Tishk International University
Engineering Faculty
Mechatronics Department

Avionics

TOPIC: Aircraft Navigation System

Week7_Lecture1

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TO NAVIGATE A PILOT NEEDS TO KNOW THE FOLLOWING:

- Starting point (point of departure)
- Ending point (final destination)
- Direction of travel
- Distance to travel
- Aircraft speed
- Aircraft fuel capacity
- Aircraft weight & balance information

With this information flight planning can commence and the proper method of navigation can be put to use.

INTRODUCTION

AIRCRAFT NAVIGATION SYSTEMS INCLUDE –

- ✓ VHF OMNIDIRECTIONAL RANGE (VOR)
- ✓ INSTRUMENT LANDING SYSTEM (ILS)
- ✓ DISTANCE MEASURING EQUIPMENT (DME)
- ✓ AUTOMATIC DIRECTION FINDERS (ADF)
- ✓ DOPPLER NAVIGATION SYSTEM
- ✓ INERTIAL NAVIGATION SYSTEM

VHF OMNIRANGE SYSTEM (VOR)

- ✓ VOR, short for **VHF omnidirectional** radio **range**, is a type of radio navigation system for aircraft, enabling them to find their position and stay on course by receiving radio signals emitted by a network of radio beacons. It uses frequencies in very high frequency (**VHF**) from 108 to 117.95 MHz.

- ✓ VHF Omnidirectional Radio Range (VOR), is an aircraft navigation system operating in the VHF band. VORs broadcast a VHF radio composite signal including the station's Morse Code identifier (and sometimes a voice identifier), and data that allows the airborne receiving equipment to derive the magnetic bearing from the station to the aircraft. This line of position is called the "radial". Alternatively, the VOR radial may be combined with magnetic heading from the aircraft compass to provide a bearing relative to the aircraft axis, which cn be used to home to the beacon. VOR beacons are frequently used as way-points on conventional Airway systems, or as the basis for a Non-Precision Approach.

- ✓ **It produces 360 usable radials or courses ,any one of which is radial path connected to the station.**

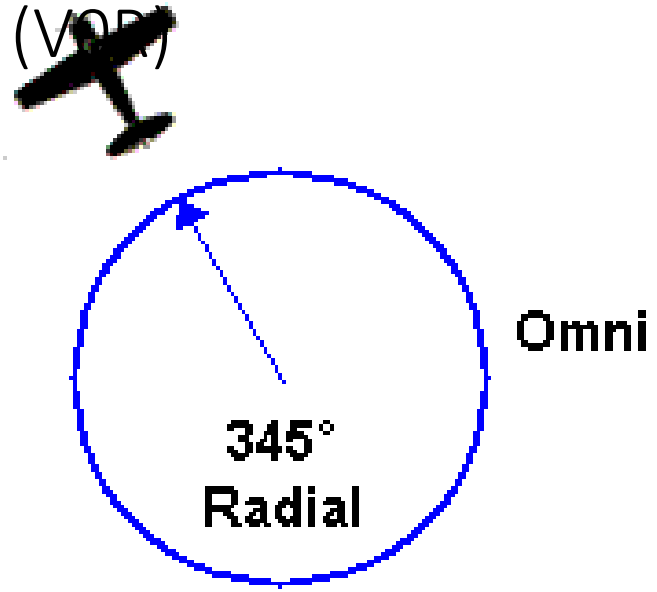
VOR Station

❖ BENEFITES

- More accurate and precise flying
- Reliable
- Voice capable
- Reduces interference from atmosphere and precipitation

✓ Navigation info is visually displayed on an instrument in cockpit called the CDI (course deviation indicator.)

VHF OMNIRANGE (VOR)



