

MICROWAVE LANDING SYSTEM—A FAVOURED ALTERNATIVE TO CURRENT ILS

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The Instrument Landing System (ILS) has been in operation for about four decades. While this system has served aviation well during this period of rapidly growing aircraft traffic, speeds and variety, its limitations have steadily been coming to the forefront. Among its chief drawbacks in the present form are (i) restriction of flight control manoeuvrability, (ii) limited landing traffic rates, and (iii) special terrain and siting requirements. With explosive growth in aviation, these drawbacks are being emphasized and a need has been felt in recent years for a more flexible and modern system.

In order to overcome the operational and technical problems of ILS, International Civil Aviation Organisation (ICAO) has formulated guidelines for a futuristic system that will replace the ILS. After evaluating the various systems proposed by different countries, ICAO has accepted the Time Reference Scanning Beam Microwave Landing System (TRSB-MLS) for world-wide use. This paper reviews the limitations of the current ILS and presents the salient features of the TRSB-MLS which is on the verge of implementation throughout the world including India. The current year is the originally stipulated ICAO target for operational implementation of the system.

Indexing terms: Instrument landing system, Microwave landing system

THE Instrument Landing System (ILS) provides the pilot of an aircraft with steering information which enables him, despite poor conditions of visibility, fog etc, to make an accurate and controlled approach and landing on a runway [1]. This is accomplished by the provision of azimuth guidance, elevation guidance and distance-from-threshold information. This equipment meets the requirements laid down by the All Weather Operations Panel of International Civil Aviation Organisation (ICAO).

The main constituents of the current ILS are the localiser, glidepath and marker beacons [1,2]. The localiser operating in the 108-112 MHz band, provides azimuth guidance information through the differential depth of modulation (ddm) of two signals at 90 and 150 Hz. The ddm is zero along the centre line of the runway and varies linearly over the course sector. The elevation guidance is provided by the glideslope in the 328-336 MHz band, also operating on the ddm principle with 90 and 150 Hz tones.

Simultaneous nulling of the ddm from localiser and glidepath equipment will define a descent line at a desired elevation, but lying in the vertical plane through the runway centre line. For the current ILS, the descent path is fixed for all aircraft approaching a particular airport.

The distance information is provided by two 75-MHz marker beacons located at about 7 km (Outer Marker) and 1.05 km (Middle Marker) from the landing threshold. These beacons have fixed vertical fan beams and are

identified by coded audio modulation. The system composition is schematically shown in Fig 1.

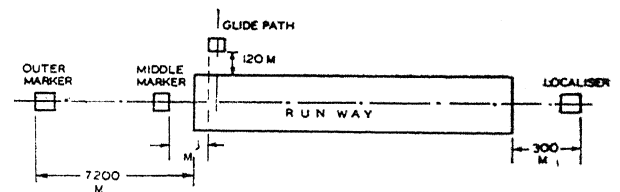


Fig 1 ILS system layout

LIMITATIONS OF ILS

Though the ILS has served the airspace the world over for about four decades now, it has a number of technical and operational limitations. An aircraft on or near the glideslope receives not only the direct signals from the antenna system but also signals reflected from the intervening terrain. The effect of reflection, which varies from location to location, must be taken into account both in ILS antenna siting as well as in glideslope operation. The most widely used antenna designs use ground reflections to establish a proper glidepath [3]. The design of the arrays is based on the image theory in which the ground plane is idealised as being infinite and perfectly conducting. Since the elevation angles involved are small and wavelengths fairly large, wide stretches of plane ground must be available in front of the antenna to obtain a reasonable approximation to the ideal image patterns. Three different configurations of image glidepath arrays are in use, as given in Table 1.

