Instrument Landing System Operational Notes
Contents

Disclaimer

These notes are a reproduction of a booklet originally published by the Department of Aviation. Although these notes are no longer in print, they continue to provide a valuable resource and are made available as reference material for students, pilots and instructors. The notes have not been edited, and as they were written 20 or more years ago, may contain information relating to systems that are no longer in production or have been modernised.

1. Introduction

The Instrument Landing System (ILS) is an instrument presented, pilot interpreted, precision approach aid. The system provides the pilot with instrument indications which, when utilised in conjunction with the normal flight instruments, enables the aircraft to be manoeuvred along a precise, predetermined, final approach path.

The ILS ground facilities have been categorised by international standardisation as follows:

Facility Performance Category I

An ILS which provides a specified quality of guidance information from the coverage limit of the ILS to the point at which the localiser course line intersects the ILS glide path at a height of 200 ft or less above the threshold. Using this category of equipment and provided that appropriate supplementary ground and airborne equipment is installed and operating, operations can be permitted down to a decision height of 200 ft and with a runway visual range (RVR) of the order of 800 metres.

Facility Performance Category II

An ILS which provides a specified quality of guidance information from the coverage limit of the ILS to the point at which the localiser course line intersects the ILS glide path at a height of 50 ft or less above the threshold. Using this category of equipment and provided that appropriate supplementary ground and airborne equipment is installed and rating, operations can be permitted down to a decision height of 100 ft and with a RVR of the order of 400 metres.

Facility Performance Category III

An ILS which, with the aid of ancillary equipment where necessary, provides the specified quality of guidance information from the coverage limit of the facility to and along the surface of the runway. Using this category of equipment and provided that appropriate supplementary ground and airborne equipment is installed and operating, operations can be permitted with no decision height limitation and without reliance on external visual reference.

It should be noted that some equipment presently used in Australia is not categorised.

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1. Introduction

There are three main elements in the complete ILS:

- A localiser radio beam to furnish directional guidance to and along the runway
- A glide path radio beam to furnish vertical guidance at the correct descent angle to the runway touchdown point
- Fan markers (outer marker and middle marker). In some cases DME has been authorised for use when markers are not available or cannot be installed.

A suitable radio navigation aid is provided on most installations to assist in interception of the localiser and holding procedures. At some locations two of these aids are provided. This aid can be either a VOR or a low-powered NDB (Locator).

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Figure 2 is a diagram of a basic ILS installation. The localiser transmitters radiate field patterns of 90-hertz and 150-hertz modulated energy on opposite sides of the instrument runway centreline to provide a course for guidance in azimuth. The 150-hertz modulation is always on the right looking towards the runway from the outer marker and is known as the 'blue sector'. The left side is modulated at 90-hertz and is known as the 'yellow sector'. The course line (on-course) is a locus of points of equal 90-150-hertz modulation. It is aligned along the runway centreline extended in both directions and may be separated at the localiser antenna into a front course and a back course. In order to obtain the quality in the front course of the localiser necessary for CAT I and higher, a back course is not radiated in Australia.

Glide path equipment radiates field patterns of 90-and 150-hertz modulated energy to provide a path for approach slope guidance. The field patterns are orientated so that a preponderance of the 150-hertz energy lies below the glide path and a preponderance of the 90-hertz energy is above the glide path. The line of the glide path (on-path), similar to the localiser course line, is a locus of points of equal 90-and 150-hertz modulation and is aligned at the correct approach angle for descent to the runway touchdown point.

Figure 3 illustrates the radiation patterns of the localiser and glide path.

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3. Ground Equipment

3.1 Localiser

The localiser aerial is on the runway extended centreline at the opposite end to the approach end, at a distance which ensures that it lies below the runway take-off obstruction clearance plane. The transmitter building is usually located 100–120 metres to the side of the aerial. The field pattern radiated by the localiser is illustrated in *Figure 3* with the course line lying along the extended runway centreline. The localiser beam 'width', as it is interpreted by the travel of the localiser needle on the aircraft cross pointer indicator from full deflection in the blue sector (150-hertz) to full deflection in the yellow sector (90-hertz) is normally 5° for uncategorised systems and all other systems are adjusted to 210 metres wide at the landing threshold.

