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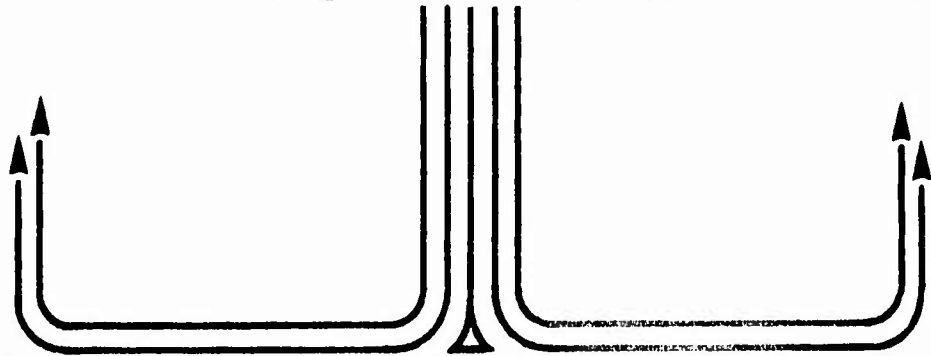


AIR COMMAND AND STAFF COLLEGE

STUDENT REPORT
COMING SOON TO A THEATER NEAR YOU...
THE MICROWAVE LANDING SYSTEM
MAJOR KELLY S.C. HAMILTON 85-1025
"insights into tomorrow"

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TITLE COMING SOON TO A THEATER NEAR YOU... THE MICROWAVE
LANDING SYSTEM.

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Submitted to the faculty in partial fulfillment of
requirements for graduation.

**AIR COMMAND AND STAFF COLLEGE
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PREFACE

This informational handbook has been prepared in response to a requirement levied by the 5AC Instrument Flight Course (SIFC), Castle AFB, California. The Microwave Landing System (MLS) is projected for worldwide installation and use by both civilian and military facilities. This handbook has been developed for use in conjunction with an individualized lesson plan, prepared by the SIFC faculty. We have attempted to layout the history, development, advantages, and future projections for this excellent system.

The handbook is not a text for engineers, but for the pilot who is interested in safety of flight, noise abatement, and increased system confidence. My intent in authoring this project was to provide a brief introduction to the reasons behind the transition from Instrument Landing System (ILS) to the Microwave Landing System (MLS), and the international scope of this endeavor. Through the comparison of the operational and maintenance advantages of these two systems, I hope to capture the interest of pilots by making them aware of the tremendous technological gains embodied in the Microwave Landing System.

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ABOUT THE AUTHOR

Major Kelly S.C. Hamilton, a 1973 graduate of Officer Training School, attended Avionics Maintenance Officer Course, Lowry AFB, Colorado. Initially assigned to Nellis AFB, Nevada specializing in integrated avionics systems, she worked test stations for the F-111. In 1974, she became responsible for the operational testing and evaluations of communications, navigation, and electronic countermeasures systems for T-38, A-7, A-10, F-4C, F-5, F-105, and F-111 tactical aircraft. She was awarded the Meritorious Service Medal for her contributions to the technical development of Electronic Countermeasures (ECM) and Counter-countermeasures (ECCM) for the original Project Red Flag war scenario. Her experience includes serving as avionics maintenance project officer for: operational test and evaluation of the AIM-9 missile, the ALQ-119 ECM pod, the APN-118 TACAN system, and the ARC-164 UHF radio. She was also the avionics consultant for F-5 foreign military sales programs, and the first operational testing of the AWACS. She was personally responsible for technical changes to the F-5 avionics systems, and traveled with the F-5E "Aggressors" in support of Dissimilar Air Combat Training (DACT).

A graduate of Undergraduate Pilot Training (UPT) in 1978, she served as a KC-135 co-pilot until 1980, when she upgraded to aircraft commander. A Distinguished Graduate of the SAC Combat Crew Training School, her outstanding performance record with the 43d Air Refueling Squadron, earned her the Air Force Commendation Medal, and Humanitarian Service Medal. Assigned to the 924th Air Refueling Squadron, as a Flight Commander from 1981 until 1983, her combined avionics and aviation background, were key in her selection as B-52/KC-135 Test Director, 4200 Test and Evaluation Squadron, Castle AFB, California. As Test Director, she represented SAC and AFLC in acceptance testing and evaluation of aircrew training devices for the B-52 Offensive Avionics System, and KC-135 flight simulators. Her performance earned her the First Oakleaf Cluster to the Meritorious Service Medal.