TABLE 1 Image glidepath antenna configuration

Antenna element number	Image type glidepath		
	NR	SR	CE
1	$\lambda/4\sin\theta$ ($=h_1$)	$\lambda/8\sin\theta$ ($=h_1$)	$\lambda/4\sin\theta$ ($=h_1$)
2	$h_2=2h_1$	$h_2=3h_1$	$h_2=2h_1$
3			$h_3=3h_1$

Note:—NR Null reference, SR Sideband reference, CE Capture effect, θ =Glidepath angle

For the null reference system which is more commonly in use, the reflecting ground required for imaging at the flight path angle should satisfy the relations [4]

$$X \geq \lambda/2(1 - \cos \theta) \quad (1)$$

and

$$X > h/\tan \theta \quad (2)$$

from the antenna to the aircraft, θ is the glide angle and λ is the wavelength (approximately 1 metre). The formula (1) is based on geometric line-of-sight considerations and (2) is derived taking into account the ground image of the antenna. If the lowest angle at which guidance is required is $\theta=0.8$ degrees, then X is about 4660 metres and 730 metres from formulae (1) and (2) respectively. For the nominal glideslope of $\theta=3.0$ degrees, the respective figures are 365 and 190 metres. Normally about 850 metres of plane reflecting ground is provided, though in such a case, image radiation at 0.8 degrees elevation will be lower than ideal. Thus large stretches of ground in front of the antenna are required to be maintained level. More importantly, such area must either be included within airport boundaries or otherwise forced to remain unutilised by mandate. This leads to large expenses, and at certain sites the levelling of the terrain to the required extent may not be feasible due to topographical reasons.

The insufficient plane ground in front of the glidepath antenna usually results in what are known as course bends. The study of the performance of glideslope arrays [5] on different types of terrain has thus been of great interest and considerable work has been done to design glidepath antennas that will give a satisfactory course even with such nonideal terrain. The end fire arrays [6] and the flush mounted types [7] are examples of such designs. However, such schemes besides being complex and expensive, have not succeeded in fully overcoming the problems that are associated with uneven and difficult terrains. During the past decade, considerable effort has been made to mathematically model the terrain and various techniques based on physical optics [8], and geometrical theory of diffraction (9) have been put forward.

Localiser problems are attributable to the multipath radiation due to reflections from vertically oriented obstruc-

tions which are mostly manmade. Reductions in localiser course bends or irregularities may be effected by restricting the radiation in particular directions. However, this option cannot often be employed for two reasons. Firstly nulling the radiation along possible reflectors would leave certain directions within the desired sector without significant localiser coverage. Secondly, the null directions and their number may have to be changed frequently as fresh reflecting structures appear within the field.

At many airports, the extended runway centre line is not available for the siting of the localiser antenna. Such situations require offset installations which will result in an increase in landing minimums. Further, the size of the antenna (about 20 m wide and 5.5 m high for localiser and about 14 m high for the glidepath installations) make it unsuitable for small landing sites as installation of such big structures pose problems.

A major difficulty with the present ILS system is that it cannot provide high sustained landing traffic rates when the aircraft have varying approach speeds. The difficulty in meeting this requirement arises from the necessity for all aircraft to follow a common path just before and after landing. This common path includes (i) the final approach during which alignment with extended centre line of the runway is established and (ii) roll out along the runway during which speed is decreased until a turnoff can be made safely. During these operations, neither vertical nor lateral separation of aircraft can be provided and hence sufficient longitudinal separation must be established. But in an environment of several aircraft approaching at different speeds nearly simultaneously, their separations will have to be determined in each case to avoid overtaking and/or close encounters (near misses) during the flight through the common segment of the flight path. The larger the velocity spread among the types of aircraft using a runway, the larger must be the average spacing between successive aircraft. For this reason, the present ILS cannot provide high sustained landing traffic rates.

If the traffic into the terminal airspace is high, the lower traffic rate imposed by the ILS would necessitate in-flight holding of aircraft until they can be accommodated by the ILS. This procedure is expensive particularly for jet aircraft which consume large amounts of fuel per unit time in low-level flight. It may be pointed out that holding operations are time-based and hence fuel consumption per unit time is the pertinent parameter for computing expenses. It may be seen that the chief limitation of the current ILS arises from the restriction on the aircraft to follow a single straight line path for a significant length before touchdown. Clearly, much more flexibility in landing can be attained by permitting aircraft to approach within an extended sector. Further, individual flight paths need not be restricted to be straight lines.

