Chapter 1. NAVIGATION AIDS

Section 1. AIR NAVIGATION RADIO AIDS

1. GENERAL

Various types of air navigation aids are in use today, each serving a special purpose. These aids have varied owners and operators namely: the Federal Aviation Administration (FAA), the military services, private organizations, individual states and foreign governments. The FAA has the statutory authority to establish, operate, maintain air navigation facilities and to prescribe standards for the operation of any of these aids which are used for instrument flight in federally controlled airspace. These aids are tabulated in the Airport/Facility Directory.

2. NONDIRECTIONAL RADIO BEACON (NDB)

a. A low or medium frequency radio beacon transmits nondirectional signals whereby the pilot of an aircraft properly equipped can determine his bearing and "home" on the station. These facilities normally operate in the frequency band of 190 to 535 kHz and transmit a continuous carrier with either 400 or 1020 Hz modulation. All radio beacons except the compass locators transmit a continuous three-letter identification in code except during voice transmissions.

b. When a radio beacon is used in conjunction with the Instrument Landing System markers, it is called a Compass Locator.

c. Voice transmissions are made on radio beacons unless the letter "W" (without voice) is included in the class designator (HW).

d. Radio beacons are subject to disturbances that may result in erroneous bearing information. Such disturbances result from such factors as lightning, precipitation static, etc. At night radio beacons are vulnerable to interference from distant stations. Nearly all disturbances which affect the ADF bearing also affect the facility's identification. Noisy identification usually occurs when the ADF needle is erratic. Voice, music or erroneous identification may be heard when a steady false bearing is being displayed. Since ADF receivers do not have a "FLAG" to warn the pilot when erroneous bearing information is being displayed, the pilot should continuously monitor the NDB's identification.

3. VHF OMNI-DIRECTIONAL RANGE (VOR)

a. VORs operate within the 108.0 to 117.95 MHz frequency band and have a power output necessary to provide coverage within their assigned operational service volume. It is subject to line-of-sight restriction, and the range varies proportionally to the altitude of the receiving equipment. The normal service ranges for the various classes of VORs are given in PARA. 10.d.

b. Most VORs are equipped for voice transmission on the VOR frequency. VORs without voice capability are indicated by the letter "W" (without voice) included in the class designator (VORW).

c. The only positive method of identifying a VOR is by its Morse Code identification or by the recorded automatic voice identification which is always indicated by use of the word "VOR" following the range's name. Reliance on determining the identification of an omnirange should never be placed on listening to voice transmissions by the Flight Service Station (FSS) (or approach control facility) involved. Many FSSs remotely operate several omniranges with different names. In some cases, none of the VORs have the name of the "parent" FSS. During periods of maintenance, the facility may radiate a T-E-S-T code (— ● ●●● —) or the code may be removed.

d. Voice identification has been added to numerous VORs. The transmission consists of a voice announcement, "AIRVILLE VOR" alternating with the usual Morse Code identification.

e. The effectiveness of the VOR depends upon proper use and adjustment of both ground and airborne equipment.

(1) Accuracy:The accuracy of course alignment of the VOR is excellent, being generally plus or minus 1 degree.

(2) Roughness:On some VORs, minor course roughness may be observed, evidenced by course needle or brief flag alarm activity (some receivers are more susceptible to these irregularities than others). At a few stations, usually in mountainous terrain, the pilot may occasionally observe a brief course needle oscillation, similar to the indication of "approaching station." Pilots flying over unfamiliar routes are cautioned to be on the alert for these vagaries, and in particular, to use the "to/from" indicator to determine positive station passage.

(a) Certain propeller RPM settings or helicopter rotor speeds can cause the VOR Course Deviation Indicator to fluctuate as much as plus or minus six degrees. Slight changes to the RPM setting will normally smooth out this roughness. Pilots are urged to check for this modulation phenomenon prior to reporting a VOR station or aircraft equipment for unsatisfactory operation.

4. VOR RECEIVER CHECK

a. The FAA VOR test facility (VOT) transmits a test signal which provides users a convenient means to determine the operational status and accuracy of a VOR receiver while on the ground where a VOT is located. The airborne use of VOT is permitted; however, its use is strictly limited to those areas/altitudes specifically authorized in the Airport/Facility Directory or appropriate supplement.

b. To use the VOT service,tune in the VOT frequency on your VOR receiver. With the Course Deviation Indicator (CDI) centered, the omni-bearing selector should read 0 degrees with the to/from indication showing "from" or the omni-bearing selector should read 180 degrees with the to/from indication showing "to". Should the VOR receiver operate an RMI (Radio Magnetic Indicator), it will indicate 180 degrees on any OBS setting. Two means of identification are used. One is a series of dots and the other is a continuous tone. Information concerning an individual test signal can be obtained from the local FSS.

c. Periodic VOR receiver calibration is most important. If a receiver's Automatic Gain Control or modulation circuit deteriorates, it is possible for it to display acceptable accuracy and sensitivity close into the VOR or VOT and display out-of-tolerance readings when located at greater distances where weaker signal areas exist. The likelihood of this deterioration varies between receivers, and is generally considered a function of time. The best assurance of having an accurate receiver is periodic calibration. Yearly intervals are recommended at which time an authorized repair facility should recalibrate the receiver to the manufacturer's specifications.

d. Federal Aviation Regulations (FAR 91.25) provides for certain VOR equipment accuracy checks prior to flight under instrument flight rules. To comply with this requirement and to ensure satisfactory operation of the airborne system, the FAA has provided pilots with the following means of checking VOR receiver accuracy:

(1) VOT or a radiated test signal from an appropriately rated radio repair station.

(2) Certified airborne check points.

(3) Certified check points on the airport surface.

e. A radiated VOR test signal from an appropriately rated radio repair station serves the same purpose as an FAA VOR signal and the check is made in much the same manner as a VOT with the following differences:

(1) The frequency normally approved by the FCC is 108.0 MHz.

(2) Repair stations are not permitted to radiate the VOR test signal continuously; consequently, the owner or operator must make arrangements with the repair station to have the test signal transmitted. This service is not provided by all radio repair stations. The aircraft owner or operator must determine which repair station in his local area provides this service. A representative of the repair station must make an entry into the aircraft logbook or other permanent record certifying to the radial accuracy and the date of transmission. The owner, operator or representative of the repair station may accomplish the necessary checks in the aircraft and make a logbook entry stating the results. It is necessary to verify which test radial is being transmitted and whether you should get a "to" or "from" indication.

f. Airborne and ground check points consist of certified radials that should be received at specific points on the airport surface or over specific landmarks while airborne in the immediate vicinity of the airport.

(1) Should an error in excess of plus or minus 4 degrees be indicated through use of a ground check, or plus or minus 6 degrees using the airborne check, IFR flight shall not be attempted without first correcting the source of the error.

*CAUTION:*No correction other than the correction card figures supplied by the manufacturer should be applied in making these VOR receiver checks.

(2) Locations of airborne check points, ground check points and VOTs are published in the Airport/Facility Directory.

(3) If a dual system VOR (units independent of each other except for the antenna) is installed in the aircraft one system may be checked against the other. Turn both systems to the same VOR ground facility and note the indicated bearing to that station. The maximum permissible variations between the two indicated bearings is 4 degrees.

5. TACTICAL AIR NAVIGATION (TACAN)

a. For reasons peculiar to military or naval operations (unusual siting conditions, the pitching and rolling of a naval vessel, etc.) the civil VOR/DME system of air navigation was considered unsuitable for military or naval use. A new navigational system, TACAN, was therefore developed by the military and naval forces to more readily lend itself to military and naval requirements. As a result, the FAA has been in the process of integrating TACAN facilities with the civil VOR/DME program. Although the theoretical, or technical principles of operation of TACAN equipment are quite different from those of VOR/DME facilities, the end result, as far as the navigating pilot is concerned, is the same. These integrated facilities are called VORTAC's.

b. TACAN ground equipment consists of either a fixed or mobile transmitting unit. The airborne unit in conjunction with the ground unit reduces the transmitted signal to a visual presentation of both azimuth and distance information. TACAN is a pulse system and operates in the UHF band of frequencies. Its use requires TACAN airborne equipment and does not operate through conventional VOR equipment.

6. VHF OMNI-DIRECTIONAL RANGE/TACTICAL AIR NAVIGATION (VORTAC)

a. A VORTAC is a facility consisting of two components, VOR and TACAN, which provides three individual services: VOR azimuth, TACAN azimuth and TACAN distance (DME) at one site. Although consisting of more than one component, incorporating more than one operating frequency, and using more than one antenna system, a VORTAC is considered to be a unified navigational aid. Both components of a VORTAC are envisioned as operating simultaneously and providing the three services at all times.

b. Transmitted signals of VOR and TACAN are each identified by three-letter code transmission and are interlocked so that pilots using VOR azimuth with TACAN distance can be assured that both signals being received are definitely from the same ground station. The frequency channels of the VOR and the TACAN at each VORTAC facility are "paired" in accordance with a national plan to simplify airborne operation.