Major Hamilton completed Squadron Officer School, Air Command and Staff College, a Master of Public Administration, and is presently completing National Security Management by correspondence.

TABLE OF CONTENTS

Preface	iii
List of Illustrations	vi
Introduction	1
Why a New Landing System?	1
Limitations of the Instrument Landing System (ILS)	1
Microwave Landing System (MLS) Design Requirements	2
MLS - Going Operational	3
Standard Configuration	4
Advantages of the MLS	4
Flying the MLS	8
The Future - Joint Tactical Microwave Landing System (JTMLS)	10
Bibliography	12
Glossary	13
Index	14

LIST OF ILLUSTRATIONS

FIGURES

FIGURE 1 - Alaska Terminal Approach Plate (ILS/STOL-I) Rwy 6, Valdez, Alaska	5
FIGURE 2 - MLS (cockpit) control and annunciator panels	7
FIGURE 3 - Comparison of Microwave Landing System and Instrument Landing System	9
FIGURE 4 - JTMLS Advantages	11

MLS - An Introduction

"Flying can best be characterized as hours of boredom punctuated by brief moments of stark terror." The pilot that made this observation may well have been referring to the terror experienced during a "real weather minimums approach." The purpose of this handbook is to introduce you to one of technology's answers to the terror of transition, approach and landing, or missed approach in minimum weather conditions. A basic familiarization with the history, design and application of the Microwave Landing System should aid you in understanding how to best use this new system to your advantage.

Why a New Landing System?

Since 1949, the aviation community has used the instrument landing system (ILS) as the worldwide standard for precision approaches. The military employed their own backup system, the ground controlled precision approach radar (PAR). Both systems were design limited to a single approach path and an operational minima of a 200-foot ceiling and forward visibility of one-half mile (1:12)

The ILS and PAR systems have constituted the cornerstone of military landing systems for the last thirty-five years. During this time, the systems have undergone major modifications which have resulted in significant improvements in performance and reliability. With the addition of many costly improvements to protect against signal degradation, lower minima (designated Cat II/ Cat III) could be obtained on the ILS (1:12) However, the systems still remained severely limited from a design standpoint.

Limitations of the ILS

There are five major technical limitations to the ILS system. The most significant deficiency is it's susceptibility to signal interference. Multipath reflections from topographic features, buildings, and other aircraft, airborne or on the ground, result in signal interference to both localizer and glide slope information. This erroneous data manifests itself in the momentary loss of signal during the approach, or misalignment of centerline and glidepath information. The second limitation is due to stringent requirements on antenna placement. To assure proper signal propagation, the ILS glide slope antenna requires a flat area void of obstacles for at least 1200 feet directly in front of the antenna. Therefore, terrain at the ground site becomes the primary

determining factor in beam patterning. Obstacles often result in blind spots on the approaches, as a result, many airfields are deemed unsuitable for ILS use. Third, the ILS glide path signal is designed to be bounced off the ground, as a result, changes in ground patterning or moisture content due to such severe atmospheric effects as snow, heavy rain, or sleet adversely affect transmission of the glide slope signal. Fourth, inherent in the use of VHF and UHF frequencies, is the limited 40 channel frequency availability with even greater service limitations in some areas due to frequency assignments already in existence. The fifth, and most significant limitation to air traffic control is the single beam design. Providing narrow course guidance (± 3 to 6 degrees), combined with a single glide path, limited to 4 degrees elevation aircraft are often stacked in holding patterns to facilitate the straight-in approach sequencing. The lack of system flexibility and limited guidance make sequencing of priority traffic a problem, and often require overflight of populated areas (1-12) (10-14). Recognizing these constraints, the Federal Aviation Administration (FAA), International Civil Aviation Organization (ICAO), and international user governments began the search for a worldwide replacement for the present non-visual precision approach and landing system suitable for both military and civilian application.

