Chapter 13 Microwave landing system

The microwave landing system (MLS) was adopted in 1978 as the long-term replacement for instrument landing systems (ILS). The system is based on the principle of time referenced scanning beams and provides precision navigation guidance for approach and landing. MLS provides three-dimensional approach guidance, i.e. azimuth, elevation and range. The system provides multiple approach angles for both azimuth and elevation guidance. Despite the advantages of MLS, it has not yet been introduced on a worldwide basis for commercial aircraft. Military operators of MLS often use mobile equipment that can be deployed within hours. In this chapter, we will review MLS principles and discuss its advantages over the ILS.

13.1 MLS overview

MLS was introduced to overcome a number of problems and limitations associated with ILS. The principle of MLS allows curved, or segmented approaches in azimuth together with selectable glide slope angles. All of these features are beneficial in mountainous regions, or for environmental reasons, e.g. over residential areas of a town or city. MLS installations are not affected by ground vehicles or taxiing aircraft passing through the beam as with the localizer. Aircraft making an approach using ILS in low visibility have to maintain sufficient separation to preserve the integrity of the localizer beams; with MLS, this separation is not required. The combination of all these features allows for increased air traffic control flexibility and higher take-off and landing rates for a given airfield. Two ground transmitters provide azimuth and elevation guidance; these **scanning beams** extend the coverage for an approach compared with the ILS, see Figure 13.1.

13.2 MLS principles

The system is based on the principle of time referenced scanning beams and operates in the C-band at 5 GHz. Two directional fan-shaped beams are used for azimuth and elevation guidance. The **azimuth** approach transmitter is located at the stop end of the runway; the **elevation** transmitter is located near the threshold of the runway. Azimuth scanning is through ±40° either side of the runway centreline with a range of 20 nm, see Figure 13.2(a). An expansion capability can extend azimuth coverage to ±60°, but with a reduced range of 14 nm. Elevation scanning sweeps over an angle of 15 degrees (with 20 degrees as an option) providing coverage up to 20,000 feet, see Figure 13.2(b).

At the aircraft receiver, a pulse is detected each time the respective beams sweep past the aircraft. Consider an aircraft on the approach as illustrated in Figure 13.3. The (azimuth) time referenced scanning beam sweeps from left to right (‘TO’), and then returns from right to left (‘FRO’). If the aircraft is in position A, it is to the left of the centreline and will receive a pulse at time interval t_1 as the beam sweeps ‘TO’, and then at time t_2 when the beam sweeps ‘FRO’. The two pulses are therefore close together with the aircraft to the left of centreline. If the aircraft were in position B, i.e. to the right of the centreline, it would receive pulses at t_3 and t_4 due to the relative position of the aircraft.

The aircraft receiver in a given aircraft will interpret the timing of each pulse, in terms of when they occurred and the time difference between each pulse. These **pulse timings** provide a precise position fix for the aircraft with respect to the runway centreline. Elevation guidance is calculated in the same way as in azimuth, except that the beam is scanning up and down. Timing signals are referenced to a selected elevation approach angle.