In such an operation, only the touchdown point would be the common point to aim at.

DEVELOPMENT OF MICROWAVE LANDING SYSTEM

Thus it has become obvious that the system that improves upon the ILS should have the following features:

(i) Reduction in the sensitive area *i.e.* the area near the antenna responsible for beam interference.

(ii) Enhancement of the region of coverage so that guidance can be provided along curved paths and in three dimensions. Aircraft can then control their own separations and landing procedure in accordance with routine stipulations.

(iii) Provision for receiver course selection in the aircraft by the pilot. This means that the wider coverage is not used merely as a gathering zone for the aircraft to finally settle on a single predetermined path, but that almost any path, straight or curved, within the sector can be defined by the pilot as his desired approach path. Such paths may be selected depending on what is considered best for the current situation based on factors such as forward speed, rate of descent, angle of attack, etc.

In the early sixties, a number of systems were proposed by different countries/agencies as replacement for current ILS incorporating many of the above features. However they involved different operating principles, parameters and signal formats. The aviation community recognized the need for a single system for the sake of uniformity of airborne equipment. In 1967, the Radio Technical Commission for Aeronautics (RTCA) formed a special committee to evaluate the various systems and to come up with a single system for endorsement by the ICAO. The SC 117 working group of RTCA evaluated 23 different systems and recommended the time reference scanning beam (TRSB) MLS system developed by the USA for worldwide use [10].

Another serious contender for the MLS system was the Doppler MLS proposed by UK [11]. This system uses the Doppler shift from a reference frequency caused by a signal that is switched sequentially down a linear array of 13 radiators. This scheme was not adopted by the ICAO working group in view of its complexity, but is believed to be under further development within UK. In the selection of an international standard MLS system, a major consideration was that guidance information must be air-derived, obviating the need for a communication link. Certain schemes such as those proposed by Germany and France were unacceptable on this account.

MLS has all the essential features necessary to accommodate the traffic problem associated with the growth of aviation in the next century. These include:

- (i) availability of 200 channels
- (ii) continuous angle and range information
- (iii) improved signal quality
- (iv) reduced requirement for siting and environment
- (v) wider guidance coverage, and
- (vi) multilevel system design using advanced technology.

MLS can increase the airport capacity. This may involve use of short runways, higher angle glidepaths, converging runways and upto three parallel runways. The main problems associated with independent operations on converging and triple parallel runways lie in separating aircraft during missed approaches. A back course incorporated into the design of MLS can provide the precision guidance to help ensure the required separation in such cases. Thus the pilot work load on flying back-course is minimized and the precision of missed approach guidance is increased. Further, in an automatic air traffic control system (ATC), the MLS can reduce the time dispersions at the final approach gate, leading to increase in runway capacity.

PRINCIPLE OF TRSB-MLS

The TRSB-MLS is based on the principle of converting the angular position of the receiver (in aircraft) into a time difference between two received pulses. It uses two narrow beams which are scanned in an oscillatory manner in the azimuth and elevation sectors. At every position within the scan sector, an aircraft will receive two pulses from each beam corresponding to the to and fro scans. The aircraft derives its position within the coverage volume by measuring the time difference between these pulses pairwise.

The azimuth scan uses a fan beam broad in the vertical plane and narrow in the horizontal plane. Similarly, the elevation beam scans up and down using a fan beam broad in horizontal plane and narrow in vertical plane. Each beam scans its assigned sector (azimuth or elevation) at a constant sweep rate. There is a finite dwell time or beam pause at the end of each stroke. A schematic representation of beam sweep angle as a function of time is shown in Fig 2. The same figure applies to both the beams with different scales.

