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Microwave Landing Systems For Heliport Operators, Owners, and Users

Kristen J. Venezia
Edwin D. McConkey

Systems Control Technology, Inc.
2326 S. Congress Ave., Suite 2A
West Palm Beach, Florida 33406

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This document contains information on the utilization of the Microwave Landing System (MLS) at heliports and helipads. It was designed to familiarize heliport operators and users with the features of the MLS and its capabilities in supporting heliport operations. For this reason the major sections of the document present information on MLS siting, operational characteristics, selecting and specifying an MLS system. In addition, other sections provide additional MLS information to familiarize pilots with MLS avionics, pilot training requirements and aircraft performance considerations.

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1.0 INTRODUCTION

This document contains information on the utilization of the Microwave Landing System (MLS) at heliports. It was designed to familiarize heliport operators and users with the features of the MLS and its capabilities in supporting heliport operations. For this reason the major sections of the document present information on MLS siting, operational characteristics, and selecting and specifying an MLS system. In addition, other sections provide additional MLS information to familiarize pilots with MLS avionics, pilot training requirements and aircraft performance considerations.

1.1 BACKGROUND

The Instrument Landing System (ILS) has been the world's standard precision approach system since 1948. Throughout the years the system has undergone significant improvements in performance and dependability. However, an ILS was not developed with helicopters in mind. Due to its characteristics, an ILS installation is physically not feasible for most heliports and helipads. The current transition from ILS to MLS will provide, for the first time, capability of precision approaches at heliports and helipads. Many helicopter operations could be greatly enhanced by the use of an Instrument Flight Rule (IFR) capability.

Helicopters with IFR capabilities have been available for 25 years, yet there are currently no IFR heliports in the United States. At the same time, the number of heliports (approximately 4000, 400 of these being public-use) is increasing concurrent with an increase in the number of rotorcraft and rotorcraft operations. The viability of accommodating these increases depends on the ability of helicopters to operate independent of other aircraft and to perform all weather operations at both airports and heliports. The basic design concept of the MLS system inherently provides the flexibility that is so greatly needed for helicopter IFR operations.

The MLS could be used to accommodate this increase in growth by allowing for approach procedures that would take advantage of helicopter capabilities. Approach procedures, developed for ILS and ATC terminal areas, have been designed specifically for fixed-wing aircraft, constraining helicopters to fixed-wing procedures. Only recently have Terminal Instrument Procedures (TERPS) been developed to capitalize on the unique capabilities of helicopters. However, the procedures that have been developed up to this time still do not permit the helicopter to fully utilize its unique flight characteristics in the approach and landing phase of flight. New navigation equipment and new procedures are needed to make use of these characteristics. MLS has many features which makes it a very strong contender for fulfilling this role.

The ILS will continue to be a primary precision approach system for at least a decade. The International Civil Aviation Organization (ICAO) has established a protection date of 1995 for ILS at international airports. However, as the transition from ILS to MLS takes place, TERPS criteria, flight inspection, air traffic, and other elements of the airspace system will accommodate helicopter operations and not concentrate, as in the past, on a fixed-wing environment.

2.0 OPERATIONAL CHARACTERISTICS

As with ILS, MLS provides both lateral and vertical guidance for aircraft on approach to, and landing on, a runway or heliport. An azimuth station (AZ) supplies the lateral guidance signals, while the elevation station (EL) is used for the vertical guidance signals. Collocated with the AZ is a Distance Measuring Equipment (DME) transponder which provides continuous range information. Figure 2.1 shows a typical configuration of the AZ, EL and DME antennas at a heliport. Several unique characteristics set MLS apart from ILS. These include:

- Coverage Volume
- Integral Precision DME (DME/P)
- Frequency Allocation
- Integral Data (Basic and Auxiliary)

Coverage Volume

The AZ station is analogous to an ILS localizer, but has much wider proportional guidance coverage. The FAA MLS AZ proportional guidance coverage is ±40 degrees from the azimuth reference radial, as opposed to ±3 to ±6 degrees of coverage for the ILS localizer. The EL station is analogous to the glide slope facility of the ILS. However, the FAA MLS EL transmitter provides vertical signal coverage as low as 0.9 degrees (as influenced by line-of-sight) up to 15 degrees. This allows for the possibility of a wide range of glide path angles at a particular landing facility (from 3° to 12°). The present ILS glide slope transmitter coverage is fixed at a 3 degree glide slope. MLS coverage volumes are shown in Figure 2.2. (It should be noted that the service volume for the AZ station differs slightly from the service volume of the EL station. The AZ station provides coverage over the runway. The horizontal coverage of the EL station must be at least as wide as the azimuth proportional coverage.)

The Back Azimuth Station (BAZ) is similar to the AZ. The BAZ is somewhat analogous to the back course of an ILS localizer, as it is intended to supply guidance for missed approaches and for departures. Due to its larger area coverage, as compared to ILS, the BAZ station is far more useful for missed approaches and departures. To utilize this function, a tail antenna may be required because of aircraft structure shielding of antenna locations on the forward part of the aircraft.

For a runway equipped with dual MLS facilities (one for each direction), the azimuth stations can function either as an AZ or as a BAZ, depending on the approach guidance direction selected. For full precision approach capability in either direction, each MLS facility would need its own EL and DME/P.

Integral Precision DME (DME/P)

The precision DME transponder (ground station) is compatible with standard DME avionics. It provides precision DME guidance coverage of