7. DISTANCE MEASURING EQUIPMENT (DME)

a. In the operation of DME, paired pulses at a specific spacing are sent out from the aircraft (this is the interrogation) and are received at the ground station. The ground station (transponder) then transmits paired pulses back to the aircraft at the same pulse spacing but on a different frequency. The time required for the round trip of this signal exchange is measured in the airborne DME unit and is translated into distance (Nautical Miles) from the aircraft to the ground station.

b. Operating on the line-of-sight principle, DME furnishes distance information with a very high degree of accuracy. Reliable signals may be received at distances up to 199 NM at line-of-sight altitude with an accuracy of better than 1/2 mile or 3 percent of the distance, whichever is greater. Distance information received from DME equipment is SLANT RANGE distance and not actual horizontal distance.

c. DME operates on frequencies in the UHF spectrum between 962 MHz and 1213 MHz. Aircraft equipped with TACAN equipment will receive distance information from a VORTAC automatically, while aircraft equipped with VOR must have a separate DME airborne unit.

d. VOR/DME, VORTAC, ILS/DME, and LOC/DME navigation facilities established by the FAA provide course and distance information from collocated components under a frequency pairing plan. Aircraft receiving equipment which provides for automatic DME selection assures reception of azimuth and distance information from a common source when designated VOR/DME, VORTAC, ILS/DME, and LOC/DME are selected.

e. Due to the limited number of available frequencies, assignment of paired frequencies is required for certain military noncollocated VOR and TACAN facilities which serve the same area but which may be separated by distances up to a few miles. The military is presently undergoing a program to collocate VOR and TACAN facilities or to assign nonpaired frequencies to those that cannot be collocated.

f. VOR/DME, VORTAC, ILS/DME, and LOC/DME facilities are identified by synchronized identifications which are transmitted on a time share basis. The VOR or localizer portion of the facility is identified by a coded tone modulated at 1020 Hz or a combination of code and voice. The TACAN or DME is identified by a coded tone modulated at 1350 Hz. The DME or TACAN coded identification is transmitted one time for each three or four times that the VOR or localizer coded identification is transmitted. When either the VOR or the DME is inoperative, it is important to recognize which identifier is retained for the operative facility. A single coded identification with a repetition interval of approximately 30 seconds indicates that the DME is operative.

g. Aircraft equipment which provides for automatic DME selection assures reception of azimuth and distance information from a common source when designated VOR/DME, VORTAC and ILS/DME navigation facilities are selected. Pilots are cautioned to disregard any distance displays from automatically selected DME equipment when VOR or ILS facilities, which do not have the DME feature installed, are being used for position determination.

8—9. RESERVED

10. NAVAID SERVICE VOLUMES

a. Most air navigation radio aids which provide positive course guidance have a designated standard service volume (SSV). The SSV defines the reception limits of unrestricted NAVAIDS which are usable for random/unpublished route navigation.

b. A NAVAID will be classified as restricted if it does not conform to flight inspection signal strength and course quality standards throughout the published SSV. However, the NAVAID should not be considered usable at altitudes below that which could be flown while operating under random route IFR conditions (FAR 91.119), even though these altitudes may lie within the designated SSV. Service volume restrictions are first published in the Notices to Airman (NOTAM) and then with the alphabetical listing of the NAVAID's in the Airport/Facility Directory.

c. Standard Service Volume limitations do not apply to published IFR routes or procedures.

d. VOR/DME/TACAN STANDARD SERVICE VOLUMES (SSV)

Standard service volumes (SSVs) are graphically shown in Figures 10-1 through 10-5. The SSV of a station is indicated by using the class designator as a prefix to the station type designation.

EXAMPLE:

TVOR, LDME, and HVORTAC.

Within 25 NM, the bottom of the T service volume is defined by the curve in Figure 10-4. Within 40 NM, the bottoms of the L and H service volumes are defined by the curve in Figure 10-5.

SSV CLASS DESIGNATOR	ALTITUDE AND RANGE BOUNDARIES
T (Terminal)	From 1000 feet above ground level (AGL) up to and including 12,000 feet AGL at radial distances out to 25 NM. See Figures 10-3 and 10-4.
L (Low Altitude)	From 1000 feet AGL up to and including 18,000 feet AGL at radial distances out to 40 NM. See Figures 10-2 and 10-5.
H (High Altitude)	From 1000 feet AGL up to and including 14,500 feet AGL at radial distances out to 40 NM. From 14,500 feet AGL up to and including 60,000 feet at radial distances out to 100 NM. From 18,000 feet AGL up to and including 45,000 feet AGL at radial distances out to 130 NM. See Figures 10-1 and 10-5.

FIGURE 10-1. STANDARD HIGH ALTITUDE SERVICE VOLUME

(refer to FIGURE 5 for altitudes below 1000 feet)

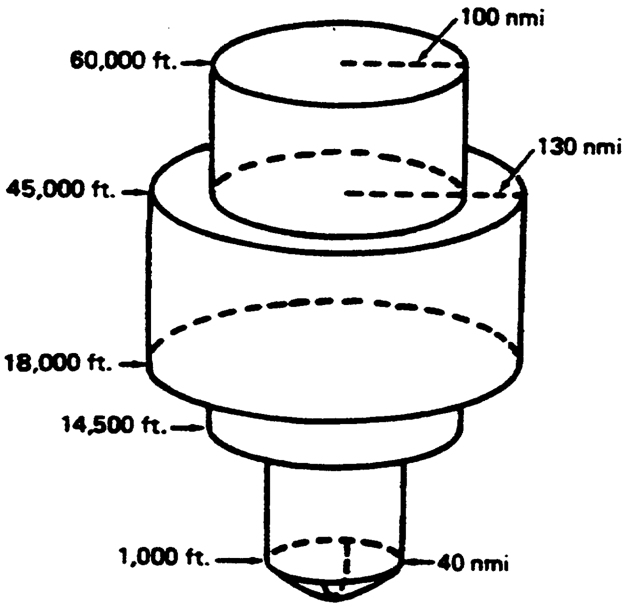
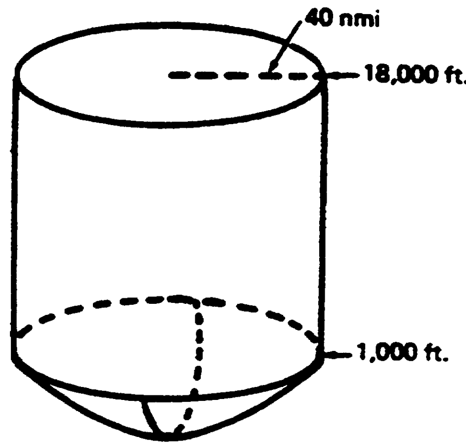


FIGURE 10-2. STANDARD LOW ALTITUDE SERVICE VOLUME

(refer to FIGURE 5 for altitudes below 1000 feet)



NOTE: All elevations shown are with respect to the station's site elevation (AGL). Coverage is not available in a cone of airspace directly above the facility.

FIGURE 10-3. STANDARD TERMINAL SERVICE VOLUME

(refer to FIGURE 4 for altitudes below 1000 feet)

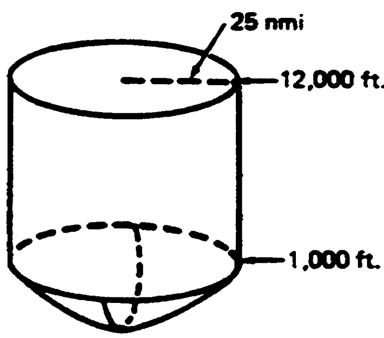


FIGURE 10-4. DEFINITION OF THE LOWER EDGE OF THE STANDARD T (TERMINAL) SERVICE VOLUME

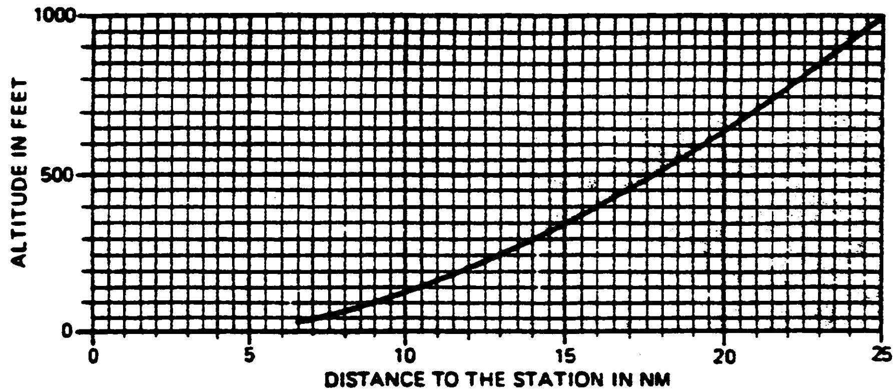
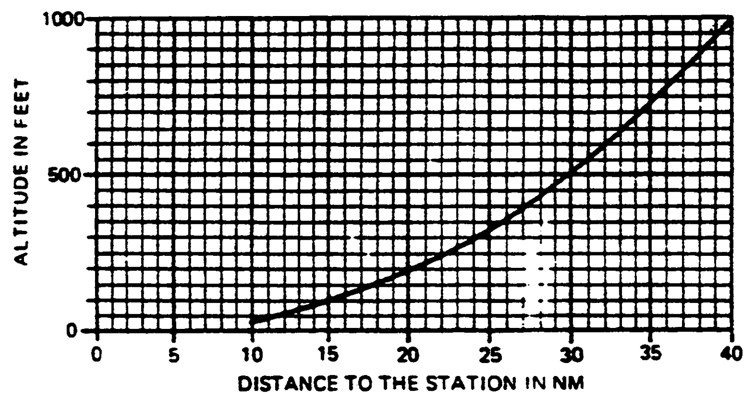