Total width in terms of degrees will depend on position of aerials and length of runway. The equipment is designed to provide a usable on-course signal at a minimum distance of 25 nautical miles from the runway at a minimum altitude of 2,000 ft above the threshold. Each localiser is identified aurally by a coded designator consisting of three letters, the first of which is the letter 'I'. The transmitters are usually duplicated, with an automatic changeover facility from primary to secondary equipment in the event of failure or malfunction.

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3.2 Glide Path

The transmitter buildings and glide path aerial are in close proximity and are usually located approximately 225–380 metres from the approach end and 120–210 metres to the side of the runway centreline. The field pattern radiated by the glide path equipment is illustrated in *Figure 3*, with the on path line set at an angle of 2½ to 3° from the touchdown point on the runway. The glide path 'width' as it is interpreted by the travel of the glide path needle on the aircraft cross pointer indicator from a full 'fly-up' indication to a 'fly-down' indication, varies from 1° to 1.5°. There is no sector colour identification associated with the glide path. The transmitters are duplicated, with an automatic change-over facility from primary to secondary equipment in the event of failure or malfunction.

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3.3 Marker Beacons

The marker beacons used with the ILS are low powered, operate on a frequency of 75 MHz and radiate a fan shaped field pattern. There are usually two marker beacons:

Outer Marker

The outer marker is located approximately 3.9 nautical miles from the runway threshold and is aligned across the front beam of the localiser. Its purpose is to provide height, distance and equipment functioning checks to aircraft on final approach. It is modulated at 400-hertz and keyed to transmit dashes continuously at a rate of two per second.

Middle Marker

The middle marker, also a fan marker, is aligned across the front beam of the localiser and is situated approximately 1050 metres from the runway threshold. Its purpose is to indicate the imminence, in low visibility conditions, of visual approach guidance. This marker is modulated at 1300-hertz and keyed to transmit alternate dots and dashes.

Some overseas installations utilise a third marker beacon (inner marker) which is modulated at 3000-hertz, identified by a keyed continuous signal of six dots per second and is located 75–450 metres from the runway threshold. There are no inner markers associated with ILS installations in Australia.

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3.4 Monitoring

The localiser, glide path and marker beacons are monitored. Actuation of a particular monitor will result in the automatic change-over to the second equipment of the component concerned or the component will ‘close down’.

The localiser monitor will be actuated if any of the following conditions occur:

- Shift of the ‘on-course’ line from the runway alignment by more than a specified amount. For equipment up to CAT I this is 10.5 metres, for CAT II, 7.5 metres and for CAT III, 3 metres, measured at the landing threshold
- Reduction of power output below a usable level
- A change in sensitivity of 17%. A decrease in sensitivity produces an increase in course width and an increase in sensitivity shows a narrowing of the course.

The glide path monitor will be actuated if any of the following conditions occur:

- Shift of the glide path angle by more than 0.1° or if the bottom edge of the beam shifts by more than 0.1°
- Reduction of power below a usable level.

The marker beacon monitors will be actuated by any failure of the modulation or keying, or by reduction of power below a usable level.

The tower controller has available a continuous visual indication of the state of each component of the ILS on a monitor panel and is given warning of failures by a system of lights and audible signals.

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4. Airborne Equipment

The advent of CAT II and higher ILS requires an increase in the amount and quality of airborne equipment. This extra equipment is in addition to that previously carried. There has been no change in the basic airborne equipment for ILS use other than receiver sensitivity and reliability. Most of the additional equipment has been added to allow automatic approach, overshoot or landing and is only utilised in conjunction with a duplex (two system) or triplex (three system) auto pilot.

There are several different types of airborne equipment and installations vary with different types of aircraft. Basic components of a simple installation, however, are listed in the following paragraphs.