For a given scanning speed and pause time, the elevation angle θ can be calculated from the equation,

$$\theta = (t_0 - t) V/2$$

where

θ = angular position of aircraft in degrees

V = angular speed of the scanning beam (0.02 degrees per microsecond)

t = actual time interval between pulses received from to and fro scans in microseconds

t_0 = value of t in microseconds for $\theta=0$ (4800 microseconds for AZ and 3350 microseconds for EL).

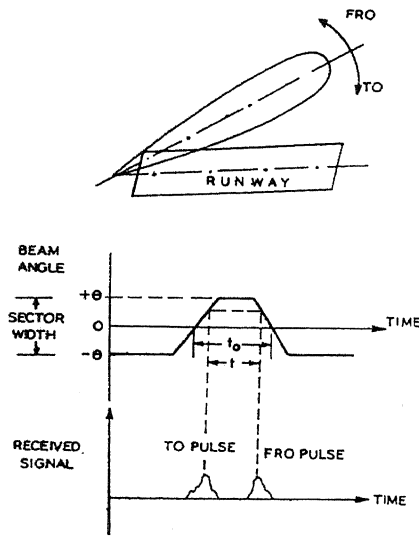


Fig 2 Elevation angle measurement

The TRSB-MLS will be less affected by multipath signals because of its narrow ground antenna beams. Further, the shape of the nonscan dimensions of the antenna radiation pattern is controlled to reduce the multipath effects.

MLS SIGNAL FORMAT

In order to be able to use the same carrier frequency for all the functions, the MLS signal format operates in time division multiplex (TDM) mode. The carrier frequency may be one of a total of 200 channels separated 300 kHz apart in the 5031-5090.7 MHz band. The signal format is shown in Figures 3(a) and 3(b). A full frame occupies 592 ms and has two subsequences repeated four times each in alternation with varying time gaps in between. The details of each subsequence are shown in Fig 3(a). Each subsequence contains three elevation slots, three flare slots, and one azimuth slot. Since angular sweep rates in azimuth and elevation are the same (0.02 deg/microsec) and since azimuth sector is much wider

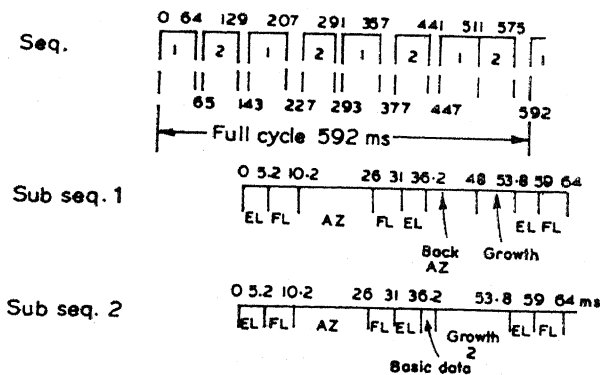


Fig 3(a) MLS signal format showing frame details (adapted from ICAO source material)

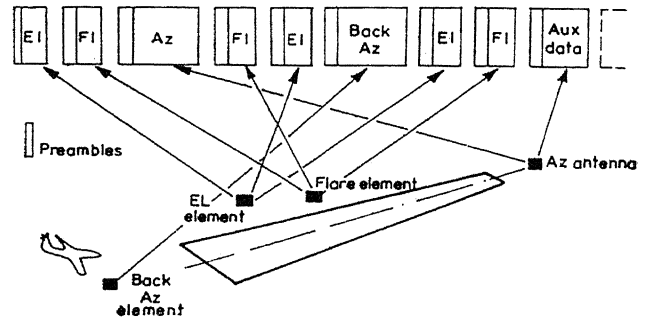


Fig 3(b) MLS signal format showing correspondence with different equipment (adapted from ICAO source material)

(± 40°) than the elevation sector (0.9 to 15 deg), the azimuth time slot width is comparatively higher than the elevation slot. During each azimuth and elevation slot, only one to-and-fro cycle of the beam will be completed. In addition, the subsequence 2 will initially contain a blank 17.6 ms slot for future growth in format and a 5.3 ms slot for basic data such as identification. In subsequence 1, out of this 22.9 ms, 11.8 ms is occupied by the back azimuth signal slot, leaving only 11.1 ms for future growth. The back azimuth slot thus occurs only once in every alternate sequence, making it only half as frequent as the forward azimuth slot, which in turn, is one-third as frequent as the elevation slot. A higher sampling is provided in elevation than azimuth because of higher accuracy requirement in the former. An actual slot count will show that the elevation signal occurs at a rate of 39 Hz, azimuth signal at 13 Hz and back azimuth at 6.5 Hz.