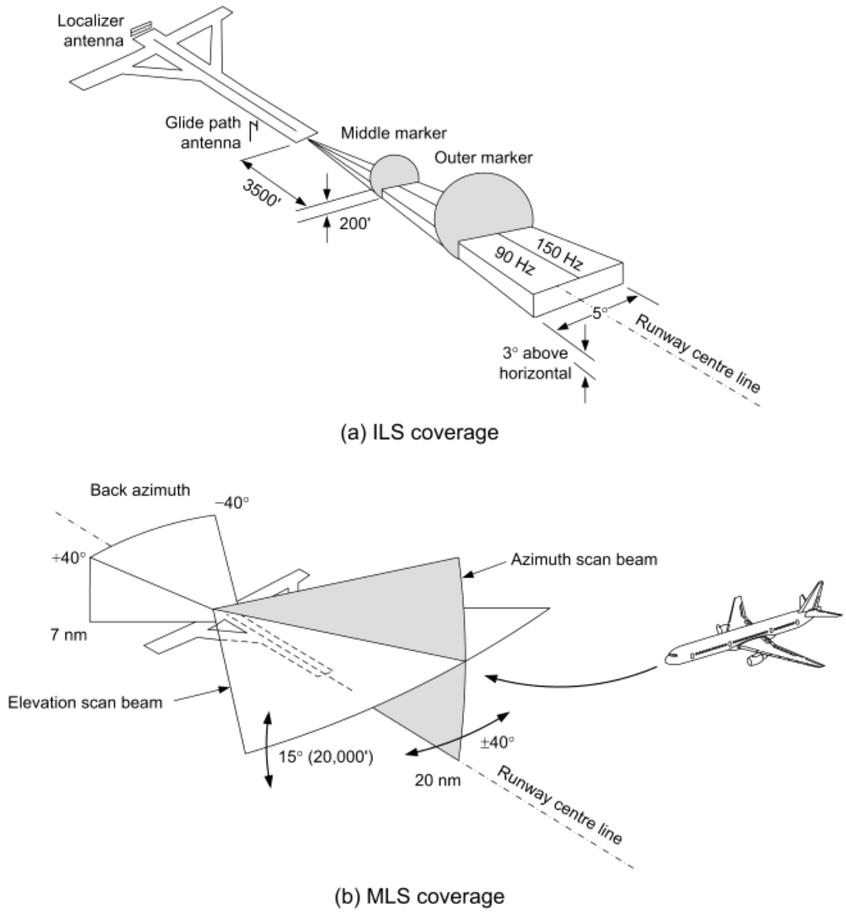

Figure 13.1 Comparison of ILS/MLS coverage

Key point

MLS was introduced to overcome a number of problems and limitations associated with ILS. The scanning principle of MLS allows curved, or segmented approaches in azimuth together with selectable glide slope angles.

Key point

MLS is based on the principle of time referenced scanning beams; two ground transmitters provide azimuth and elevation guidance. MLS operates at around 5 GHz in the C-band.

Key point

MLS installations are not affected by ground vehicles or taxiing aircraft passing through the beam as with the localizer.

Key point

Locations of the MLS ground equipment are not as critical as with ILS; this is particularly useful in mountainous regions.

