INTRODUCTION

This chapter discusses the uses of the NDB. Even though pilots are unlikely to use the instrument for plotting position lines, they need to understand this procedure as it helps a General Navigation course. The process of homing and understanding the Jeppesen plate is essential in instrument flying for the Instrument Rating.

RELATIVE BEARING INDICATOR (RBI)

The bearing displayed on a fixed card indicator is a relative bearing; thus the name Relative Bearing Indicator (RBI). Since the card is fixed, zero is always at the top and 180° always at the bottom.

A relative bearing is always measured clockwise from the nose of the aircraft. In the diagram here, the needle is pointing to 100°. This means that the station is 100° to the right of the aircraft nose.

In the diagram below the relative bearing is 340°. The NDB is 340° right of the nose.

A more convenient way of expressing this is that the station is 20° left of the nose.

It is sometimes convenient to describe the bearing of the NDB in relation to the NOSE or TAIL of the aircraft.

Since the card is fixed, the indicated relative bearing must be combined with the magnetic heading of the aircraft in order to obtain the magnetic bearing to the station (QDM). If the result of this addition exceeds 360°, it is necessary to subtract 360° from the result in order to obtain a meaningful bearing.

Example:
Assume for the diagram above that the aircraft is heading 230°M
The bearing to the NDB is:

230° + 340° = 570°

Because this is more than 360, it is necessary to subtract 360 from 570 = 210°

The QDM is 210°.

This means the QDR is 030°.

The magnetic bearing of the aircraft from the station, the QDR, is the reciprocal of the QDM. A quicker way to determine the QDM is to mentally superimpose the RBI needle onto the directional gyro. This is not very accurate, but it is a good double check for calculations. Visualize the QDR as the tail of the needle when it is mentally transferred from the RBI onto the directional gyro indicator.

RADIO MAGNETIC INDICATOR (RMI)
This combines the Relative Bearing Indicator and Remote Indicating Gyro Compass into a single instrument, with the compass card being aligned automatically with Magnetic North. In the diagram below:

- The heading is 332°M.
- The VOR or ADF can be indicated by either pointer depending upon the switching.
- The QDM is continuously indicated by the arrow head of the pointer.
- The QDR is continuously indicated under the tail.

This is now the most common type of presentation.

If the double pointer represents the ADF then the QDM is 300' and the QDR is 120'.

ADF BEARING
The procedure for obtaining an ADF bearing is:

- Determine the frequency, identification, and modulation of the required beacon and ensure that the aircraft is within the published (promulgated) range.
- Switch on the ADF and adjust volume.
- Tune the frequency and identify the station.
- Select ADF on the control panel and note the bearing on the indicator.

LINE OF POSITION (LOP) USING THE RBI
With the help of the information provided by instruments, the pilot is now able to determine the line of position along which the aircraft is situated. To draw this LOP on the chart, the pilot needs the QDR or the QTE. Assume the aircraft is on a heading of 015°M:

The relative bearing from the indicator is 340°.

The QDM is the relative bearing plus the heading.

340 + 015 = 355°

The QDR is the reciprocal, or 175°.

LINE OF POSITION (LOP) USING THE RMI

An RMI solves the bearing automatically. The RMI continuously provides ODMs and ODRs. Magnetic Bearings can only be used on charts that are oriented to magnetic north. The beacons on most instrument charts have the direction of magnetic north attached with an arrow.

Assuming that the single pointer is the ADF:

- The QDM is 017
- The QDR is 197

HOMING

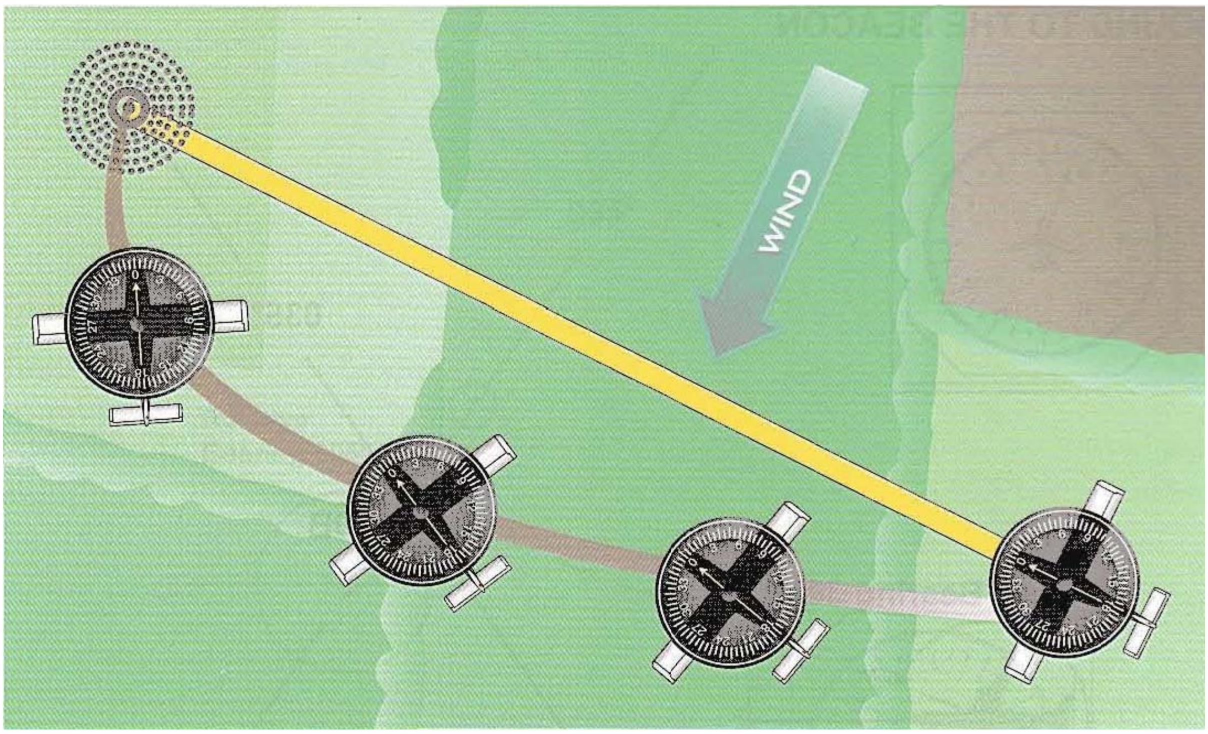
The ADF needle always points toward the station, and the easiest way to reach the beacon is to constantly fly with the needle pointing to the top of the indicator. This procedure is known as homing.

The easiest way to home to a station is to turn the aircraft in the direction of the needle until the needle points to the top of the indicator. This points the nose of the aircraft directly toward the station.

Once aimed at the station, any crosswind component displaces the aircraft to either side of the straight track to the station and the ADF needle swings away from the top of the indicator.

The pilot must then make a correction of the heading toward the needle in order to continue heading to the station.

This process must be repeated again and again, since the crosswind continues to push the aircraft away from the straight track. As a result, the path to the station is a curved one.



The crosswind component requires the aircraft to turn further and further into the wind in order to continue toward the station. The aircraft must turn until eventually reaching a point where the aircraft faces directly into the wind. At that point, the aircraft no longer drifts off the direct track and is now heading straight to the station. The actual curved path that results is different for each combination of crosswind and TAS. A strong crosswind component and low TAS results in a large deviation. A weak crosswind component and a high TAS results in a small deviation. Since the actual track over the ground varies with every wind and airspeed combination, there is no way to ensure that any given aircraft stays within the boundaries of an airway or approach path when homing. Homing is a very simple but extremely inefficient procedure. Because of the uncertain demands on airspace, it is not commonly used.

