

CHAPTER 4

Equipments

1. We have already looked at the general principle of operation of both radio communication and radar. In this Chapter we will look more closely at a variety of different types of equipment used in the RAF, to see how and where they are used.

Precision Approach Radar (PAR)

PAR 2. The purpose of PAR is to plot the approach of an aircraft wishing to land and allow ATC to give accurate guidance to the pilot to achieve a safe landing. The system can be used in poor weather conditions (ie low cloud, limited visibility), thus reducing interruptions to a station's flying programme.

Fig 4-1: A typical layout of a PAR cabin

3. PAR consists of a Radar Head cabin connected to the ATC operations cell in the control tower. The Radar Head is mounted on a strong framework and can rotate around a central point. This means the cabin can be turned to serve whichever runway is in use. The turning mechanism can be operated remotely from the operation cell in ATC, or manually in the cabin itself.

The radar head 4. The Radar Head has 3 distinctive assemblies – the Azimuth antenna module, the Elevation module and the Radar Cabin. PAR offers the facility of allowing the safe approach in bad weather to a point where the pilot's "visual" of the runway allows a safe landing. It can guide pilots from up to 15 nautical miles away from the runway.

Principle of Operation

- Cross shaped beam** 5. A narrow wedge shaped beam is transmitted from both PAR antennas. One is a horizontal beam (2° wide by 0.5° high) and the other a vertical beam (0.5° wide by 2° high). These beams are then interlocked to give a cross shaped beam. The scanning motion is controlled by the ATC operator in the control tower and allows the aircraft to be “captured” in the beam pattern. This information is then displayed on to the controller a screen with two displays. One display is of the elevation scan and the other shows the azimuth scan. Using both of these displays the controller is able to guide the aircraft down on a safe “glide path” and approach the runway on the correct course.

Fig 4-2: Aircraft are caught in the cross beams.

Instrument Landing System (ILS)

- ILS** 6. The ILS is a pilot-interpreted system which provides accurate guidance to the runway for a safe landing without a ground controller.
7. An ILS ground installation is situated near the runway, and it transmits signals that allow a pilot who is on a landing approach to accurately locate the aircraft's position relative to the touchdown point. These signals provide the pilot with:
- a. A visual indication (on a cockpit instrument) of the aircraft's azimuth relative to the runway centre line.
 - b. A visual indication (on the same cockpit instrument) of the aircraft's elevation in relation to the correct descent angle.
 - c. Both an audio (via radio headset) and visual (a flashing light on the cockpit instrument) indication of the aircraft's distance from touch down.
 - d. An audio indication to the pilot of the identity of the airfield ahead (in Morse), to confirm that he is landing at the right airfield!

- 3 elements of ILS** 8. The ILS ground system has 3 separate elements, each providing different information:

Localiser a. Localiser. The localiser gives azimuth and airfield identification information (7a and 7d above), and it is installed usually some 1,000 ft beyond the upwind end of the instrument runway.

Glide path b. Glide Path. The glide path gives elevation information (7b), and is installed slightly to one side of the runway, near the ideal touch-down point.

Marker beacons c. Marker Beacons. The marker beacons give range information, by "telling" the pilot when he is over them (7c above). They are installed in a direct line with the centre line of the runway, as follows:

(1) The Outer Marker. This is located at a point where the glide slope and the landing pattern intersect (typically 5 nm from the end of the runway).

(2) The Middle Marker. This is located on line with the localiser (typically 1/2 to 3/4 miles from the end of the runway).

(3) The Inner Marker. This is installed in very few systems. If used it would be positioned at the beginning of the runway.

Fig 4-5: How the glide-path looks to the pilot

9. To use the ILS a pilot must position the aircraft (using radar or other means) in line with the instrument runway at a range of some 20 to 25 miles. As he flies towards the runway, in due course, he passes over the outer marker, which “tells” him he has 5 miles to go. By now the localiser and glide-path beams will be giving indications on the cockpit instruments, and the pilot has total ILS guidance, with which he can safely proceed on instruments towards touchdown, with the middle marker next warning that there is 3/4 miles or less to go. Shortly after that, the pilot should be able to see the runway and land visually.

Principles of Operation

10. The instrument that gives the pilot visual indications is a meter with two pointers. One pointer indicates in which direction to fly (left or right), to align with the runway centre line. The other pointer indicates in which direction to fly (up or down), to align with the correct glide-path. When the two pointers cross at the centre of the display it indicates that the aircraft is on the glide-path and the correct heading for landing. The instrument also has warning flags which remain “set” until there is sufficient signal strength for the system to operate. There are also dots on the display, to help the pilot in determining the flight path adjustments required to gain the correct approach angle or direction.

