# NAVIGATION INTRUMENTATION – ADF

## 1. Introduction

The Automatic Direction Finding (ADF) equipment on-board of aircraft is used together with the Non Directional Beacon (NDB) transmitters installed on the ground. The on-board ADF is able to receive and decode NDB signals through an antenna system and a HF receiver to provide pilots with an indication of the relative position shown in the instrument.

A Non Directional Beacon, abbreviated 'NDB', is a ground installation consisting of a LF transmitter which transmits vertically polarized radio signals continuously and in all directions.

This radio navigation system is used mainly for Instrument Flight Rules flights (IFR). However, during VFR flights it can be quite useful in order to check aircraft's position.

This system is an old radio-aid system which is getting replaced slowly with more modern and accurate systems such as VOR or even GPS systems.

## 2. Ground equipment: NDB

NDBs transmit their signals in the Low Frequency (LF) and Medium Frequency (MF) bands, operating from 190 to 1750 KHz. The radio signal propagates as a surface wave does, which provides quite a big amount of errors on the ADF which may sometimes cause the instrument indication not to be reliable. With the purpose of suppressing those errors as much as possible, they normally transmit between 250 and 450 KHz.
NDB errors may not be found on our perfect simulators.
Each NDB has its own frequency and all of them are identified by names consisting of two or three letters or an alphanumeric combination.

There are two types of NDB, regarding the purpose for which they have been installed:

- Locator NDBs (L): These are low power NDBs located near an aerodrome. They are useful to simple design instrumental approach procedures for this airfield, or sometimes arrival or departure reference beacon. They can be also co-located with ILS system markers, which usually provide distance to touchdown when no DME is associated with the ILS. Locators range varies between 10 and 25 NM.
- En-route NDBs: These are higher powered NDBs which provide a greater range.
    - Low power: used for IFR procedures not so near of an aerodrome, as a holding facility or en-route station, providing a range up to 50 NM.
    - High power: used only for en-route navigation with ranges of more than 50 NM.

NDB can transmit other information for local aircraft like:

- ATIS: Automatic Terminal Information Service
- AWIS: Automatic Weather Information Service
- AWOS: Automated Weather Observation System
- ASOS: Automated Surface Observation System
- VOLMET: Meteorological Information Broadcast
- TWEB: Transcribed Weather Broadcast

Figure: ground NDB installation

## 3. NDB on charts

The symbol of NDB radio navigation beacons on charts can be like the figures below

Associated with the NDB figure, you can have additional information written in a rectangle:

- Full clear name of the NDB
- Frequency in kHz
- 2 or 3 letter call sign of the NDB
- Morse code of the call sign

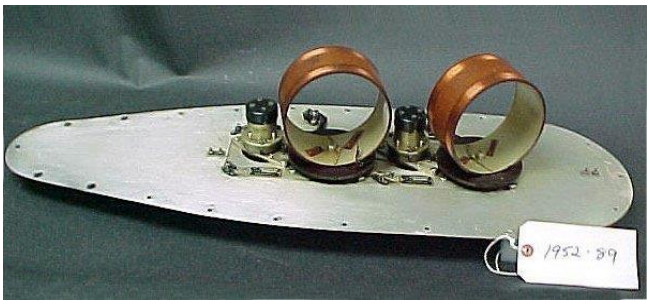

# 4. On-board equipment: ADF

The Automatic Direction Finder – ADF - when tuned to a selected NDB frequency, is the on-board equipment that determines the relative bearing (RB) from the aircraft to the ground beacon or station.

The relative bearing (RB) is the number of degrees measured clockwise between the heading of the aircraft and the direction from which the bearing is taken.
The relative bearing must be corrected with the aircraft position's variation and heading to obtain the magnetic bearing (MB) (the variation is the difference between the true north and the magnetic north).

Typical ADF equipment includes:

- 2 antennas:
  - Sense aerial: is the non-directional antenna that receives signals from all directions.
  - Loop aerial: is the rotating antenna that bests receives signals from only two directions.
- Receiver: the control unit, usually found next to radio panels.
- Indicator instrument: the instrument where the information is presented to pilots. It does not normally have any form of failure warning system such as a flag, so great care must be taken.



The NDB transmits signals in all directions that reach airborne ADF's loop and sense antennas. When both inputs are processed together, the equipment is able to display the relative bearing on the indicator instrument.

## 4.1. Frequency selector

The ADF receiver is the control unit where pilots select NDB frequencies from which they want to obtain the bearing.