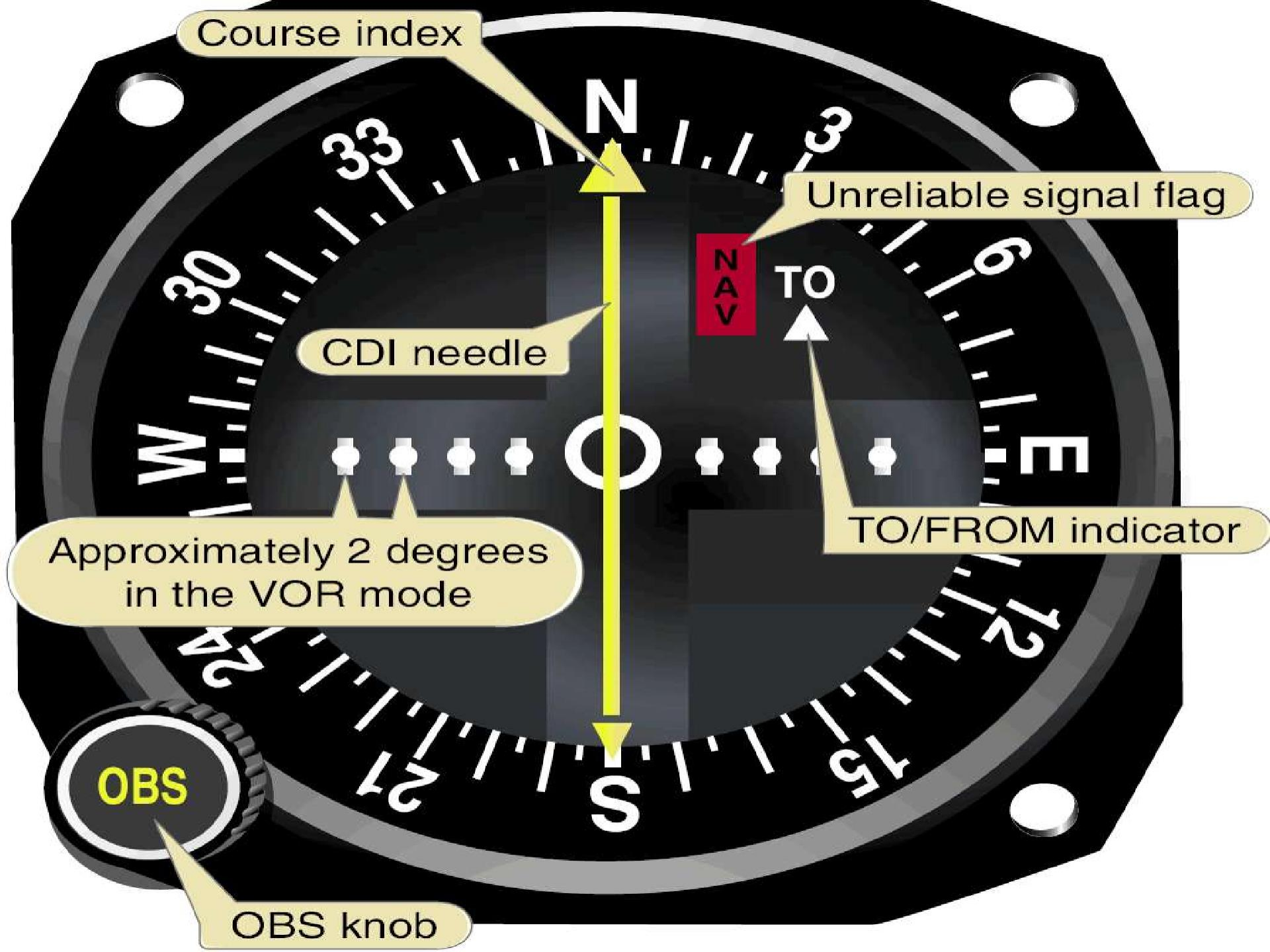
VOR RECEIVING SYSTEMS CONSIST OF

- ✓ **A RECEIVER**
- ✓ **VISUAL INDICATOR**
- ✓ **ANTENNAS**
- ✓ **A POWER SUPPLY**
- ✓ **FREQUENCY SELECTOR: USED TO TUNE RECEIVER TO SELECTED VOR GROUND STATION**

INFO FROM THE VOR RECEIVER IS DISPLAYED ON THE CDI (COURSE DEVIATION INDICATOR).

WORKING OF VOR

- ✓ **Info from the VOR receiver is displayed on the CDI (Course Deviation Indicator).**
- ✓ **The vertical needle is used as the course indicator.**
- ✓ **Vertical needle also indicates when the aircraft deviates from the course and**
- ✓ **The direction of the aircraft must be turned to attain the desired course**


Course index
Unreliable signal flag
NAV
TO
CDI needle
Approximately 2 degrees
in the VOR mode
TO/FROM indicator
OBS
OBS knob
N
E
S
W
33
30
3
6
12
15
21
24