FIGURE 10-5. DEFINITION OF THE LOWER EDGE OF THE STANDARD H (HIGH) AND L (LOW) SERVICE VOLUMES



e. NONDIRECTIONAL RADIO BEACON (NDB)

NDBs are classified according to their intended use. The ranges of NDB service volumes are shown below. The distances (radius) are the same at all altitudes.

CLASS	DISTANCE (RADIUS)
Compass Locator	15 NM
MH	25 NM
H	50 NM*

CLASS	DISTANCE (RADIUS)
HH	75 NM

* Service ranges of individual facilities may be less than 50 nautical miles (NM). Restrictions to service volumes are first published in the Notice to Airmen and then with the alphabetical listing of the NAVAID in the Airport/Facility Directory.

11. MARKER BEACON

a. Marker beacons serve to identify a particular location in space along an airway or on the approach to an instrument runway. This is done by means of a 75 MHz transmitter which transmits a directional signal to be received by aircraft flying overhead. These markers are generally used in conjunction with en route NAVAIDs and ILS as point designators.

b. There are three classes of en route marker beacons: Fan Marker (FM), Low Powered Fan Markers (LFM) and Z Markers. They transmit the letter "R" (dot dash dot) identification, or (if additional markers are in the same area) the letter "K," "P," "X," or "Z."

(1) Class FMs are used to provide a positive identification of positions at definite points along the airways. The transmitters have a power output of approximately 100 watts. Two types of antenna array are used with class FMs.

(a) The first type used, and generally referred to as the standard type, produces an elliptical shaped pattern, which, at an elevation of 1,000 feet above the station, is about 4 NM wide and 12 NM long. At 10,000 feet the pattern widens to about 12 NM wide and 35 NM long.

(b) The second array produces a dumbbell or boneshaped pattern, which, at the "handle", is about three miles wide at 1,000 feet. The boneshaped marker is preferred at approach control locations where "timed" approaches are used.

(2) The class LFM or low powered FMs have a rated power output of 5 watts. The antenna array produces a circular pattern which appears elongated at right angles to the airway due to the directional characteristics of the aircraft receiving antenna.

(3) The Station Location, or Z-Marker, was developed to meet the need for a positive position indicator for aircraft operating under instrument flight conditions to show the pilot when he was passing directly over a low frequency navigational aid. The marker consists of a 5 watt transmitter and a directional antenna array which is located on the range plot between the towers or the loop antennas.

NOTE—ILS marker beacon information is included in PARA. 12 INSTRUMENT LANDING SYSTEMS (ILS).

12. INSTRUMENT LANDING SYSTEM (ILS)

a. GENERAL

(1) The ILS is designed to provide an approach path for exact alignment and descent of an aircraft on final approach to a runway.

(2) The ground equipment consists of two highly directional transmitting systems and, along the approach, three (or fewer) marker beacons. The directional transmitters are known as the localizer and glide slope transmitters.

(3) The system may be divided functionally into three parts:

(a) Guidance information —localizer, glide slope

(b) Range information —marker beacon, DME

(c) Visual information —approach lights, touchdown and centerline lights, runway lights

(4) Compass locators located at the Outer Marker (OM) or Middle Marker (MM) may be substituted for marker beacons. DME, when specified in the procedure, may be substituted for the OM.

(5) Where a complete ILS system is installed on each end of a runway; (i.e. the approach end of Runway 4 and the approach end of Runway 22) the ILS systems are not in service simultaneously.

b. LOCALIZER

(1) The localizer transmitter operates on one of 40 ILS channels within the frequency range of 108.10 to 111.95 MHz. Signals provide the pilot with course guidance to the runway centerline.

(2) The approach course of the localizer is called the front course and is used with other functional parts, e.g., glide slope, marker beacons, etc. The localizer signal is transmitted at the far end of the runway. It is adjusted for a course width of (full scale fly-left to a full scale fly-right) of 700 feet at the runway threshold.

(3) The course line along the extended centerline of a runway, in the opposite direction to the front course is called the back course.

CAUTION: Unless the aircraft's ILS equipment includes reverse sensing capability, when flying inbound on the back course it is necessary to steer the aircraft in the direction opposite the needle deflection when making corrections from off-course to on-course. This "flying away from the needle" is also required when flying outbound on the front course of the localizer. DO NOT USE BACK COURSE SIGNALS for approach unless a BACK COURSE APPROACH PROCEDURE is published for that particular runway and the approach is authorized by ATC.

(4) Identification is in International Morse Code and consists of a three-letter identifier preceded by the letter I(..)transmitted on the localizer frequency.

EXAMPLE:

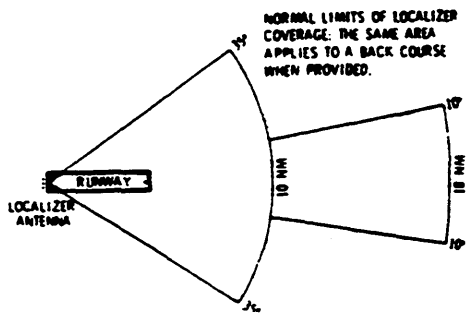
I-DIA

(5) The localizer provides course guidance throughout the descent path to the runway threshold from a distance of 18 NM from the antenna between an altitude of 1,000 feet above the highest terrain along the course line and

4,500 feet above the elevation of the antenna site. Proper off-course indications are provided throughout the following angular areas of the operational service volume:

(a) To 10 degrees either side of the course along a radius of 18 NM from the antenna, and

(b) From 10 to 35 degrees either side of the course along a radius of 10 NM.



(6) Unreliable signals may be received outside these areas.

c. LOCALIZER—TYPE DIRECTIONAL AID

(1) The Localizer-type Directional Aid (LDA) is of comparable use and accuracy to a localizer but is not part of a complete ILS. The LDA course usually provides a more precise approach course than the similar Simplified Directional Facility (SDF) installation, which may have a course width of 6 or 12 degrees. The LDA is not aligned with the runway. Straight-in minimums may be published where alignment does not exceed 30 degrees between the course and runway. Circling minimums only are published where this alignment exceeds 30 degrees.

d. GLIDE SLOPE/GLIDE PATH

(1) The UHF glide slope transmitter, operating on one of the 40 ILS channels within the frequency range 329.15 MHz, to 335.00 MHz radiates its signals in the direction of the localizer front course. The term "glide path" means that portion of the glide slope that intersects the localizer.

*CAUTION:*False glide slope signals may exist in the area of the localizer back course approach which can cause the glide slope flag alarm to disappear and present unreliable glide slope information. Disregard all glide slope signal indications when making a localizer back course approach unless a glide slope is specified on the approach and landing chart.

(2) The glide slope transmitter is located between 750 feet and 1,250 feet from the approach end of the runway (down the runway) and offset 250 to 650 feet from the runway centerline. It transmits a glide path beam 1.4 degrees wide. The signal provides descent information for navigation down to the lowest authorized decision height (DH) specified in the approved ILS approach procedure. The glidepath may not be suitable for navigation below the lowest authorized DH and any reference to glidepath indications below that height must be supplemented by visual reference to the runway environment. Glidepaths with no published DH are usable to runway threshold.

(3) The glide path projection angle is normally adjusted to 3 degrees above horizontal so that it intersects the MM at about 200 feet and the OM at about 1,400 feet above the runway elevation. The glide slope is normally usable to the distance of 10 NM. However, at some locations, the glide slope has been certified for an extended service volume which exceeds 10 NM.

(4) Pilots must be alert when approaching the glidepath interception. False courses and reverse sensing will occur at angles considerably greater than the published path.

(5) Make every effort to remain on the indicated glide path (reference: FAR 91.87(d)(2)). Exercise caution: avoid flying below the glide path to assure obstacle/terrain clearance is maintained.