ADF equipment has its own controls:

- Frequency selector: used to select the NDB frequency. It can be digital or analogic, depending on the equipment. Frequencies are tuned by rotating a knob until the wanted frequency is obtained.
- BFO (Best Frequency Oscillator): it must be turned on when identifying a non A1A beacon, so that the aural identification can be heard.
- Antenna mode:
    - ANT: only sense aerial will work
    - NDB/ADF: both sense and loop aerials will work. This mode is the most advisable
    - LOOP: only loop aerial will work. It usually is linked to another switch called 'Loop L/R' which with the aerial can be rotated left or right.

Depending on the equipment, there could also be two displays showing the ACTIVE and STANDBY ('SBY') frequencies. In this type of control units, the frequency is first selected on the STANDBY frequency display and then transferred to the ACTIVE frequency using the transfer switch (XFR) located normally between the displays.



Figures: 2 examples of ADF frequency selector:

## 4.2. Indicator instruments

Relative bearing from NDBs can be shown in two different instruments:

- Radio Bearing Indicator (RBI)
- Radio Magnetic Indicator (RMI)

Basic instruments consist of a compass rose with one needle that may indicate Relative Bearing (RB) or Magnetic Bearing (MB), depending on the instrument. The head of the needle indicates bearing TO the station and the tail of the needle indicates bearing FROM the station.

### 4.2.1. Radio bearing indicator with fixed card

It only has one needle and a fixed (not movable) compass rose. It always indicates heading North at the top of the instrument.

The moving needle indicates the Relative Bearing (RB) to the station, relative to the longitudinal axis of the aircraft (fore and aft axis). That Relative Bearing (RB) is read clockwise from 0º until the value the needle is pointing.

This is the simplest instrument and so its usage is not easy since the Magnetic Bearing (MB) is not shown at first glance. Relating to the current heading, the pilot will need to check the relative bearing and calculate the Magnetic Bearing (MB) each time.

Magnetic Bearing (MB) = Relative Bearing (RB) + aircraft heading.

### 4.2.2. Radio bearing indicator with movable card

Similar to the radio bearing indicator with fixed card, this instrument has the advantage to have a compass rose which can be rotated manually by the pilot.


So the aircraft's current heading can be set on the top. This allows the instrument to show directly the Magnetic Bearing (MB), which eases the pilot's work.
In the figure, the movable card was put at a heading 345°. In consequence the NDB magnetic heading is 060°.

### 4.2.3. Radio magnetic indicator (automatic)

This is an advanced instrument as it automatically rotates the compass rose to represent the current aircraft heading at the top. The Magnetic Bearing (MB) can be obtained easily.

The RMI has one or two needles which can be used to indicate navigation information from either the ADF or the VOR receivers. Both needles are different in appearance, one of them operating with NAV 1 or ADF 1 radio and the other one operating with NAV 2 or ADF 2 radio.

There are two switches that allow the pilot to change each needle source from VOR to ADF or from ADF to VOR.

### 4.2.4. Electronic horizontal situation indicator EHSI

In more complex instruments mounted on bigger or commercial airplanes, the ADF might be integrated into glass cockpits EHSI where NDB bearings may be shown in the Navigation Display.

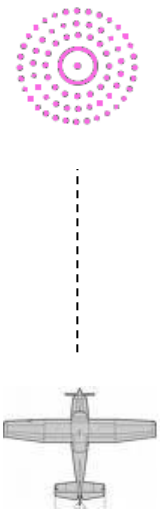

Figure: ADF is the blue arrow

## 4.3. Relative position between aircraft and NDB

The head of the needle indicates bearing TO the station and the tail of the needle indicates bearing FROM the station. The needle is not in function of aircraft heading.

### 4.3.1. Inbound NDB

The needle on the ADF is pointing north. Then the NDB is in front of the aircraft.

