

# Ex. 24 e – Radio Navigation Aids

VOR, NDB, GPS



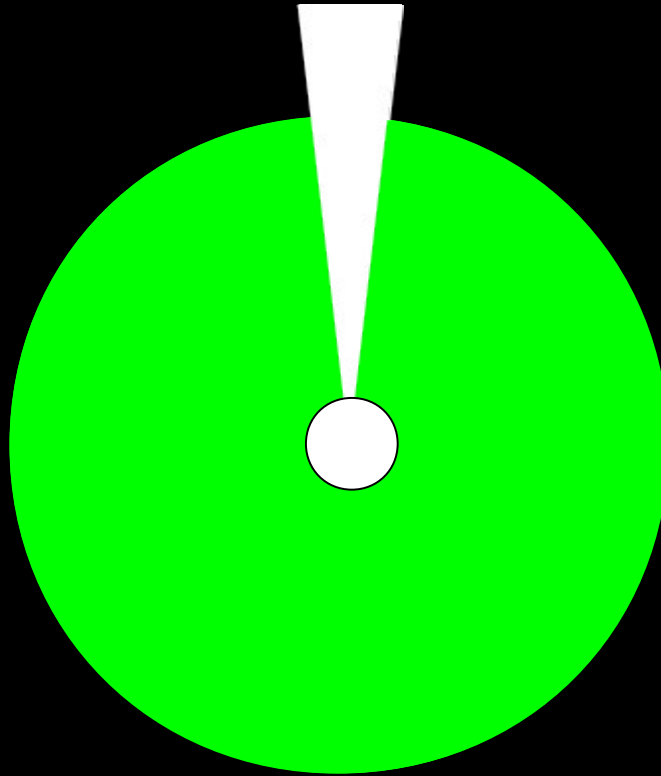
# What you will learn:

- ✓ How to use radio navigation aids to assist in cross-country navigation and determining your position when lost.

# Why learn this:

- ✓ Radio navigation aids can provide an additional cross-check of dead reckoning and pilotage navigation techniques
- ✓ Especially useful at night and over unfamiliar or featureless terrain
- ✓ Can be used when lost to help determine your position.