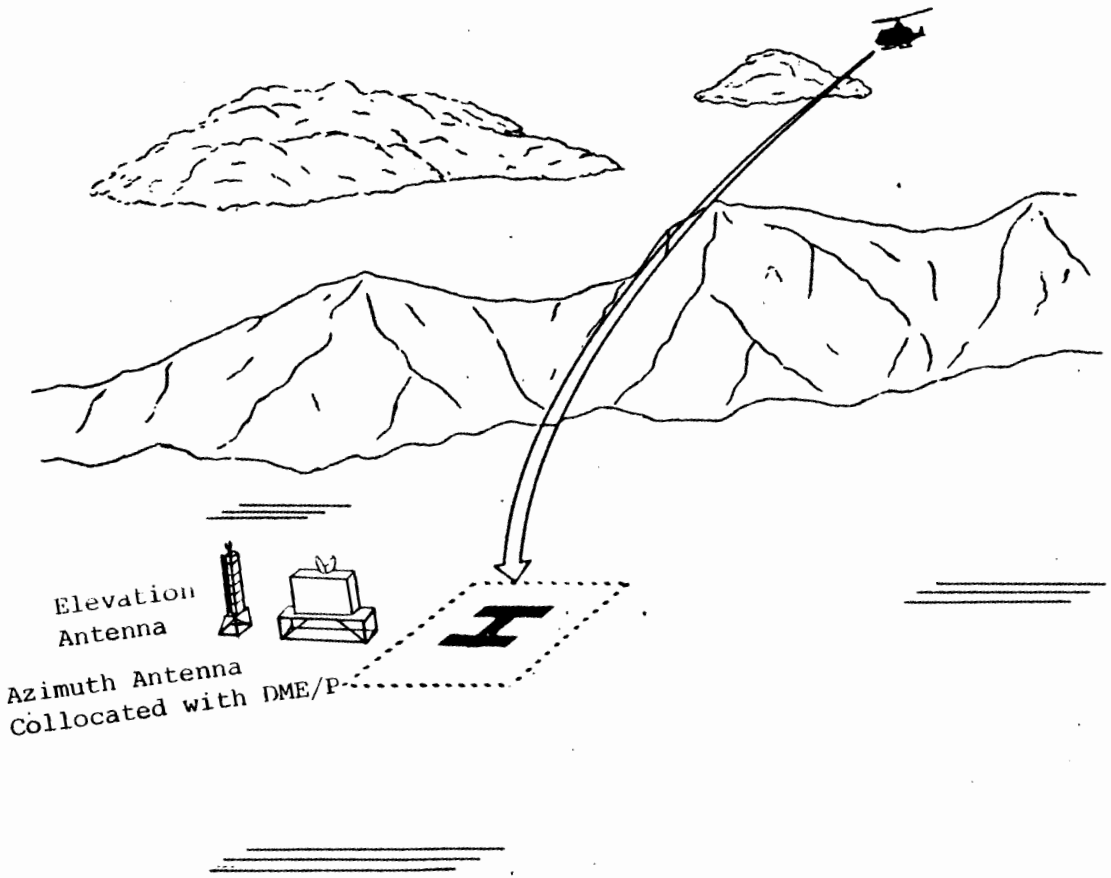

Figure 2.1 AZ, EL, and DME/P Antenna Configuration

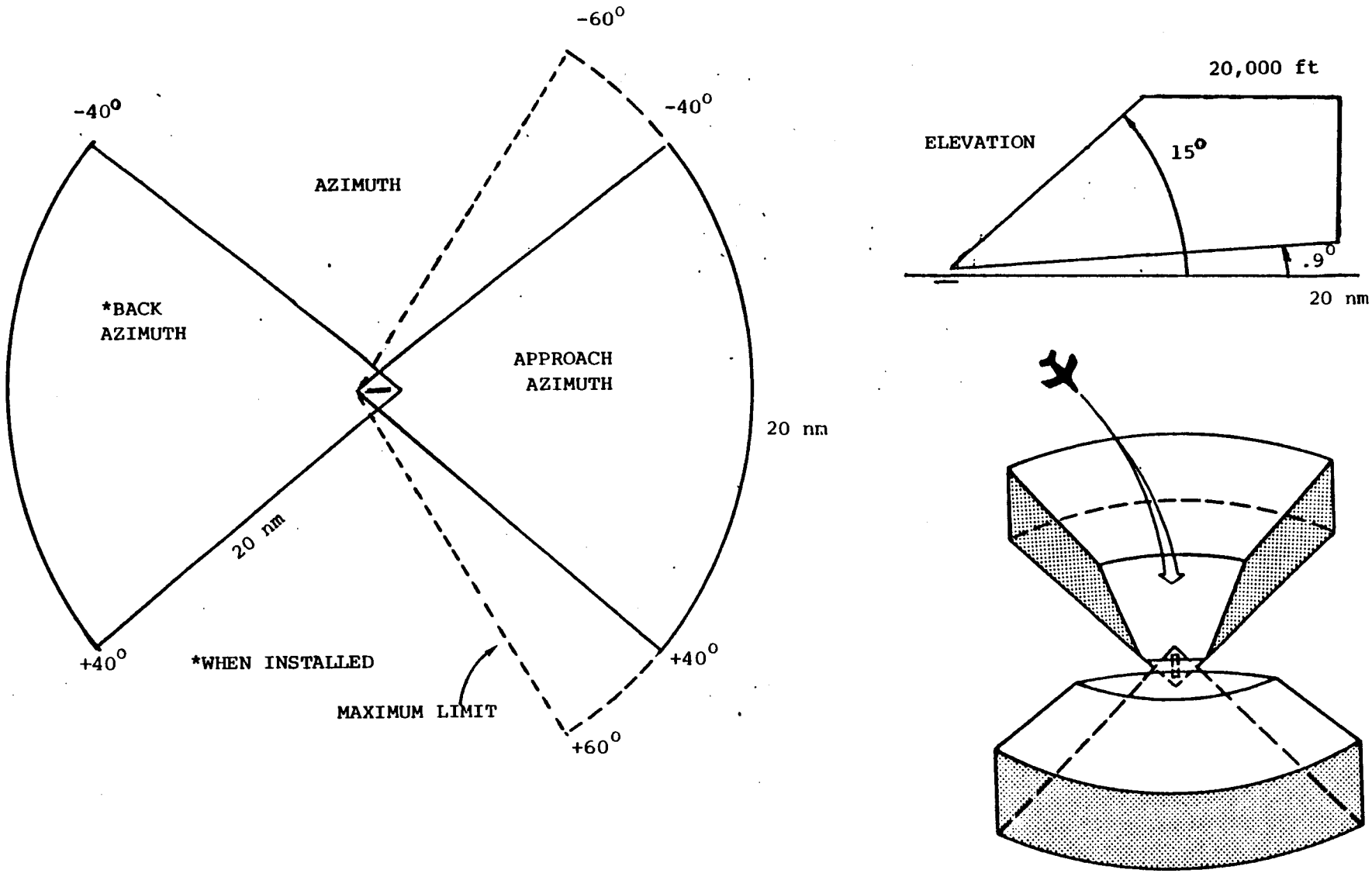

Figure 2.2 Coverage Volumes

360° horizontally, within a coverage of 0.9 to 15 degrees elevation up to 20,000 feet. The accuracy of the range measurements of a DME/P make it applicable for precision approach and landing.

Precision DME transponders will be used with FAA installations. Non-federal systems may use either DME/P or standard DME (DME/N). Both the DME/N and DME/P avionics are interoperable with the DME/N and DME/P transponders, with some corresponding accuracy degradation when DME/N ground system or avionics are used.

Frequency Allocation

The microwave landing system received its name from the region of the electromagnetic spectrum in which it operates. The MLS operates at 5031 to 5090.7 MHz, 46 times the ILS localizer frequency and 16 times the ILS glide slope frequency. At these higher frequencies the MLS can provide the desired signal in space largely independent of local terrain features, tidal effects, snow accumulation, etc. This is due to the fact that the short wavelength signal of MLS is influenced by a much smaller immediate area around the MLS sites than is the case with the much longer ILS wavelengths. The net result is that heliports may be able to accept MLS installations with minimal site preparation. As with ILS, MLS coverage is limited by line of site.

Integral Data

Because the MLS provides flexibility in the design of instrument approach procedures (as well as siting of ground equipment), the airborne system and flight crew need a considerable amount of data to describe the specific features of a particular approach. An MLS data link, which consists of the Basic Data Function and the Auxiliary Data Function, provides these data to the aircraft. Basic data includes the following types of data: coverage limits, minimum glidepath, station identification, and ground equipment performance level.

Auxiliary data currently includes the three dimensional siting geometry of the ground antennas. In the future, auxiliary data may include the following types of data:

a. Approach, missed approach, and departure course data - These include data to define initial and final approach paths, and, where provided, missed approach and departure paths in support of two- or three-dimensional, area navigation-based (RNAV) operations.

b. Operational data - These include data the pilot would normally need to plan and execute the approach, such as runway conditions.

These data functions may be of special significance to heliport users who may need unique approach procedures for a particular facility.

The unique operational characteristics of MLS discussed previously could enhance the utility of fixed-wing aircraft and helicopters by providing for IFR procedures and independent flight paths, which cannot be applied through the use of an ILS. Improvements within the operational ATC environment, as a result of incorporating the MLS into the ATC system, are critical to the increased capacity of airports and heliports. These improvements include:

- Lower minimums
- Complex approach profiles
- Noise abatement procedures
- Obstacle clearance capabilities

Lower Minimums

Without IFR procedures and approved landing aids, or even with non-precision approach aids, helicopter operations can be delayed or even cancelled, producing an economic burden upon the helicopter operator. The availability of lower minimums, provided by MLS, increases the reliability of operations for heliport owners, operators and users who equip their facilities.

Complex Approach Profiles

MLS should allow airports to handle more IFR traffic. With the availability of MLS and appropriate procedures, the air traffic system may be capable of supporting simultaneous aircraft MLS approaches from different approach directions. This will greatly facilitate helicopter operations, allowing them to operate independent of fixed-wing air traffic.

Noise Abatement Procedures

The use of MLS can facilitate the development of approach procedures for the purpose of avoiding noise sensitive areas. This feature may be helpful to heliport operators when they are trying to maximize operations while satisfying environmental concerns.

Obstacle Clearance Capabilities

Procedures similar to those for noise abatement can be developed to navigate in areas of high terrain or numerous obstructions. Obstacle avoidance routings are applicable to helicopter operations in the "concrete canyons" of urban central business districts, in the mining areas of Applachia and in areas with severe natural barriers such as

Aspen, Colorado and Valdez, Alaska. As before, the MLS could provide guidance to allow for flight paths which would facilitate the use of all weather operations that would otherwise be prohibited.

Many of the improvements obtained from using an MLS become even more beneficial when an area navigation (RNAV) or other navigation computer is integrated with airborne MLS equipment. Segmented approaches, as well as curved approaches, could be performed.

3.0 OPERATIONAL AND ECONOMIC BENEFITS

The implementation of the MLS will provide both operational and economic benefits to the National Airspace System (NAS) user community. This section analyzes these operational and economic benefits associated with having an MLS facility at a heliport. The analysis is structured around the development of establishment criteria contained in Reference 19 for a standard MLS with approach lights.

Operationally, the advantages of the MLS over the ILS are substantial:

- The use of narrow scanning beams minimizes multipath reflection problems from buildings, aircraft, vehicles, terrain, water, etc. Therefore, the MLS can be implemented and provide precision approach capabilities at locations were ILS cannot be utilized.

- Wide proportional signal coverage provides for flexible, complex approaches which will facilitate growth and increased airport capacity as well as fuel savings and allow for noise abatement procedures. Complex approaches are those which utilize segmented or curved paths. Complex approach profiles could resolve airspace conflicts during IFR operations for a heliport in close proximity to an airport or another heliport.

From Reference 19, the economic criteria for the establishment of an MLS facility, is based on the following:

- Safety benefits.

- Aircraft operating costs (decreased due to the shortened flight paths provided by the MLS).

- Avoidance of flight disruptions (realized by allowing a heliport to provide IFR operations to traffic when weather would otherwise have closed it).

- Investment costs (compared to ILS, investment costs, including site preparation expenses, are less due to the characteristics of the propagated signal).

- Operating and maintenance costs (reduced because of higher reliability, as compared to ILS, and the integration of the Remote Maintenance Monitor System (RMMS). The RMMS will only be applicable to FAA MLS facilities. Similar functions can be utilized at private facilities to monitor the MLS equipment).

An initial estimation of the viability of an MLS at a heliport can be determined from Annual Instrument Approach (AIA) criteria. To determine whether a heliport meets the AIA criteria, several steps must be taken, as described in Reference 19:

1) Determine the lowest approach minimums currently authorized at the candidate heliport.

2) Reference Table 3.1 to select the required number of AIA's at the candidate heliport for the minimums referenced in the preceding step. Use of the AIA parameter implies that a heliport has an existing instrument approach procedure. Historically this assumption has not been valid at heliports. Because of this, no data is currently available for the number of annual instrument approaches at these facilities. Estimates of the AIA parameter can be made based on the percent of operations cancelled due to weather, the percent of time weather is at or near the desired minimums, and the number of IFR equipped helicopters using the facility. The following discussion is provided as an example.

   Table 3.1 was derived by taking 5.7% (annual percentage of total helicopter operations that are IFR) of the required annual itinerant operations necessary to achieve a benefit/cost ratio of unity (Reference 1). The annual percentage of IFR operations was derived using References 22 and 23, which state, respectively, that 3.5% and 7.9% of all helicopter operations are aborted or cancelled due to IFR conditions. A nominal value (5.7%) between 3.5% and 7.9% was used. As the MLS is implemented at heliports and helipads, and the number of IFR equipped helicopters increase, the percentage of IFR helicopter operations will also increase, altering the values in Table 3.1.

3) Compute the number of recorded AIA's at the candidate runway as follows:

a. Determine the AIA's by on-site survey, or

b. Calculate AIA's from the following estimation model.

$$\text{instrument approaches} = \frac{\text{itinerant operations}}{2} \times (\text{PIFR} - \text{PC})$$

PIFR is the probability of weather with either ceiling less than 1500 feet or visibility less than 3 miles. PC is the probability of weather below MLS minima for the instrument approach which has the lowest minima. Details of similar estimation models can be found in Appendix C of Reference 19.

4) Determine the ratio of recorded to required AIA's for the candidate heliport.

$$\frac{\text{Recorded AIA}}{\text{Required AIA}} = \text{X.XX}$$

Table 3.1 MLS Qualifying (Required) AIA Count

Current Minimums	500-1	700-1½	1000-1½
Annual Instrument Helicopter Operations	2309	1119	699

As a general criteria, a ratio of 1.0 or more may indicate that an MLS is a viable precision landing system for the candidate heliport. However, other factors may be considered. The demand curve for helicopter operations does not follow a linear trend, characteristic of fixed-wing operations. Demand is very sensitive to schedule reliability. This must be recognized either exclusively, or along with AIA criteria.

To further validate the viability of implementing an MLS at a heliport, a comparison can be made between the present value of the quantitative benefits of installing an MLS and the present value of the establishment costs (benefits/cost criteria). The MLS benefits are compared with MLS costs over a 15 year time frame. The costs include investment costs and annual costs. From Reference 19, these costs are as follows:

Costs	MLS
Investment	
Acquisition	$462,000
Installation	$185,000
Nonrecurring Logistics	$ 82,000
	$729,000
Annual O & M	$ 40,000

These values reflect the cost of an FAA Type I MLS facility such as that described in Section 4.0. The costs for a non-federal MLS facility will vary and may cost less than that listed above.

Nonrecurring logistic support costs could include costs for providing the initial spares and support equipment, for training maintenance personnel, for providing the necessary technical manuals and other documentation, and for transporting the system to its destination.