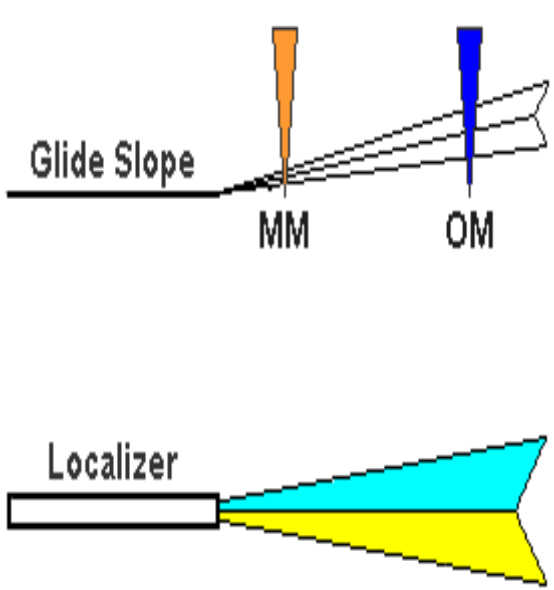
WORKING OF VOR THROUGH CDI

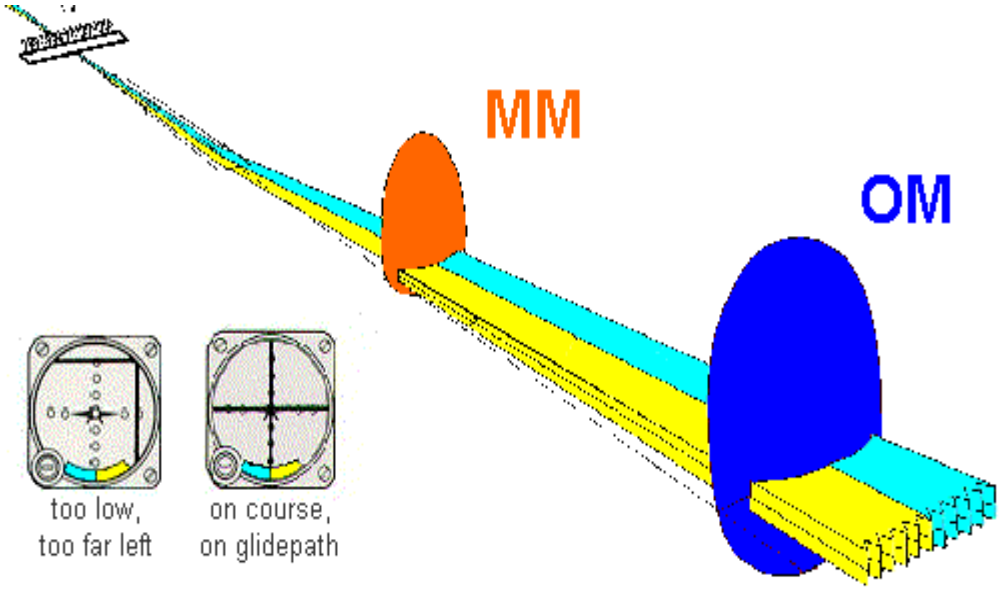
- ✓ **To-from indicator presents the direction to or from the station along the omni radial.**
- ✓ **When the localizer signals are selected on the receiver ,the indicator shows the position of the localizer beam relative to the aircraft and the direction the aircraft must be turned to intercept the localizer.**
- ✓ **During VOR operation the VOR radial to be used is selected by rotating the OBS (omni-bearing selector).**
- ✓ **OBS is graduated in degrees from 0 to 360.**

INSTRUMENT LANDING SYSTEM (ILS)

- ✓ In aviation, the **instrument landing system** (**ILS**) is a radio navigation **system** that provides short-range guidance to aircraft to allow them to approach a runway at night or in bad weather.
- ✓ **It Operates in the VHF portion of the electromagnetic spectrum**
- ✓ **System consists of a runaway localizer, a glide slope signal, and marker beacons for position location**
- ✓ **Localizer equipment produces a radio course aligned with the centre of an airport runaway. The on course signals result from the equal reception of two signals; Blue sector(150 Hz) and yellow sector(90 Hz)**

GLIDE SLOPE INFORMATION





- ✓ **The glide slope : assists pilot in making the correct angle of descent**
- ✓ **Glide slope signals are radiated from two antennas located adjacent to the touchdown point of the runway.**
- ✓ **Info from both localizer and glide slope receivers is presented to the CDI;**