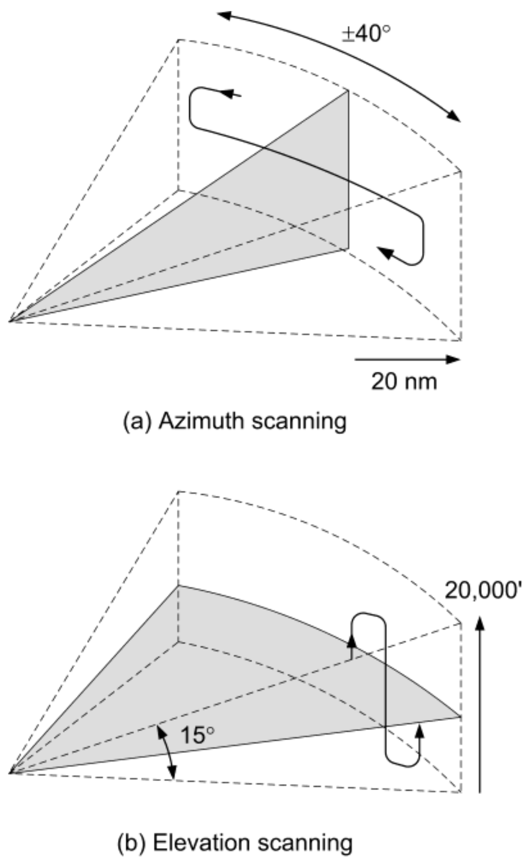

Figure 13.2 MLS azimuth and elevation scanning

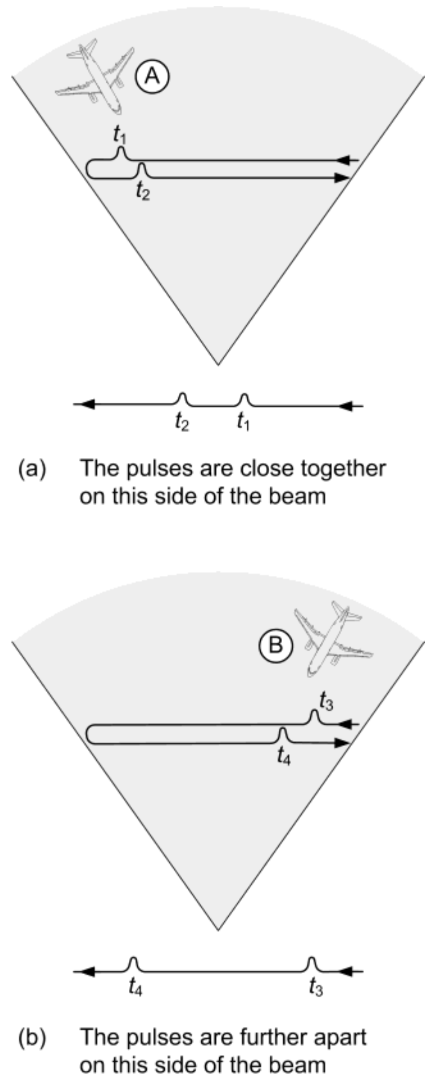

Figure 13.3 Time referenced MLS scanning beam

Key point

MLS installations are not affected by ground vehicles or taxiing aircraft passing through the beam as with the localizer.

Test your understanding 13.1

Explain the principle of operation of the time referenced azimuth scanning beam used in the MLS.

Test your understanding 13.2

In what frequency band does MLS operate?

Test your understanding 13.3

What range and altitude does MLS cover?

13.3 Aircraft equipment

The aircraft is fitted with two antennas located on the nose and aft centrelines. An MLS receiver (often incorporated into a multi-mode receiver with ILS, marker beacon and VOR capability) is tuned into one of 200 channels and calculates azimuth and elevation guidance as described.

The receiver operates in the frequency range 5031 MHz to 5091 MHz with 300 kHz spacing. Referring to Figure 13.4 and Table 13.1, the pulse timing is used to determine the three aircraft positions.

An integral part of the MLS is a distance measuring equipment (DME) system to provide range; this can either be a conventional DME system as described in Chapter 11, or a dedicated system operating in the 962 MHz to 1105 MHz frequency range. DME frequencies are automatically tuned with the azimuth and elevation beams to provide range information.

Typical MLS airborne equipment is illustrated by the CMA-2000 system, Figure 13.5 (data and image courtesy of CMC Electronics). This system is installed on a number of military aircraft in the USA including the C-130 and Air Force One. Control of the MLS is via a control display unit (CDU), where the crew selects the desired MLS channel, together with azimuth and glide path approach angles. The system meets the requirements of ARINC 727 and provides three-dimensional positional data within a large airspace volume.

Azimuth and glide path guidance outputs are either displayed on a conventional course deviation indicator (CDI) or incorporated into multipurpose electronic displays. A summary of the CMA-2000 microwave landing system leading particulars is given in Table 13.2.

Table 13.2 CMA-2000 microwave landing system leading particulars

Feature	*Specification*
Range/channels	200 channels in C-band (5031 to 5090.7 MHz)
Control unit weight	6.7 kg
CDU weight	1.4 kg
Power supply	115 V AC, 400 Hz, 60 VA nominal
Control unit microprocessor	8086, 128 kbyte EPROM, 64 kbyte RAM
Range	Up to 40 nm
Azimuth range	0° through 360°
Elevation range	2° to 29.5° (in increments of 0.1°)
Resolution	0.005°
Sensitivity	−106 dBm
Dynamic range	95 dB
Digital interfaces	ARINC 429 and MIL-STD-1553B
Analogue interfaces	Synchro, DC voltages
Navigation aids	DME tuning, frequency tuning

Test your understanding 13.4

How many MLS channels are available?

