2 VHF Direction Finding

This chapter explains the principle of operation and the use of the VHF Ground Direction Finding (VDF). VDF provides a means of determining the aircraft bearing from a ground station. VDF stations are capable of measuring the direction of arrival of radio transmissions from aircraft. In earlier days, such a service operated in MF, HF, and VHF bands. Today, the service (for civil aviation) operates on frequencies from 118 to 137 MHz in the VHF band. These frequencies are identical with the working frequencies of the aircraft communication radio.

Military airfields provide direction-finding service in the UHF band, so-called UDF.

2.1 Principle of Operation

As stated in Chapter 1, aerials, whether transmitter or receiver, can be made directional. In the basic VDF system an arrangement of two pairs of dipole aerials (known as an Adcock Aerial) is used in conjunction with a single omni directional aerial.

The aerial shown in *fig. RN 2.1* is a more sophisticated form of a VDF aerial that provides improved accuracy.

If the communications transmitter on an aircraft is tuned to the VDF frequency and the transmitter is activated, the aerials at the VDF unit will detect the incoming transmission and each aerial element will feed a signal to the VDF receiver. Since the aerial elements will all be at slightly different distances from the source of the signal, each will detect a slightly different phase of that signal at the same instant. The value of these detected phase differences will be directly related to the direction of the incoming signal. The phase differences are used to drive the bearing indicator.

On some VDF units a simple digital read out gives the bearing. A ground DF station can give true or magnetic bearings. It is common to use the so-called «Q-codes» to

Fig. RN 2.1 VDF aerial

represent bearings. These codes originate from the old days when telegraphy was used for communication, where it was convenient to transmit short codes instead of full text messages. Therefore, the Q codes are not abbreviations. A number of codes were used, but in aviation, only a few exist today. Listed below are the codes that are relevant to direction finding.

QTE True bearing from the station
QDR Magnetic bearing from the station
QDM Magnetic bearing to the station
QTF Position of a station taken by bearings from D/F stations
QUJ True bearing to the station

In practice, only QDM and QDR are normally used. The accuracy of the bearing is measured in degrees. Bearings are categorised, in accordance with the ICAO defined classifications, as given in the following list:

Class A accurate within ± 2°
Class B accurate within ± 5°
Class C accurate within ± l0°
Class D accuracy less than Class C

Due to topography, some VDF stations are approved for use within certain sectors only. In that case, specific information for that aerodrome will be given in AIP. Stations that are listed in the AIP provide a ‘homing’ service. Generally the class of bearing is no worse than class B. (Many states will not permit Class C & D bearings to be provided). Ground DF stations should not be used as en-route navigation aids. However, in case of emergency or where other essential navigation aids have failed, their service is available. When flying VFR under marginal weather conditions, a DF station is a useful navigation tool to fall back on. VDF facilities may also be obtained on the emergency frequency 121.5 MHz.

To request a bearing or a heading to steer, the pilot should call the aeronautical station on the listed frequency. The pilot should then specify the type of service that is desired by using the appropriate “Q” code or the appropriate phrase.

After the bearing or heading to steer has been requested, the DF station will advise the aircraft station the following way: The appropriate Q code, the bearing or heading to steer, the class of bearing and time of observation (if necessary). The pilot will read back the bearing or heading to steer as soon as the message has been received.

A typical example of phraseology related to direction finding will be:

Aircraft: «Torp Tower, LN-ABC, request QDM»
Tower: «LN-ABC, QDM 180°, Class B»
Aircraft: “QDM 180°, class B, LN-ABC»

In the above example, the pilot of LN-ABC needs to get his position confirmed. Therefore he is asking for the magnetic bearing from his aircraft to the airport. He should fly a magnetic course of 180° to reach the airport. Note that QDM will only give a position line, not a fix position. The effect of wind is not accounted for.

2.2 VDF Approach

This is a procedure in which the controller will provide the pilot with a series of QDM's in order to enable the pilot to follow a let down approach path. This path generally involves a number of steps described in the appropriate approach chart and summarised as follows, *see fig. RN 2.2.*

- Guiding the pilot into a position over the airfield
- Establishing the pilot on an outbound leg, which is about 20° off the reciprocal of the desired final approach path. This path is flown at a safe level above the airfield and the surrounding obstructions. The pilot times the outbound leg (allowing for wind effect and using the distances given in the approach plate) and, using the QDM information supplied, establishes the drift being experienced
- At the end of the appropriate time a rate one turn is carried out to intercept the inbound final approach path
- On intercepting the final approach the course is maintained by using the drift established outbound (with the sign changed) as an inbound wind correction angle. This can be adjusted as the controller provides new QDM information
- At the prescribed time the 'let down' is commenced

DF stations have the authority to refuse to give bearings when conditions are unsatisfactory or when the bearings do not fall within the calibrated limits of the station. The station will state the reason at the time of refusal.

Full R/T procedures to be used, when requiring VDF assistance, are contained in the Communications section of your notes. These must be consulted and learned.

2.3 Range and Errors

Being a VHF transmission, the range is generally line of sight. The range will primarily depend on the height of the transmitter and the receiver.