INTERCEPTING A COURSE

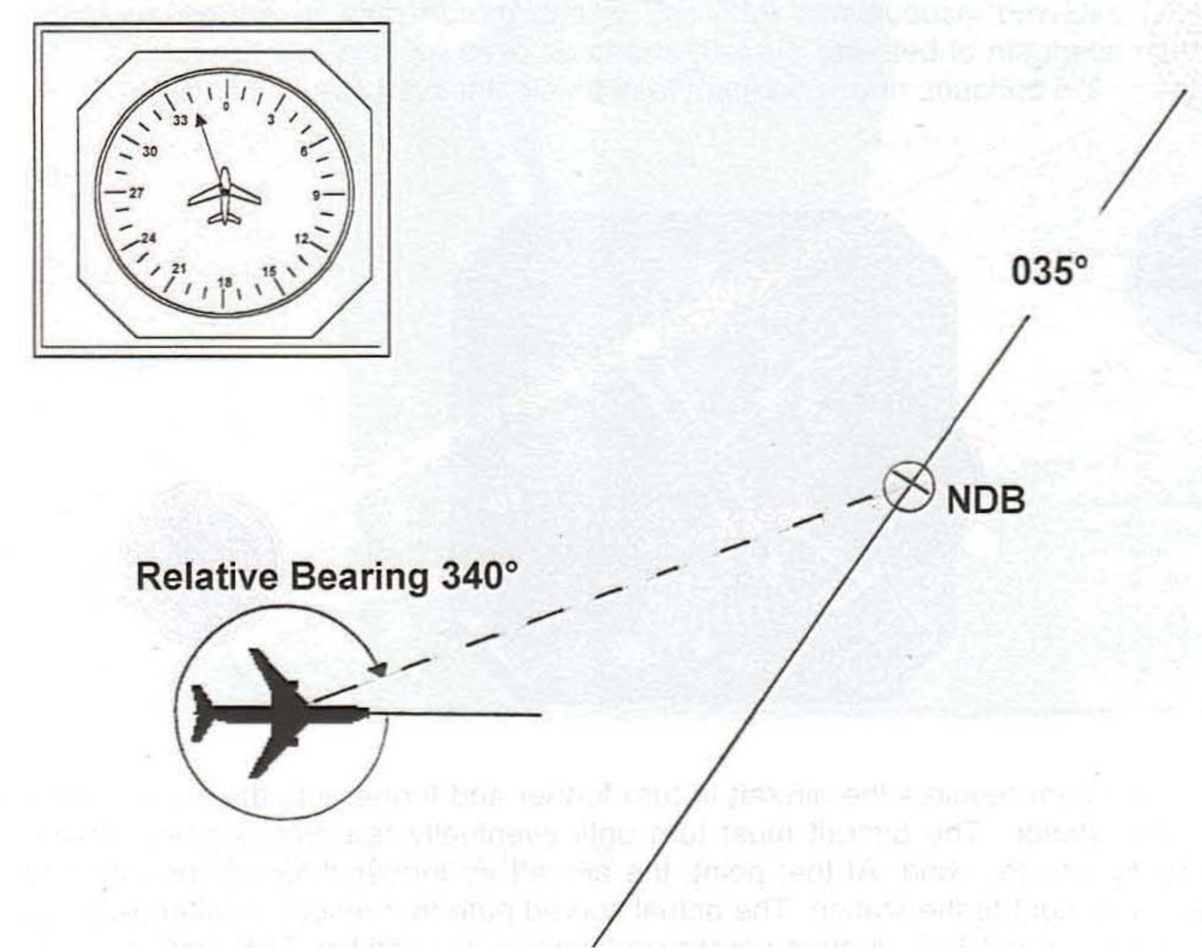
To navigate with the help of ADF and NDB:

- Visualize the aircraft's position
- Intercept the desired course
- Maintain the course to or from the station

The first step is to visualize the aircraft's position. Once this is completed, intercept the desired course, which in this case is 035° inbound.

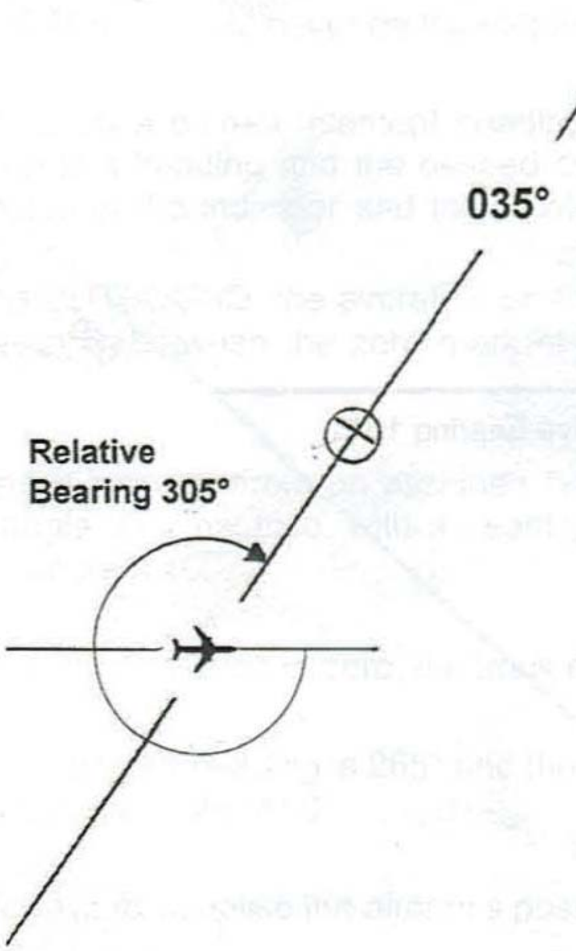
The second step is to make any turn necessary to the heading that provides a suitable intercept. Observe the instrument readings during the turn.