A further dissection of the format will show that (Fig 3b) each slot has its independent preamble consisting of carrier acquisition (time reference code for setting a reference time to decode the receiving signal) and function identification code for identifying the signal (e.g. azimuth, elevation etc) to the receiver.

The speciality of this format is that each guidance function is self contained in an independent time slot in the sequential format. The airborne receiver recognises each function and processes it independently. Thus functions can be added or deleted from the ground station without affecting the operation of the receiver. Further, provision also exists (in the basic data or growth slots) for the transmission of data to supplement landing guidance information.

SYSTEM COMPOSITION

The TRSB-MLS system composition is shown in Fig 4. A brief description of the various system components are furnished below.

Approach azimuth equipment

This equipment is installed on an extension of the centre line of the runway at a distance ranging from 125

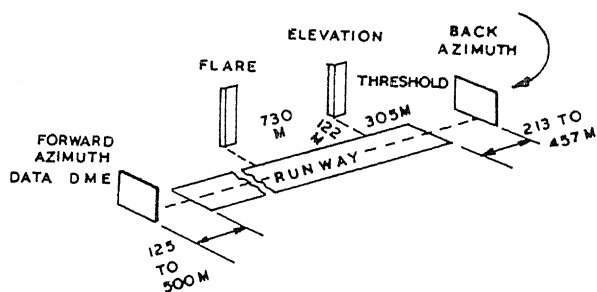


Fig 4 TRSB-MLS system composition

to 500 metres from the runway end. While the scanning beam helps the aircraft to obtain its azimuth position, auxiliary information can also be transmitted from this equipment within the constraints of the signal format. A simplified block diagram of the setup is shown in Fig 5.

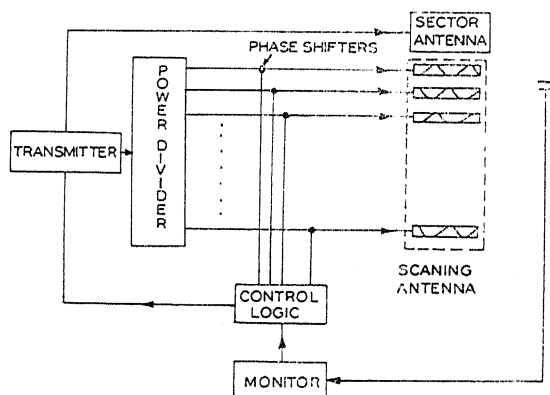


Fig 5 Simplified block schematic of azimuth station

For generating oscillating fan beams in elevation and azimuth, several schemes have been considered, *e.g.*, [12]. It consists of a transmitter, an electronically scanning linear phased array, a control unit and a monitoring system. By suitable switching of the phase shifters, it is possible to scan the beam at constant angular speeds in either direction. The phase shifters are four-bit digital type using PIN diodes which cover 360 degrees in sixteen steps of 22.5 degrees each.

The radiating elements are slotted waveguides. The beam has a fixed pattern along its wider direction which is vertical. Since this can be achieved with a fixed phased array, a vertical array of slot radiators fits well. It is important to minimise the reflection of RF energy off the ground in front of the antenna; hence the individual slot phases are adjusted so that the vertical pattern presents a sharp cutoff at ground-grazing angles (better than 7 dB/deg) and low sidelobes at negative elevation angles. The beam is steerable along its narrow dimension which is horizontal. A horizontally-oriented linear array of slotted waveguide sections (*i.e.* the fixed arrays mentioned above) is used with progressively phase shifted signal

provided to each section (see Fig 5). Slotted waveguide radiators require involved design procedures but are relatively simple and neat to fabricate.