(6) The published glide slope threshold crossing height (TCH)*DOES NOT*represent the height of the actual glide path on course indication above the runway threshold. It is used as a reference for planning purposes which represents the height above the runway threshold that an aircraft's glide slope antenna should be, if that aircraft remains on a trajectory formed by the four-mile-to-middle marker glidepath segment.

(7) Pilots must be aware of the vertical height between the aircraft's glide slope antenna and the main gear in the landing configuration and, at the DH, plan to adjust the descent angle accordingly if the published TCH indicates the wheel crossing height over the runway threshold may not be satisfactory. Tests indicate a comfortable wheel crossing height is approximately 20 to 30 feet, depending on the type of aircraft.

e. DISTANCE MEASURING EQUIPMENT (DME)

(1) When installed with the ILS and specified in the approach procedure, DME may be used:

(a) In lieu of the OM.

(b) As a back course (BC) final approach fix (FAF).

(c) To establish other fixes on the localizer course.

(2) In some cases, DME from a separate facility may be used within Terminal Instrument Procedures (TERPS) limitations:

(a) To provide ARC initial approach segments.

(b) As a FAF for BC approaches.

(c) As a substitute for the OM.

f. MARKER BEACON

(1) ILS marker beacons have a rated power output of 3 watts or less and an antenna array designed to produce a elliptical pattern with dimensions, at 1,000 feet above the antenna, of approximately 2,400 feet in width and 4,200 feet in length. Airborne marker beacon receivers with a selective sensitivity feature should always be operated in the "low" sensitivity position for proper reception of ILS marker beacons.

(2) Ordinarily, there are two marker beacons associated with an ILS, the OM and MM. Locatons with a Category II and III ILS also have an inner marker (IM). When an aircraft passes over a marker, the pilot will receive the following indications:

MARKER	CODE	LIGHT
OM	— — —	BLUE
MM	○ — ○ —	AMBER
IM	○ ○ ○ ○	WHITE
BC	○ ○ ○ ○	WHITE

(a) The OM normally indicates a position at which an aircraft at the appropriate altitude on the localizer course will intercept the ILS glide path.

(b) The MM indicates a position approximately 3,500 feet from the landing threshold. This is also the position where an aircraft on the glide path will be at an altitude of approximately 200 feet above the elevation of the touchdown zone.

(c) The inner marker (IM) will indicate a point at which an aircraft is at a designated decision height (DH) on the glide path between the MM and landing threshold.

(3) A back course marker normally indicates the ILS back course final approach fix where approach descent is commenced.

g. COMPASS LOCATOR

(1) Compass locator transmitters are often situated at the MM and OM sites. The transmitters have a power of less than 25 watts, a range of at least 15 miles and operate between 190 and 535 kHz. At some locations, higher powered radio beacons, up to 400 watts, are used as OM compass locators. These generally carry Transcribed Weather Broadcast (TWEB) information.

(2) Compass locators transmit two letter identification groups. The outer locator transmits the first two letters of the localizer identification group, and the middle locator transmits the last two letters of the localizer identification group.

h. ILS FREQUENCY

(1) The following frequency pairs are allocated for ILS.

Localizer MHz	Glide Slope
108.10	334.70
108.15	334.55
108.3	334.10
108.35	333.95
108.5	329.90
108.55	329.75
108.7	330.50
108.75	330.35
108.9	329.30
108.95	329.15
109.1	331.40
109.15	331.25
109.3	332.00
109.35	331.85
109.50	332.60
109.55	332.45
109.70	333.20
109.75	333.05
109.90	333.80
109.95	333.65
110.1	334.40
110.15	334.25
110.3	335.00
110.35	334.85
110.5	329.60
110.55	329.45
110.70	330.20
110.75	330.05
110.90	330.80
110.95	330.65
111.10	331.70
111.15	331.55
111.30	332.30
111.35	332.15
111.50	332.9
111.55	332.75
111.70	333.5
111.75	333.35
111.90	331.1
111.95	330.95

i. ILS MINIMUMS

(1) The lowest authorized ILS minimums, with all required ground and airborne systems components operative, are

(a) Category I - Decision Height (DH) 200 feet and Runway Visual Range (RVR) 2,400 feet (with touchdown zone and centerline lighting, RVR 1800 Category A, B, C; RVR 2000 Category D).

(b) Category II - DH 100 feet and RVR 1,200 feet.

(c) Category IIIA - RVR 700 feet.

NOTE— Special authorization and equipment are required for Category II and IIIA.

j. INOPERATIVE ILS COMPONENTS

(1) Inoperative localizer: When the localizer fails, an ILS approach is not authorized.

(2) Inoperative glide slope: When the glide slope fails, the ILS reverts to a nonprecision localizer approach.

NOTE— Refer to the Inoperative Component Table in the U.S. Government IAPs publications, Supplementary Information Section, for adjustments to minimums due to inoperative airborne or ground system equipment.

k. ILS COURSE DISTORTION

(1) All pilots should be aware that disturbances to ILS localizer and glide slope courses may occur when surface vehicles or aircraft are operated near the localizer or glide slope antennas. Most ILS installations are subject to signal interference by either surface vehicles, aircraft or both. ILS CRITICAL AREAS are established near each localizer and glide slope antenna.

(2) ATC issues control instructions to avoid interfering operations within ILS critical areas at controlled airports during the hours the Airport Traffic Control Tower (ATCT) is in operations as follows:

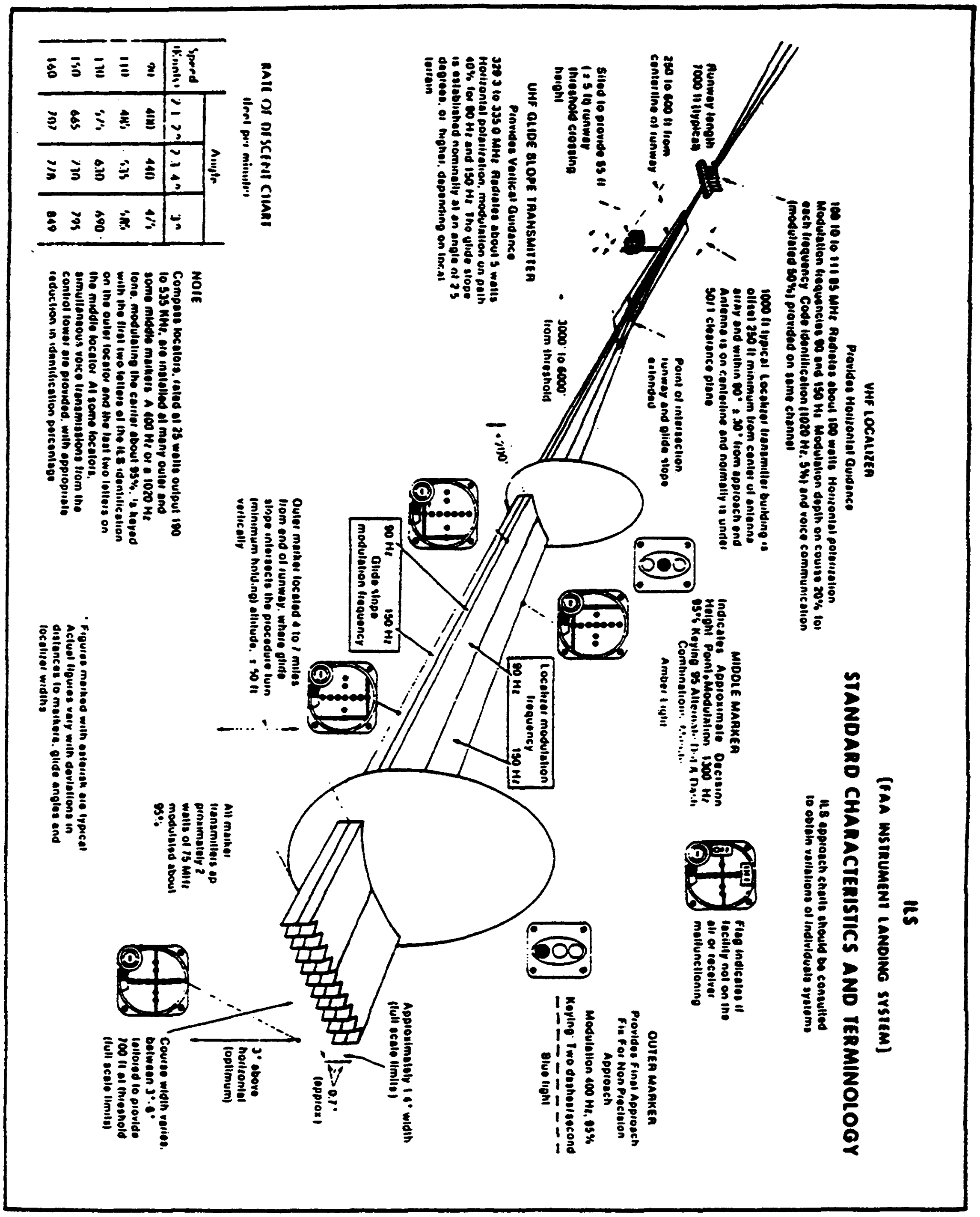
(a) Weather Conditions - Less than ceiling 800 feet and/or visibility 2 miles.