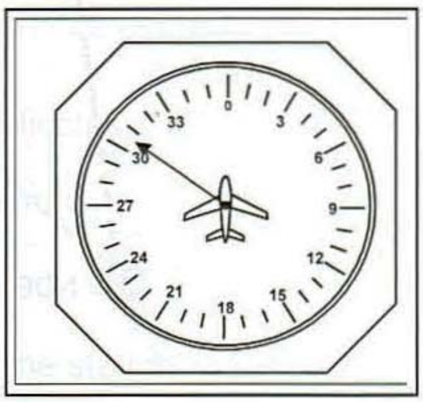
INBOUND TO THE BEACON



Now look at the corresponding plan view.

The heading of 090° provides an intercept angle of 55°. Since the desired QDM is 035°, the aircraft is on track when the RBI indicates a relative bearing of 305° as shown in the diagram on the next page.



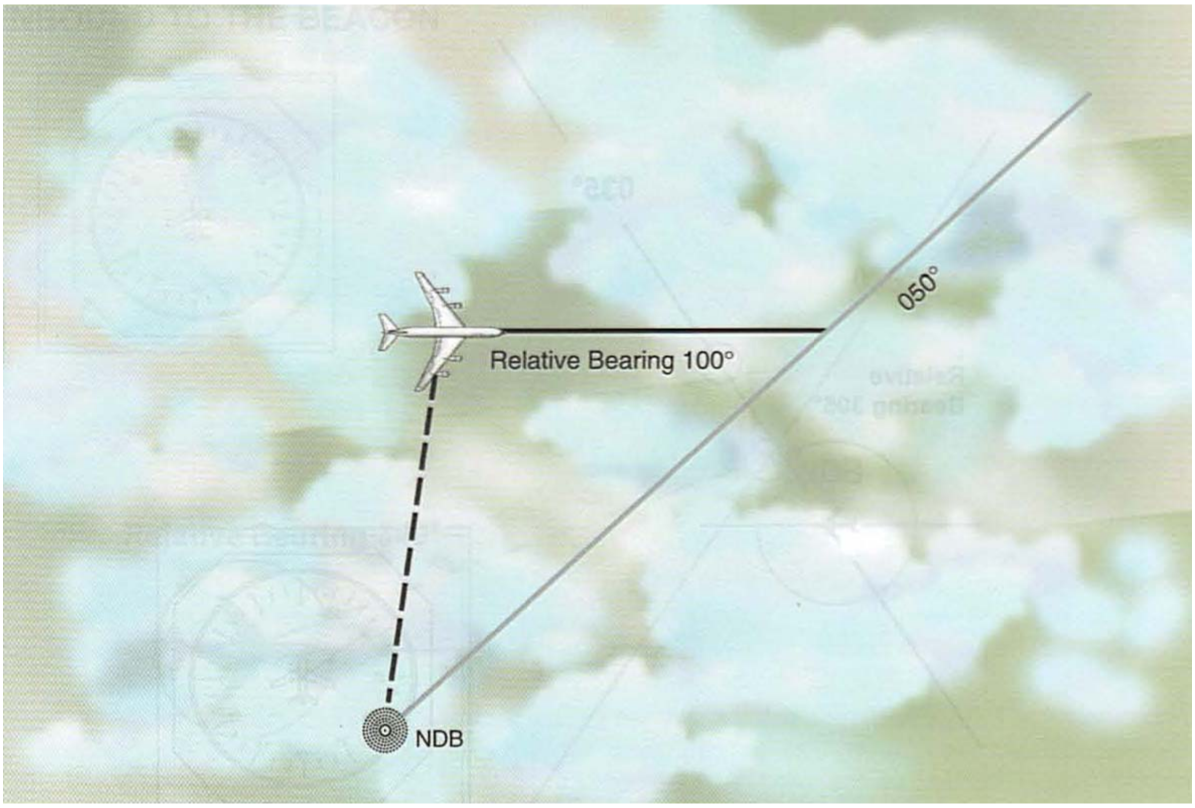


When the needle nears the desired relative bearing, in this case 305°, begin the turn toward the station. This places the aircraft on the desired inbound track. Compare with the instrument indications.