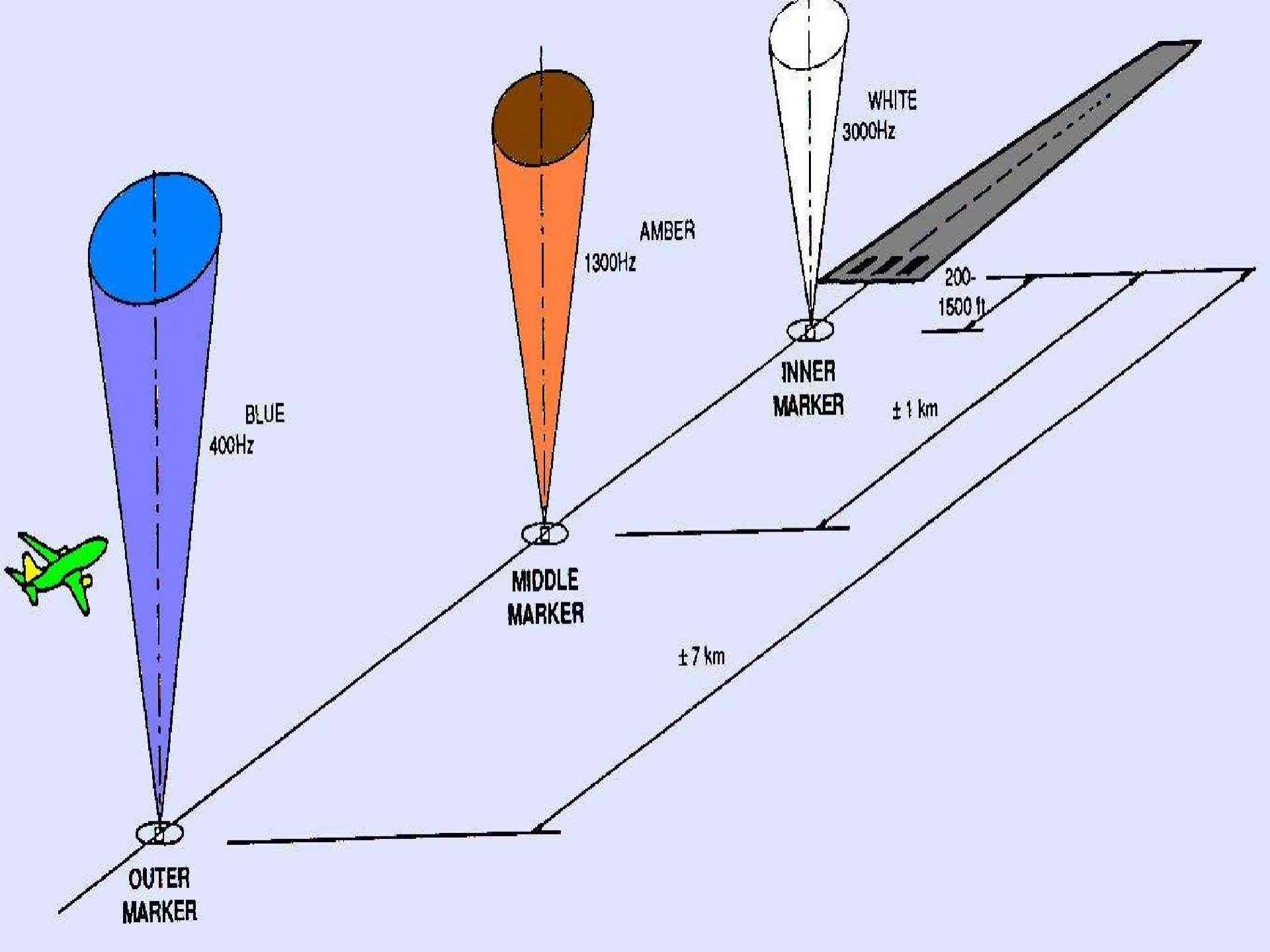
THE COURSE DEVIATION INDICATOR

- ✓ **The vertical needle: localizer information**
- ✓ **Horizontal needle : Glide slope information**

When both needles are centered, the aircraft is on course and descending at the proper rate

MARKER BEACONS

- ✓ **In connection with the instrument landing system.**
- ✓ **signals which indicate the position of the aircraft along the approach to the runway**
- ✓ **Three markers are used in each installation:**
  - ➢ **Outer marker - the beginning of the approach path is modulated by a 400 HZ signal, a tone keyed in long dashes**
  - ➢ **Middle marker: 3500 ft from the end of the runway is modulated at 1300 Hz, a higher-pitched tone keyed with alternate dots and dashes**


WHITE
3000Hz
AMBER
1300Hz
BLUE
400Hz
200-
1500 ft
INNER
MARKER
± 1 km
MIDDLE
MARKER
± 7 km
OUTER
MARKER

DISTANCE MEASURING EQUIPMENT(DME)

- ✓ **Constant visual indication of the distance the aircraft is from a ground station**
- ✓ **<u>NOT</u> a true indication of point to point distance as measured over the ground**
- ✓ **Indicates the slant range between the aircraft and the ground station**

WORKING OF DME

- ✓ **Transceiver transmits a pair of spaced pulses to the ground station**
- ✓ **Ground station responds with a pulse transmission on a separate frequency to send a reply to the aircraft**
- ✓ **Time elapsed is time between the challenges and are measured;**
- ✓ **Time travel is the distance separating plane and station.**
- ✓ **Distance is indicated in 'nautical miles' by a cockpit instrument**

✓ **Transmitting frequencies are in 2 groups**

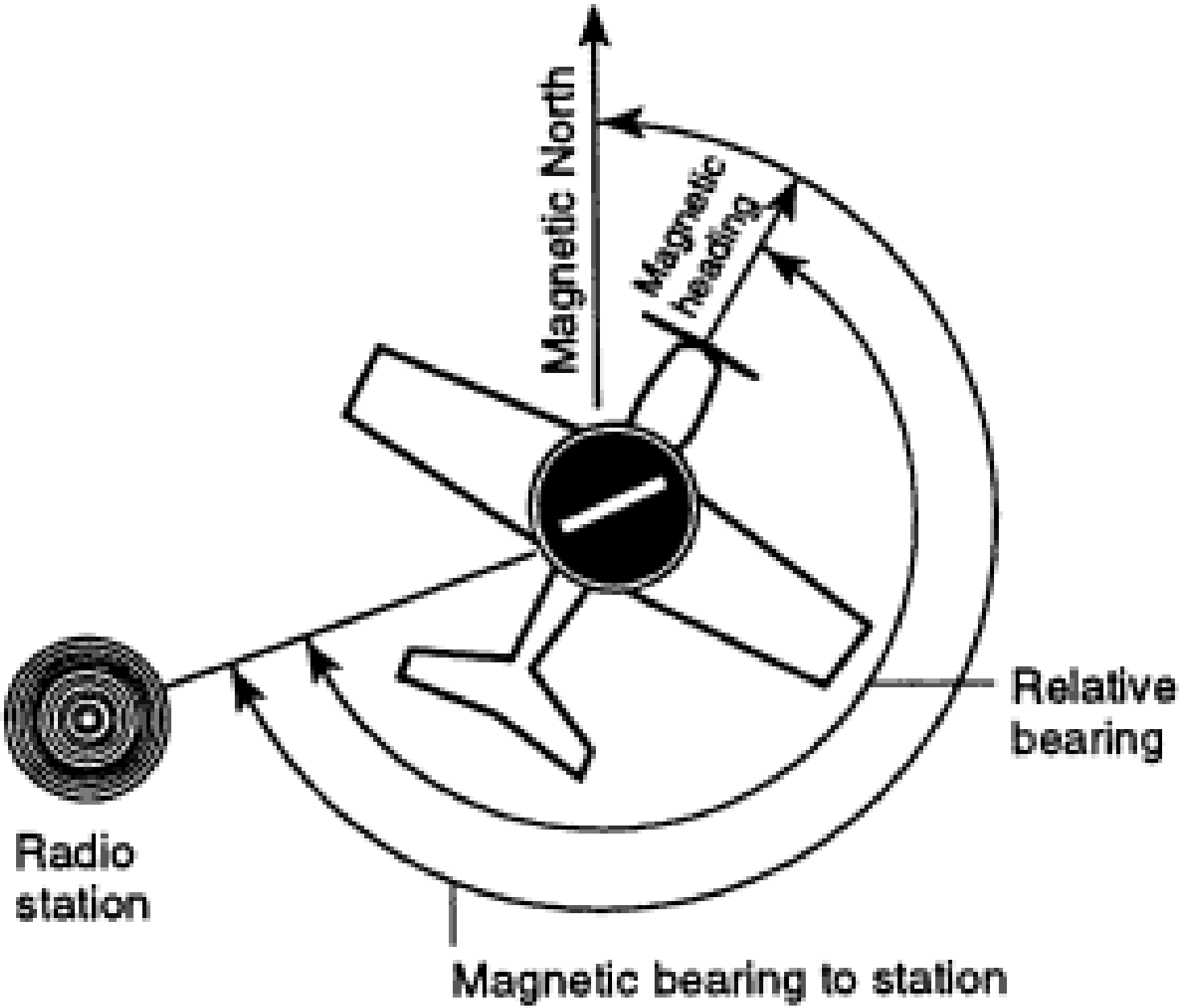
- **962 MHz to 1024 MHz**
- **1151 MHz to 1212 MHz**