(i) LOCALIZER CRITICAL AREA - Except for aircraft that land, exit a runway, depart or miss approach, vehicles and aircraft are not authorized in or over the critical area when an arriving aircraft is between the ILS final approach fix and the airport. Additionally, when the ceiling is less than 200 feet and/or the visibility is RVR 2,000 or less, vehicle and aircraft operations in or over the area are not authorized when an arriving aircraft is inside the ILS MM.

(ii) GLIDE SLOPE CRITICAL AREA - Vehicles and aircraft are not authorized in the area when an arriving aircraft is between the ILS final approach fix and the airport unless the aircraft has reported the airport in sight and is circling or side stepping to land on a runway other than the ILS runway.

(3) Aircraft holding below 5000 feet between the outer marker and the airport may cause localizer signal variations for aircraft conducting the ILS Approach. Accordingly, such holding is not authorized when weather or visibility conditions are less than ceiling 800 feet and/or visibility 2 miles.

(4) Pilots are cautioned that vehicular traffic not subject to ATC may cause momentary deviation to ILS course or glide slope signals. Also, critical areas are not protected at uncontrolled airports or at airports with an operating control tower when weather or visibility conditions are above those requiring protective measures. Aircraft conducting coupled or autoland operations should be especially alert in monitoring automatic flight control systems.


ILS
(FAA INSTRUMENT LANDING SYSTEM)
STANDARD CHARACTERISTICS AND TERMINOLOGY
ILS approach charts should be consulted to obtain variations of individuals systems
VHF LOCALIZER
Provides Horizontal Guidance
108 10 to 111 95 MHz Radiates about 100 watts Horizontal polarization Modulation frequencies 90 and 150 Hz Modulation depth on course 20% for each frequency Code identification (1020 Hz, 5%) and voice communication (modulated 50%) provided on same channel
1000 ft typical Localizer transmitter building is offset 250 ft minimum from center of antenna array and within 90° ± 30° from approach end Antenna is on centerline and normally is under 50/1 clearance plane
Runway length 7000 ft (typical)
250 to 600 ft from centerline of runway
Sited to provide 55 ft (± 5 ft) runway threshold crossing height
Point of intersection runway and glide slope extended
3000' to 6000' from threshold
UHF GLIDE SLOPE TRANSMITTER
Provides Vertical Guidance
329 3 to 335 0 MHz Radiates about 5 watts Horizontal polarization, modulation on path 40% for 90 Hz and 150 Hz The glide slope is established nominally at an angle of 2 5 degrees, or higher, depending on local terrain
MIDDLE MARKER
Indicates Approximate Decision Height Point. Modulation 1300 Hz 95% Keying 95 Alternate Dot & Dash
Amber Light
Flag indicates if facility not on the air or receiver malfunctioning
OUTER MARKER
Provides Final Approach Fix For Non Precision Approach
Modulation 400 Hz, 95%
Keying: Two dashes/second
Blue light
Localizer modulation frequency
90 Hz 150 Hz
90 Hz 150 Hz
Glide slope modulation frequency
Approximately 1 4° width (full scale limits)
0.7° (approx)
3° above horizontal (optimum)
Course width varies, between 3°-6° tailored to provide 700 ft at threshold (full scale limits)
Outer marker located 4 to 7 miles from end of runway, where glide slope intersects the procedure turn (minimum holding) altitude, ± 50 ft vertically
All marker transmitters approximately 2 watts of 75 MHz modulated about 95%
RATE OF DESCENT CHART
(feet per minute)
Speed (Knots)
Angle
2 1 2° 2 3 4° 3°
90 400 440 475
110 485 535 585
130 575 630 690
150 665 730 795
160 707 778 849
NOTE
Compass locators, rated at 25 watts output 190 to 535 KHz, are installed at many outer and some middle markers A 400 Hz or a 1020 Hz tone, modulating the carrier about 95%, is keyed with the first two letters of the ILS identification on the outer locator and the last two letters on the middle locator At some locators, simultaneous voice transmissions from the control tower are provided, with appropriate reduction in identification percentage
* Figures marked with asterisk are typical Actual figures vary with deviations in distances to markers, glide angles and localizer widths

(b) Weather Conditions - At or above ceiling 800 feet and/or visibility 2 miles.

(I) No critical area protective action is provided under these conditions

(II) If an aircraft advises the TOWER that an AUTOLAND or COUPLED approach will be conducted, an advisory will be promptly issued if a vehicle or aircraft will be in or over a critical area when the arriving aircraft is inside the ILS MM.

EXAMPLE:

GLIDE SLOPE SIGNAL NOT PROTECTED.

13. SIMPLIFIED DIRECTIONAL FACILITY (SDF)

a. The SDF provides a final approach course similar to that of the ILS localizer. It does not provide glide slope information. A clear understanding of the ILS localizer and the additional factors listed below completely describe the operational characteristics and use of the SDF.

b. The SDF transmits signals within the range of 108.10 to 111.95 MHz.

c. The approach techniques and procedures used in an SDF instrument approach are essentially the same as those employed in executing a standard localizer approach except the SDF course may not be aligned with the runway and the course may be wider, resulting in less precision.

d. Usable off-course indications are limited to 35 degrees either side of the course centerline. Instrument indications received beyond 35 degrees should be disregarded.

e. The SDF antenna may be offset from the runway centerline. Because of this, the angle of convergence between the final approach course and the runway bearing should be determined by reference to the instrument approach procedure chart. This angle is generally not more than 3 degrees. However, it should be noted that inasmuch as the approach course originates at the antenna site, an approach which is continued beyond the runway threshold will lead the aircraft to the SDF offset position rather than along the runway centerline.

f. The SDF signal is fixed at either 6 degrees or 12 degrees as necessary to provide maximum flyability and optimum course quality.

g. Identification consists of a three-letter identifier transmitted in Morse Code on the SDF frequency. The appropriate instrument approach chart will indicate the identifier used at a particular airport.

14. MICROWAVE LANDING SYSTEM (MLS)

a. GENERAL

(1) The MLS provides precision navigation guidance for exact alignment and descent of aircraft on approach to a runway. It provides azimuth, elevation, and distance.

(2) Both lateral and vertical guidance may be displayed on conventional course deviation indicators or incorporated into multipurpose cockpit displays. Range information can be displayed by conventional DME indicators and also incorporated into multipurpose displays.

(3) The MLS initially supplements and will eventually replace ILS as the standard landing system in the United States for civil, military and international civil aviation. The transition plan assures duplicate ILS and MLS facilities where needed to protect current users of ILS. At international airports ILS service is protected to the year 1995.

(4) The system may be divided into five functions:

(a) Approach azimuth.

(b) Back azimuth.

(c) Approach elevation.

(d) Range.

(e) Data communications.

(5) The *standard configuration* of MLS ground equipment includes:

(a) An azimuth station to perform functions (a) and (e) above. In addition to providing azimuth navigation guidance, the station transmits basic data which consists of information associated directly with the operation of the landing system, as well as advisory data on the performance of the ground equipment.

(b) An elevation station to perform function (c).

(c) Precision Distance Measuring Equipment (DME/P) to perform function (d). The DME/P provides continuous range information that is compatible with standard navigation DME but has improved accuracy and additional channel capabilities.

(6) MLS Expansion Capabilities — The standard configuration can be expanded by adding one or more of the following functions or characteristics.

(a) Back azimuth — Provides lateral guidance for missed approach and departure navigation.

(b) Auxiliary data transmissions — Provides *additional* data, including refined airborne positioning, meteorological information, runway status, and other supplementary information.

(c) Larger proportional guidance.

(7) MLS identification is a four-letter designation starting with the letter M. It is transmitted in International Morse Code at least six times per minute by the approach azimuth (and back azimuth) ground equipment.

b. APPROACH AZIMUTH GUIDANCE

(1) The azimuth station transmits MLS angle and data on one of 200 channels within the frequency range of 5031 to 5091 MHz. See Table 1 (page C1-S1-14) for MLS angle and data channeling, and Table 2 (page C1-S1-15) for the DME.

(2) The equipment is normally located about 1,000 feet beyond the stop end of the runway, but there is considerable flexibility in selecting sites. For example, for heliport operations the azimuth transmitter can be collocated with the elevation transmitter.

(3) The azimuth coverage (see Figure 1 page C1-S1-16) extends:

(a) Laterally, at least 40 degrees on either side of the runway.