OUTBOUND FROM THE BEACON

To intercept a track outbound, follow the same procedures. First of all, visualize the aircraft's position.

The relative bearing of 100° combined with the magnetic heading of 125° indicates a location North and East of the NDB.



The desired track is 050° outbound. The intercept angle is 40°. When the relative bearing is 140° the aircraft has reached its outbound course. Observe the instruments' indications.

When the needle reaches 135° degrees, start turning to intercept the outbound course. Look at the instrument.

Heading 050°, with relative bearing 180°, places the aircraft on course. This heading will only maintain the course in still air. A crosswind component will require a drift correction.

Example 1: In order to intercept a specific course:

- First determine the aircraft's position relative to the desired course.
- Then establish a suitable interception angle.

Consider the following situation. To assist in visualizing the situation, draw a plan and the instrument indications.

- The aircraft is on a heading of 340°.
- The relative bearing to the NDB is 080°.
- The required course is 090° inbound.

By maintaining a heading of 340°, the aircraft eventually intercepts the 090° course. This would be a rather untidy intercept because a turn of 110° would be required when the aircraft is on track.

A more efficient intercept can be achieved by turning onto an initial heading of 360°, for a 90° intercept. A heading of 030° leads to a 60° intercept with the required inbound course.

Since the aircraft is on QDR 240, a heading of 060° would turn the aircraft directly toward the station, and the QDM 090 would never be intercepted.

Once the aircraft is on a correct intercept heading, the rule is a simple one. When the angle formed by the aircraft's heading and the desired course is the same as the angle between the zero mark at the top of the indicator and the pointer, then the aircraft is on the desired course (QDR or QDM).
When intercepting OUTBOUND, the aircraft is on the desired course when the intercept angle is the same as the angle between the zero mark at the top of the indicator and the TAIL of the needle.

To intercept a specific course from an assigned heading using this technique requires knowing the interception angle. For instance, with a heading of 220° and a clearance to intercept QDM 180, the intercept angle is 40°.

When the needle is 40° to the left of zero, the track has been intercepted.

Example 2: The aircraft heading is 265° and the RBI indicates 005°. The aircraft must join QDM 240 at an intercept angle of 60°.

The first step is always to visualize the aircraft's position:

- What is the QDR? In this instance, it is east of the station.
- Which way must the aircraft turn to make the intercept, left or right?

The course is to the right of the aircraft, so a right turn has to be made for the interception.

Which heading is required in order to intercept the QDM 240 with an intercept angle of 60°?

To intercept QDM 240 at 60°, the aircraft should turn to a heading of 300°.

Maintain a heading of 300°, and observe the RBI needle.

Since this is a 60° intercept, wait until the pointer falls 60° to the left of the zero indication on RBI. Mentally superimposing the RBI needle on the directional gyro always provides a good crosscheck for the calculations. To avoid overshooting the intended course, turn a few degrees before reaching the desired QDM. Observe the instruments and initiate the turn a few degrees before reaching QDM 240.The RMI eliminates the need to do any mental calculation. It always displays the QDM under the pointer and the QDR under the tail.

The procedure of intercepting QDRs and QDMs becomes a lot easier if the pilot maintains a mental picture of where the aircraft is and where it should be.

TRACKING

With no crosswind, a direct inbound course is achieved by:

- Heading the aircraft directly at the NDB
- Maintaining the ADF needle on the nose of the aircraft.

If there is no drift, the aircraft homes straight to the NDB.

Any crosswind will cause the aircraft to be blown off track. In the cockpit, the ADF needle indicates this as it starts to move away from the top of the indicator.

To fly a straight course to the station is called TRACKING. To track to the station requires establishing a wind correction angle (WCA) to compensate for the drift caused by the crosswind. If the exact W/V is not known, then use an estimated WCA obtained from the available information (forecasts, pilot reports, etc.). Remember that the higher the crosswind, the greater the WCA and, for the same crosswind, slower aircraft must establish a greater WCA than faster aircraft.

Once the aircraft is on a course with a wind correction angle to compensate for drift, observe the instruments and look at where the crosswind is coming from and what the impact is on the aircraft.