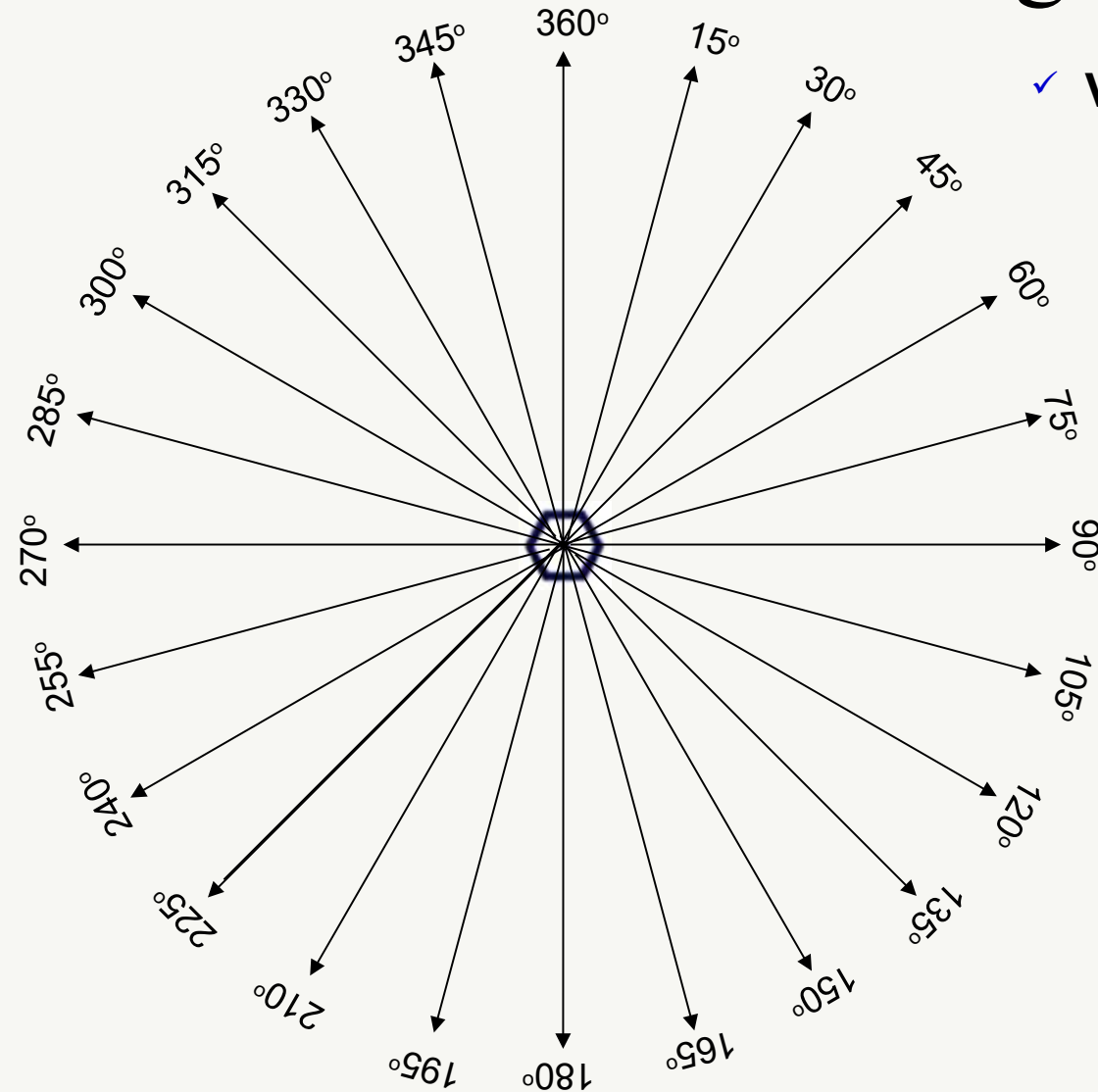
# VOR: Stations and Signals



You know that the lighthouse sends out a sweeping narrow beam of white light that takes 4 seconds to complete the full circle. Every time the white beam passes through north, a green light shines in all directions.

You saw a green light and then a white light 3 seconds later. What radial are you on with respect to the lighthouse?

# VOR: Stations and Signals



- ✓ **VOR = VHF Omnidirectional Range**
- ✓ **108.1 – 117.95 MHz**
- ✓ **360 radials**
- ✓ **radials always point away from the station**
- ✓ **identified by a three-letter Morse code**

# VOR: Stations and Signals

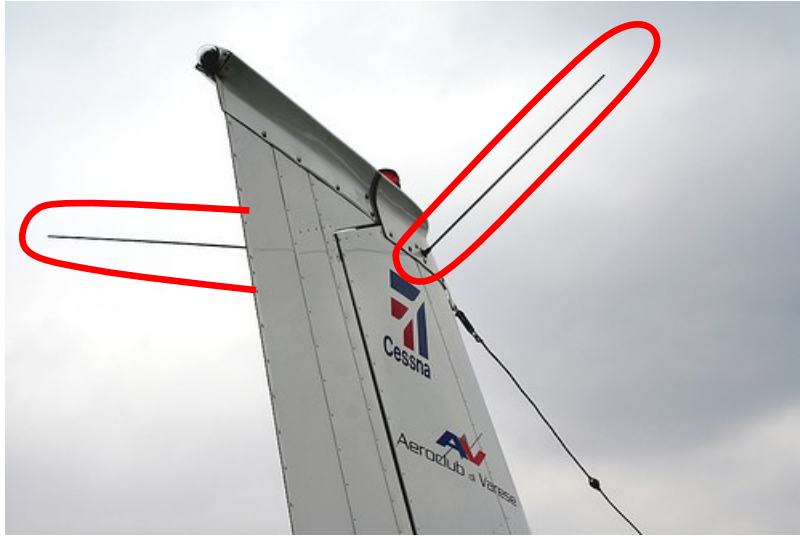
## ADVANTAGES

- ✓ Radio waves in the VOR band do not get deflected or distorted
- ✓ Relatively free from static and interference
- ✓ Unaffected by weather