- **Receiving frequency is between 1025 to 1149 MHz**

Aircraft's DME transceiver is tuned to the selected DME ground station

AUTOMATIC DIRECTION FINDERS

- ✓ADF (Automatic Direction Finder) is the radio signals in the low to medium frequency band of 190 Khz. to 1750 Khz. It was widely used today. It has the major advantage over VOR navigation in the reception is not limited to line of sight distance. The ADF signals follow the curvature of the earth. The maximum of distance is depend on the power of the beacon. The ADF can receives on both AM radio station and NDB (Non-Directional Beacon). Commercial AM radio stations broadcast on 540 to 1620 Khz. Non-Directional Beacon operate in the frequency band of 190 to 535 Khz.


Magnetic North
Magnetic heading
Relative bearing
Radio station
Magnetic bearing to station

- ✓ **Consists of**
  - **Receiver, Loop antenna,**
  - **Sense or non-directional antenna,**
  - **Indicator and control unit.**

- ✓ **Loop antenna rotates through 360 degrees**

- ✓ **Receives Max signal strength:**
  In parallel position with the direction of the transmitted signal

- ✓ **Reaches the Min when perpendicular to the transmitted signal position of the loop, is called the null position**

- ✓ Null position of the loop is used for direction finding
- ✓ Two null positions exist (180 degrees apart)
- ✓ Loop antenna cannot differentiate, require sense antenna
- ✓ Signal strength of the sense antenna is superimposed with the null antenna
- ✓ Only one null position of the loop

DOPPLER NAVIGATION SYSTEM

- ✓**Automatically and continuously computes and displays ground speed and drift angle of an aircraft without the aid of ground stations, wind estimates or true air speed data**

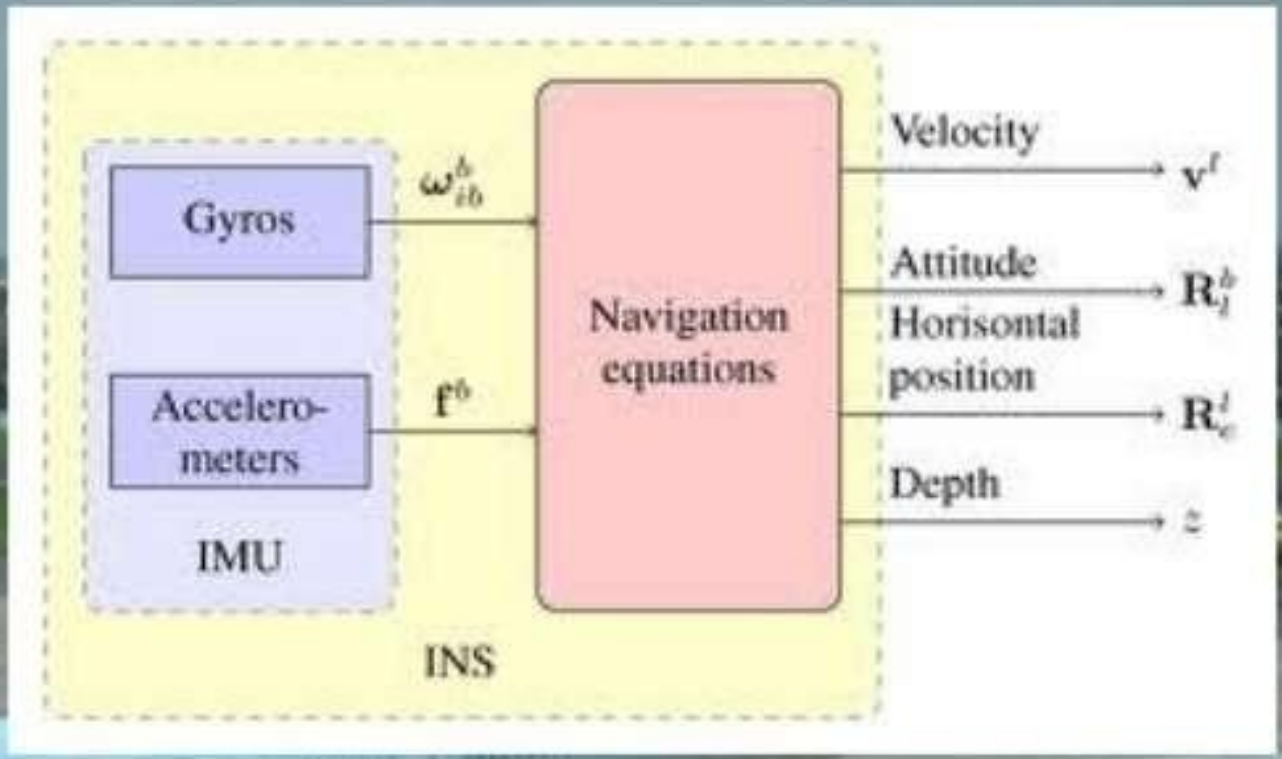
- ✓**Does not sense direction as search radar does**