From Reference 19, present value cost is given by:

$$PV_c = (7.976 \times C1) + C2$$

where: C1 = Annual Costs
C2 = Investment Costs

Therefore, from the above dollar values, the present value of the MLS is approximately $1,048,040. This is a life cycle cost over a 15 year period.

The benefits used in developing the establishment criteria are:

- Improved safety
- Reduced flight disruptions

The safety and reduced flight disruption benefits are derived by discounting future benefits to the present at a 10 percent compound rate. The summation of the safety and reduced flight disruption benefits results in the total benefits.

Safety benefits of precision landing aids are estimated by comparing the incidence and resulting costs of non-precision approach accidents with the same for precision approach accidents to estimate a differential cost per approach. This differential is then multiplied by the number of annual precision instrument approaches to complete the safety benefit for a given year. Accident costs are measured by the frequency and resulting costs of fatalities, injuries (serious and minor) and aircraft damage. From Reference 1, the overall safety benefits could be approximated at $41 per approach.

Reduced flight disruption benefits provided by a precision landing system are the number of precision instrument approaches made when weather limits are below non-precision approach minimums over the useful life of the system. The reduced flight disruption benefits include: reduced aircraft flight time; avoided passenger handling expenses; avoided profit loss due to passenger cancellations and diversions; and saved passengers' time. From Reference 1, the following costs per flight disruption are shown for five operational areas:

Operational Area	Cost Per Disruption
City center	$290
Major hub airport	$350
Non hub airport	$240
Remote area	$190
Offshore	$210

As with the annual instrument approach criteria, the benefit/cost criteria is met when the ratio of benefits to costs is 1.0 or greater. This indicates that the benefits of implementing an MLS outweigh the costs. A ratio value less than 1.0 would indicate that the benefits are not sufficient to substantiate the costs of an MLS. From Reference 1, the estimates of the number of average daily itinerant operations required to achieve a benefit/cost ratio of unity, with alternative system minimums for five operational areas, are listed in Table 3.2.

Table 3.2 Average Daily Operations

	Alternative System Minimums		
Operational Area	500-1	700-1½	1000-1½
City center	90	44	27
Major hub airport	100	51	32
Non hub airport	110	52	33
Remote area	130	63	39
Offshore	125	59	37

It should be noted that the benefit and cost values previously discussed are preliminary. Reference 19 should be monitored for future updates.

Elements of a non-federal MLS facility which may vary in terms of costs and/or benefits include:

- Distance measuring equipment
- Proportional coverage limits
- Maintenance requirements
- Beamwidth specifications
- Remote maintenance monitoring requirements

Distance measuring equipment costs and benefits may vary between the utilization of a precision DME (DME/P), a standard DME (DME/N). Proportional coverage of ±10, ±40 or ±60 degrees, along with the appropriate beamwidth also affect the costs and benefits of the system. These MLS elements are discussed further in Section 4.0. Remote maintenance monitoring must be considered, along with the decision to provide for maintenance or contract for maintenance.

In addition, there are broader operational issues beyond cost/benefit criteria. Costs and benefits may vary depending on the type of MLS system specified. Other benefits such as reliability of schedule, increased safety and decreased liability may supercede the cost/benefit criteria and need to be addressed. Finally, there may be other considerations for cost, such as the implementation of a heliport as an integral part of a hub and spoke network, which limit the flexibility of the decision.

4.0 SELECTING AND SPECIFYING AN MLS SYSTEM

Once the economic and operational benefits of the MLS at a particular facility have been determined, and the decision has been made to implement the MLS, the proper equipment must be selected to realize these benefits. A typical FAA MLS ground facility located at a heliport would consist of:

- AZ antenna
- EL antenna
- DME/P (antenna and transponder)
- AZ, EL and DME field monitors
- Heating (for batteries and deicing)
- Uninterruptable power supply
- Mounting bases for AZ, EL and field monitors
- Electronic cabinets
- Remote control and status unit

Optional equipment, which may be considered, includes:

- Back azimuth antenna with associated electrical components
- Additional functions in the MLS signal format

The above list is shown only to provide an example of the components needed for an MLS facility. When specifying the requirements for a non-federal MLS system the following must be considered:

- Collocated or split site
- Proportional coverage
- Beamwidth
- Type of distance measuring equipment
- IFR lighting and marking system
- Category of operation
- Maintenance
- Contractor and contractor support
- Approach procedures
- Commissioning and periodic flight inspections

The hardware components and performance requirements of the MLS facility must be specifically stated to ensure the acquisition of equipment which meets the needs of the heliport. The configuration of the facility can be either a split site or collocated system. If sufficient real estate is available, a split site system may be optimum. Generally, a split site system is one in which the elevation and azimuth antennas are separated by a distance of not less than 200 meters (656 feet). However, if there are constraints on the available real estate, a collocated system may be necessary. A collocated system is such that the AZ, EL and DME/P antennas are all located together (a distance less than 200 meters). A facility configuration was illustrated in Figure 2.1.

The amount of proportional coverage required by the AZ antenna may depend on such things as traffic flow, and types of approach profiles desired (straight-in, segmented or curved). This coverage may vary from ±10 degrees to ±60 degrees, depending on the system. Proportional coverage of ±10 degrees may be adequate for straight-in approaches. Proportional coverage of ±40 and ±60 degrees is applicable for complex segmented and curved approach profiles. The wider proportional coverage may provide two other benefits. First, it may allow simultaneous approaches and departures on separate radials of the same MLS ground system. Second, it may allow missed approaches to be done without the need for a separate back azimuth system (i.e. approach on the -30° radial and missed approach on the +30° radial).

The vertical proportional coverage provided by the EL antenna will generally be 0.9 to 15 degrees, influenced by line-of-sight, providing glide path guidance from 3 degrees to 12 degrees.

Table 4.1 shows the range of antenna characteristics that are available. Beamwidth selection is based upon at least 2 items; (a) accuracy at threshold, which is given in feet and converts to an angle which depends on the distance to threshold. The receiver measures angle and the accuracy of measurement is a function of the beamwidth; and (b) the multipath environment; so a reflector is not illuminated by the beam at the same time the beam is illuminating the aircraft at threshold. An in-beam multipath can cause errors in the receiver processing. Beamwidth is a factor in equipment cost; a narrower beamwidth is generated by a larger aperture antenna with more radiators and associated circuits. For additional information on azimuth performance and beamwidth requirements, refer to FAR Part 171, Subpart J, Section 313.

Table 4.1 Antenna Characteristics

Antenna	Beamwidth	Coverage
Azimuth	1° to 3°	±10° minimum ±60° maximum
Elevation	1° to 2°	0.9° to 15°

The type of distance measuring equipment may depend on the approach profiles desired at a particular facility. For accuracy, the optimum equipment would be a precision DME (DME/P). Alternatively, a DME/N may be economically more feasible but would not offer the lowest possible minimums. If segmented profiles are desired, DME/N may provide the necessary accuracy required. However, the DME/P is needed when complex segmented or curved profiles are established. Also, if complex vertical profiles are developed, the accuracy requirements may be dictated by the DME/P. This is due to the steep approach angle capability of helicopters. As the approach angle increases, with a given decision height, the available decelerating distance decreases. Depending on the accuracy of the facility, minimums may be affected. Minimum standard performance requirements for DME components are specified in FAR 171, Subpart G.

A heliport intended for IFR approaches will need an IFR lighting and marking system. The system chosen would have to be compatible with the limited space restrictions usually available at heliport locations, particularly in urban areas. Also, the IFR helicopter approach lighting system would have to be sufficiently different from the standard fixed-wing configurations as to prevent confusion between the two types of systems. If the elevation antenna is located in front of the approach end of the helipad, in the approach area, the portion of the approach lighting system in front of the pad may have to be extended to provide the necessary early visual contact at the decision height.

The category of operations may need to be determined for proper equipment acquisition. If CAT I operations are desired, the minimum system requirements, specified in FAR Part 171, Subpart J, are adequate. If CAT II operations are necessary, reliability/availability may dictate the need for additional transmitters, etc. For CAT III operations, an upgraded MLS facility should be specified.

The MLS facility will include several forms of monitoring:

- Integral monitoring
- Field monitoring
- Maintenance monitoring

The internal and field monitors are used primarily for performance monitoring. They also provide input for maintenance monitoring and fault diagnostics. Maintenance monitoring will provide data on the operational performance of the MLS to a remote location. It may also provide instant alert if any parameters degrade or fail.

There are three methods of maintenance monitoring:

1) FAA Remote Maintenance Monitoring System (RMMS).
2) Private purchase of a maintenance monitoring system.
3) Maintenance monitoring by a contractor.

The RMMS is a specific FAA maintenance policy for FAA MLS systems, to reduce maintenance costs through economics of scale by centralizing maintenance monitoring at particular FAA locations in each region. A private purchase of a maintenance monitoring system is an option for non-federal MLS systems. In this case the monitoring function may be remotely performed by designated personnel. Another option for a non-federal MLS system may be to have the maintenance monitoring function performed by a specified contractor.

A facility procurement can be implemented via a sole source or a competitive award to a contractor. Specific requirements of the contractor may include:

- Engineering drawings showing location, description, requirements for footings, power, communication lines, data lines and lightning protection.

- Installation of the MLS facility in accordance with the above drawings and specifications, and execution of all the necessary leveling and alignment adjustments, including system test and operation required for flight inspection by the FAA.

- Recommendation of a location for, and installation of, the IFR lighting and marking system.

- Recommendation of a location for, and installation of, the MLS monitor antennas.

- Proper spares to support the system over a specified time period. These spares may include parts, components and assemblies that may require on-site replacement.

The development of procedures (approach, departure and missed approach) should be performed by the FAA. Upon completion of the procedures, the commissioning of the facility, by the FAA, can be executed. Commissioning and flight inspection, and procedure development are discussed further in Sections 7.0 and 8.0, respectively.

5.0 SITING THE SYSTEM

Information concerning the proposed site should be gathered in order to become acquainted with the heliport and adjacent areas. This information may include:

- Obstruction clearance charts
- Topographic charts of the heliport area
- Types of service
- Proposed approach paths
- Ground traffic patterns
- Type of MLS proposed and associated data
- Indication of heliport property lines

From this information, nominal MLS component sites can be selected. This will require discussions with airport management personnel and FAA Flight Standards, Air Traffic, Airports, and Airways Facilities Divisions.