If the ADF needle indicates a constant relative bearing while maintaining a constant magnetic heading, the current wind correction angle is correct and the aircraft is tracking directly to or from the station. A wind correction angle that does not compensate for the present wind allows the aircraft to drift off course, and the ADF needle shows a gradually changing relative bearing.

If the head of the ADF needle moves to the right, it indicates that a turn to the right is necessary to maintain the course to the NDB and, conversely, if the head of the needle moves to the left, a left turn is required.

How large each correcting turn should be depends upon the deviation from the course. A simple method is to double the angle of bearing change. Observe that if the aircraft deviates 10° to the left, the needle has moved 10° to the right. Doubling the angle of bearing change simply means the pilot must alter the heading 20 degrees to the right.

Having regained the course, turn left by half of the correcting turn of 20°. In other words, turn left10° to maintain the track. This WCA should provide reasonable tracking.

In real life, the perfect track is difficult to achieve and the pilot makes a number of minor corrections to the heading, a technique known as bracketing the track.

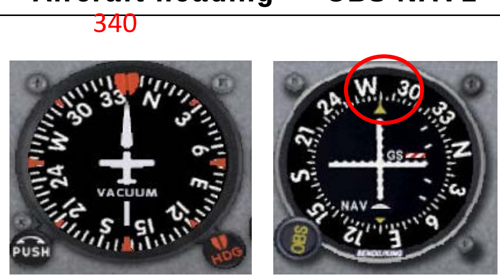
The ADF needle becomes more and more sensitive as the aircraft nears the NDB station. Minor displacements to the left or right of the track cause larger and larger changes in the relative bearings and the QDM. When passing overhead the NDB, the ADF needle oscillates then moves toward the bottom of the dial and settles down. When close to the NDB, do not change heading. Maintain the heading until obtaining accurate readings on the outbound fight.

To facilitate the QDR calculations when tracking outbound, remember that the QDR is equal to the Magnetic Heading plus or minus the deflection of the tail of the needle. Suppose that the desired course outbound from an NDB is QDR 040 and the pilot estimates a WCA of 10° to the right to counteract the wind from the right.

To fix the QOR 040 in a no wind condition fly heading 040°. With a right crosswind that requires a10° WCA, the heading is 050°.