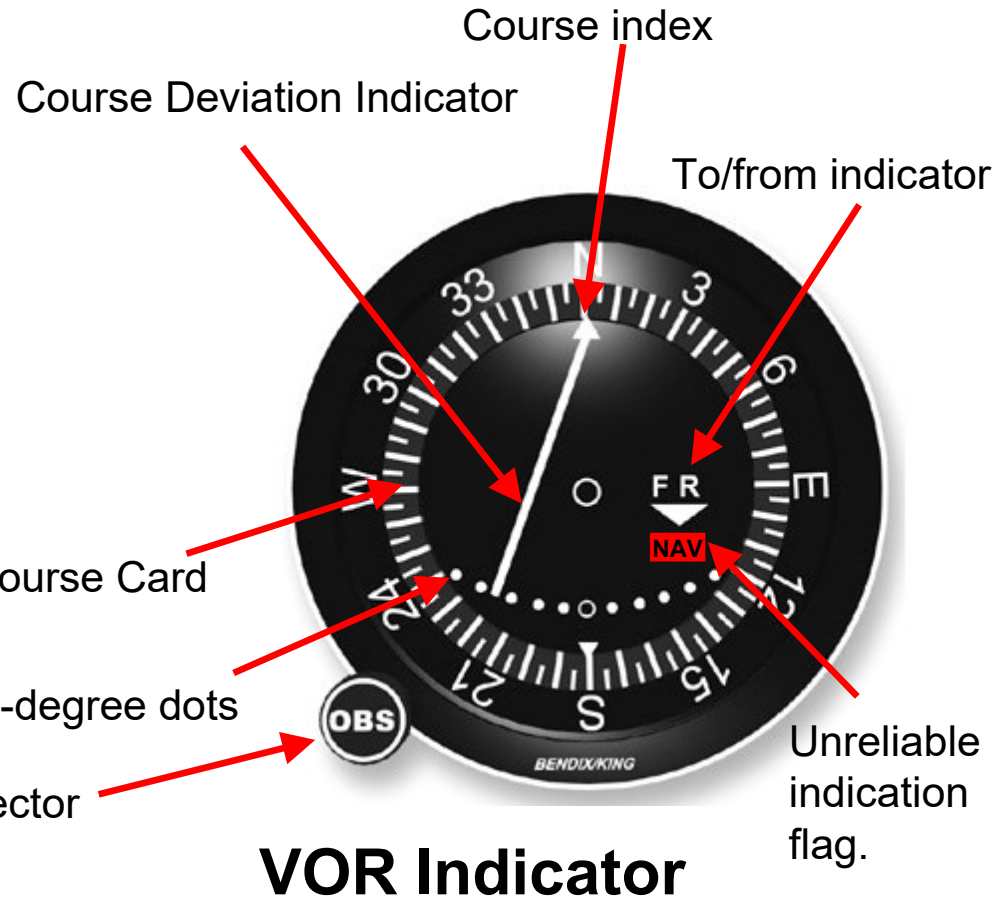
## LIMITATIONS

- ✓ Line of sight reception
- ✓ Reception distance (NM) =  $1.23 \times \sqrt{\text{elevation (AGL)ft}}$  .

# VOR: Equipment

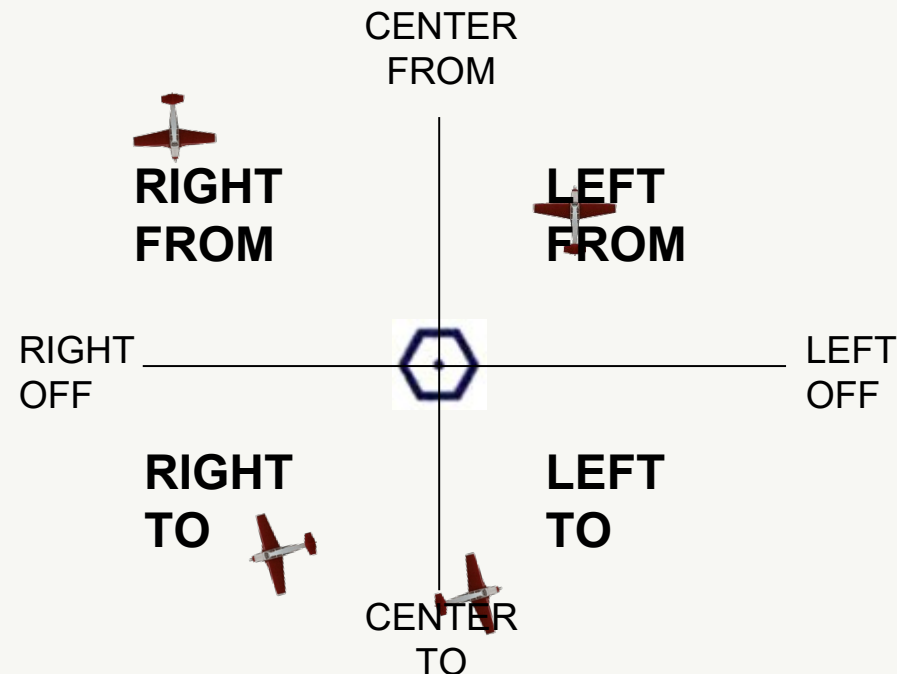


**VOR Antenna**



# VOR: Instrument Indications and Interpretations

- ✓ VOR indicator will indicate
  - whether you're going towards or away from the station
  - whether the selected radial is to your left or to your right
 provided that your heading matches selected course!