New beginnings - MLS design requirements

In 1971, the Radio Technical Commission for Aeronautics Special Committee No. 117 (RTCA SC-117), a group representative of government, industry and aviation system users, presented a Development Objective (DO-148) which established the guidelines for the ensuing search for a replacement for the present ILS. In 1973, the International Civil Aviation Organization (ICAO), provided the operational requirement for "A New Non-Visual Precision Approach and Landing System." Requirements for a new microwave landing system were:

- a. Provide a high integrity signal in space, which is insensitive to a physically dense airport environment;
- b. Permit all-weather operations with an extremely high degree of safety;
- c. Provide for a common civil/military system in accordance with national policy;
- d. Provide for low cost versions which will permit the extension of service to low density airports on an economical basis;

- e. Fulfill operational needs of V/STOL aircraft for approach and landing services;
- f. Provide a flexible guidance system which will aid in noise abatement;
- g. Provide the capability for generating curved approaches to runways as a means for increasing airport capability;
- h. Permit less separation (2500 feet) of parallel instrument flight rules (IFR) runways;
- i. Provide for tactical military versions of the system on a compatible basis;
- j. Provide a system design which will be internationally acceptable as a replacement for the ICAO standard VHF/UHF ILS and will meet worldwide requirements until at least the year 2000 (1:16)

The MLS - Going Operational

Between 1971 and 1978, numerous systems were tested worldwide, and the ICAO selected the Time Reference Scanning Beam (TRSB) technique as the new world standard. After its selection, the new TRSB Microwave Landing System spent thirteen years in design, test, and evaluation. As intended, the development and proofing of the system was truly an international effort. A contractor's informational manual described the worldwide status of the MLS, in 1983 as follows:

ICAO: Standards and Recommended Practices (SARPs) for the angle portion of the system have been completed. The Precision (DME/P) SARPs are expected to be completed in 1983.

U.S. FAA: A request for proposal was issued in April 1983 for 172 systems plus options to be procured with FY-1982 through FY-1986 funds. By 1989, the FAA expects to be installing 100 systems per year until they have 1,250 installations. These first 172-plus systems will become operational between 1986 and 1988.

U.S. Non-Federal: The world's first MLS (a Bendix system) was commissioned for IFR operations at Valdez, Alaska, on 16 November 1982. Additional commissionings are expected in 1983.

International: The Japanese CAB is testing the second iteration of MLS built in Japan. The British CAA has ordered a Bendix system and will start testing at Stenstead near London in September 1983. Transport Canada is awaiting delivery of a test system which will be

used to develop their specifications for procurement in 1985. France has a system in development. The U.S.S.R. is testing their second iteration TRSB system in Leningrad" (8-10)

Worldwide, 400-500 microwave landing systems are projected to be operational by 1990. Total transition from ILS to MLS is estimated to include 3,000 systems with an operational target date of the year 2000. (8-10) As of 1984, Valdez, Alaska (Fig. 1) remains the only operational MLS system within the United States. A second system is presently undergoing testing at the Air Force's designated lead-in base, Shemya, Alaska. Equipment certification includes specification and performance testing of airborne and ground equipment as well as the establishment of FAA maintenance reporting and technician certification. (1-2)

Standard Configuration

An impressive new system, the MLS is functionally divided into five separate parts: (a) approach azimuth angle guidance, (b) back azimuth angle guidance (c) approach elevation angle guidance (d) range guidance and (e) data communications. These functions reflect a standard configuration MLS. A description of the associated ground equipment's functions are as follows:

The approach azimuth station provides the angle guidance and data communications information for the system. The data communications information refers to the status of the equipment and transmission reliability.

The approach elevation station to provide approach elevation guidance angle.

Range guidance is provided through the precision distance measuring equipment (DME/P) similar to the previously used DME systems but with upgraded accuracy and increased channel capabilities.

The MLS identification is alphabetic, four letters long, and is preceded by the letter M (7-321)