(b) In elevation, up to an angle of 15 degrees — and to at least 20,000 feet.

(c) In range, to at least 20 NM.

c. BACK AZIMUTH GUIDANCE (See Figure 1 page C1-S1-16).

(1) The back azimuth transmitter is essentially the same as the approach azimuth transmitter. However, the equipment transmits at a somewhat lower data rate because the guidance accuracy requirements are not as stringent as for the landing approach. The equipment operates on the same frequency as the approach azimuth but at a different time in the transmission sequence.

(2) The equipment is normally located about 1,000 feet in front of the approach end of the runway. On runways that have MLS service on both ends (e.g., Runway 9 and 27), the azimuth equipment can be switched in their operation from the approach azimuth to the back azimuth and vice versa, and thereby reduce the amount of equipment required.

(3) The back azimuth provides coverage as follows:

(a) Laterally, at least 40 degrees on either side of the runway centerline.

(b) In elevation, up to an angle of 15 degrees.

(c) In range, to at least 7 NM from the runway stop end.

NOTE— The actual coverage is normally the same as for the approach azimuth.

d. ELEVATION GUIDANCE (See Figure 1)

(1) The elevation station transmits signals on the same frequency as the azimuth station. A single frequency is time-shared between angle and data functions.

(2) The elevation transmitter is normally located about 400 feet from the side of the runway between runway threshold and the touchdown zone.

(3) Elevation coverage is provided in the same airspace as the azimuth guidance signals:

(a) In elevation, to at least +15 degrees.

(b) Laterally, 40 degrees on either side of the runway centerline.

(c) In range, to at least 20 NM.

e. RANGE GUIDANCE

(1) The MLS Precision Distance Measuring Equipment (DME/P) functions the same as the navigation DME described in PARA. 7, but there are some technical differences. The beacon transponder operates in the frequency band 962 to 1105 MHz and responds to an aircraft interrogator. The MLS DME/P accuracy is improved to be consistent with the accuracy provided by the MLS azimuth and elevation stations.

(2) A DME/P channel is paired with the azimuth and elevation channel. A complete listing of the 200 paired channels of the DME/P with the angle functions is contained in FAA Standard 022 (MLS Interoperability and Performance Requirements). For illustrative purposes the first page is shown in Table 2.

(3) The DME/P is an integral part of the MLS and is installed at all MLS facilities unless a waiver is obtained. This occurs infrequently — and only at outlying, low density airports where marker beacons or compass locators are already in place.

f. DATA COMMUNICATIONS

(1) The data transmission can include both basic and auxiliary data words. All MLS facilities transmit basic data. In the future facilities at some airports, including most high density airports, will also transmit auxilary data.

(2) Coverage limits — MLS data are transmitted throughout the azimuth (and back azimuth when provided) coverage sectors.

(3) Basic data content — Representative data include:

(a) Station identification.

(b) Exact locations of azimuth, elevation and DME/P stations (for MLS receiver processing functions).

(c) Ground equipment performance level.

(d) DME/P channel and status.

(4) Auxiliary data content — Representative data include:

(a) 3-D locations of MLS equipment.

(b) Waypoint coordinates.

(c) Runway conditions.

(d) Weather (e.g., RVR, ceiling, altimeter setting, wind, wake vortex, wind shear).

g. Operational flexibility. The MLS has the capability to fulfill a variety of needs in the transition, approach, landing, missed approach and departure phases of flight. For example: Curved and segmented approaches; selectable glide path angles; accurate 3-D positioning of the aircraft in space; and the establishment of boundaries to ensure clearance from obstructions in the terminal area. While many of these capabilities are available to any MLS-equipped aircraft, the more sophisticated capabilities (such as curved and segmented approaches) are dependent upon the particular capabilities of the airborne equipment.

h. SUMMARY

(1) Accuracy. The MLS provides precision three-dimensional navigation guidance accurate enough for all approach and landing maneuvers.

(2) Coverage. Accuracy is consistent throughout the coverage volumes shown in Figure 1.

(3) Environment. The system has low susceptibility to interference from weather conditions and airport ground traffic.

(4) Channels. MLS has 200 channels — enough for any foreseeable need.

(5) Data. The MLS transmits ground-air data messages associated with the systems operation.

(6) Range information. Continuous range information is provided with an accuracy of about 100 feet.

Table 1. MLS Channeling

(Azimuth, Elevation, & Data)

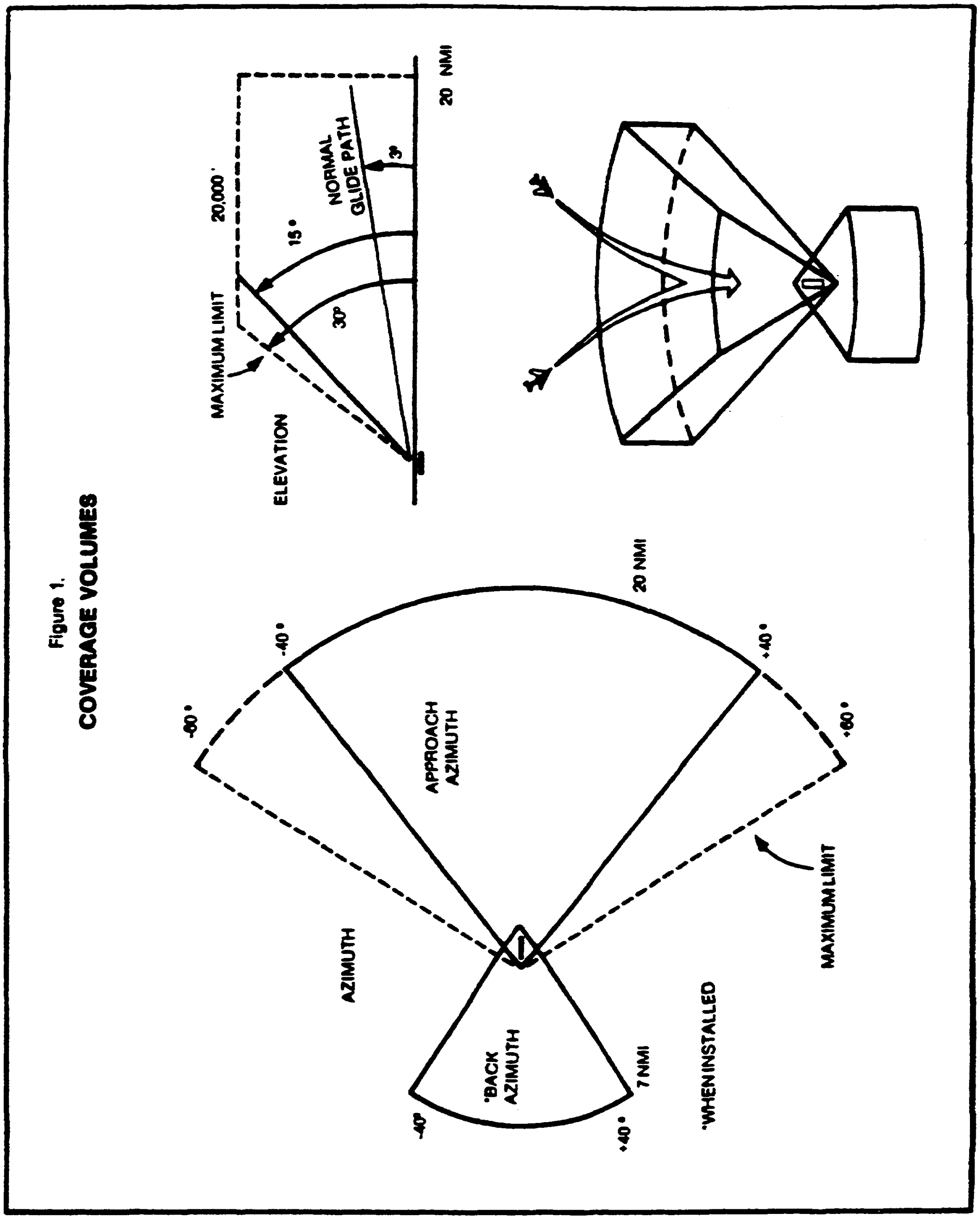
CHANNEL NUMBER	FREQUENCY (MHz)	CHANNEL NUMBER	FREQUENCY (MHz)	CHANNEL NUMBER	FREQUENCY (MHz)	CHANNEL NUMBER	FREQUENCY (MHz)	CHANNEL NUMBER	FREQUENCY (MHz)
500	5031.0	540	5043.0	580	5055.0	620	5067.0	660	5079.0
501	5031.3	.	.	.	.	.	.	.	.
502	5031.6	.	.	.	.	.	.	.	.
503	5031.9	.	.	.	.	.	.	.	.
504	5032.2	.	.	.	.	.	.	.	.
505	5032.5	545	5044.5	585	5056.5	625	5068.5	665	5080.5
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
510	5034.0	550	5046.0	590	5058.0	630	5070.0	670	5082.0
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
515	5035.5	555	5047.5	595	5059.5	635	5071.5	675	5083.5
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
520	5037.0	560	5049.0	600	5061.0	640	5073.0	680	5085.0
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
525	5038.5	565	5050.5	605	5062.5	645	5074.5	685	5086.5
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
530	5040.0	570	5052.0	610	5064.0	650	5076.0	690	5088.0
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
535	5041.5	575	5053.5	615	5065.5	655	5077.5	695	5089.5
.	.	.	.	.	.	.	.	696	5089.8
.	.	.	.	.	.	.	.	697	5090.1
.	.	.	.	.	.	.	.	698	5090.4
.	.	.	.	.	.	.	.	699	5090.7