# VOR: Homing

- ✓ Tune, identify
- ✓ Turn OBS until needle is centered AND to/from flag shows TO
- ✓ Turn to heading indicated by the course index and fly to the station
- ✓ To correct for drift:
  - if needle drifted off centre, adjust heading by 10-20° into direction of the CDI to return to centre
  - after needle returns to centre, adjust heading by 5° from original to correct for drift
  - if needle drifts off again, recenter it and use a bigger heading correction
- ✓ Flag will change from TO to OFF and then FROM as the station is passed.

# VOR: Intercepting a radial from the station

- ✓ Tune, identify
- ✓ Turn OBS until the radial you want to intercept is at the top
- ✓ Ensure FROM flag is on
- ✓ Turn to and fly heading in the direction of CDI at desired intercept angle
- ✓ Once CDI is nearly centered, turn to desired track
- ✓ Use drift corrections to keep CDI centered.

You want to intercept 050 radial from the station. To which heading will you turn for a 45° intercept? 90°?



# VOR: Intercepting a radial to the station

- ✓ Tune, identify
- ✓ Turn OBS until the radial you want to intercept is at the bottom
- ✓ Ensure TO flag is on
- ✓ Turn to and fly heading in the direction of CDI at desired intercept angle
- ✓ Once CDI is nearly centered, turn to desired track
- ✓ Use drift corrections to keep CDI centered.



# VOR: Obtaining Position Fix

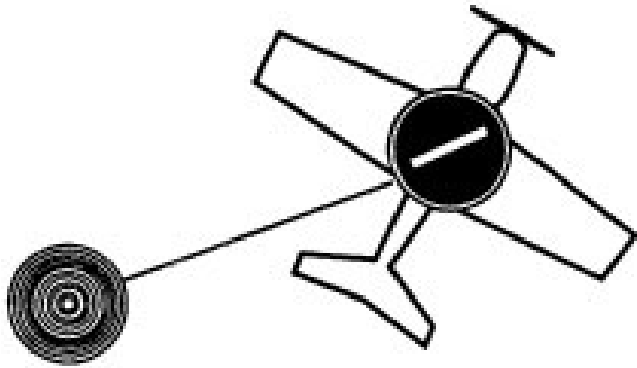
- ✓ Tune, identify
- ✓ Turn OBS until the needle is centered and the FROM flag is showing
- ✓ Draw the corresponding radial on the map
- ✓ You are somewhere along that line
- ✓ Repeat with a second VOR: the intersection of two lines is your position fix

**Best to use two VOR indicators set to two different stations simultaneously.**

# Considerations

- ✓ When setting a VOR radial to track under course index, remember: **FROM top TO bottom**
  - i.e., your track should always be at the top
  - if you want to track radial 210 to the station, you need to fly track 030, so set the OBS so that 210 is at the bottom and 030 is at the top
  - if you want to track radial 210 away from the station, set 210 at the top
- ✓ Shallow intercepts ( $45^\circ$  or less) are ok for tracking outbound (from a station). Use  $90^\circ$  intercepts when tracking to the station, if the station is nearby
- ✓ During intercepts, start turns to heading slightly before the radial/bearing is intercepted
- ✓ The needles will become more sensitive near the stations: being even a very short distance off track will correspond to many degrees off
- ✓ Needle that's moving/swinging slowly as you approach the station indicates that you are further off course; needle moving/swinging rapidly indicates that you are passing almost directly overhead.

# NDB: Stations and Signals



- ✓ **NDB = Non-Directional Beacon**
- ✓ **ADF = Automatic Direction Finder**
- ✓ **NDB transmits a signal in all directions**
- ✓ **Low frequency: 190KHz to 1750KHz**
- ✓ **1, 2, or 3-letter Morse code identifier**

# NDB: Stations and Signals

## ADVANTAGES

- ✓ Radio waves propagate further (ground and sky waves)
- ✓ Can be used as a primitive storm scope (points towards thunderstorms)
- ✓ Can use ADF equipment to listen to AM radio :-)

## LIMITATIONS

- ✓ Affected by:
  - thunderstorms
  - night/twilight
  - terrain and coastal features
  - airplane bank attitude
- ✓ Harder to use to track to/from station.