Fig 4-6: The ILS pointers in an aircraft cockpit.

11. The localiser radiates two radio beams, one of 90 Hz frequency and the other of 150 Hz. If the aircraft is off course to the left, 90 Hz is dominant and the azimuth pointer on the cockpit instrument moves to the right. The opposite happens if the aircraft is to the right of the centre line, where 150 Hz is dominant. If the pilot is on course, the instrument shows no difference in the signal, by aligning with the centre of the dial. Similarly, the glide path equipment transmits 2 radio beams of 90 Hz and 150 Hz and the pilot can tell whether the aircraft is too high or too low from the glide path pointer, which reacts to the strengths of the signal received (see Fig: 4-5).

Fig 4-7: The ILS localiser aerial (note the photograph shows a technicians training set-up. There would be no office block in a real site).

ICCAO standards 12. ILS is an important tool in the safe handling of aircraft in the landing stage of flight. All ILS installations must conform to International Civil Aviation Organisation (ICAO) standards. These standards are high for the best reasons – safety.

Digital Resolution Direction Finding (DRDF)

- DRDF** 14. When used as a primary aid, this ground-based equipment provides direction fixing for an aircraft, but it can also be used as a backup to other navigational aids, or as an auto-triangulation system.

Fig 4-8: A typical DRDF equipment site

15. DRDF provides the controller with information on bearings of aircraft in the following forms:

- | | |
|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Vectors | a. Digital pulses which are used to give a digital read-out and a vector display. |
| Bearing | b. Direct Current (DC) voltage proportional to the angle of the bearing. This is then displayed on the operator's console. |
| Auto-triangulation | c. Digital pulses which are combined with information from other stations to provide the exact position of an aircraft on a large scale map situated at one of the UK's two main control centres (this is auto-triangulation). |

Fig 4-9: How triangulation is used to locate aircraft in distress.

Principle of Operation

Centres at Preswick and West Drayton 16. The DRDF is used primarily for aircraft in distress, and it helps air traffic controllers pinpoint an aircraft accurately. The aircraft will transmit a code which is detected by a DRDF station and used to determine which bearing the aircraft is on. This information is then passed to a main control centre, which uses similar information from other stations to triangulate the aircraft's position. There are two control centres in the UK, one is at West Drayton and the other is at Prestwick – each serving as the hub of a network of outstations.

TACAN

TACAN 17. A Tactical Air Navigation (TACAN) beacon operates as a transponder by providing regular transmissions of bearing information. This information, and the identity, and range of the beacon, is available to all aircraft within 200 miles range of it. Any aircraft fitted with the correct equipment can interrogate the beacon. One TACAN can give accurate bearing, distance and identification information to 100 (correctly equipped) aircraft simultaneously.

Brief System Description

Distance and bearing 18. Cockpit instruments indicate the range and bearing of the beacon from the aircraft, from which the aircrew fix the aircraft's position. The beacon also transmits an identification code, so the aircrew can be certain which beacon is being worked. For TACAN to operate as a complete system, both ground and airborne installations are required. The ground installation contains a transmitter/receiver and an antenna array. The ground base receives and decodes incoming signals from aircraft and then initiates a response sequence. The beacon also provides the Morse code identification signal at fixed intervals.

Principle of Operation

Aircraft interrogates TACAN 19. The request for distance information is generated in the aircraft by distance interrogation signals (DIS). These signals are randomly-generated codes which are sent to the beacon. The beacon receives this code and almost immediately re-transmits it back to the aircraft. The aircraft's installation awaits the reply to its code, and from the time taken between transmission and reception is able to calculate its distance from the beacon. The information is then displayed on a meter to the pilot. To measure the compass bearing from aircraft to beacon, the TACAN transmits a 15 Hz signal – rotated through 360°. This signal has a peak of power as it passes through east. The aircraft equipment can use this as a reference and calculate where it is in relation to north, in the diagram:

Fig 4-10: TACAN provides bearing information.

- a. Aircraft 1 is 60° from east (in the negative) therefore the calculation is east- 60° to give a bearing of 30° with respect to north.
- b. Aircraft 2 is at east and therefore there is no deduction or addition so it is 90° with respect to north.
- c. Aircraft 3 is 110° from east (in the positive) therefore the calculation is $110^\circ + 90^\circ$ to give a bearing of 200° with respect to north.

20. TACAN is a useful navigational aid for aircraft going on long sorties across country, because it allows pilots to fix their position accurately, and helps them remain on course.

Airfield Communications System

Mascot Minicomms 21. It is all very well detecting the position of an aircraft using navigational aids, but unless controllers can communicate with the pilot the system would be ineffective. The controllers may also need to talk to other agencies like fire and ambulance, in the case of an emergency. For this reason the system of communication was established that gives controllers access to both radio and landline communications, called Mascot Minicomms.