Test your understanding 13.5

What frequency range does MLS use?

Table 13.1 Azimuth angle relationship

Aircraft position	*TO scan*	*FRO scan*	*Difference*	*Angle (+ is left)*
A	6.6 ms	11.5 ms	4.9 ms	+20°
B	5.7 ms	12.2 ms	6.3 ms	0°
C	3.6 ms	14.2 ms	10.6 ms	−40°

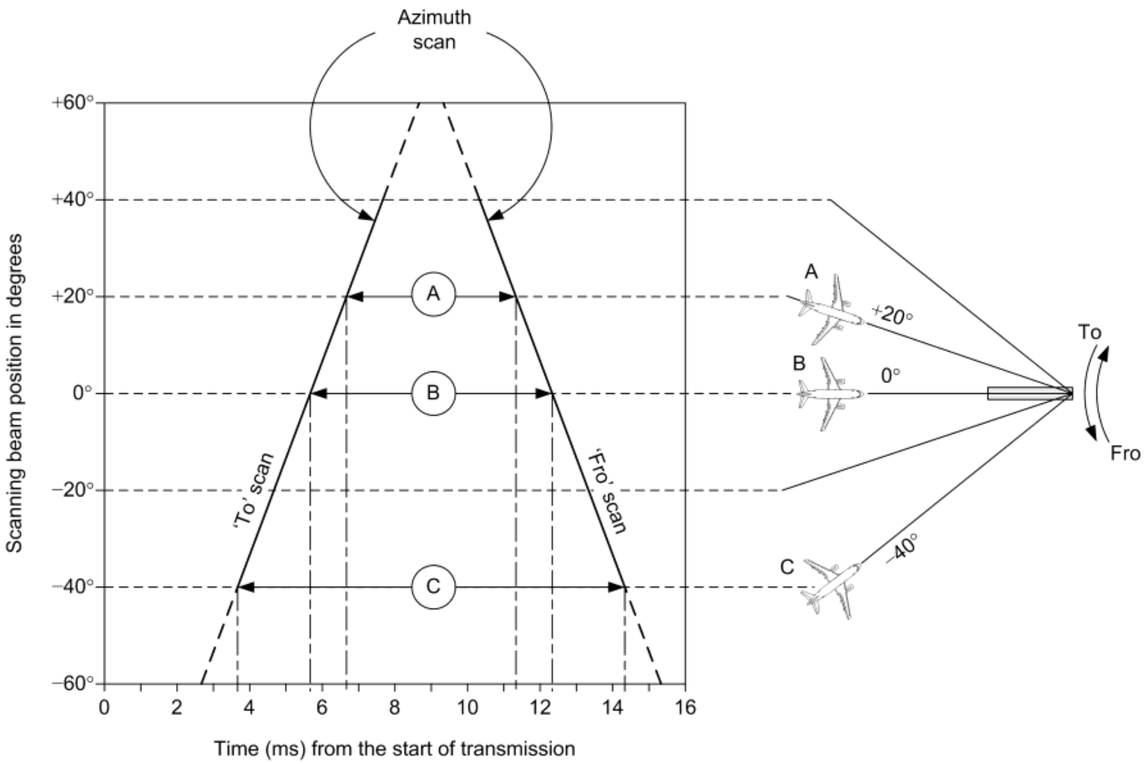

Figure 13.4 Relationship between transmissions and position of aircraft

Figure 13.5 MLS airborne equipment (courtesy of CMC electronics)

13.4 Ground equipment

The items of ground equipment needed for MLS are the azimuth and elevation transmitters and a DME navigation aid. This basic system can be expanded to provide lateral guidance for missed approaches. Both azimuth and elevation transmissions are radiated on the same frequency with a time-sharing arrangement.