Advantages of the MLS

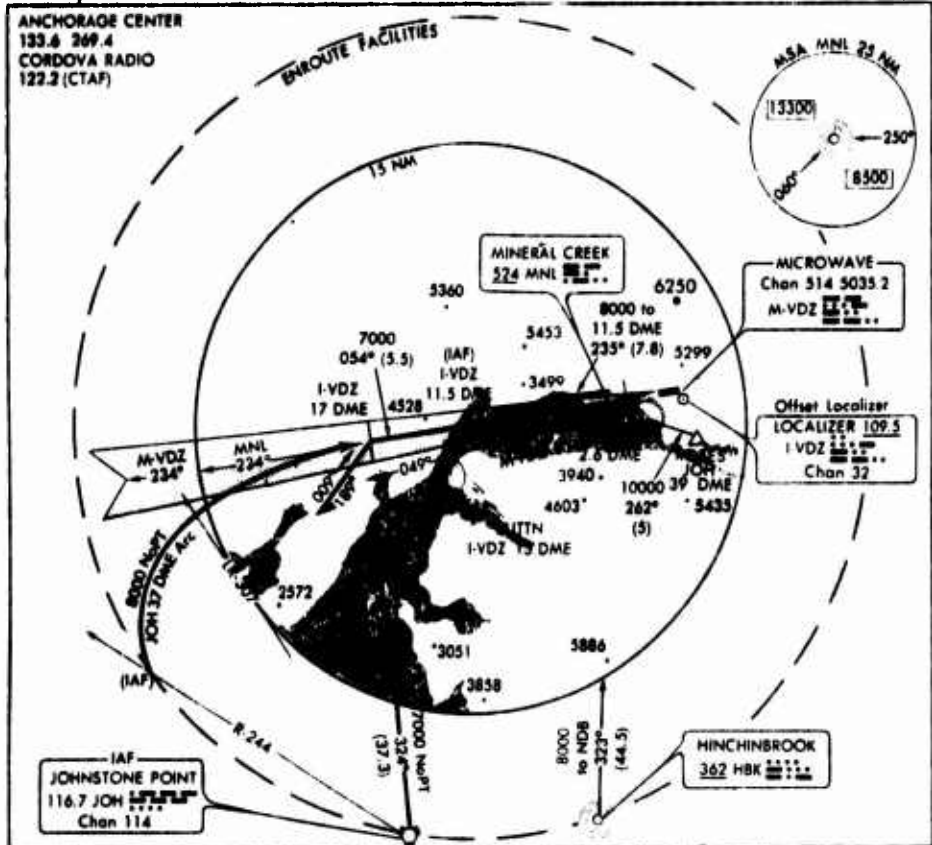
Long in development, the Microwave Landing System (MLS) promises to pay back even longer in benefits. The new MLS fulfills all of the requirements of ICAO Development Objective 148, boasting the answers to problems created by difficult terrain features, increased margins of safety during instrument conditions, approaches over populated areas, and severe weather conditions.

MLS/STOL -1 RWY 6 Valdez, Alaska (Fig. 1)

Excerpt from Alaska Terminal Approach Publication

FOR TRAINING PURPOSES ONLY

Amdt 1 **MLS/STOL-1 RWY 6** 251 AL-6213 (FAA) VALDEZ NO. 2 (VDZ) VALDEZ, ALASKA



MISSED APPROACH

Remain within 10 NM

7000 234°

Use I-VZ DME when on MLS course
GS 6.7°
TCH 50'

7000 054°

I-VZ 11.5 DME

Immediate climbing right turn to 7000 via 255° heading and M-VDZ 229° course (5° RIGHT) or I-VZ LDA 229° course to Sutin 13 DME and hold.

I-VZ 2.6 DME

1030

8.9 NM

ELEV 120

TDZE 75

HIRL Rwy 6-24
REIL Rwy 6 and 24

Knots	60	90	120	150	180
Min:Sec					

CATEGORY	A	B	C	D
S-MLS 6		1000-1 1/4	925 (1000-1 1/4)	
S-LOC	Approach NA when G/S not utilized.			
CIRCLING	1120-3 1000 (1000-3)		1200-3 1080 (1100-3)	

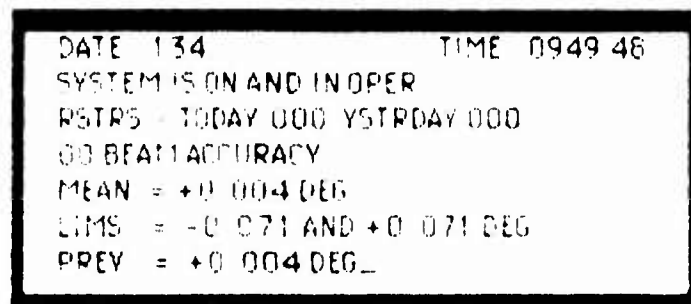
Mountains in excess of 5000 in all quadrants. Circling not authorized north of Rwy 6-24. Procedure not authorized when Valdez altimeter setting not available. ACTIVATE VASI Rwy 6, HIRL and REIL Rwy 6 and 24-122.2. Strong winds may cause severe turbulence. DME from I-VZ LDA. Simultaneous reception of M-VDZ and I-VZ DME required. Procedure not authorized at night.