Patching together 22. Mascot Minicomms is the interface between many different communications systems available to the RAF and enables the ATC controller to “patch” together different support agencies. For example in the case of an emergency, the pilot of an aircraft, using the aircraft’s radio, could talk to a doctor in a hospital who was using the telephone.

United Kingdom Air Defence Ground Environment (UKADGE)

UKADGE 23. UKADGE is a network of radars (both fixed and mobile) that together cover the whole of the UK and its airspace. Many individual sensor units such as ships or early airborne warning aircraft, can input information into the system to provide a large-scale overall picture of the UK’s airspace. The control centre will then have all the information needed to make a judgement of any threat and how to deal with it. UKADGE is one of the worlds most modern data processing and communication systems.

Defence Communications Network (DCN)

DCN 24. The DCN is a tri-service common network for communications. The types of information carried on the DCN are; operational, meteorological and administrative. This network is world-wide and uses HF radio, long-distance cables and satellites to transmit signals from sender to receiver, wherever they may be. This system is very similar to the civilian telex system or fax. A person writes a message, which is then transmitted to its destination where the recipient gets a paper copy of the message. The DCN is a modern communications system and uses computers to decide the best route through the system for the messages to take. For security reasons the messages being carried may be encrypted, so that if they were intercepted they would be unreadable to anyone who does not know the code.

Fig 4-11: A mobile radar provides cover where needed

Strike Command Integrated Communications System (STCICS)

STCICS 25. The STCICS system replaced the ageing HF communication system in the early 1970's. At that time the system was new and had up-to-date technology to perform its task. As the years have passed, improvements have been made to keep the equipment modern and the system in good working order. The system has two identical control centres which pass information to the user units. The system provides specific services to its users including:

- a. Scheduled broadcasts giving:
 - (1) Meteorological information.
 - (2) Airfield states (ie whether they are open or not).
- b. Flight watch – this is the initial contact, by radio, for aircraft who are entering UK airspace.
- c. Message switching and relay.

26. With the advent of networking technology and its availability to the RAF, the advantages in expanding the system are obvious. This would mean that the system could be used more diversely, and would increase both the type and number of users.

RAF Fixed Telecommunications System (RAF FTS)

RAF FTS 27. The RAF FTS is important because it supports UKADGE in the defence of UK airspace. If a target is detected, and central control considers action needs to be taken, good communications to other operational units, support units and emergency services are essential. The RAF FTS ensures good communications between all these agencies and authorities. The systems requirement has 3 areas to consider:

- a. Voice – person to person (either secure or not)
- b. Recorded messages – written orders or signals (currently achieved via DCN).
- c. Data – transfer of data is important and circuits carrying data normally have dedicated lines.

28. The RAF FTS consists of a variety of different types of media used for carrying information (called Boxer) and various types of equipment used to send and receive the information (called Uniter).

Boxer

Boxer – data links 29. This is the network of Service-owned liens and information links that carry information all round the country. It includes fibre optic, microwave and satellite links.

Uniter

Uniter – hardware 30. Uniter provides the switching and terminal equipment which allows the user to communicate information to a receiver. Communication will include voice, recorded messages and data as described above.

Fig 4-12: layout of Boxer and Uniter systems

Satellite Communications

31. With the advent of reliable satellite communications and the advances in technology, the use of HF systems has reduced over recent years in preference to satellite communications. Satellite communications provides high speed data links over a much broader bandwidth. This area will be covered more extensively in “Satellite Communications” ACP 35 Volume 4.

Self Assessment Questions

Do not mark this page in any way! Write your answers on a separate piece of paper.

1. What does PAR stand for?
 - a. Precision Approach Radar
 - b. Primary Aircraft Radar
 - c. Portable Aircraft Radar
 - d. Pin-point Approach Radar
2. What information comes from an ILS Localiser?
 - a. Height
 - b. Azimuth
 - c. Range
 - d. Elevation
3. What does TACAN stand for?
 - a. Tactical Air Communications and Networking
 - b. Technical Air Navigation
 - c. Tactical Air Navigation
 - d. Terminal Approach Radar
4. What is the name of the system that can link an ordinary telephone to an aircraft's radio?
 - a. Uniter
 - b. RF FTS
 - c. Boxer
 - d. Mascot Minicomms

5. What is the air defence system used in the UK called?
- a. United Kingdom Air Defence Ground Environment
 - b. United Kingdom Defence of Air Ground Equipment
 - c. Air Defence Ground Environment (United Kingdom)
 - d. Ground Equipment for United Kingdom's Air Defence