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4. Airborne Equipment

4.1 Receivers

The localiser, glide path and sometimes the marker beacon and DME receivers are actuated by the one control unit. Every localiser frequency has a corresponding glide path frequency. This pairing of the localiser and glide path frequencies is determined by ICAO and is an internationally accepted standard. The glide path receiver automatically tunes to the correct frequency when the localiser frequency is selected on the control unit. When DME is used in lieu of markers, it is similarly automatically tuned. Examples of localiser frequencies with their paired glide path frequencies and DME channels are listed below:

Localiser Frequency	Glide Path Frequency	DME Channel
109.3 MHz	332.0 MHz	30x
109.5 MHz	332.6 MHz	32x
109.7 MHz	333.2 MHz	34x
109.9 MHz	333.8 MHz	36x

The output of the localiser receiver is separated into 90-hertz and 150-hertz components by bandpass filters and after being rectified the two voltages are applied to the vertical needle of the cross pointer indicator. On aircraft with more than one VHF navigation receiver switching is provided to allow the pilot to connect any of the receivers to his indicator.

The glide path receiver output is also separated into 90-hertz and 150-hertz components, rectified and the voltages applied to the horizontal needle of the cross pointer indicator. There is no audio identification signal associated with the glide path (*Figure 3*).

The output from the marker beacon receiver actuates the appropriate marker beacon lamps and provides an identifying audio signal.

Radio altimeter receiver output information is presented on an appropriate instrument on the pilot’s instrument panel. The radio altimeter is normally only used for auto pilot coupled approaches.

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4. Airborne Equipment

4.2 Aerials

On most modern high speed aircraft flush or recessed localiser aerials are normally located in the vertical stabiliser. The same aerial may feed two localiser receivers; the aerial system and receivers are generally used for VOR also. If a third localiser receiver is installed its aerial is generally located in the nose section, typically within the radome provided for weather radar.

The glide path receiver aerial is normally located on the nose of the aircraft or within the radome. On very large aircraft, or those which land with an unusually high nose attitude, locating the glide path aerial on the nose may result in the wheels being too low over the threshold. In this case the aerial may be located on the underside of the aircraft or on the landing gear so that correct wheel height guidance is obtained.

The radio altimeter aerial is of the flush mounted type usually situated underneath the aircraft with an unobstructed ‘view’ downwards.

Marker beacon aerials are also of the flush variety and are also mounted underneath the aircraft.

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There are a number of different types of ILS indicators in operational use. A description of a basic type of cross pointer indicator is given in this section to best illustrate the function of the instrument. The cross pointer indicator is a special type of meter, which is located on the instrument panel in easy view of the pilot.

The indicator is constructed with two needles. The localiser needle is pivoted on the top of the dial and swings in pendulum fashion from left to right. The glide path needle is pivoted at the left side of the dial and swings up and down.

The stationary scale on the instrument is marked with a target circle in the centre of the dial, and four radial rows of four dots each, extending up, down, left and right from the circle (*see Figure 4*). The perimeter of the target circle is the 'first dot' position. These markings serve to divide the scale of the instrument into equal vertical and horizontal spaces. At the bottom of the dial the left side of the scale is marked with blue, the right side with yellow.

Localiser Indications

The localiser (vertical) needle indicates, by deflection, the colour area of the sector in which the aircraft is flying. If the aircraft is flying in the blue sector of the localiser, the vertical needle will be deflected into the blue area of the indicator. Conversely, if the aircraft is flying in the yellow sector, the needle will be deflected into the yellow area of the indicator. When the aircraft is directly on the localiser course, the needle will be centred vertically across the circle in the middle of the dial. **Regardless of the position or heading of the aircraft, the localiser needle will always be deflected in that colour area in which the aircraft is flying.**

Movement of the needle is very sensitive and will give a full scale deflection (5 dots) when the aircraft is approximately 2½° to either side of the on-course. This high sensitivity permits the use of the indicator for accurate runway directional guidance.

Glide Path Indications

The glide path (horizontal) needle indicates, by deflection, the position of the glide path in relation to the aircraft. When the aircraft is above the glide path, the horizontal needle is deflected **downward**. Conversely, when the aircraft is below the glide path, the needle will be deflected **upward**. When the aircraft is directly on the glide path, the needle will be centred horizontally across the circle, in the middle of the dial. The glide path course is much sharper than the localiser, measuring less than 1.5° from full 'fly up' to full 'fly down' on the instrument.