MLS/STOL-1 RWY 6 61°08'N-146°15'W 251 VALDEZ, ALASKA VALDEZ NO. 2 (VDZ)

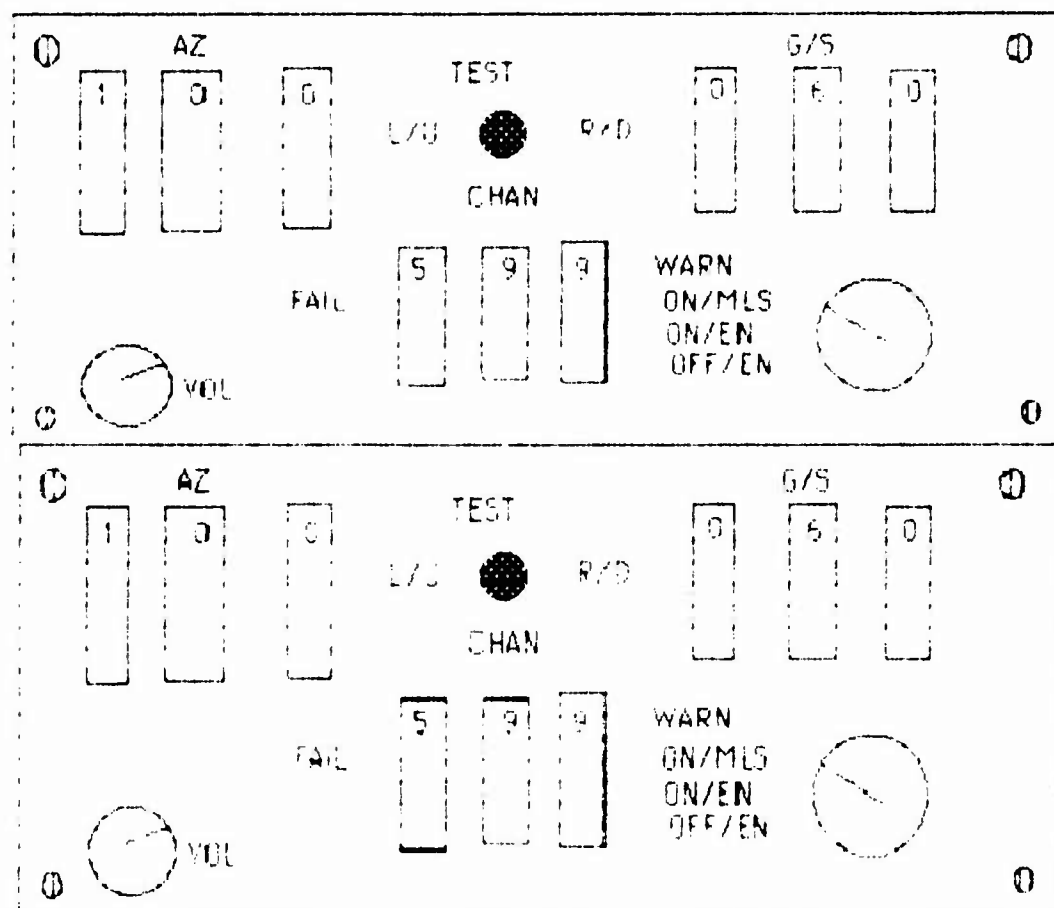
which hindered the operation of the old ILS system. How does the MLS deliver on all these promises? It delivers with precise definition of an arched approach path from any point in space the pilot selects. This state-of-the-art air navigation aid provides this curved path guidance through precise azimuth, elevation angles, and range information. All aspects of this data can be displayed on conventional course deviation indicators or incorporated into new CRT cockpit displays.(Fig.2)(2,4,5) The MLS allows tremendous flexibility in approach paths while assuring terrain clearance through data inherent in the ground equipment. This increased operational capability represents the FAA's principle motivation in supporting the development and deployment of MLS. Increased precision of the approach guidance, ease of system installation, improved reliability, a decreased susceptibility to electromagnetic interference (both on the ground and in the air) and the far higher number of available transmission channels result in the MLS being rated technologically superior to the present ILS.