Table 2. DME/P Channels, Frequencies, and Pairings

DME CHANNEL (NUMBER)	VHF CHANNEL (MHz)	C-BAND CHANNEL (MHz)	ANGLE CHANNEL (NUMBER)	INTERROGATOR FREQUENCY (MHz)	NON-PRECISION INTERROGATOR PULSE CODE (USEC)	PRECISION INTERROGATOR PULSE CODE (USEC)	TRANSPONDER FREQUENCY (MHz)	TRANSPONDER PULSE CODE (USEC)
1X				1025	12		962	12
1Y				1025	36		1088	30
2X				1026	12		963	12
2Y				1026	36		1089	30
3X				1027	12		964	12
3Y				1027	36		1090	30
4X				1028	12		965	12
4Y				1028	36		1091	30
5X				1029	12		966	12
5Y				1029	36		1092	30
6X				1030	12		967	12
6Y				1030	36		1093	30
7X				1031	12		968	12
7Y				1031	36		1094	30
8X				1032	12		969	12
8Y				1032	36		1095	30
9X				1033	12		970	12
9Y				1033	36		1096	30
10X				1034	12		971	12
10Y				1034	36		1097	30
11X				1035	12		972	12
11Y				1035	36		1098	30
12X				1036	12		973	12
12Y				1036	36		1099	30
13X				1037	12		974	12
13Y				1037	36		1100	30
14X				1038	12		975	12
14Y				1038	36		1101	30
15X				1039	12		976	12
15Y				1039	36		1102	30
16X				1040	12		977	12
16Y				1040	36		1103	30
17X	108.00	-	-	1041	12	-	978	12
17Y	108.05	5043.00	540	1041	36	42	1104	30
17Z	-	5043.30	541	1041	21	27	1104	15
18X	108.10	5031.00	500	1042	12	18	979	12
18W	-	5031.30	501	1042	24	33	979	24
18Y	108.15	5043.60	542	1042	36	42	1105	30
18Z	-	5043.90	543	1042	21	27	1105	15
19X	108.20	-	-	1043	12	-	980	12

C1—S1—14

Figure 1.
COVERAGE VOLUMES



15. INTERIM STANDARD MICROWAVE LANDING SYSTEM (ISMLS)

a. The ISMLS is designed to provide approach information similar to the ILS for an aircraft on final approach to a runway. The system provides both lateral and vertical guidance which is displayed on a conventional course deviation indicator or approach horizon. Operational performance and coverage areas are similar to the ILS system.

b. ISMLS operates in the C-band microwave frequency range (about 5000 MHz). ISMLS signals will not be received by unmodified VHF/UHF ILS receivers. Aircraft with ISMLS must be equipped with a C-band receiving antenna in addition to other special equipment mentioned below. The C-band antenna limits reception of the signal to an angle of about 50 degrees from the inbound course. An aircraft so equipped will not receive the ISMLS signal until flying a magnetic heading within 50 degrees either side of the inbound course. Because of this, ISMLS procedures are designed to restrict the use of the ISMLS signal until the aircraft is in position for the final approach. Transition to the ISMLS, holding and procedure turns at the ISMLS facility must be predicated on other navigation aids such as NDB, VOR, etc. Once established on the approach course inbound, the system can be flown the same as an ILS. No back course is provided.

c. The ISMLS consists of the following basic components:

(1) C-Band (5000 MHz-5030 MHz) localizer.

(2) C-Band (5220 MHz-5250 MHz) glide path.

(3) VHF marker beacons (75 MHz).

(4) A VHF/UHF ILS receiver modified to recieve ISMLS signals.

(5) C-Band antenna.

(6) Converter unit.

(7) A Microwave/ILS Mode Control.

d. Identification consists of a three letter Morse Code identifier preceded by the Morse Code for "M"(- -)(e.g., M—STP). The "M" distinguishes this system from ILS which is preceded by the Morse Code for "I"(..)(e.g., I-STP).

e. Approaches published in conjunction with the ISMLS are identified as "MLS Rwy—(Interim)." The frequency displayed on the ISMLS approach chart is a VHF frequency. ISMLS frequencies are tuned by setting the receiver to the listed VHF frequencies. When the ISMLS mode is selected, receivers modified to accept ISMLS signals receive a paired C-band frequency that is processed by the receiver.

*CAUTION:*Pilots should not attempt to fly ISMLS procedures unless the aircraft is so equipped.

16. MAINTENANCE OF FAA NAVAIDS

During periods of routine or emergency maintenance, coded identification (or code and voice, where applicable) is removed from certain FAA NAVAIDs. Removal of identification serves as a warning to pilots that the facility is officially off the air for tune-up or repair and may be unreliable even though intermittent or constant signals are received.

NOTE-During periods of maintenance VHF ranges may radiate a T-E-S-T code (— • ••• —).

17. NAVAIDS WITH VOICE

a. Voice equipped en route radio navigational aids are under the operational control of either an FAA FSS or an approach control facility. Most NAVAIDs are remotely operated.

b. Unless otherwise noted on the chart, all radio navigation aids operate continuously except during interruptions for voice transmissions on the same frequencies where simultaneous transmission is not available, and during shutdowns for maintenance. Hours of operation of facilities not operating continuously are annotated on charts and in the Airport/Facility Directory.

18. RESERVED

19. USER REPORTS ON NAVAID PERFORMANCE

a. Users of the National Airspace System (NAS) can render valuable assistance in the early correction of NAVAID malfunctions by reporting their observations of undesirable NAVAID performance. Although NAVAID's are monitored by electronic detectors, adverse effects of electronic interference, new obstructions or changes in terrain near the NAVAID can exist without detection by the ground monitors. Some of the characteristics of malfunction or deteriorating performance which should be reported are: erratic course or bearing indications; intermittent, or full, flag alarm; garbled, missing or obviously improper coded identification; poor quality communications reception; or, in the case of frequency interference, an audible hum or tone accompanying radio communications or NAVAID identification.

b. Reporters should identify the NAVAID, location of the aircraft, time of the observation, type of aircraft and describe the condition observed; the type of receivers in use is also useful information. Reports can be made in any of the following ways:

(1) Immediate report by direct radio communication to the controlling Air Route Traffic Control Center (ARTCC), Control Tower, or FSS. This method provides the quickest result.

(2) By telephone to the nearest FAA facility.

(3) By FAA Form 8000-7, Safety Improvement Report. This is a self addressed, postage-paid card designed for this purpose. These cards may be obtained at FAA FSSs, General Aviation District Offices and General Aviation Fixed Base Operations.

c. In aircraft that have more than one receiver, there are many combinations of possible interference between units. This can cause either erroneous navigation indications or, complete or partial blanking out of the communications. Pilots should be familiar enough with the radio installation of the particular airplanes they fly to recognize this type of interferrence.