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4.4 Cross Pointer Flag Alarm

Two tiny meters are installed within the case of the cross pointer indicator. Only a current sufficient to operate the localiser or glide path needle will suppress the flag alarm and hold it out of sight beyond the rim of the dial. The flag alarm, a small red tag, with the word ‘OFF’ clearly inscribed, will move across either the localiser needle or the glide path needle when:

- A usable signal is not being received from the ground equipment
- Either receiver is malfunctioning to such an extent that the output is not sufficient to hold the flag alarm out of sight.

Figure 4 illustrates the flag alarm.

> NOTE: The localiser or glide path should only be used for an instrument approach when the associated flag alarm is fully suppressed.

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4.5 Marker Receiving Equipment

The marker receiving installation used with the 75 MHz ground marker beacons comprises three basic elements:

a. Receiver

b. Indicator

c. Aerial.

Receiver

The receiver unit, which is fixed-tuned to the frequency of 75 MHz, feeds the signal received from the marker transmitter through conventional superheterodyne circuits to the aircraft intercommunication system for aural reception of the modulation tones and to the visual circuits where the modulation tones are fed through special filters to the indicating lights. The filters allow the signal to actuate only the light associated with the one modulation tone. For example the blue light is actuated by only a modulation tone of 400 Hz, the amber light by a tone of 1300 Hz, and the white light by a tone of 3000 Hz. Thus markers may be identified visually as well as aurally.

Indicator

Three lights are provided, blue, amber and white, which are actuated by the 400 Hz, 1300 Hz, and 3000 Hz modulation tones respectively. As the modulation tones identify the type of marker, the lights are designated in the following manner:

Blue	(400 Hz Tone)—'Outer' (Marker for Ils)
Amber	(1300 Hz Tone)—'Middle' (Marker for Ils)
White	(3000 Hz Tone)—'Airway' and 'Z' (Also Inner Marker for Ils) Not used in Australia.

The 'HI-LO' switch shown in *Figure 1* allows a choice of two sensitivity settings of the marker receiver. When the switch is in the 'HI' position, the receiver is in its most sensitive condition and it is in this position the equipment is normally operated. Changing the switch to the 'LO' sensitivity position decreases, by approximately one half, the time that the signal may be received.

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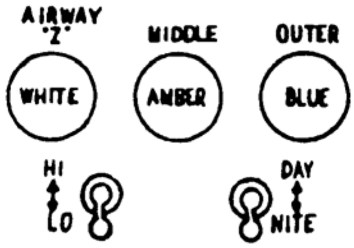

Figure 1. Marker Indicator

The 'day-nite' switch allows the lamp brilliance to be adjusted to suit individual requirements. Normally the switch is placed in the 'day' position for flights in daylight and 'nite' for night flying.

The marker receiver is not normally provided with a separate audio volume control: adjustment of level is normally made on the volume control in the selector box.

Aerial

The marker beacon receiver aerial is in most cases mounted on the underside of the fuselage or wings of the aircraft in a position clear of all other aerials and obstructions. In some aircraft an aerial in a boat shaped housing is used, whilst other installations use an aerial recessed flush with the skin of the aircraft.

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5. Points to Observe when Flying the ILS

1. Carefully study the appropriate ILS approach chart before committing the aircraft to an ILS holding pattern or approach.

2. Ensure that equipment indications are normal and that the flag alarms are not visible before committing the aircraft to holding or final approach.

3. Identify the ILS aurally and select the marker beacon aural switch for aural identification before commencing final approach.

4. Check the aircraft altitude on reception of the marker beacons with the altitudes given on the ILS approach chart. This will provide a check that equipment is functioning normally.

5. Remember that a 5 dot indication either from the glide path or localiser course, at the outer marker, represents a greater physical displacement of the aircraft than at the middle marker (see *Figure 2*). In other words, the ‘sensitivity’ of the glide path and localiser increases as the aircraft approaches the runway threshold.

6. Major corrections to flight path should not be attempted after passing the outer marker. The approach should be discontinued if major corrections to the flight path are required at this stage.

7. Momentary fluctuations of the localiser needle may be caused by another aircraft taking off over the localiser aerials. Similarly, fluctuations of the glide path needle may be caused by a preceding landing aircraft.