The MLS system is required to have a standby transmitter. There is provision for continuous monitoring of the transmission in the near field. A changeover to standby occurs if the parameters of radiation deviate from the specified values, and if this does not correct the fault, the equipment is shut-off and an alarm provided at the remote site. Besides near-field monitoring, an extensive internal monitoring scheme is also incorporated, which operates integrally with the near-field monitor.

Elevation equipment

The elevation antenna is located about 305 m from the beginning of the runway, offset on either side by about 122 m from the runway centre line (see Fig 4). The main features of the elevation antenna system are similar to those of the azimuth section except that beam is oscillatory in the vertical direction. Also the fixed horizontal width of the beam is enough to cover the entire azimuth sector. For this reason, instead of the fixed-phase slot arrays, as in the case of the azimuth antenna, the elevation antenna is a linear vertical array of dipoles only. The sector antenna transmits an out-of-coverage indication (OCI) signal to prevent erroneous indication due to antenna sidelobes. Even when an aircraft is outside the elevation coverage, at close ranges and/or with sensitive equipment, it may receive elevation signals from antenna sidelobes which also scan at the same rate as the main beam. This may produce misleading elevation information. To avoid such possibilities, an OCI signal is transmitted from the sector antenna which is part of the elevation antenna. Sidelobe identification is achieved through amplitude comparison. A specific time segment is allocated to the radiation from the sector antenna in the signal format, Fig 3(a). Auxiliary information such as station identification can also be transmitted from this sector antenna.

Back azimuth

The back azimuth is installed on the runway centre-line at a distance of 213 to 457 m from the beginning of the runway towards the approach side. It transmits azimuth angle information to aircraft that have missed approach.

Flare equipment

This is located at a distance ranging from 730 to 915 m from the elevation station (see Fig 4). Aircrafts are not designed to touch down at the 1.8-4.9 m/sec sink rate that exists along the glidepath. A flare manoeuvre is therefore essential to reduce the descent rate of aircraft to 0.6-0.9 m/sec at touchdown. During glideslope approach,

the lift force on the aircraft is equal to its weight and the speed is adjusted for a specified stall margin. The flare requires an elevator deflection to increase the angle of attack $\Delta\alpha$ in order to produce an upward acceleration [13]

$$\ddot{h} = (\Delta\alpha/M)C_{L\alpha}DW_a \quad (4)$$

where

$C_{L\alpha}$ = derivative of lift co-efficient with respect to the angle of attack

D = dynamic pressure, equal to $\rho V^2/2$

W_a = wing area and

M = mass of the aircraft.

The upward acceleration causes the vertical velocity to decrease from its value during glideslope approach. Thus if it is required to flare from steeper glide angles, (where the aircraft would have higher sink velocities) a large flare would be required. This problem does not arise in the current ILS, since the glideslope angle is fixed. However in the MLS, the possibility of a variable glideslope angle would require a correspondingly variable flare length, and since it may not always be possible to initiate optimal flare manually, the flare equipment is a necessity in the case of MLS.

The approach taken to achieve this is to generate a flare trajectory online as a function of the glideslope angle, the desired touchdown flight path angle and the touchdown point so that when the glideslope is steeper, the flare initiation altitude is higher [14].

Precision distance measuring equipment (DME/P)

This is usually co-located with the azimuth station. DME/P is an integral part of the MLS system for aircraft approach, landing and missed approach operations. This must be capable of providing high accuracy range information in a severe multipath environment such as that encountered during landing operations. The accuracy required for such operation is at least better than that provided by the present conventional DME (DME/N) system.

DME/N utilises 252 channels using L-band frequency pairs, the details of which can be had from [15]. The frequencies are separated 1-MHz apart with the uplink and downlink frequency pairs of each channel spaced 63-MHz apart. Specific channels are presently used for en-route navigation and instrument landing operation.