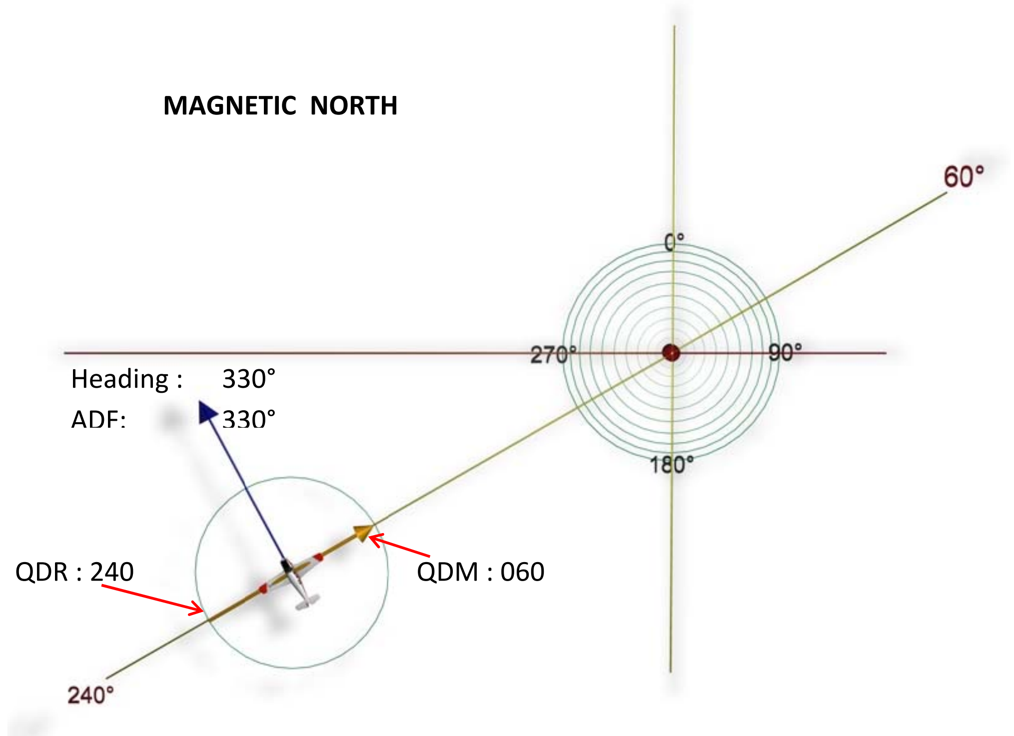
Quickview: Headings and bearings

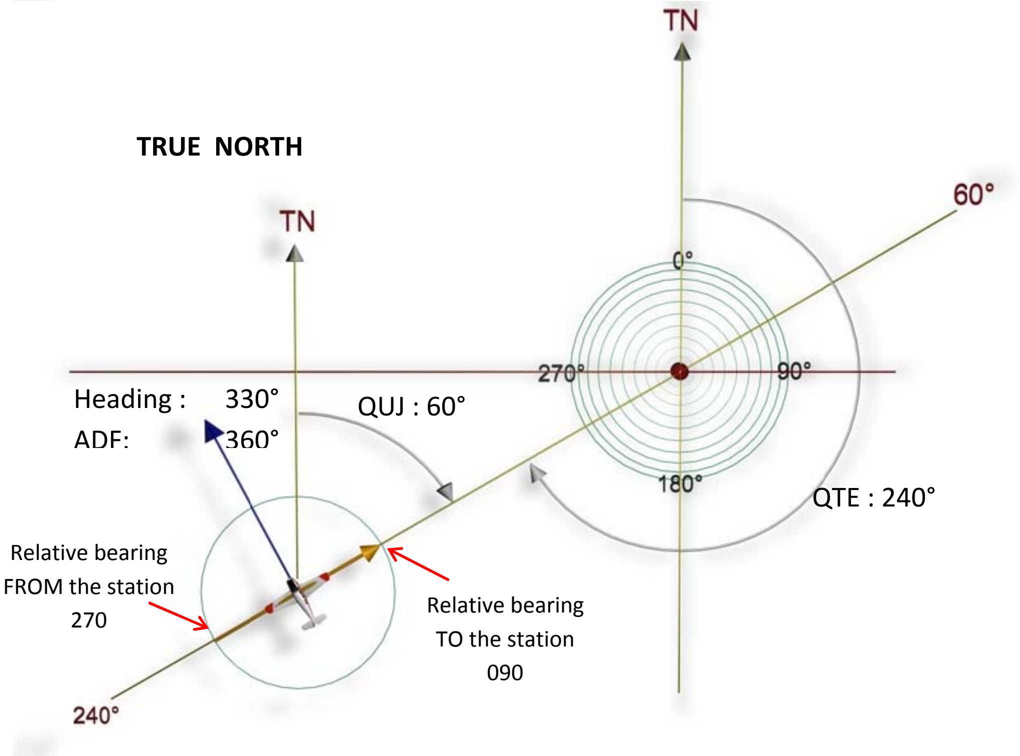
Q-code		Point of position	Aircraft heading + ADF card
-	Relative Bearing **TO** The station	**Aircraft:** ADF chart on Top (360°) Relative bearing = 245 (arrow head point)	
-	Relative Bearing **FROM** The station	**Station:** ADF chart on Top (360°) QTE= reciprocal QUJ True bearing = 065 (arrow tail point)	
QDM	Magnetic bearing **TO** the station	**Aircraft:** ADF chart on aircraft heading QDM= QUJ + heading QDM= 225 (arrow head point)	
QDR	Magnetic bearing **FROM** the station	**Station:** ADF chart on aircraft heading QDR= reciprocal QDM QDR= 045 (arrow tail point)	

Q-code		Point of position	Aircraft heading + OBS NAV1
QDM	Magnetic bearing **TO** the station	**Aircraft:** Turn OBS on Radial intercept until Perfect straight line QDM= 280 (arrow head point)	
QDR	Magnetic bearing **FROM** the station	**Station:** Turn OBS on Radial intercept until Perfect straight line QDR= 100 (arrow tail point)	

Q-code		Point of position	Aircraft heading = 340
QDM	Magnetic bearing **TO** the station	**Aircraft:** ADF chart on aircraft heading (automatically) QDM= 245 (arrow head point)	
QDR	Magnetic bearing **FROM** the station	**Station:** ADF chart on aircraft heading (automatically) QDR= 065 (arrow tail point)	

Graphic representation





With:

QUJ : True bearing TO the station
QTE : True bearing FROM the station