Airspace management is also enhanced by the MLS. Flying the MLS allows a degree of flexibility for Air Traffic Controllers previously realized only in VFR conditions. Course guidance for the MLS depicts a curved path similar to a visual high key, or low key flightpath. Therefore, the MLS affords an increase in numbers of aircraft which can be effectively handled under instrument conditions. Flying the ILS, aircraft must carefully sequence along the narrow beam guidance. The flight path closely resembles a VFR straight-in approach path. The result is lack of flexibility, sequencing delays and overcrowding. In contrast the MLS is responsive to performance criteria of different aircraft and limitations of terrain, and overflight restrictions. Using the 19 to 20 degree MLS elevation scan, a pilot may select varied approach angles (to include two-step glide slopes), best suited to his aircraft and circumstance. The separate 40 degree horizontal, wide sweep plane, permits use of unique curved flight paths. These curved approach paths, similar to a VFR flight path, join the projected runway centerline at a predetermined point on the approach. These new instrument options result in less delays in approach sequencing within the airport terminal area. The ability for a controller to safely sequence large and small aircraft onto the final approach path provides an added amount of flexibility and safety when dealing with restrictions of wake turbulence and noise abatement. One of the most unusual features of the MLS is it provides missed approach guidance. This guidance includes glide/climb path data to assure safe transition with terrain and obstacle clearance. This guidance is provided within a 40 degree fan on the departure end, extending to 5 nm, and

FIGURE 2 - MLS INSTRUMENTATION



Inside enclosed area behind the azimuth antenna is the MLS monitoring equipment. CRT here displays real time information as well as a record of past performance of MLS approach aid. (2-3 Fig 1)



MLS control panels. Each panel contains controls for frequency (Channel), azimuth (course), and glide slope selection. Also visible are "fail" and "warning" lights. One additional panel (not shown) calls up specific information like "runway condition" and "minimum glideslope" (2-4 Fig 2)

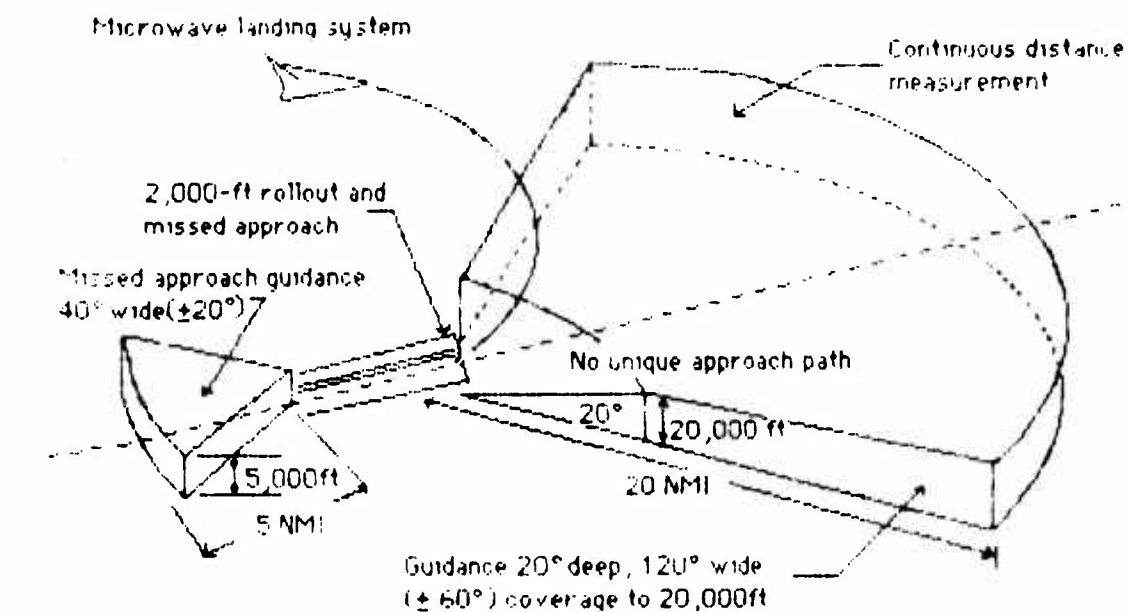
5,000 ft. AGL (Fig. 3) (5.Ch.4:Fig.8) This safety factor allows the pilot to depart the terminal airspace and safely transition to a designated pattern reentry point (5.64)

Designed with reliability and maintainability in mind, MLS ground equipment can be remotely operated and monitored by maintenance or tower personnel. This new system's digital design of the ground equipment, built to facilitate quick change-out of line-replaceable units (LRU), features redundant systems and "fail-soft" technology. All ground equipment has been designed with a self-monitoring capability which can be evaluated at non-collocated areas such as the airport tower, or maintenance facility.(3.10)