8. If a visual reference has not been established at the authorised minimum, commence a missed approach without delay.

9. On a back beam approach or when outbound on a front beam, the localiser needle will still indicate the sector in which the aircraft is flying; but needle movement, in relation to aircraft heading corrections, will be reverse to the movement of the needle on a normal front beam approach.

10. On a back beam approach, the localiser aerials are situated at the landing end of the runway and, in the final stages of the approach, the localiser needle movements will be more ‘sensitive’ than on the front beam approach.

11. If any doubt exists about the normality of any component of the ILS, check with the tower controller **before** commencing the final approach.

12. With modern localisers course reversals will be experienced outside a sector approximately 45° either side of the course centreline. Before commencing the approach check aircraft on centreline by reference to other aids.

As with any other skill, perfection in flying the ILS is acquired with practice.

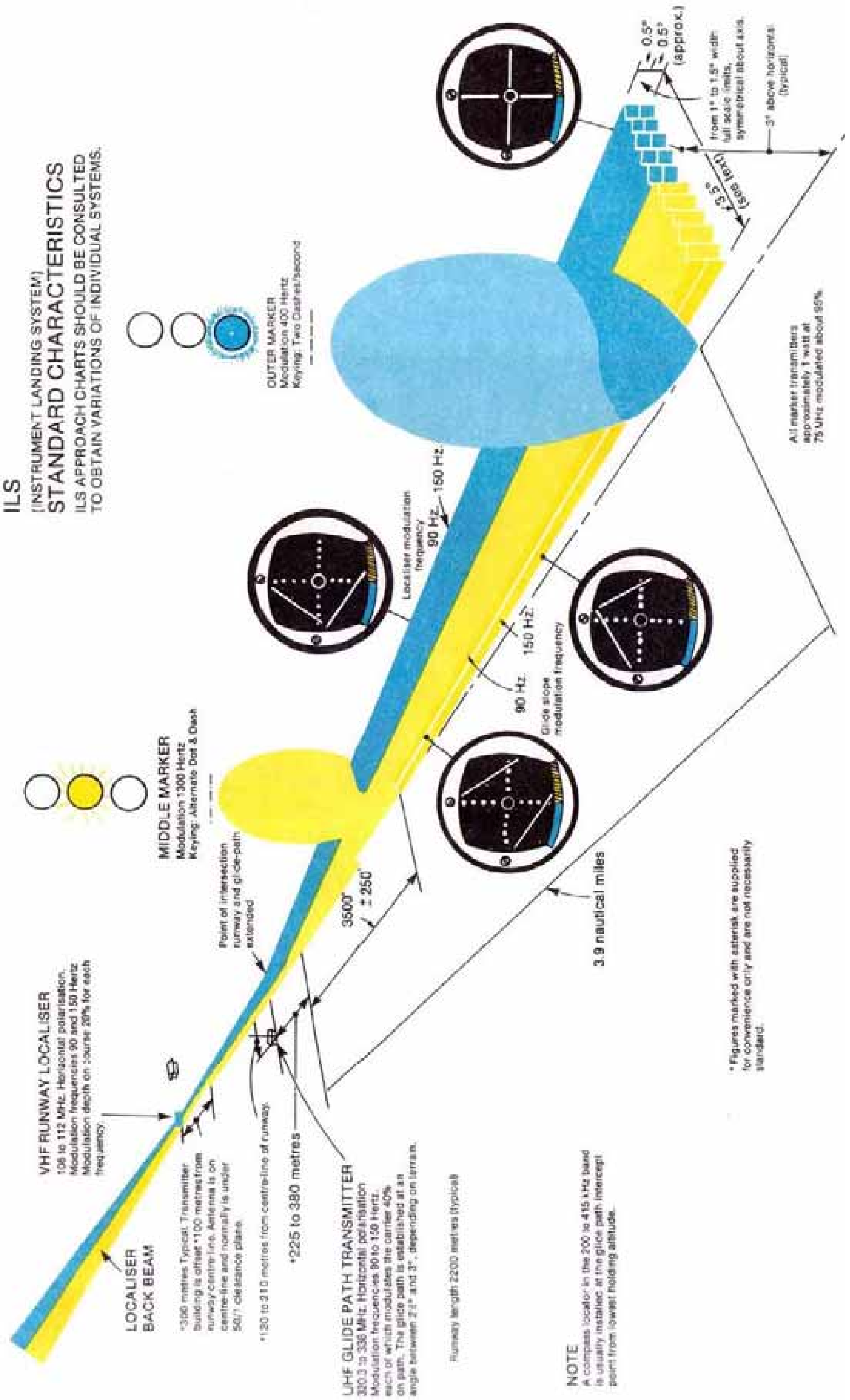

Figure 2. Instrument Landing System

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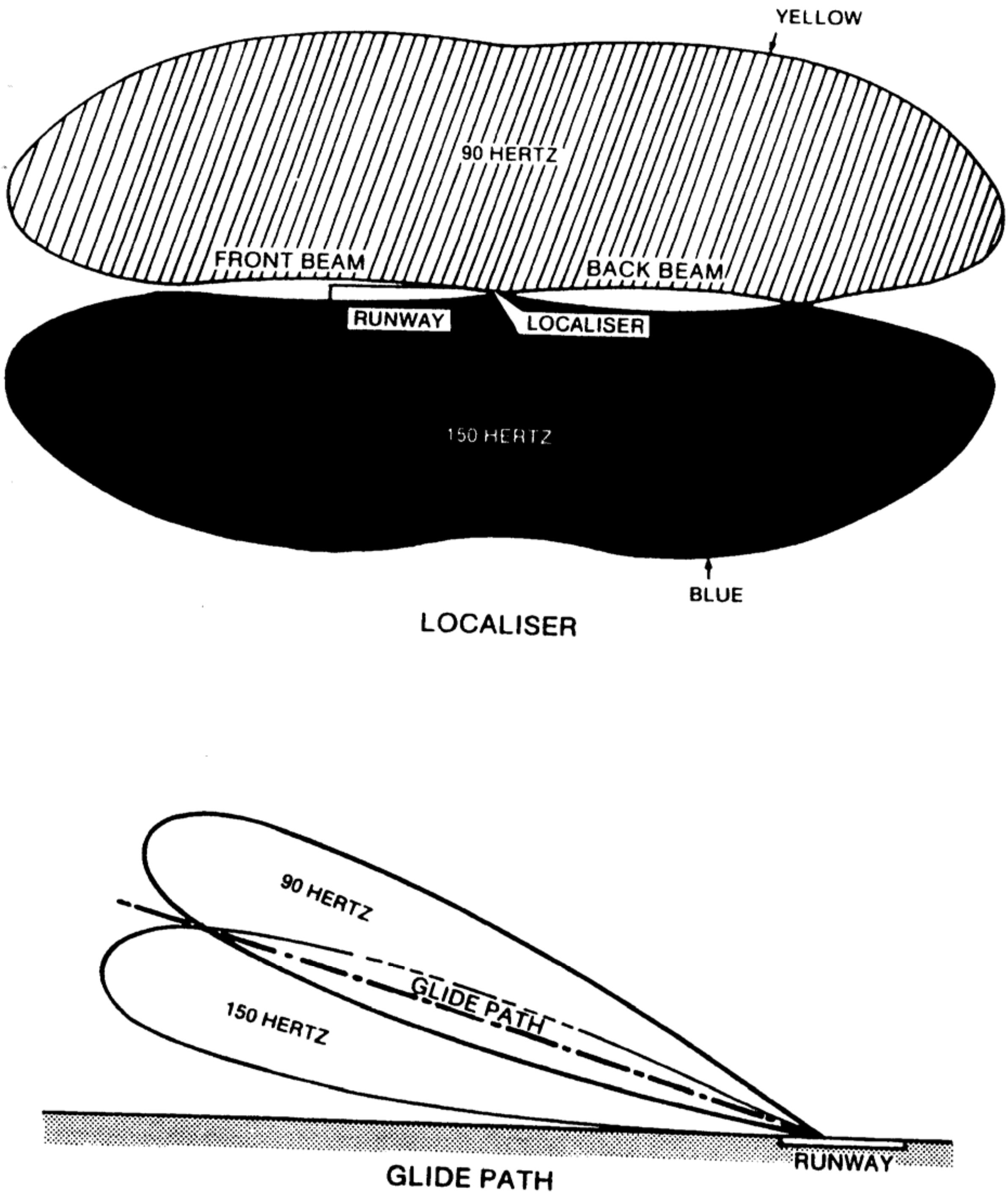