Additional channels are needed to match the pairs of DME/P with the 200 MLS channels. Since no additional frequency allocations are possible in L-band, the extra channel capability is provided by additional pulse code multiplexing [16].

PROTOTYPE DEVELOPMENT

Globally, a number of MLS system configuration options have been available, at least conceptually. There

is a large spread in system specifications and, therefore, cost. At this time, there appears to be a consensus on retaining three levels of system sophistication to give an installation freedom to trade cost for complexity. Accordingly, efforts are currently concentrated on a small community, a basic and an expanded system. The tentative specifications of the three levels are given in Table 2. The three levels will have much of the equipment in common, the only major difference being in the antenna systems. Thus any change/upgradation between the various levels will be modular.

TABLE 2 Levels of MLS prototype specification

	Prototype			Production	
	SC	BNA	BWA	OP 1	OP 2
<i>Antenna Beamwidth (deg)</i>					
(j) AZ	3	2	1	2	1
(ii) EL	2	1.5	1	1.5	1
<i>Coverage (deg)</i>					
(i) AZ	$\pm 10(P)$ $\pm 40(CL)$	$\pm 40(P)$	$\pm 60(P)$	$\pm 10(P)$ $\pm 40(P)$ $\pm 60(P)$	$\pm 40(P)$ $\pm 60(P)$
(ii) EL	1 to 15	1 to 15	1 to 15	1 to 15	1 to 15
<i>Transmitter</i>	SS	TWT	TWT	SS	SS
<i>Antenna Tech.</i>	PA/MO	MO	PA	PA	PA
<i>DME/P</i>	Optional	Yes	Yes	Yes	Yes

Notes: SC=Small Community, BNA=Basic (Narrow Aperture), BWA=Basic (Wide Aperture), P=Proportional Guidance, CL=Clearance signal, PA=Phased Array, MO=Micro-wave optics, SS=Solid State, OP=Option

MLS COVERAGE

The MLS coverage requirements are shown in Fig 6. This coverage provides three-dimensional data in azimuth, elevation and range anywhere within the approach and landing coverage area.

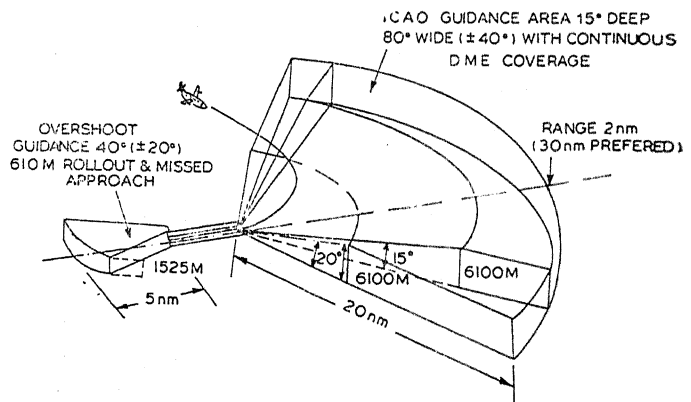


Fig 6 MLS coverage

The landing process is shown in Fig 7. The wide-angle proportional guidance allows aircraft to acquire

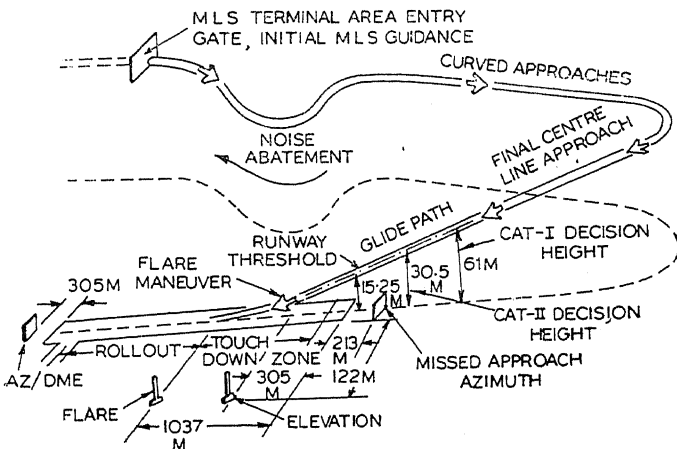


Fig 7 Landing process (adapted from ICAO source material)