20. LORAN

a. LORAN-A service has been terminated in the U.S. coastal confluence region.

b. LORAN-C was developed to provide the Department of Defense with a radio navigation capability having longer range and much greater accuracy than its predecessor, LORAN-A. It was subsequently selected as the U.S. Government provided radio navigation system for civil marine use in the U.S. coastal areas.

c. Operation

LORAN-C is a pulsed, hyperbolic system, operating in the 90-110 kHz frequency band. The system is based upon measurement of the difference in time of arrival of pulses of radio-frequency energy radiated by a group, or chain of transmitters which are separated by hundreds of miles. Within a chain, one station is designated as the Master station (M), and the other stations are designated as Secondary stations, Whiskey (W), X-ray (X), Yankee (Y), and Zulu (Z). Signals transmitted from the Secondary stations are synchronized with those from the Master station. The measurement of a time-difference (TD) is made by a receiver that achieves accuracy by comparing a zero crossing of a specified radio- frequency cycle within the pulses received from the Master and Secondary stations of a chain. Only groundwave signals are used for air navigation in the National Airspace System. Within the groundwave range, LORAN-C will provide the user, who uses an adequate receiver, with predictable accuracy of 0.25 nautical miles (2 drms) or better. All accuracy is dependent on the user's location within the signal coverage area of the chain of stations.

d. Signal coverage

Expansion of the LORAN-C system to meet the requirement for the U.S. coastal waters of the conterminous 48 states and southern Alaska was completed in the late 1979. Stations have been built to provide service to the U.S. east and west coasts, the Gulf of Mexico, the Gulf of Alaska and Aleutians, and the Great Lakes. The coastal transmitters also provide inland coverage over about two-thirds of the area of the 48 states and over the southwestern portion of Alaska. Missing, from an aviation view point, is signal coverage over the mid-continent area.

e. Aviation uses

LORAN-C has been approved as an en route IFR navigation aid under provisions of Advisory Circular 20-121, "Airworthiness Approval of Airborne LORAN-C Systems for Use in the U.S. National Airspace System," August 23, 1984. The first LORAN-C guided nonprecision approach was made at Bedford, Massachusetts, on November 4, 1985, as part of an early implementation project established by the FAA in close cooperation with the National Association of State Aviation Officials. Until operational signal monitor receivers, similar in function to those used in the limited implementation project, are installed in existing coverage areas, the number of approved nonprecision approach procedures will be limited.

f. Planned expansion

Current plans are to procure and install signal monitors in existing signal coverage areas with completion expected by mid-1988. The monitors will serve two functions: (1) they will provide immediate advisories on signal status to air traffic for use in granting approach clearances, and (2) they will be the source of calibration values that will be published on approach charts. The calibration values will remove most of the seasonal error that could cause LORAN-C accuracy to be worse than approach accuracy requirements. The mid-continent area will be provided with signal coverage after the planned installation of additional transmitters; completion of the installation is expected in 1989. In addition to the transmitters, signal monitors will be installed in the mid-continent to support nonprecision approaches.

g. Notices to Airman (NOTAMs) are issued for LORAN-C chain or station outages. Domestic NOTAM (D)'s are issued under the identifier "LRN." International NOTAMs are issued under the KNMH series. Pilots may obtain these NOTAMs from FSS briefers upon request.

21. OMEGA AND OMEGA/VLF NAVIGATION SYSTEMS

a. OMEGA

(1) OMEGA is a network of eight transmitting stations located throughout the world to provide worldwide signal coverage. These stations transmit in the Very Low Frequency (VLF) band. Because of the low frequency, the signals are receivable to ranges of thousands of miles. The stations are located in Norway, Liberia, Hawaii, North Dakota (USA), La Reunion, Argentina, Australia, and Japan.

(2) Presently each station transmits on four basic navigational frequencies: 10.2 kHz, 11.05 kHz, 11.3 kHz, and 13.6 kHz, in sequenced format. This time sequenced format prevents interstation signal interference. With eight stations and a silent .2-second interval between each transmission, the entire cycle repeats every 10 seconds.

(3) In addition to the four basic navigational frequencies, each station transmits a unique navigation frequency. An OMEGA station is said to be operating in full format when the station transmits on the basic frequencies plus the unique frequency. Unique frequencies are presently assigned as follows:

STATION	LOCATION	FREQUENCY
Station A	Norway	12.1 kHz
Station B	Liberia	12.0 kHz
Station C	Hawaii	11.8 kHz
Station D	North Dakota	13.1 kHz
Station E	La Reunion	12.3 kHz
Station F	Argentina	12.9 kHz
Station G	Australia	13.0 kHz
Station H	Japan	12.8 kHz

b. VLF

(1) The U.S. Navy operates a communications system in the VLF band. The stations are located worldwide and transmit at powers of 500-1000 kW. Some airborne OMEGA receivers have the capability to receive and process these VLF signals for navigation in addition to OMEGA signals. The VLF stations generally used for navigation are located in Australia, Japan, England, Hawaii and in the U.S. in Maine, Washington and Maryland.

(2) Although the Navy does not object to the use of VLF communications signals for navigation, the system is not dedicated to navigation. Signal format, transmission,

and other parameters of the VLF system are subject to change at the Navy's discretion. The VLF communications stations are individually shut down for scheduled maintenance for a few hours each week. Regular NOTAM service regarding the VLF system or station status is not available. However, the Naval Observatory provides a taped message concerning phase differences, phase values, and shutdown information for both the VLF communications network and the OMEGA system (phone 202-653-1757).

c. Operational Use of OMEGA and OMEGA/VLF

(1) The OMEGA navigation network is capable of providing consistent fixing information to an accuracy of plus or minus 2 NM depending upon the level of sophistication of the receiver/processing system. OMEGA signals are affected by propagation variables which may degrade fix accuracy. These variables include daily variation of phase velocity, polar cap absorption, and sudden solar activity. Daily compensation for variation within the receiver/processor, or occasional excessive solar activity and its effect on OMEGA, cannot be accurately forecast or anticipated. If an unusual amount of solar activity disturbs the OMEGA signal enlargement paths to any extent, the U.S. Coast Guard advises the FAA and an appropriate NOTAM is sent.

(2) At 16 minutes past each hour, WWV (Fort Collins, Colorado) broadcasts a message concerning the status of each OMEGA station, signal irregularities, and other information concerning OMEGA. At 47 minutes past each hour, WWVH (Hawaii) broadcasts similar information. The U.S. Coast Guard provides a taped OMEGA status report (703-866-3801). NOTAMS concerning OMEGA are available through any FSS. OMEGA NOTAMs should be requested by OMEGA station name.

(3) The FAA has recognized OMEGA and OMEGA/VLF systems as an additional means of en route IFR navigation in the conterminous United States and Alaska when approved in accordance with FAA guidance information. Use of OMEGA or OMEGA/VLF requires that all navigation equipment otherwise required by the Federal Aviation Regulations be installed and operating. When flying RNAV routes, VOR and DME equipment is required.

(4) The FAA recognizes the use of the Naval VLF communications system as a supplement to OMEGA, but not the sole means of navigation.

22. VHF DIRECTION FINDER

a. The VHF Direction Finder (VHF/DF) is one of the common systems that helps pilots without their being aware of its operation. It is a ground based radio receiver used by the operator of the ground station. FAA facilities that provide VHF/DF service are identified in the Airport/Facility Directory.

b. The equipment consists of a directional antenna system and a VHF radio receiver.

c. The VHF/DF receiver display indicates the magnetic direction of the aircraft from the ground station each time the aircraft transmits.

d. DF equipment is of particular value in locating lost aircraft and in helping to identify aircraft on radar. (See PARA. 452 - DIRECTION FINDING INSTRUMENT APPROACH PROCEDURE.)

23. INERTIAL NAVIGATION SYSTEM (INS)

A totally self-contained navigation system, comprised of gyros, accelerometers, and a navigation computer, which provides aircraft position and navigation information in response to signals resulting from inertial effects on system components, and does not require information from external references. INS is aligned with accurate position information prior to departure, and thereafter calculates its position as it progresses to the destination. By programming a series of waypoints, the system will navigate along a predetermined track. New waypoints can be inserted at any time if a revised routing is desired. INS accuracy is very high initially following alignment, and decays with time at the rate of about 1-2 nautical miles per hour. Position update alignment can be accomplished inflight using ground based references, and many INS systems now have sophisticated automatic update using dual DME and or VOR inputs. INS may be approved as the sole means of navigation or may be used in combination with other systems.

24. DOPPLER RADAR

A semiautomatic self-contained dead reckoning navigation system (radar sensor plus computer) which is not continuously dependent on information derived from ground based or external aids. The system employs radar signals to detect and measure ground speed and drift angle, using the aircraft compass system as its directional reference. Doppler is less accurate than INS or OMEGA however, and the use of an external reference is required for periodic updates if acceptable position accuracy is to be achieved on long range flights.

25. FLIGHT MANAGEMENT SYSTEM (FMS)

A computer system that uses a large data base to allow routes to be preprogrammed and fed into the system by means of a data loader. The system is constantly updated with respect to position accuracy by reference to conventional navigation aids. The sophisticated program and its associated data base insures that the most appropriate aids are automatically selected during the information update cycle.

26. GLOBAL POSITIONING SYSTEM (GPS)

A space-base radio positioning, navigation, and time-transfer system being developed by Department of Defense. When fully deployed, the system is intended to provide highly accurate position and velocity information, and precise time, on a continuous global basis, to an unlimited number of properly equipped users. The system will be unaffected by weather, and will provide a worldwide common grid reference system. The GPS concept is predicated upon accurate and continuous knowledge of the spatial position of each satellite in the system with respect to time and distance from a transmitting satellite to the user. The GPS receiver automatically selects appropriate signals from the satellites in view and translates these into a three-dimensional position, velocity, and time. Predicatable system accuracy for civil users is projected to be 100 meters horizontally. Performance standards and certification criteria have not yet been established.

27—29. RESERVED

THIS PAGE IS INTENTIONALLY LEFT BLANK.