- ✓**Uses continuous carrier wave transmission energy and determines the forward and lateral velocity component of the air craft by utilizing the principle known as <u>DOPPLER EFFECT</u>**

INERTIAL NAVIGATION SYSTEM

- ✓ **Used on large aircraft as a long range navigation aid**
- ✓ **Self-contained system; DOES NOT require any signal inputs from ground navigational facilities**
- ✓ **Derives altitude, velocity, and heading information from measurement of the aircraft's accelerations**
- ❖ **Two accelerometers are required, one referenced towards east and other towards north.**
- ✓ **The accelerometers are mounted on a gyro stabilized unit, called the stable platform**
- ✓ **Averts the introduction of errors resulting from the acceleration due to gravity.**

INERTIAL NAVIGATION SYSTEM



An inertial navigation system is a complex containing four basic components :-

- ✓ **A stable platform which is oriented to maintain accelerometers horizontal to the earth's surface.**
- ✓ **Accelerometers arranged on the platform to supply specific components of acceleration**
- ✓ **Integrators which receive the output from the accelerometers and furnish velocity and distance.**
- ✓ **A computer which receives signals from the integrators and changes distance travelled to position in selected coordinates.**

RADIO ALTIMETER

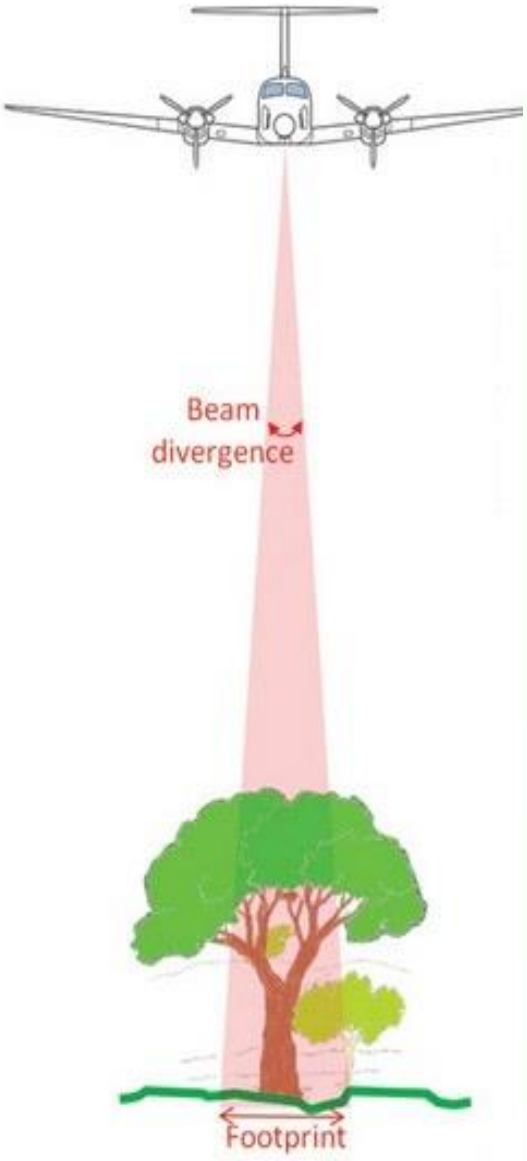
Radio altimeters are based on the principle of reflection of electromagnetic wave pulses by the surface of the earth or sea. These waves fall within the radio spectrum range.