Various operational and technical considerations need to be evaluated prior to the detailed selection of the MLS hardware sites. The operational considerations include:

- Deceleration (stopping) distance
- Approach speeds and glide path angles
- Ceiling and visibility minimums
- Airspace consumption
- Obstacle clearance and noise abatement

Technical factors that should be addressed include:

- Multipath
- Shadowing
- Critical areas
- Steering sensitivity

Operational Considerations

Ceiling and visibility minimums, as well as the decelerating (stopping) distance, are key elements of siting the MLS equipment. The location of the MLS equipment must provide for minimums that will enhance the utility of existing or proposed landing areas. In addition, the proposed approach path must allow for adequate maneuvering to the helipad (including deceleration distance).

Approach speeds and glide path angles may dictate the acceptable minimums and deceleration distances. As the glide path angle increases, the available deceleration distance decreases which could result in higher minimums to compensate. The feasibility of decelerating helicopter approaches at 30 or 40 knots should allow for lower minimums than could be achieved at approach speeds of 60 knots or greater. It

should be recognized that work on the application of lower approach speeds and decelerating approaches is underway both by the FAA and helicopter manufacturers. However, much work is yet to be done.

The ceiling/visibility minimums and the deceleration distance are dependent on the location of the elevation antenna in relation to the approach end of the helipad. Lower minimums are attainable with the elevation antenna placed ahead of the approach end of the helipad. This arrangement is shown in Figure 5.1. From Reference 11, total deceleration distance data are shown in Table 5.1. This table contains "measured" mean total deceleration distance in feet (from the decision height to the landing zone) where the pilot maintained a 60 knot approach speed until reaching decision height. This work was conducted using pilots with minimal training and flying at maximum workload. Deceleration distances for decision heights of 50, 100, 150 and 200 feet are listed. Given glide path angle, decision height and a 60 knot range rate, Table 5.1 can be used to determine a preliminary location for the elevation antenna.

Table 5.1 Total Deceleration Distance Data (60 Knot Range Rate)

Descent Angle(Deg)	Mean Total Deceleration Distance Data (feet)			
	50' DH	100' DH	150' DH	200' DH
4	400	1377	1385	
5	739	1617	1528	1727
6	960	1392	1571	1860
7	940	1327	1529	1816
8	934	1135	1397	1691
9	823	1089	1536	1661
10	823	1273	1373	1567
11	731	1376	1234	1574
12		1214	1302	1287

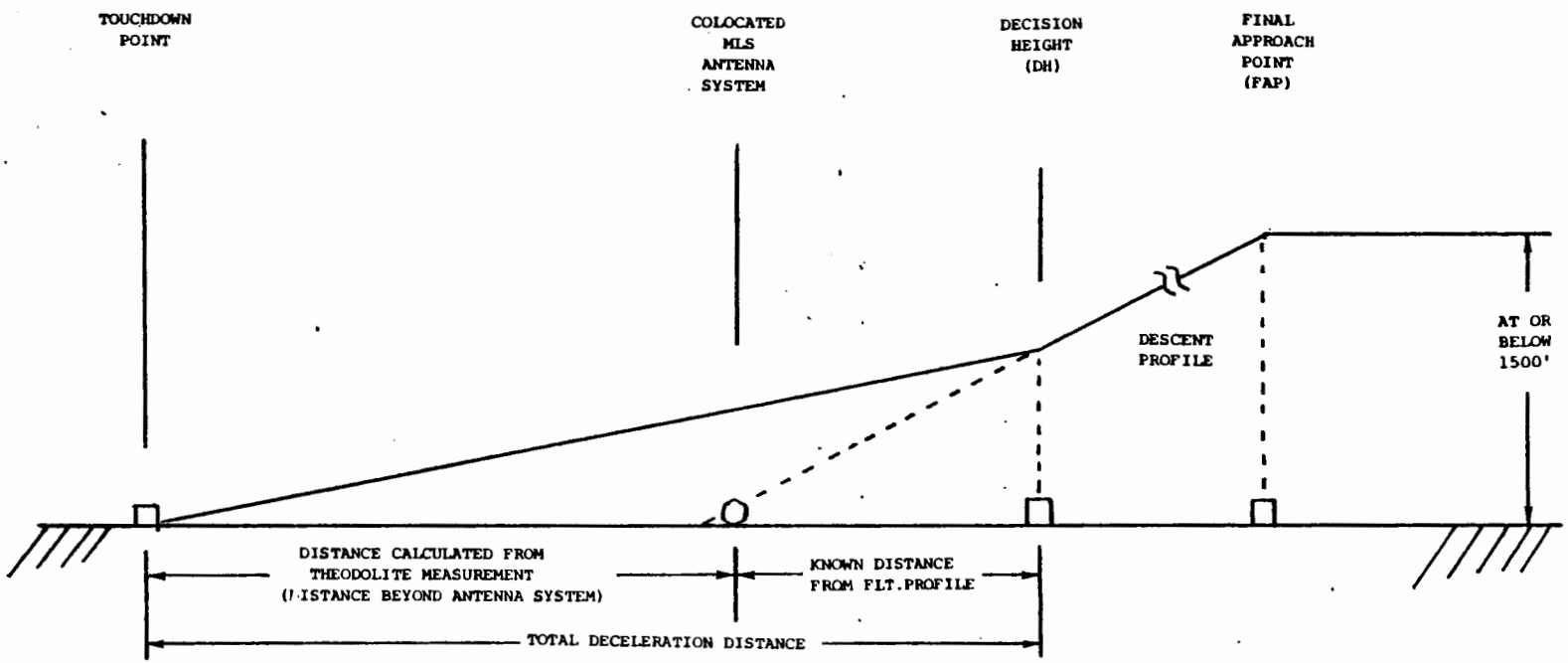

Figure 5.1 Flight Profile

The assumption associated with Table 5.1 is that there are no restrictions to the amount of real estate available at a heliport. When real estate problems exist, the MLS equipment will need to be collocated close to the helipad (approximately 200 feet). Collocation of the system 200 feet to one side of the helipad will require the decision height to be located 1800 to 3000 feet from the approach end of the helipad. This requirement will provide for a ±3.5 degree course width along with a deceleration distance which is "comfortable" for pilots to perform an approach.

The siting of the MLS equipment should provide for appropriate approach paths particular to the heliport that is being equipped. The Terminal Instrument Procedures (TERPS) criteria (Reference 3) for helicopter split site procedures is useful to assess the airspace consumption requirements. The proposed approach paths selected must be feasible from an operational point of view in that they can be easily followed by the class of user for whom they are designed. (TERPS criteria for the collocated MLS are expected to be available in late 1987.)

Another part of MLS siting is the problem of obstacle clearance, which must be considered when designing flight paths. Normally, obstacles are a problem only within a few miles surrounding the heliport property, unless there are geographical features of extreme height in relation to the landing area, such as hills or mountains. Proposed locations for the MLS hardware should not penetrate the planes defined in FAR Part 77, Subpart C for Precision Approach Runways. This FAR will provide for aeronautical studies of obstructions to air navigation, to determine their effect on the safe and efficient use of airspace. Assistance may be provided by the manufacturer of the MLS equipment or by an independent consultant familiar with obstacle clearance requirements. The requirements for this type of assistance should be specified in the MLS contract with the manufacturer or contractor.

The proposed location of the hardware should also take into consideration possible approach paths necessary for noise abatement. These approaches may be similar to those for obstacle clearance. Depending on the minimums required and the approach paths proposed, the MLS equipment needs to be sited to provide the necessary coverage and allow for appropriate approach flight paths.

Technical Factors

To determine the existence of the following technical factors, assistance similar to that considered for obstacle clearance requirements should be provided. This assistance can be provided through contractual agreements with the MLS manufacturer/supplier or through the services of an independent consultant.

Once the general location of the MLS equipment has been selected, a determination must be made as to whether any objects in the area will

reflect scanning beam signals into the proposed approach path (multipath). The search for such objects should not be limited to the heliport grounds, but should include any objects within line-of-sight of the MLS ground antenna. Any non-horizontal surface within the proportional guidance region, particularly metal or concrete, can act as a multipath reflecting surface. In addition, hillsides may act as reflecting surfaces for the short wavelength (about 2 inches) MLS signal. Because of the MLS airborne receiver design, only reflections from objects that lie inside an angle of about 1.7 beamwidths of the azimuth radial being flown are likely to cause guidance perturbations.

Shadowing and diffraction of scanning beam signals by objects that block the line-of-sight between the ground antenna and the airborne receiver antenna are of primary concern. Such objects may include large buildings in the heliport/helipad area, towers and other antennas or structures on the heliport. Shadowing (or blockage) of the signal can result in attenuation or loss of guidance information in the shadow region. In addition, the shadowing object can produce guidance perturbations due to diffraction at the edges of the object.

The proposed location of the MLS equipment should take into account the existence of critical areas (i.e. areas where parked or moving ground vehicles are not permitted while an aircraft is using the MLS for an approach) to ensure that the radiated signal will not be degraded. The antenna should not be located where a road passes directly in front of it, unless there are assurances that vehicular traffic on the road will not act as multipath or shadowing objects. Any objects in front of the antenna can be considered potential multipath or shadowing objects. The effects of objects within critical areas on the MLS guidance signal should be studied prior to installing the antenna. These effects must be studied for the full range of MLS capabilities including straight-in, segmented and curved approach paths.

The steering sensitivity provided to the pilot increases as the AZ antenna is placed closer to the approach end of the helipad. Upon approaching the helipad the guidance may get so sensitive that it would be unflyable. In cases where the AZ and EL equipment must be collocated near the helipad (approximately 200 feet) a threshold must be located 1800 to 3000 feet from the approach end of the helipad. This will provide a ±3.5 degree course width.

An alternative which may be available in future avionics could be the use of "course softening". This requires additional signal processing by using Precision DME (DME/P) to change the sensitivity of the steering signal as a function of range. Another alternative would be to install the azimuth facility a thousand feet or so beyond the heliport and set the fixed sensitivity to some acceptable value. However, the sensitivity of the system farther out on the approach may be unacceptable, and range would therefore be restricted.

5.1 SITING OF SYSTEM COMPONENTS

Approach Azimuth Antenna

From the guidelines previously discussed for operational and technical siting considerations, a preliminary location of the approach azimuth antenna can be determined. There exists a fair degree of flexibility in siting the antenna, however, approach minimums may be affected. The azimuth antenna is normally located on the landing area centerline extended beyond the stop end of the landing area to be served at a sufficient distance not to violate the approach clearance plane of any opposing landing area. The preferred position projects guidance down the landing area centerline for straight-in approach and landing procedures. If the amount of available real estate is a constraint, the AZ antenna may be collocated with the EL antenna. It should be remembered that the sensitivity of the azimuth signal increases as the antenna is placed closer to the threshold. The ramifications of azimuth antenna guidance sensitivity has been discussed in the previous section (Section 5.0).