Some factors that will affect the expected range are:

- Intervening terrain that can screen the transmitter/receiver path

- Atmospheric refraction. An increased refractive index (resultant from the inversions of temperature and/or humidity) can cause super refraction and increased ranges. Sub-refraction will reduce the expected range

- Transmitter power

The bearing signal measured may be in error. The major sources of error are:

- Ground reflections, which can cause VHF and UHF signals to reach the DF station aerial from multiple paths. This will cause additional phase differences to be detected which will deflect the bearing indication

- Synchronous transmissions in which signals from other aircraft communications equipment are detected at the DF station at the same time as the desired signal. This causes a deflection of the measured bearing. It should be noted that this is particularly a problem in congested airspace and/or when atmospheric conditions favour super refraction and cause transmissions from beyond the 'radio horizon' to be detected.

Note:
Normally, with modern VDF installations, the indications will be based only on the strongest signals, so that this error should not arrise.

- The signal quality may be reduced if the aircraft does not fly straight and level. This is because the radio signals are vertically polarised and reception is optimal when the aircraft has only a small amount of pitch and bank. To ensure a good reception of the signal, avoid requesting bearings or heading to steer during steep turns

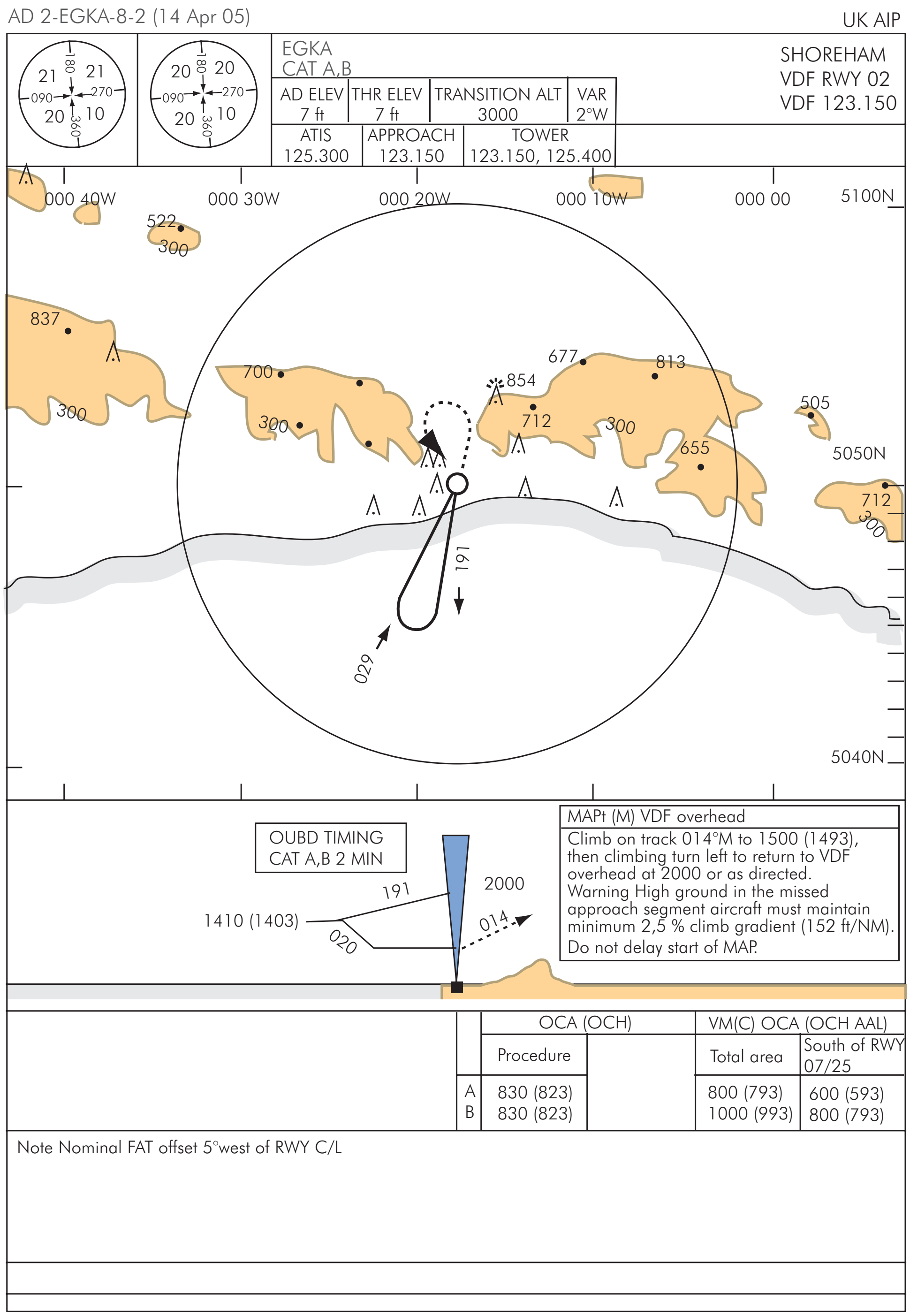

Fig. RN 2.2 Example of a VDF Approach plate