# ADF: Equipment

## ADF Sense Antenna



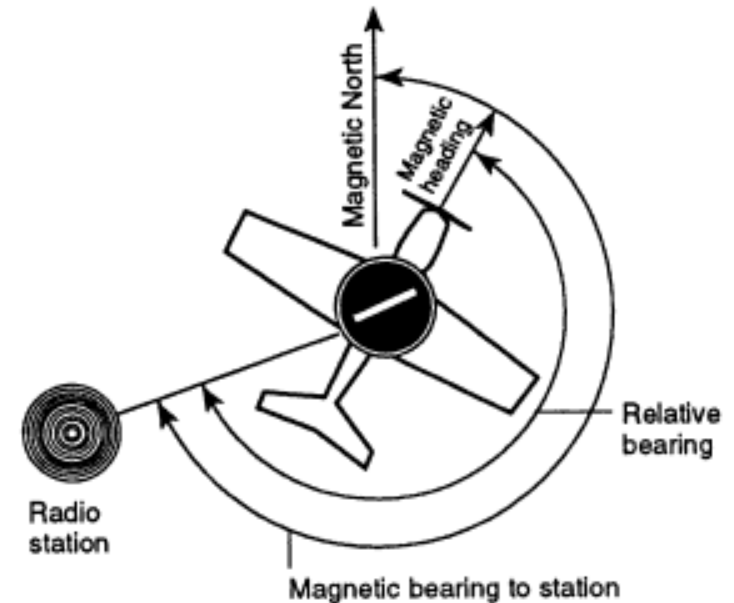
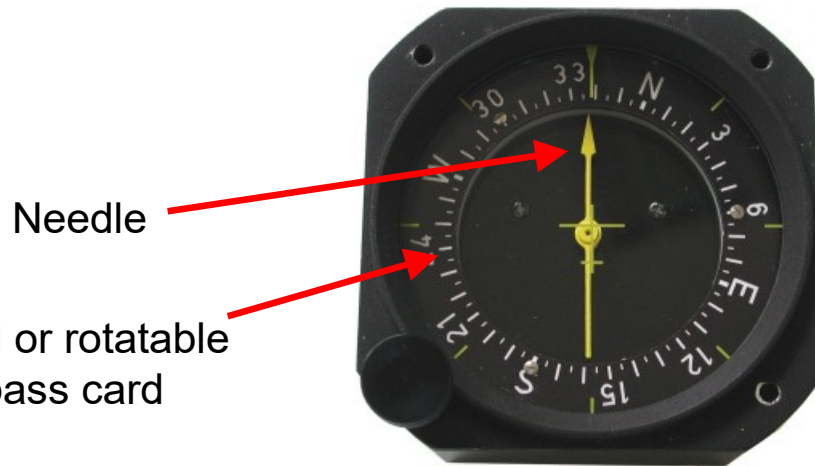
ADF Loop Antenna

- ✓ Loop antenna senses the angle of the NDB radio beam
- ✓ Sense antenna figures out whether the station is in front or behind the aircraft
- ✓ In newer planes, these antennae are rolled into one package (no tail-to-fuselage wire).



# ADF: Equipment, Instrument Indications and Interpretation

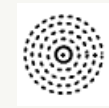
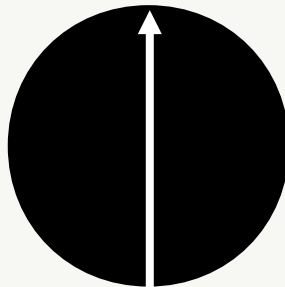
## ADF Indicator



- ✓ The needle always points to the station
- ✓  $\text{Magnetic bearing} = \text{Relative Bearing} + \text{Magnetic Heading}$
- ✓ If card is rotated to display magnetic heading at the top, the needle will point to magnetic bearing.

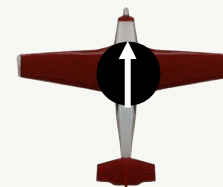
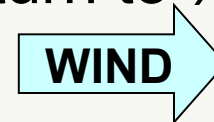
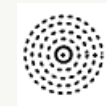
# NDB: Homing

- ✓ Tune, identify
- ✓ Turn toward the needle until it points straight up
- ✓ Follow the needle to keep it centered



# NDB: Tracking to Station

- ✓ Tune, identify
- ✓ Start homing procedure
- ✓ Any needle movement indicates drift
- ✓ To correct: turn to recenter the needle and then again the same amount
- ✓ When the track is intercepted, turn to  $\frac{1}{2}$  original drift angle
- ✓ Fly with the needle off centre
- ✓ If the needle still drifts, adjust the amount of correction.