FLYING THE MLS

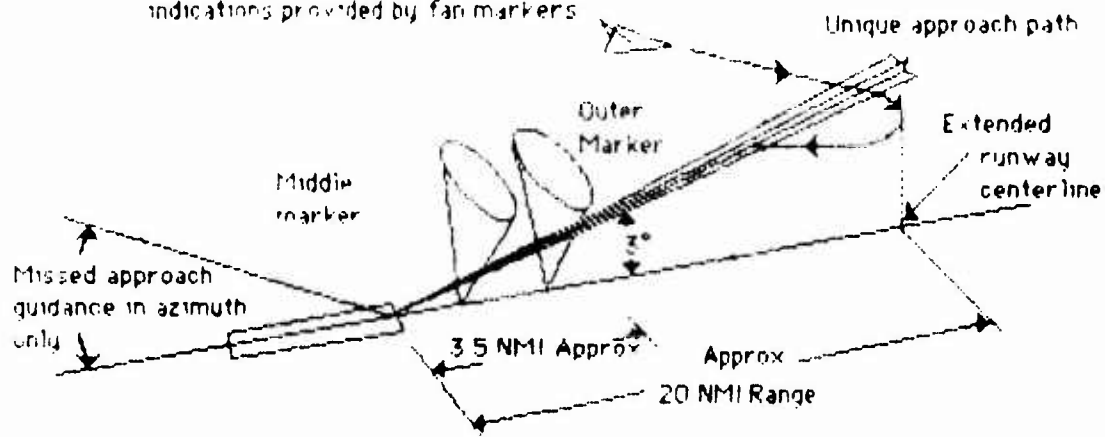
Although MLS cockpit equipment varies from the old ILS receiver, the actual guidance can be displayed on the present flight director systems most of our military aircraft use. The major notable system difference to the pilots will be the replacement of the ILS receiver with an MLS receiver. The MLS receiver, once the frequency allocations have been made, will allow the pilot to dial in one frequency which will provide course guidance and associated DME/P information. Presently, some of the developmental systems require two separate receivers one for the MLS and one for DME/P. A more pronounced difference will be the ability of the pilot to select the glideslope he determines best serves his performance requirements. It further give him the ability to set in a degree of centerline offset. This offset function allows the MLS to establish a curved flight path to the runway. Certain safety parameters are established within the MLS approach system, which will not allow the pilot to set unsafe parameters into his onboard equipment. Each operational MLS will have a maximum and minimum glideslope, and a maximum azimuth (course offset), selectable by the pilot. Should the pilot select parameters outside those established in the system, a visual and aural warning is introduced from the ground system. In the future, some MLS multiplex systems will have the ability to call up six separate areas of airfield data, to include facility identification, facility category, minimum glide slope, runway identification, runway condition, and azimuth. This system provides even more safety information for the aircrew flying the approach (2.4)

FIGURE 3-COMPARISON OF MICROWAVE LANDING SYSTEM
and INSTRUMENT LANDING SYSTEM



Instrument landing system

No continuous distance measurement two discrete range indications provided by far markers



Source: Federal Aviation Admin.

