to that radio is used to find where the aircraft is relative to the VOR station. The vertical needle called a Course Deviation Indicator (CDI) on the VOR indicator shows whether the aircraft is right or left of the chosen course. A "To/From/Off" indicator indicates whether the aircraft is on the "to" or "from" side. If the aircraft is "abeam the station", an "off" indication is given. To fly toward the station, the Omni Bearing

Selector (OBS) is turned until the CDI is centered with a "to" indication. The pilot then flies that heading. To find out where the aircraft is located from that station, center the needle with a "from" indication. If a radial is dialed into the VOR indicator, the CDI will be right or left of the center and either a "to" or a "from" indication will be seen. The heading of the aircraft does not matter.

Distance Measuring Equipment (DME)

DME as its name states is an electronic device that measures "slant range" from the DME station. Slant range is

a measure of an aircraft's position relative to the DME station that incorporates the height of the aircraft, its angle from the ground station and its unknown ground range based upon a 90° angle. The farther the aircraft is from the station and the lower the aircraft's altitude, the more accurate the distance reading. An aircraft could be directly over the DME station at an altitude of 10,500 feet above ground level (AGL) and the DME would correctly indicate the aircraft is two miles from the station.



Airborne DME measures elapsed time required for exchange of signals and converts into distance and ground speed.

Instrument Landing System (ILS)



An aircraft on an instrument landing approach has a cockpit with computerized instrument landing equipment that receives and interprets signals being from strategically placed stations on the ground near the runway. This system includes a "Localizer" beam that uses the VOR indicator with only one radial aligned with the runway. The Localizer beam's width is from 3° to 6°. It also uses a second beam called a "glide slope" beam that gives vertical information to the pilot. The glide slope is usually 3° wide with a height of 1.4°. A horizontal needle on the VOR/ILS head indicates the aircraft's vertical position. Three marker beacons (outer, middle and inner) are located in front of the landing runway and indicate their distances from the runway threshold. The Outer Marker (OM) is 4 to 7 miles from the

runway. The Middle Marker (MM) is located about 3,000 feet from the landing threshold, and the Inner Marker (IM) is located between the middle marker and the runway threshold where the landing aircraft would be 100 feet above the runway.

The VOR indicator for an ILS system uses a horizontal needle in addition to the vertical needle. When the appropriate ILS frequency is entered into the navigation radio, the horizontal needle indicates where the aircraft is in relation to the glide slope. If the needle is above the center mark on the dial, the aircraft is below the glide slope. If the needle is below the center mark on the dial, the aircraft is above the glide slope.

LORAN-C

Originally just a marine navigation system, LORAN-C determines present position by the intersection of Lines of Position (LOPs) that are hyperbolic curves. At least three stations, (a Master and two Secondaries) are needed. Accuracy is plus or minus 2.5 miles. The LORAN-C uses triangulation to measure the location of an aircraft or boat.

LORAN-C provides

- Range (RGE)
- Track (TRK)
- Ground speed (GS)
- Estimated time en route (ETE)
- Cross track error (XTD)
- Track angle error (TKE)
- Desired track (DTK)
- Winds and drift angle (DA)



LORAN-C stations across the contiguous United States