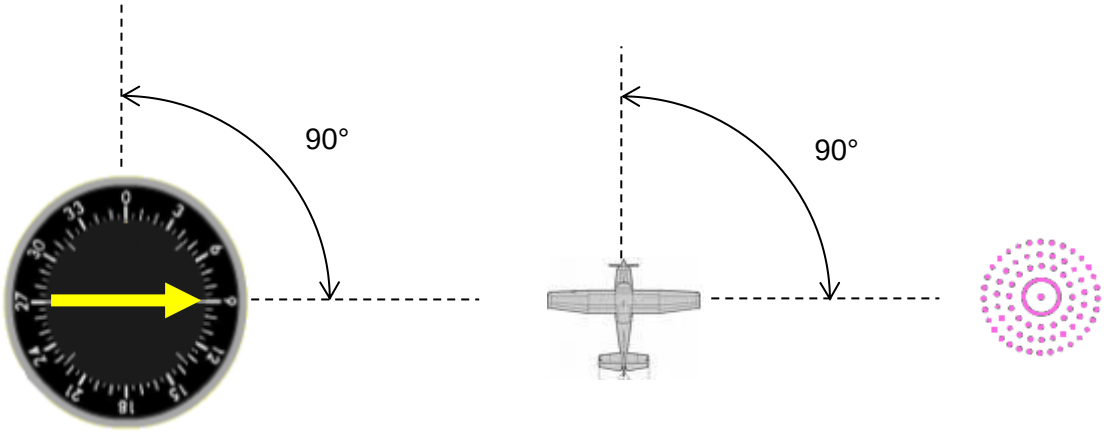


### 4.3.2. Outbound NDB

The needle on the ADF is pointing south. Then the NDB is behind the aircraft.

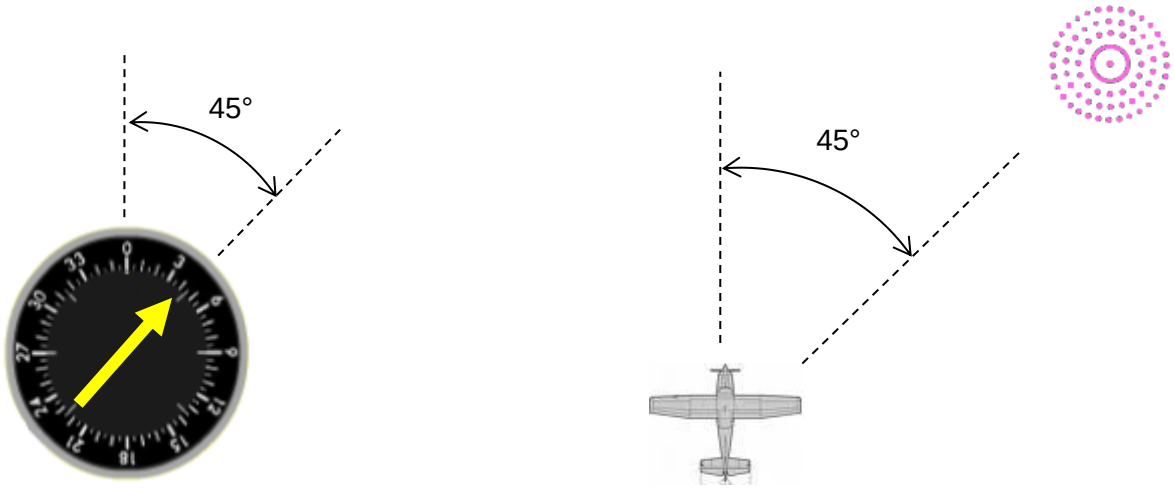
### 4.3.3. Lateral NDB

The needle on the ADF is pointing 90°. Then the NDB is on the right of the aircraft.



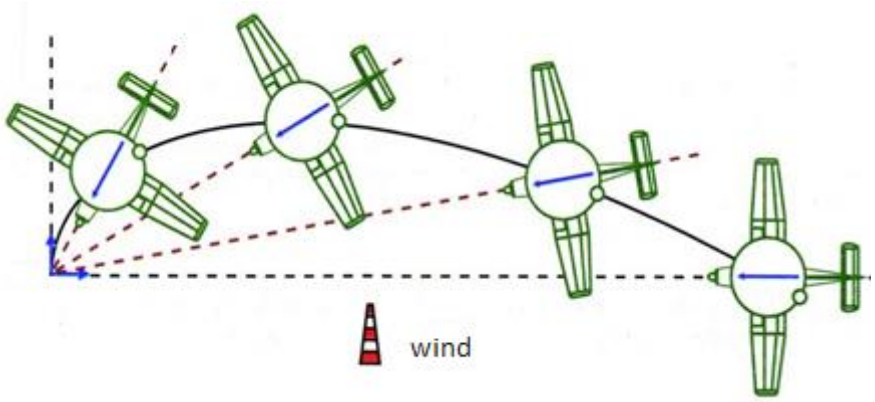
### 4.3.1. 45° track

The needle on the ADF is pointing 45°. Then the NDB is on the right of the aircraft.




## 5. Wind effect

When following a NDB navigation aid with presence of cross wind, if you maintain only the ADF at the top position of the instrument, your heading will increase or decrease like the image below.




In this case, you do not make a direct and follow the same NDB track.