At facilities where the approach azimuth antenna is offset from the helipad centerline, a correction must be made to the flight path by the pilot at the decision height (DH). The placement should provide the pilot with an adequate view of the landing area during the approach. The actual placement of the antenna may be based on real estate constraints and/or airspace restrictions. FAA Advisory Circular 150/5390-1B, "Heliport Design Guide", August 1977, or its replacement, should be reviewed for additional information.

Elevation Antenna

To achieve the lowest minimums, the elevation antenna should be located ahead of the approach end of the helipad (Figure 5.1). The influences of the elevation antenna location on desired minimums and deceleration distance have been discussed previously in Section 5.0. Reference can be made to Table 5.1 to determine an approximate location for the elevation antenna.

If the elevation antenna cannot be located ahead of the threshold, appropriate procedures must be developed to allow for adequate deceleration and landing. This arrangement of equipment could require higher minimums and longer deceleration distances. The following equation may be used to determine a preliminary antenna location.

$$SB = \left[\frac{(TH - PCH)^2}{\text{Tan } (GS)^2} - OS^2 \right]^{\frac{1}{2}} \qquad \text{(Reference 12)}$$

where
- SB = setback distance from threshold
- TH = threshold crossing height
- PCH = phase center height
- GS = glide path (elevation angle)
- OS = offset distance

Reference 7 will provide additional information along with FAA Order 8260.30, IFR Approval of MLS.

DME

The DME range equipment will normally be collocated with the AZ antenna. In FAA installations, the transponder will be a DME/P with Initial Approach (IA) and Final Approach (FA) modes. Non-federal installations may use a standard DME (DME/N).

Other Components

During the siting, interconnecting communications and 120/240 volt single phase AC power must be planned to connect the sites and allow for control and monitoring of equipment. This includes a remote control and status unit (RCSU) which must be located at an appropriate control point or maintenance facility. The monitoring of MLS equipment may include interfacing with a remote maintenance monitor system. Larger landing areas may have established buried cables with space or conduit where interconnections can be made available. Smaller facilities may require interconnections and power to be made available at the sites where they do not exist.

6.0 SITE PREPARATION AND INSTALLATION

The MLS is relatively easy to install since the site surface dimension requirements are not as extensive as for ILS. The MLS antennas provide the required signals in space independent of the local terrain. There is a great deal of flexibility in the MLS which makes it adaptable to almost any landing area. Figures 6.1 and 6.2 show a typical installation of the AZ and EL equipment. In Figure 6.2 the field monitor is shown along with the EL antenna and electronic components. This equipment is part of a non-federal MLS facility located at a runway and not a heliport.

The initial step of setting up an MLS is the preparation of the MLS site. Once the site is chosen for both the AZ and EL equipment (Section 5.0), a level concrete pad is put into place for each component. A component consists of the antenna aperture assembly together with its electronic hardware cabinet. Normally this pad would measure 8x10 feet (depending upon antenna size). Part of the concrete pad would include bolts for the purpose of mounting the MLS equipment. Appropriate concrete pads measuring approximately 2x2 feet should also be prepared for the AZ and EL field monitors. The monitors are normally placed approximately 200 feet from the associated antenna.

The depth of each concrete pad, and whether or not footings are necessary, should be determined depending on the geographical area in which the equipment is being installed. For areas of extreme cold temperatures (permafrost) footings may be necessary to prevent damage due to expansion and contraction. For FAA installed systems, the bottom of all foundations will be carried a minimum depth of 12 inches below the local frost depth unless other approved methods are used to prevent frost heave of the foundations, such as pile foundations. Additional guidelines for concrete structures and components of the FAA MLS installation can be found in Reference 15, Section 5-2-3.4. These same guidelines can be followed for non-federal systems during preliminary site preparation.

Following this, power and communication cables must be routed to the MLS site. Power is needed, not only for the antennas (AZ and EL), their electronic components and the DME transponder, but also to operate AZ and EL field monitors, heating, uninterruptable power supply, obstruction lights and possibly a remote control and status unit. Adequate, 120/240 volt, 60 HZ, 3 wire single phase AC power must be made available to connect the sites.

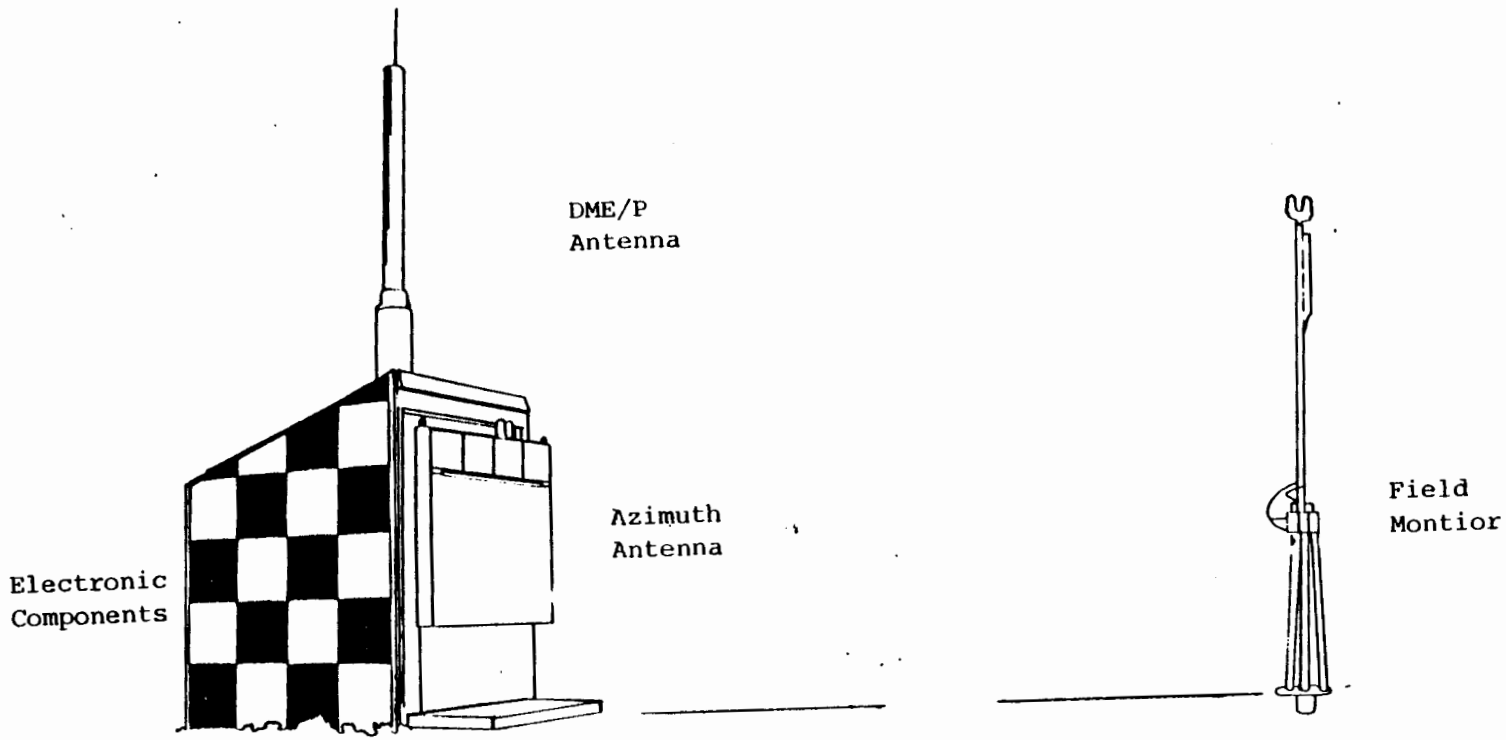

Figure 6.1 Azimuth Antenna and Electronic Components Collocated with the DME/P and the AZ Field Monitor

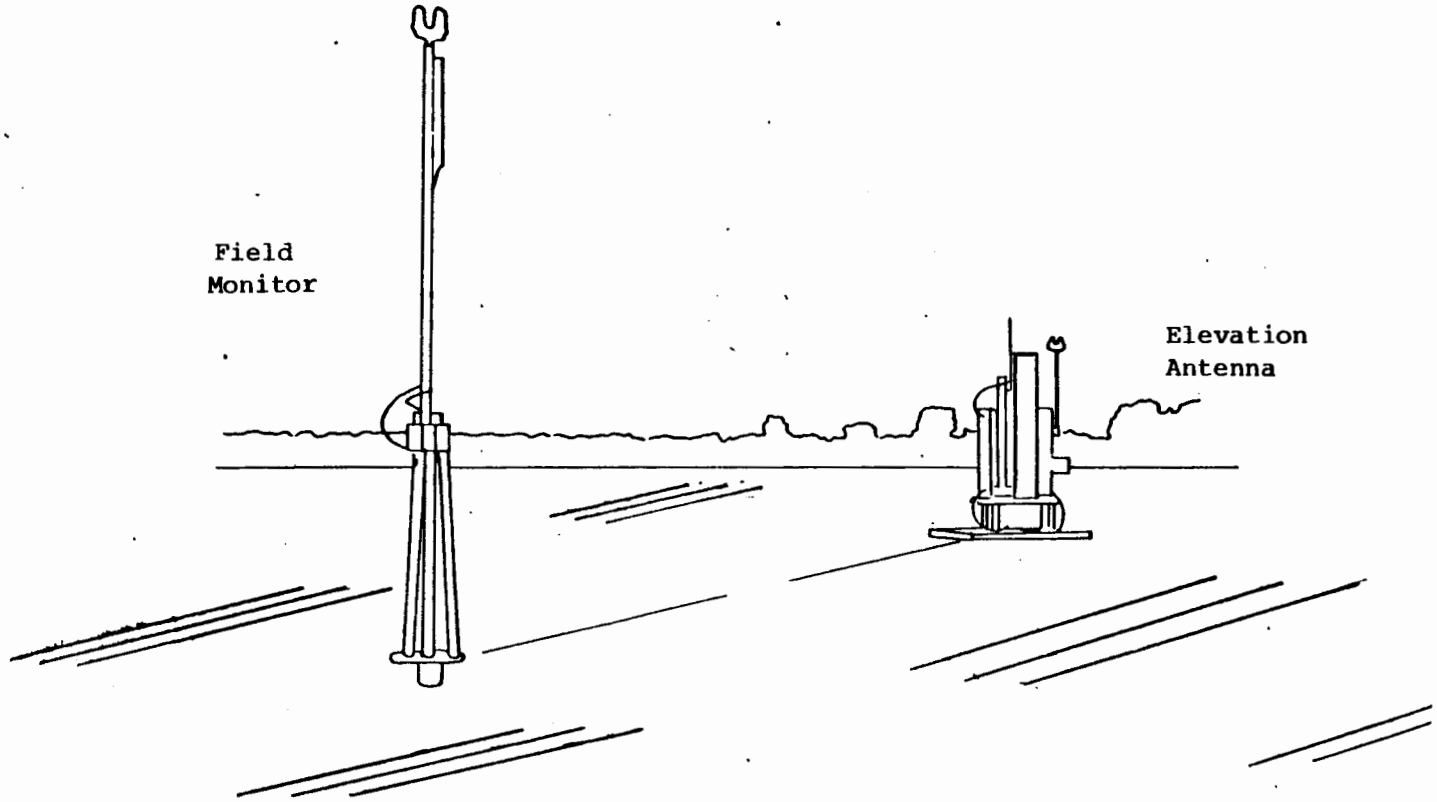

Figure 6.2 Elevation Antenna with Electronic Components and Field Monitor

The MLS is a time-multiplex system and thus the synchronizing function is a critical communication between azimuth and elevation stations. Possible options for these communications include:

- Standard wire cables
- Fiber optics
- Radio links

When the mounting pad and the power and communication cables have been put in place, the installation and tune-up of the electronic equipment, including remote monitor and control equipment can be performed. This work should also include preliminary checks of the facility. During the procurement of the MLS equipment the contract should specify that reasonable costs for installation will be assumed by the purchaser, with additional costs for tune-up, and preliminary flight checks incurred by the manufacturer of the system or the contractor. The contract should state that the purchaser will receive a commissioned MLS facility.