the MLS signals and verify that they are correct before they turn on to final approach. This wide angle approach is also beneficial during visual flight rule (VFR) operations to preclude erroneous approaches or approaches to wrong runways. Moreover, the wide angle guidance allows aircraft to better anticipate the turn-on to final approach and thus reduce overshoots on final approach.

The landing process consists of curved paths, vertical, curved or segmented guidance and the transition to the final centreline approach. The decision heights where the pilot must be able to see and land are 61 and 30.5 m for Cat I and Cat II operations respectively. The MLS must support flare manoeuvre, touchdown and rollout under instrument flight rule (IFR) conditions. The elevation equipment provides elevation guidance down to the decision window in Cat I and Cat II operations and to the threshold in Cat III. The approach azimuth provides lateral guidance upto the decision window in Cat I and Cat II operations and to touch down and roll out in Cat III. The flare manoeuvre is performed manually for Cat I & II by visual reference; but for Cat III positive azimuth and vertical guidance are required upto touch down. It may not be out of place to mention here that the operational procedures for MLS approaches are under development by RTCA special committee of ICAO.

SITING CONSIDERATIONS

At many airports, the extended centre line of the runway is not available for siting of localiser antenna of the current ILS and therefore the installation is required to be offset. This results in an increase in the landing minimums. The wide angle proportional guidance capability of MLS together with DME/P information can be used to compute a straight-in approach without an increase in the landing minimums.

For straight-in approaches, the critical area of MLS is substantially smaller than the ILS. Further, the siting criteria for the elevation station is less critical and more

flexible than ILS. Vehicles including aircraft parked or moving in the critical areas around MLS stations will cause unacceptable interference with the navigation guidance signals. However, because of the small size of the critical area, it will be relatively easy to keep this area flat and free of intrusions.

The MLS characteristics are shown in Table 3.

TABLE 3. MLS overall characteristics

Frequency:	5031—5090.7 MHz 200 channels spaced 300-kHz apart	
Information Rate:	(i) Azimuth 13 Hz for wide coverage (± 40 deg) (ii) Elevation 39 Hz for narrow coverage (± 10 deg)	
Information Coding:	(i) Angular Information Pulse space coding with a time reference scanning beam (ii) Preamble and data Biphase coding in DPSK	
Polarisation	Vertical	
Coverage (deg):	(i) Azimuth ± 40 ± 60 (for wide aperture systems) (ii) Elevation 0.9 to 15	
Distance	20 NM	
Guidance accuracy at runway threshold:	Azimuth	Elevation
(i) PFE	± 6 m	± 0.6 m
(ii) CMN	± 3.2 m	± 0.3 m

Notes: (i) Path Following Error (PFE) consists of dc and very low frequency errors in following the designated path of the aircraft
(ii) Control Motion Noise (CMN) corresponds to low frequency errors which cause oscillatory control surface motions during autocoupled flight

CONCLUSION

MLS has the potential to provide significant fuel and time savings as well as flexibility in approach and take-off compared to the current ILS. It has all the essential features to support the goals of safety, capacity, and economy in the approach and landing functions. It is in an advanced stage of trial and both the ILS and MLS will be in operation in the transition period. The flexibility and expansion capability built into the TRSB-MLS system appears to be adequate to cater to the needs of aviation well into the 21st century.

For further reading on MLS, the reader is referred to [17] and [18]. However, it must be cautioned that although the basic principle of the TRSB-MLS has remained steady since its adoption, details have been modified from time to time, and hence any quantitative figures found in relatively early literature must be verified against recent publications and ICAO bulletins.

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