In addition to guidance, the MLS also transmits data to system users. Basic data includes runway identification (four-letter Morse code), together with locations and performance levels of the azimuth, elevation transmitters and the DME transponder. The expanded data transmission provides runway conditions and meteorological data, e.g. visibility, cloud base, barometric pressures, wind speed/direction and any wind shear conditions.

Locations of the ground equipment are not as critical as with ILS; this is particularly useful in mountainous regions. Military users of MLS take advantage of this by have mobile systems that can be deployed within hours. The azimuth transmitter has an accuracy of ±4 metres at the runway threshold. The elevation transmitter has an accuracy of ±0.6 metres. The dedicated DME navigation aid has a range accuracy of 100 feet. A variety of approach patterns is possible with MLS as illustrated in Figure 13.6.

13.5 MLS summary

Despite the advantages of MLS, it has not yet been introduced on a worldwide basis for commercial aircraft. The advent and development of global navigation satellite systems (Chapter 19) has led to the reality of precision approaches and automatic landings being made under the guidance of satellite navigation systems during low visibility; however, this is not likely to be available for some time. Since MLS technology is already available, a number of European airlines have been lobbying for MLS; ground equipment has been installed at a number of airports including London Heathrow and Toulouse Blagnac for development purposes. The reader is encouraged to monitor the industry press for developments of this subject.

Key point

Despite the advantages of MLS, it has not yet been introduced on a worldwide basis for commercial aircraft. The military use mobile equipment that can be deployed within hours.

Test your understanding 13.6

Explain why MLS can be advantageous for use in mountainous areas or in areas of high population.

Test your understanding 13.7

How does the MLS provide range to the runway?

Test your understanding 13.8

Why does MLS provide more air traffic control flexibility?

13.6 Multiple choice questions

1. MLS azimuth and elevation transmitters operate in which frequency band?
   (a) 5 GHz
   (b) 962 MHz to 1105 MHz
   (c) 108 MHz to 112 MHz.

2. What are the angular extremes for azimuth guidance either side of the runway centreline in a basic MLS installation?
   (a) ±60°
   (b) ±40°
   (c) +15° to +20°.

3. What are the elevation guidance limits for an MLS installation?
   (a) ±60°
   (b) +15° to +20°
   (c) ±40°.
4. MLS range information is provided by the:

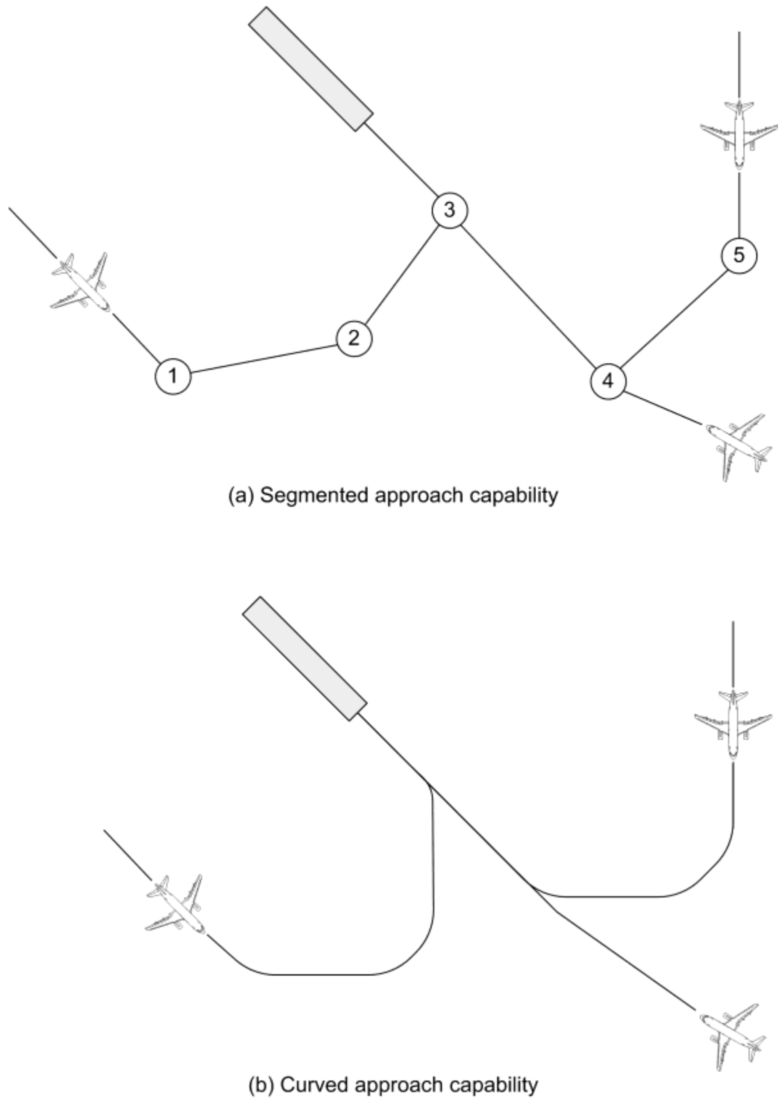

Figure 13.6 MLS approach patterns

(a) azimuth transmitter
(b) DME navigation aid
(c) elevation transmitter.

5. Time referenced scanning beams are used in the MLS to provide:
(a) range to the airfield
(b) azimuth and elevation guidance
(c) altitude above the terrain.
6. How many MLS channels are available:
(a) 40
(b) 300
(c) 200.

7. During an MLS approach, deviation in azimuth and elevation is displayed on the:
(a) HSI
(b) RMI
(c) CDU.
8. The elevation approach angle for an approach is selected by:
(a) air traffic control using the ground

equipment
(b) flight crew using the CDU
(c) flight crew using the HSI.

9. With increasing elevation approach angles, slant range to the airfield will:
(a) increase
(b) decrease
(c) stay the same.

10. MLS ground equipment identification codes are provided by:
(a) two Morse code characters
(b) three Morse code characters
(c) four Morse code characters.

11. Referring to Figure 13.7, pulses t_1 and t_2 are providing:
(a) range to the runway
(b) elevation guidance
(c) azimuth guidance.

12. Referring to Figure 13.8, the scanning is providing guidance in:
(a) range
(b) azimuth
(c) elevation.

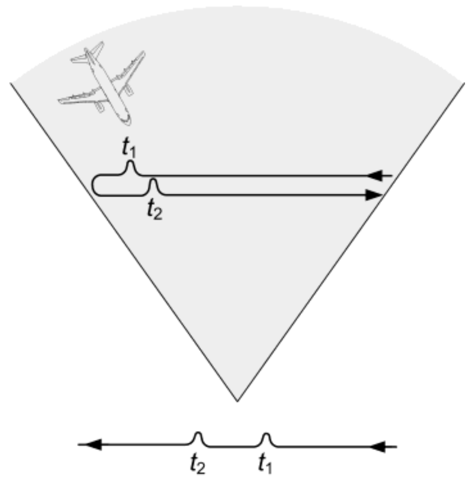

Figure 13.7 See Question 11

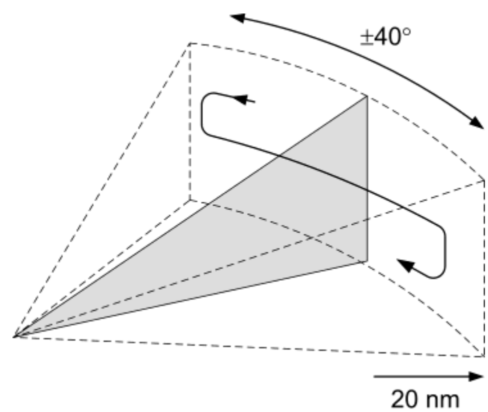

Figure 13.8 See Question 12