The AZ and EL field monitors each consist of a specially designed antenna mounted in a narrow housing (Figure 6.2). The housing is clamped to a mast which permits adjustment of the monitor to the desired height. One manufacturer's EL monitor utilizes a tripod mounting base for support and utilizes a hinge for pivoting the mast to facilitate relamping and field monitor repair.

7.0 MLS INSPECTION AND COMMISSIONING

Guidelines exist for the inspection and commissioning of a non-federal MLS system. Specific guidelines have been developed for MLS installations and can be found in references 12 and 24. These guidelines have been presented in the following section (Section 7.1) to provide some general requirements, which may be applied to the inspection and commissioning of a non-federal system. Section 7.2 is a brief discussion of a minimum set of current requirements for inspection and commissioning specified in FAR Part 171 for non-federal MLS systems.

7.1 FAA MLS FACILITY CHECK-OUT

Ground facilities that are FAA MLS installations will be contracted on a turnkey basis, with the contractor assuming a large share of the responsibility up until the actual certification of the facility. The following tasks are involved:

- Ground check
- Preliminary inspection
- Preliminary flight inspection
- Commissioning flight inspection
- Periodic flight inspections

Ground Check

The contractor, with a FAA technical representative observing, will perform all ground tests necessary to determine that the equipment is tuned for optimum operation and that the performance is within the prescribed tolerances set forth in the equipment instruction books. The contractor will perform all preliminary checks, including monitor adjustments prior to joint acceptance inspection and FAA flight inspection.

Preliminary Inspection

The contractor will ascertain to the satisfaction of the FAA technical representative that the entire installation is complete, equipment operation is at an optimum level, and facility performance parameters are within the initial tolerances stated in the applicable instruction books prior to requesting the joint acceptance inspection.

Preliminary Flight Inspection

The contractor will perform a preliminary flight inspection prior to the FAA commissioning flight inspection. The standards that must be achieved by the MLS in order to satisfactorily pass the FAA flight inspection are set forth in FAA-STD-022, 3.5, 4.3 and all subparagraphs. The contractor will conduct all tests necessary to ensure that the MLS

produces a proper signal throughout the coverage sector. After the successful completion of the preliminary flight check, a continuous 120-hour stability run of the MLS equipment will be performed. During this time the equipment will operate, under normal ambient conditions, within monitoring tolerances and demonstrate stable operation.

The contractor will notify the FAA MLS Program Manager and the FAA Technical Representative fifteen (15) days prior to the time that he is ready for the joint acceptance inspection. During this inspection, the contractor will demonstrate to the inspection team that the MLS facilities are installed in accordance with the contractor's site engineering report and the equipment instruction books, and that all parameters are operating within the maintenance standards and tolerances set forth in the handbooks associated with each equipment.

Commissioning Flight Inspection

The contractor will formally request flight inspection services when reasonably certain of success, and after a satisfactory preliminary flight inspection has been performed by the contractor. The contractor request for FAA flight inspection will be submitted at least 30 days prior to the date required. The Government will allocate up to 10 data gathering flight hours for the commissioning flight inspection. The contractor will bear the costs for any additional Government flight hours required due to the failure of the facility to meet the performance tolerances prescribed in Reference 12. For light single turbine engine helicopters the costs could vary from $350-$600 per hour. If a twin turbine helicopter is desired the costs could be in excess of $1000 per hour. These costs include pilot, fuel and insurance. Additional information could be obtained from FAA Order 2500.36I, Application of Reimbursable Flight Hour Rates.

Government final acceptance of the complete facility will be made following satisfactory completion of the stability run and facility clean-up.

Periodic Flight Inspections

Initially periodic flight inspections will be performed every 60 days and will take approximately 2 hours to complete. However, as experience is gained with the MLS, this period of 60 days will eventually increase, reducing the annual costs of providing this task. The stability of the MLS system, and its relative freedom from external influences, contribute to the potential for extending the interval between periodic flight inspections. From Reference 17, the annual cost of periodic flight inspections is approximately $5,300. This value (in 1985 dollars) is a preliminary cost for fixed-wing, and helicopter costs may differ.

7.2 NON-FEDERAL MLS FACILITY CHECK-OUT

The performance of ground facilities that are non-federal MLS installations must meet the requirements specified in FAR Part 171.307, as determined by flight and ground inspections conducted by the FAA for the following:

- Signal format
- Azimuth performance
- Azimuth monitor system performance
- Elevation performance
- Elevation monitor system performance
- DME performance
- DME monitor performance

For a non-federal MLS facility, the tasks listed previously in Section 7.1 could be performed by the individual sponsor of the facility, or the sponsor could have a contractual agreement with a contractor to perform these tasks. The contractor could assume all responsibilities and costs of meeting the requirements of FAR Part 171.307 and of any flight or ground inspection made before the MLS facility is commissioned; except that the FAA may bear certain costs subject to budgetary limitations and policy established by the Administrator. The sponsor should consider contracting to receive a system from the manufacturer such that all costs will be subject to commissioning. Additional information can be found in the Flight Inspection Manual, FAA Handbook 8200.1, which prescribes standardized procedures for flight inspection of air navigation facilities.

8.0 PROCEDURE DEVELOPMENT, PUBLICATION AND VERIFICATION

Before an MLS facility can be commissioned for use, instrument approach procedures must be developed for the area serviced by the MLS equipment. The United States standard for Terminal Instrument Procedures (TERPS), FAA handbook 8260.3B (Reference 3) prescribes standardized methods for use in designing instrument flight procedures. Specific reference should be made to TERPS, Chapter 11, Section 13*.

The capabilities of MLS will permit approach procedures other than ILS type centerline approaches. These procedures may include offset approaches, segmented and/or curved flight paths, metering and spacing techniques, etc. As MLS is implemented, users will look to develop procedures at a landing area to take advantage of the capabilities of MLS and enhance the utility of operations, as well as, the utility and feasibility of heliports. Figure 8.1 illustrates one very basic type of procedure that may be developed.

The issues involved in developing, publishing and keeping current a procedure are discussed below. These include:

- Eligibility
- Requests for procedures
- Approval
- Publishing the procedure
- Costs

Each MLS approach will have an approved instrument approach procedure which will show the range of glide path, azimuth courses and distances which can be used by the pilot. Figure 8.2 shows an approach procedure to an MLS equipped heliport. This approach procedure was developed for the Battery Park heliport in New York City. This approach is currently being evaluated by several helicopter operators in the NY/NJ area. The final form of the approach procedure may be different from what is shown in Figure 8.2 based on the operator's inputs and evaluations.

Eligibility

Terminal instrument procedures will be provided at civil landing areas open to the aviation public whenever a reasonable need is shown. No minimum number of potential instrument approaches is specified, however, the responsible FAA office must determine that a public procedure will be beneficial to more than a single user or interest. Private procedures, for the exclusive use of a single interest, may be provided on a reimbursable basis in accordance with FAR 171 where applicable, if they do not conflict with the public use of airspace.

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*NOTE: This document is only a draft and should be monitored for further updates.