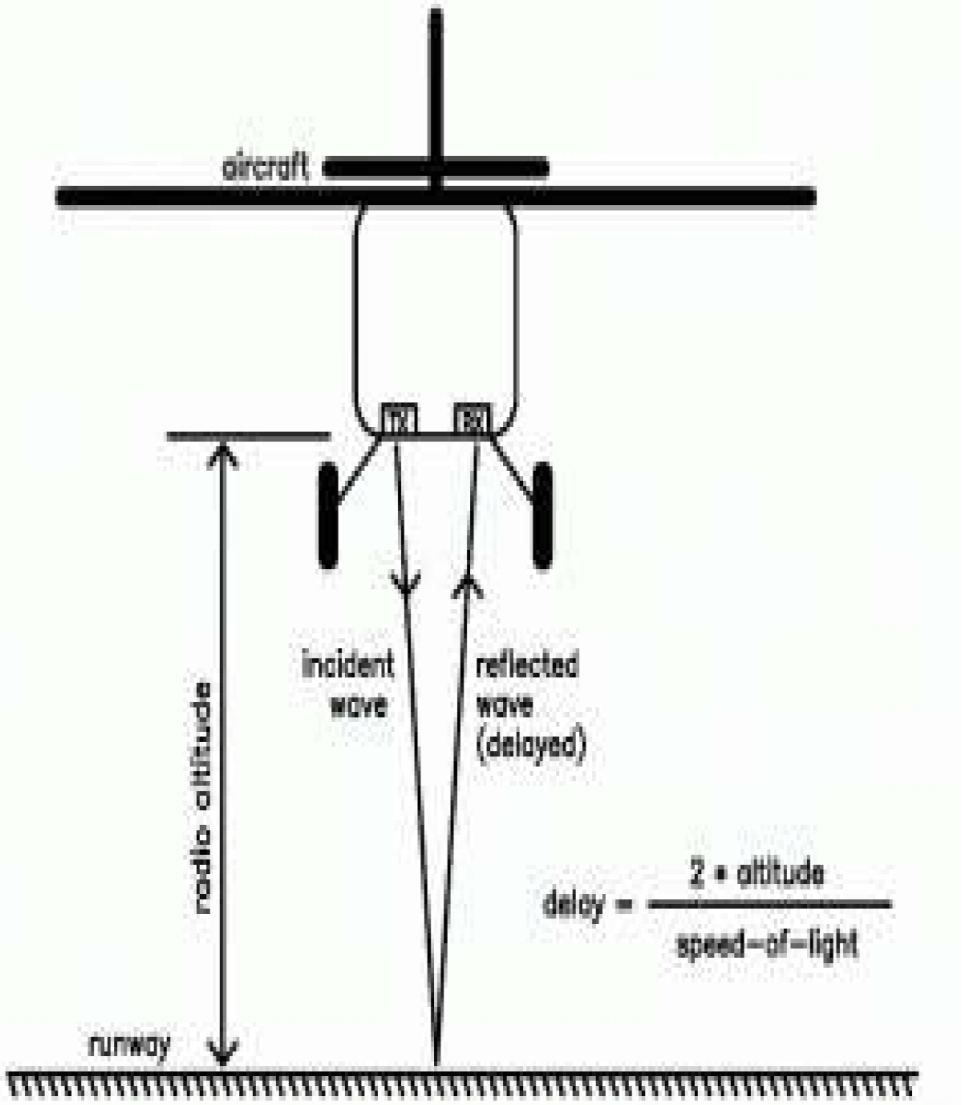
8. Electromagnetic waves travel at the speed of light and thus the calculation of the distance is effectively immediate. Although they are affected by surface irregularities generating deviations in the radio signal, radio altimeters provide a reliable and accurate method of measuring height.

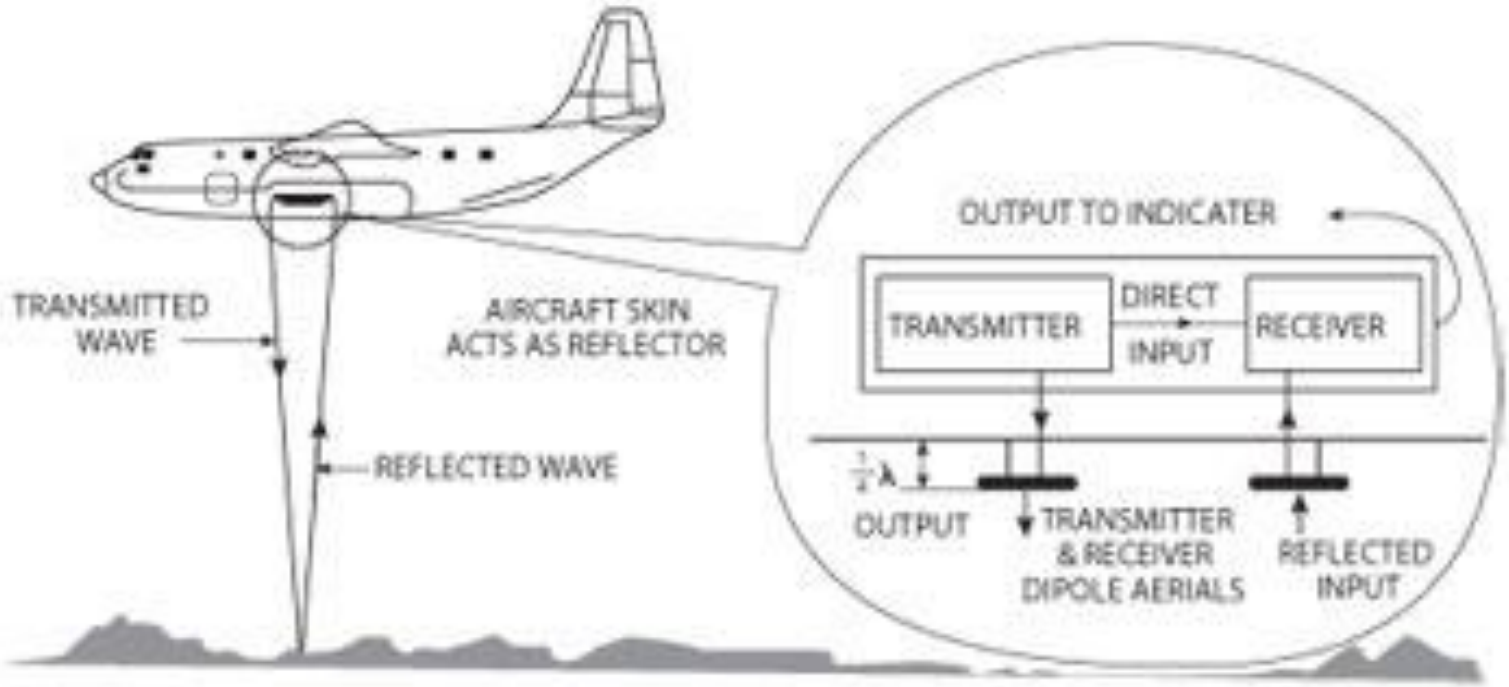
- ✓ **Measures the distance from the aircraft to the ground.**
- ✓ **Accomplished by transmitting radio frequency energy to the ground and receiving the reflected energy at the aircraft.**