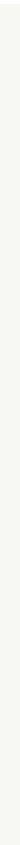
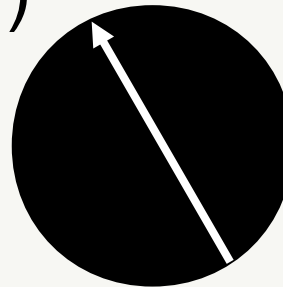
# NDB: Obtaining Position Fix

- ✓ Tune, identify
- ✓ Rotate ADF card so that magnetic heading is at the top
- ✓ Needle will point to the magnetic bearing to the station
- ✓ End of needle will point to the magnetic bearing from the station
- ✓ Correct for magnetic variation, if using lat/lon grid to draw a line
- ✓ Draw a line from the station – you are somewhere on that line

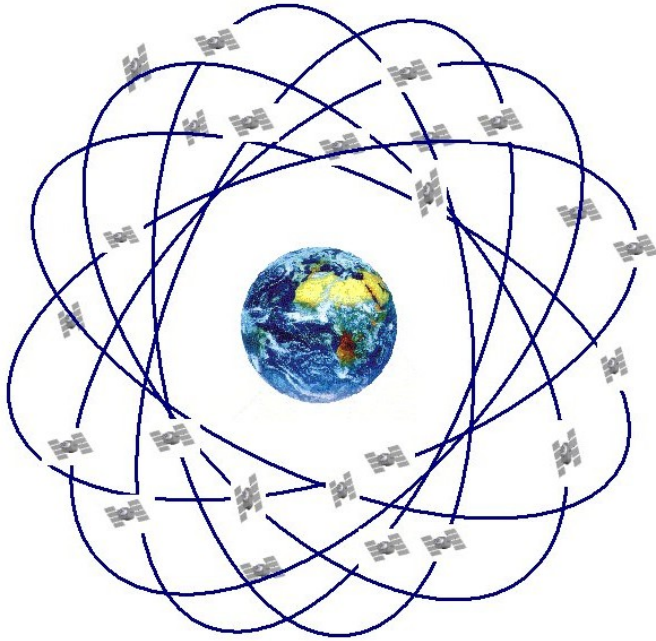
**With a fixed card, superimpose the needle onto HI, or use the formula  
 $MB = RB + MH.$**

# NDB: Intercepting a Bearing

- ✓ Tune, identify
- ✓ Turn to a heading that parallels desired track
- ✓ Turn 90° in the direction of the needle
- ✓ Once ADF indicating 90/270°, turn to desired heading (to or away from the station)
- ✓ Correct for drift as appropriate.



# GPS: Satellites and Signals



- ✓ **GPS = Global Positioning System**
- ✓ **A constellation of 24 satellites is orbiting the Earth, transmitting radio signals received by GPS units**
- ✓ **By measuring the time it takes the signal to travel to the receiver, distance to the satellite is calculated**
- ✓ **A minimum of 4 satellites is required to accurately establish position.**

# GPS: Satellites and Signals

## ADVANTAGES

- ✓ Straightforward, intuitive display showing exact location (rather than radial, bearing etc.)
- ✓ Wide coverage area

## LIMITATIONS

- ✓ Some areas do not have satellite coverage at all times
- ✓ Easy to make input error
- ✓ Database may be out of date
- ✓ Pilot tempted to look inside the cockpit:
  - poor lookout
  - no situational awareness if GPS dies/becomes unreliable.

# Review

- Q How do you intercept a VOR radial to the station?
- Q From the station?
- Q How do you intercept an NDB track?
- Q How do you correct drift when flying to an NDB?
- Q How can you use a VOR and an NDB to get a position fix?
- Q You are flying at 3500' ASL, heading north from the Frenchmans Bay. When will you be able to pick up the Simcoe VOR?



# SAFETY

- ! Aviate – Navigate – Communicate! Remember to look outside and FLY THE PLANE first!
- ! Do not become over-reliant on radio navigation aids (especially GPS). Use them to supplement your dead reckoning and pilotage, not replace them
- ! If lost and have difficulty interpreting radio nav aids indications, contact ATC and request assistance.