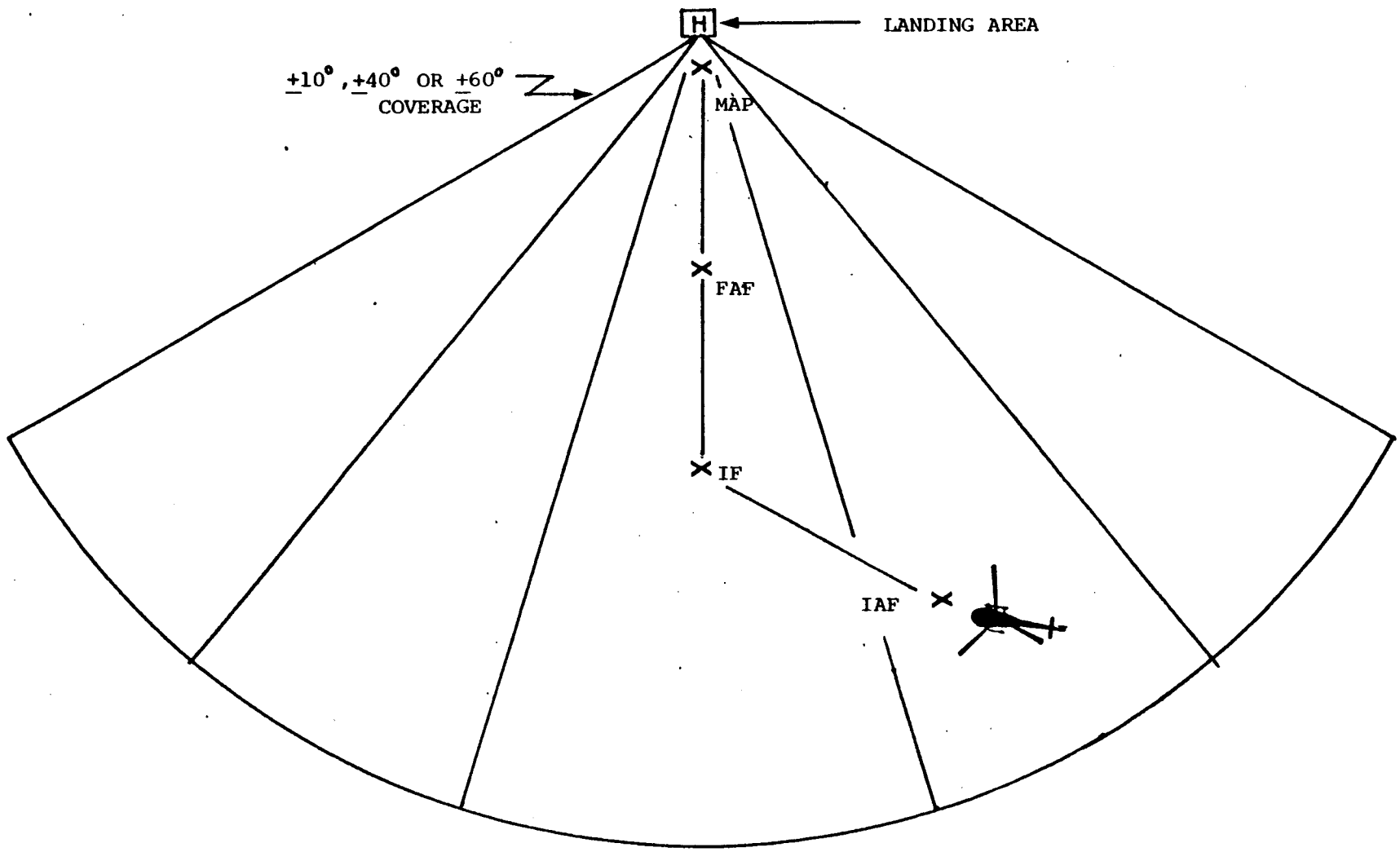

Figure 8.1 Approach to an Instrumented Helicopter Landing Area

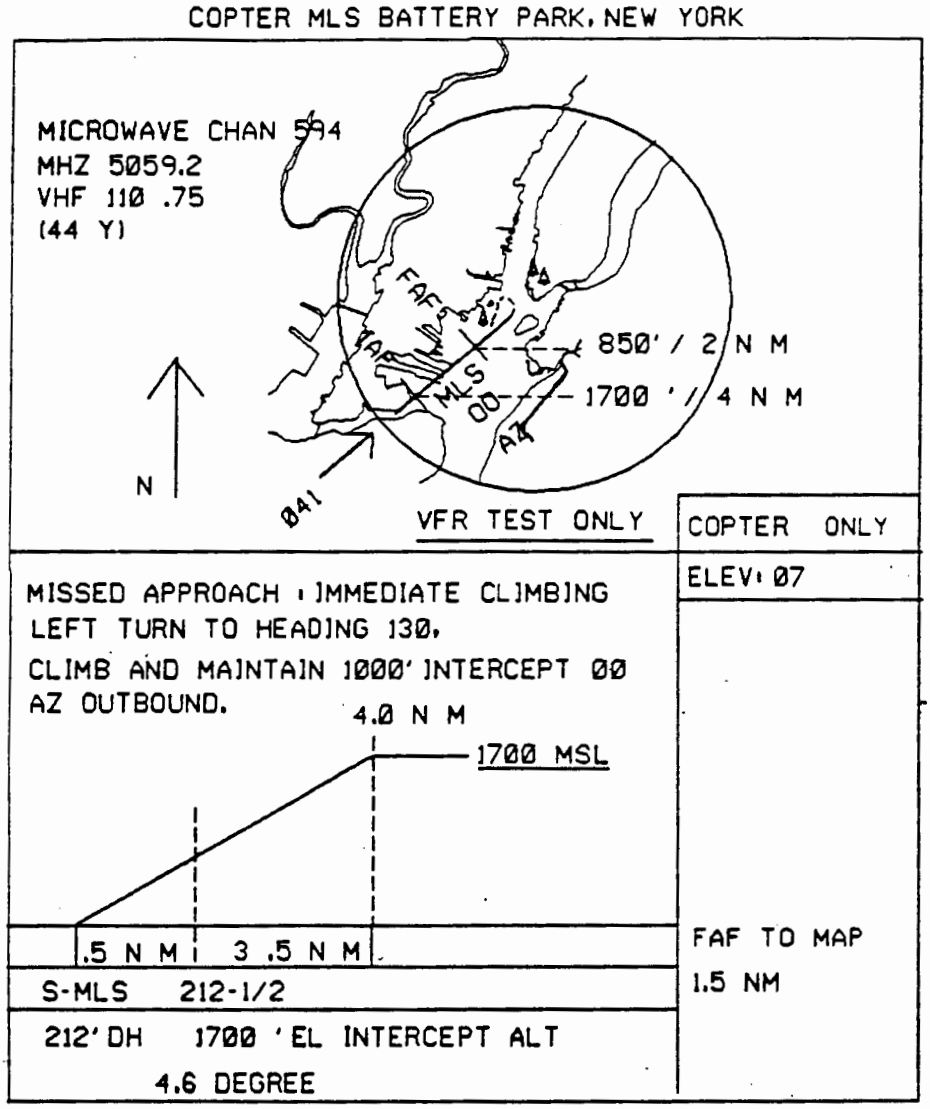

Figure 8.2 Approach Plate for an MLS Equipped Heliport

Reasonable need is deemed to exist when the instrument flight procedure will be used by:

1) A certificated air carrier, air taxi, or commercial operator, or;

2) Two or more aircraft operators whose activities are directly related to the commerce of the community

Requests for Procedures

No special form is required for requesting civil procedures. Civil requests may be made by letter to the appropriate Regional Office. Requests for civil procedures will be accepted from any aviation source, provided the request shows that the owner/operator has been advised of the request. (This advisory is necessary only when the request is for an original procedure to a heliport not already served by an approach procedure.) Heliport owners/operators will be advised of additional requests for procedures by the FAA as soon as possible after receipt thereof. Procedures development is time consuming. Requests for procedures take from 6-12 months for response from the FAA.

Approval

The FAA will establish and approve terminal instrument procedures for civil heliports. Where a reasonable civil need has been established, a request for an instrument approach procedure and/or instrument departure procedure for an heliport will be approved if the following minimum standards are met:

a. Heliport. The heliport landing surfaces must be adequate to accommodate the aircraft which can be reasonably expected to use the procedure. Landing area markings as specified in Paragraph 342.a. of Reference 3 are required if visibility credit for lighting systems is to be given. Landing area lighting is required for approval of night instrument operations. The heliport must have been found acceptable for IFR operations as a result of an airport airspace analysis conducted according to FAA Handbook 7400.2C "Procedures for Handling Airspace Matters", dated May 1, 1984 (or the current document). Only circling minimums will be approved at heliports where the landing area is not clearly defined.

b. Navigation Facility. All electronic and visual navigation facilities used must successfully pass flight inspection.

c. Obstacle Marking and Lighting. Obstacles which penetrate FAR Part 77 imaginary surfaces are obstructions and therefore should be marked and lighted insofar as is reasonably possible in accordance with FAA Advisory Circular AC 70/7460-1F "Obstruction Marking and Lighting". Those penetrating the FAR Part 77 approach and transitional surfaces must be removed or made conspicuous in accordance with AC 70/7460-1F.

d. Weather Information. Terminal weather observation and reporting facilities must be available for the heliport. Prior to commencing the approach, approved minimums and altimeter settings must be available to the pilot.

e. Communications. Air-to-ground communications must be available at the initial approach fix minimum altitude and when the aircraft executing the missed approach reaches the missed approach altitude. At lower altitudes communications will be required when essential to the safe and efficient use of airspace. Air-to-ground communication normally consists of UHF or VHF radio, but HF communication may be approved at locations which have a special need and capability. Other suitable means of point-to-point communication, such as commercial telephone, may be used to file and close flight plans.

Publishing the Procedure

Terminal instrument procedures and revisions of procedures will be processed in sufficient time to permit publication and distribution in advance of the effective date. Effective dates will normally coincide with scheduled airspace changes. The FAA period of procedure updates is every 56 days. In case of emergency or when operational effectiveness dictates, approved procedures may be disseminated by a Notice to Airmen (NOTAM). Procedures disseminated by NOTAM will also be processed in the normal fashion and published in appropriate terminal instrument procedures charts and in the Federal Register when required.

Costs

The necessary costs (in 1985 dollars) of developing a procedure can be approximated by the following:

	Hours	Rate($/Hr)	Cost($)
Specialist (including 3 days on site)	41	40	1640
Per Diem (3 days) and Travel	-	-	725
FAA (ATO)	5	40	200
Chart Preparation	20	40	800
		Total	3365

8.1 FUTURE DEVELOPMENT OF PROCEDURES

Advanced cockpit technology, along with increased reliance on digital data links and ATC system automation, may require some changes in ATC procedures. In the near term the available approach procedures will be limited. The development of TERPS criteria will allow for more advanced procedures, aimed at taking advantage of the unique capabilities of MLS area navigation systems in the terminal area. The final approach azimuth or glide path can be adjusted to meet aircraft performance requirements or those specified by the FAA on the approach plate to avoid obstacles. Segmented and curved approaches can be designed to provide obstacle clearance as the aircraft approaches the airport. The controller may indicate to the pilot the area navigation-based path to follow to the final approach. The need for the controller to assign headings and project aircraft position will be reduced. Also, the controller will have more accurate control of the merging process. As an extension to this merging process, the use of 4-D navigation may be used to provide more control with the introduction of time as a control parameter for appropriately equipped aircraft.

9.0 OPERATIONS AND MAINTENANCE

Maintenance

Modern technology and advanced solid-state design make MLS inherently more reliable than ILS. Some MLS components have been designed to have a Mean Time Before Failure (MTBF) exceeding the FAA's production requirements of 4000 hours. These systems are designed to be unattended precision landing systems. The following information was obtained from FAR Part 171, Subchapter J, Sections 323 and 325, for non-federal MLS facilities.

The owner of a non-federal MLS facility must establish an adequate maintenance system and provide MLS qualified maintenance personnel to maintain the facility at the level attained at the time it was commissioned. Maintenance may be performed by designated heliport personnel or through a contractual agreement with an independent contractor. Each person who maintains a facility must meet at least the FCC licensing requirements and demonstrate the special knowledge and skills needed to maintain an MLS facility.

Non-federal MLS installations should include equipment monitors. The monitors should indicate a maintenance alert condition to the appropriate personnel responsible. Design and operation of the monitor system will cause radiation to cease and a warning will be provided at the designated control points in the event of failure of the monitor system itself.