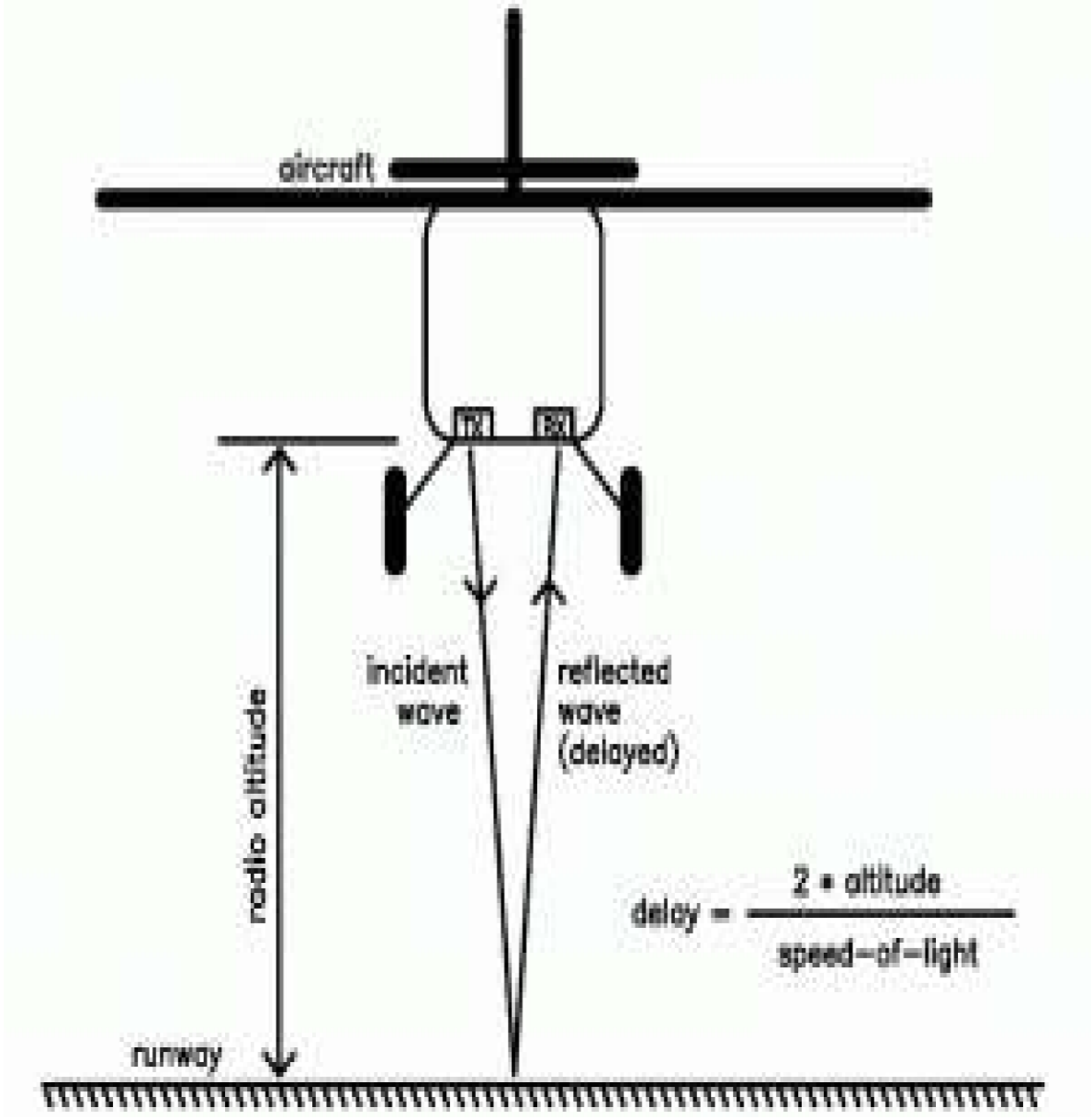
Pulse Type

- **Altitude determined by measuring time required for transmitted pulse to hit ground and return.**
- **Indicating instrument gives true altitude of aircraft**
- **Used during landing to determine decision whether to continue to land or execute climb-out**


Beam
divergence
Footprint


aircraft
incident
wave
reflected
wave
(delayed)
radio altitude
runway
delay = 2 * altitude / speed-of-light


TRANSMITTED
WAVE
AIRCRAFT SKIN
ACTS AS REFLECTOR
REFLECTED WAVE
OUTPUT TO INDICATER
TRANSMITTER
DIRECT
INPUT
RECEIVER
½λ
OUTPUT
TRANSMITTER
& RECEIVER
DIPOLE AERIALS
REFLECTED
INPUT


aircraft
TX
RX
incident wave
reflected wave (delayed)
radio altitude
runway
delay = 2 * altitude / speed-of-light

Video Links

VOR

Hhttps://www.youtube.com/watch?v=u_HJi58QhxI

https://www.youtube.com/watch?v=wuLTppemEgA

ILS

https://www.youtube.com/watch?v=PziW3iKF5GI

THANK YOU