Figure 3. Radiation Pattern

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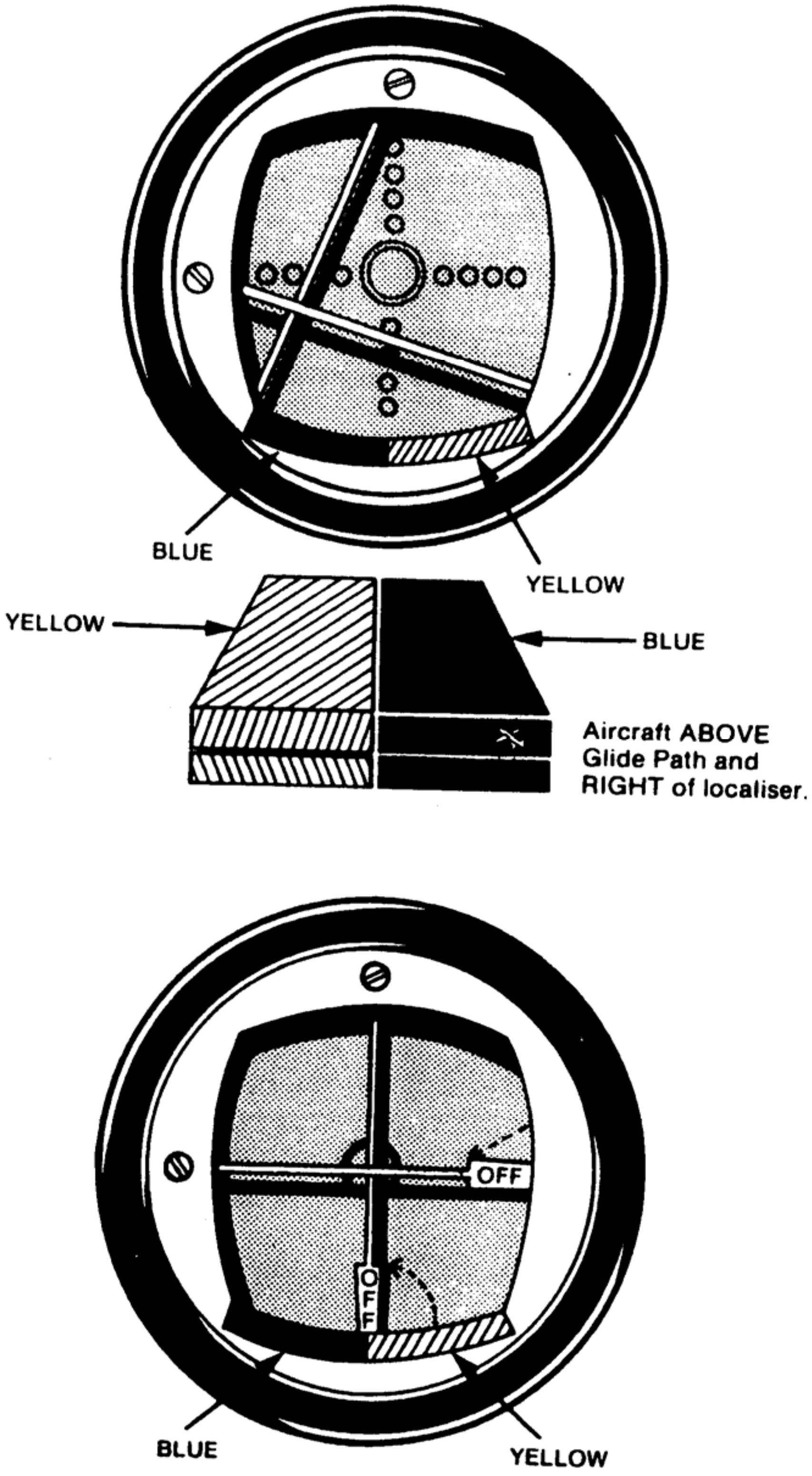

Figure 4. Cross Pointer Indicator

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