For non-federal installations the mean time between failures of the MLS equipment must not be less than 1,500 hours. This measure applies to unscheduled outage, out-of-tolerance conditions, and failure of the monitor, transmitter, and associated antenna assemblies. The mean corrective maintenance time of the MLS equipment must be equal to or less than 0.5 hours with a maximum corrective maintenance time not to exceed 1.5 hours. This measure, applied to the correction of unscheduled failures of the monitor, transmitter and associated antenna assemblies, is limited to unscheduled outages and out of tolerance conditions. Consideration could be given to specifying an MLS with higher reliability in order to reduce maintenance costs.

Operational Considerations

Each manufacturer of non-federal MLS systems will have their own version of remote maintenance monitoring. An approved monitoring capability must be provided which indicates, over standard telephone lines, the status of the equipment at the site and at a remotely located maintenance area, with monitor capability that provides pre-alarm of impending system failures. Suitable maintenance limits for various parameters will be stored in the equipment monitors (integral and field). The equipment monitors will compare actual monitored parameter values with the maintenance limits.

If the MLS owner requests the FAA to assume ownership of the facility, the monitoring feature must also be capable of interfacing with FAA remote monitoring requirements. Additional information on MLS conversions can be found in Section 11.2.

According to FAR Part 91.117, if a ground component is inoperative, or unstable or not utilized, the minimums prescribed in any approach procedure are raised. If the related airborne equipment for a ground component is inoperative or not utilized, the increased minimums applicable to the related ground component will be used. If more than one component or aid is inoperative, unusable or not utilized, each minimum is raised to the highest minimum required by any one of the components or aids which is inoperative, unusable or not utilized.

Costs

Table 9.1 lists the annual costs (in 1985 dollars), from Reference 17, for operation and maintenance (O&M) of an FAA MLS facility. One set of costs are based upon the maintenance of a single MLS facility. The other set of costs reflect the use of the Remote Maintenance Monitoring System (RMMS) concept, which is only applicable to FAA facilities. These costs can be used as an indication in the reduction of maintenance costs through the use of a centralized monitoring concept having remote diagnostic capability. The table can be used to determine an approximation of the costs for MLS maintenance.

Table 9.1 Annual MLS Ground Costs

MLS Ground Installation	CAT I	CAT II	CAT III
O&M Costs*			
• Individual Maintenance Concept	$35,300	$45,600	$67,700
• Centralized Maintenance Concept	$25,000	$35,300	$44,100

*O&M costs include flight inspection costs. Separate costs for flight inspection and commissioning costs are included in Section 7.0.

10.0 AIRCRAFT/AVIONICS/PILOT TRAINING

Aircraft

The United States National Airspace System (NAS) is the busiest and most complex in the world. Aircraft operating within the NAS display a wide variety of performance characteristics. Most of these aircraft are of the conventional takeoff and landing (CTOL) variety and require runways of various lengths. A much smaller number of aircraft are of the short take-off and landing (STOL) or the vertical take-off and landing (VTOL) variety. The VTOL (helicopter) aircraft are capable of higher glide path angles, approach at speeds from 30 to 150 knots, and are much more maneuverable than CTOL aircraft. There is a small but growing number of IFR operations by STOL/VTOL aircraft using short runways, helipads, reliever runways and stub runways.

A continued growth is expected in the number of rotorcraft, diversity of operations, and number of operations. The rotorcraft fleet, which is expected to more than double by the end of the century, could result in a significant change in the total National Airspace System (NAS) fleet mix. The implementation of MLS at heliports will help accommodate this increase in rotorcraft operations.

Avionics

MLS provides a very accurate precision approach to the pilot. In the cockpit, the flight and approach procedures may differ little from ILS. However, MLS offers the added operational flexibility of a pilot selected glide path and approach azimuth while still providing accurate flight path guidance in the terminal area. Once a bearing and glide path are selected on the MLS receiver control unit, the pilot or autopilot flies the "needles" on the HSI or CDI. Centered "needles" mean that the aircraft is "on the glide path and approach azimuth" for the bearing and glide path selected.

Precision DME (DME/P) operates in two modes; Initial Approach (IA) and Final Approach (FA) modes. The DME/P interrogator transition from IA to FA mode takes place at not more than 8 nmi from the transponder. During an approach and landing to an MLS equipped landing area, DME/P eliminates the need for marker beacon transmitters by providing range distance measurements to the airborne receiver.

The use of MLS receiving equipment, without area navigation, limits the paths that can be flown with precision guidance. However, rotorcraft using MLS receivers will have increased access to heliports and areas where rotorcraft could not go without precision approach capabilities. The addition of area navigation (RNAV) avionics, which utilize MLS signals to provide segmented or curved approaches, provides even greater access to a landing area. This capability can increase utilization and improve schedule reliability of helicopter operations. The intermediate

and final approach paths will normally be aligned with the extended centerline of the landing area. Approaches, designed to avoid noise sensitive areas or to avoid obstructions, can be flown using straight segmented paths that may not be aligned with the landing area centerline. A number of approach procedure applications may be possible by integrating RNAV with the MLS equipment. If appropriate ground equipment is available, some of these applications are:

- Straight-in approach to non-instrumented landing area
- Curved path approach
- Multiple approach paths (both azimuth and elevation)
- Metering and spacing
- Vertical transition from en route
- Displaced glide path
- Glide path for non-instrumented landing areas
- Missed approach (optional ground facility required)
- Decelerating helicopter approach
- IFR departure
- Wide-angle capture (optional antennas required)

Pilot Training

As with an ILS navaid, pilots must show their proficiency performing approach procedures using MLS for guidance. With the added capabilities of the MLS (with regard to ILS) the amount of training needed by the pilot may increase in terms of difficulty and time. The pilot may need to show proficiency in his/her ability to follow segmented/curved flight paths as well as steep approaches (above 3 degrees), and various approach speeds.

The availability of MLS may require the pilot to perform various levels of approaches. These approaches may be for obstacle avoidance, noise abatement, vortex avoidance, etc. Depending on the circumstances, a pilot should be familiar with the possible approach procedures that may be encountered. For additional information documents AC 61-27C, FAR Part 91 and the Airman's Information Manual (AIM) Part I should be monitored*.

*NOTE: No regulations exist at this time for MLS.

11.0 OTHER CONSIDERATIONS

11.1 PUBLIC VS PRIVATE-USE HELIPORTS

A public-use heliport is a heliport open to the public; and

1) publicly owned, or
2) privately owned but designated by the FAA as a reliever, or
3) privately owned but having scheduled service and at least 2,500 annual revenue enplanements

The number of enplanements stated in criteria 3) (2,500 enplanement) is large for heliports and helipads. This criteria may be altered by considering other aspects of helicopter operations, such as the necessity and utility of a heliport at a particular location where an airport may not be feasible.

The FAA will determine the eligibility of terminal locations for the establishment, modification, or discontinuance of terminal air navigation facilities and air traffic control services in accordance with FAA policy; however, eligibility determinations do not constitute a commitment to provide such facilities or services.

Public-use heliports are candidates for various facilities and services provided they meet the criteria specified in Reference 18. New public-use heliports qualify for facilities and services provided the forecast of activity made by the FAA indicate that the criteria specified in Reference 18 would be met within three years after the heliport begins operations.

Privately-owned heliports, open to and available for use by the Public, which are recognized by and contained within the National Plan of Integrated Airport Systems (NPIAS) are also candidates for the various facilities and services described in Reference 18 provided that they meet the same facility establishment standards and implementation criteria as those specified for publicly-owned heliports. In addition, owners of such heliports must enter into appropriate assurances and covenants to guarantee:

1) Compliance with that portion of Section 308(a) of the Federal Aviation Act dealing with the prohibition of exclusive rights.

2) Compliance with anti-discrimination regulations and practices in terms of race, color, religion, sex or national origin.

3) That any fees charged for services will be fair and reasonable for all types, kinds and classes of aeronautical uses.

4) Protection of the government investment and public interest through continuing operation as public use facilities for long enough periods to permit the amortization of such investment.

5) Compliance with the same safety requirements and obstacle clearance criteria applicable to publicly-owned heliports.

6) That the FAA will be furnished land without cost for the construction of facilities.

7) That compatible land use will be accomplished where feasible with the land in the immediate vicinity of the heliport.

8) That there will be compliance with the equal opportunity clause of Executive Order 11246.

For additional details and the operations agreement format, refer to Order 6030.40, FAA Policy for Receiving Assurances When Establishing F&E Facilities at Privately-Owned Public-Use Airports*.

11.2 CONVERSIONS

During the 1960-1980 time frame, the FAA agreed to "purchase" a number of non-federal navigation facilities and to assume the maintenance obligations involved. Since such equipment usually differed substantially from FAA standards, this presented numerous problems involving training of maintenance personnel, procurement and stocking of spare parts, etc. With the advent of RMMS and the accompanying maintenance philosophy, the FAA is far less receptive to proposals that non-federal facilities be converted to FAA facilities. If a sponsor is considering the possibility that a non-federal facility might later be converted to an FAA facility, consultation with the FAA should start well prior to any procurement action. This would be necessary in order to be certain that the facility meets the requirements for conversion to an FAA facility. This step could prevent costly alteration expenses if a decision is made, at a later date, to convert the facility.

One of the major issues of concern would be remote maintenance monitoring. An FAA MLS facility interfaces with the FAA Remote Monitoring Maintenance System (RMMS). If a non-federal facility is to be converted to an FAA facility, it must have the capability to interface with the FAA RMMS network. Maintenance support and manpower must also be able to provide adequate services for proper monitoring of the equipment.

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*Note: At the time of this writing Order 6030.40 did not address rotorcraft.

11.3 GRANTS

Grants for planning, development, or noise compatibility projects under the Airport Improvement Program (AIP) are intended for individual public-use airports and heliports. Further, to be eligible for a grant, an airport or heliport must be included in the National Plan of Integrated Airport Systems (NPIAS). Eligible development projects may include facilities or equipment associated with the construction, improvement, or repair (excluding routine maintenance) of an airport. Typical work items include: land acquisition; site preparation; construction, alteration, and repair of runways, taxiways, aprons, and roads within airport boundaries; construction and installation of lighting, utilities, navigational aids, and aviation-related weather reporting equipment; safety equipment required for certification of an airport facility; security equipment required of the sponsor by the Secretary of Transportation by rule or regulation; snow removal equipment; limited terminal development at commercial service airports; or equipment to measure runway surface friction. Grants may not be made for the construction of hangars, parking areas for automobiles, or for buildings not related to the safety of persons on the airport. Grants are made to the public agency or private entity that owns or operates the public-use heliport.

The FAA is planning to accept applications for MLS purchases through the use of AIP funds on a case-by-case basis. However, policy has not been established for AIP financing of MLS facilities.

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