THE FUTURE

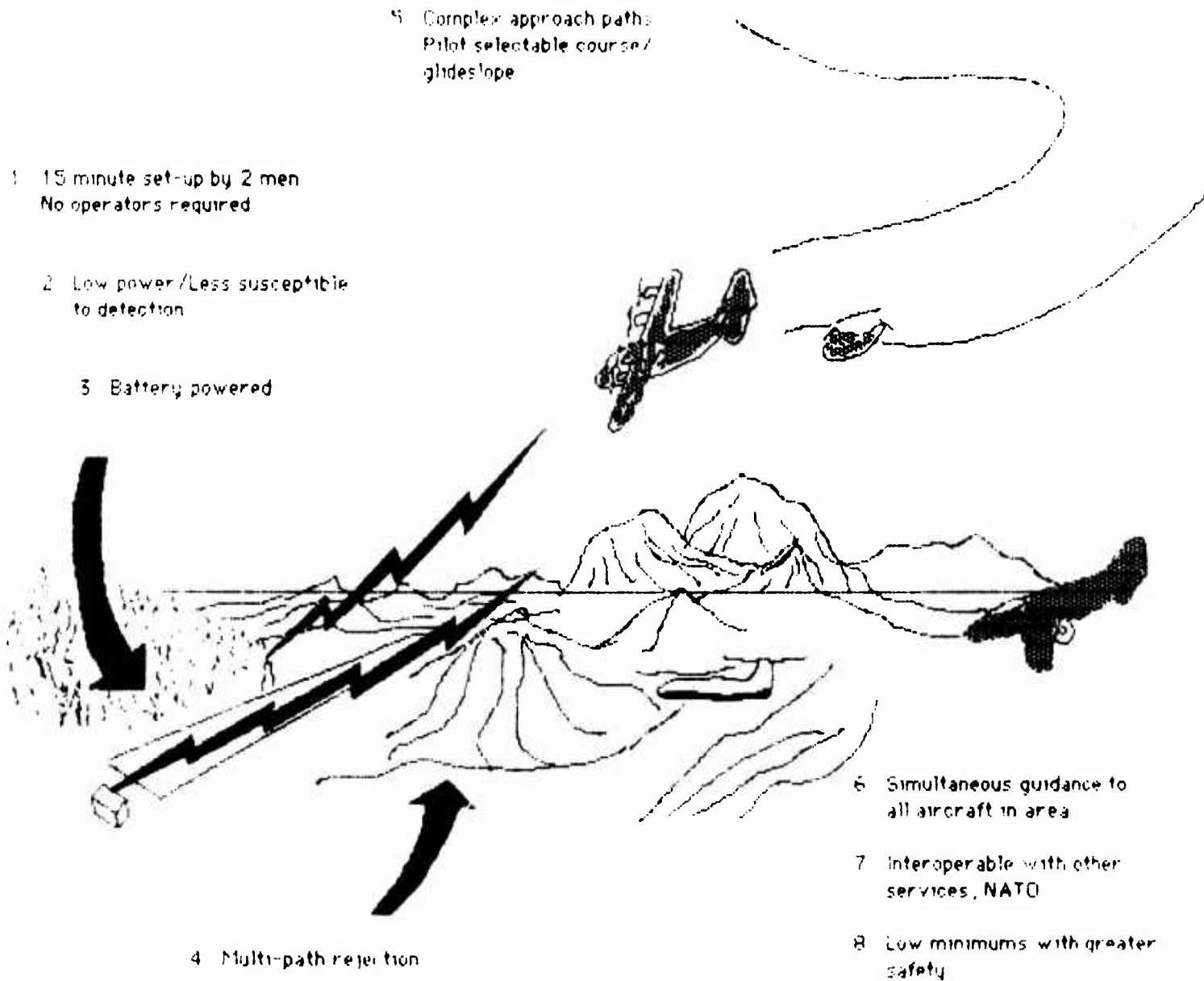
The Microwave Landing System promises to continue providing positive improvements to the international theater of flying. Future applications include portable MLS systems to be used in military deployments. Joint service testing began in 1983 on a joint tactical microwave landing system (JTMLS). With this exceptional new system, the anxiety of an approach over threatening terrain in poor weather will be significantly lessened. Highly dependable, MLS can assure reliable data from altitude through touchdown or missed approach.(3:11)

The new JTMLS is envisioned as the heartbeat of real world mobility scenarios which might require approach information in an austere landing environment. The JTMLS is a lightweight, portable landing system based on MLS technology. Set up time is projected to be 15 minutes, and can be accomplished by a crew of two technicians. This new system has received much attention from the Army. They view the JTMLS as a primary aid in assuring a positive position of mobility. If an engineering force can establish a "wartime" landing strip, this system can assure reliable instrument approach data in a zero-zero environment. This new system has many advantages which make it a key player in future mobility planning.(Fig. 4) (3:Fig6)

In the year 2000, MLS approaches will represent the standard. Approach plates calling for 5.2 degree minimum glide slope for noise abatement, a 40 degree curved final, and a roll out point 1/2 mile from the runway threshold will be common.

This handbook has endeavored to familiarize you with the history of the microwave landing system, the nuts and bolts of the system and its flight application. MLS is the wave of the future, it's beginnings are here and now. Both the MLS and the JTMLS, presently under development, will significantly enhance flight safety and mission accomplishment (3:8)

FIGURE 4 - JIMLS ADVANTAGES



(3 11 Fig6)

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GLOSSARY

- ATC - Air Traffic Control
- CAA - Civil Aeronautical Association
- CAB - Civil Aeronautics Board
- CAT II/CATIII - Category two or Category three (instrument minima)
- CRT - Cathode Ray Tube
- DME - Distance Measuring Equipment
- DME/P - Precision Distance Measuring Equipment
- DO - Development Objective
- FAA - Federal Aviation Administration
- ICAO - International Civil Aviation Organization
- IFR - Instrument Flight Rules
- ILS - Instrument Landing System
- JTMLS - Joint Tactical Microwave Landing System
- LRU - Line Replaceable Unit
- MLS - Microwave Landing System
- PAR - Precision Approach Radar
- RTCA - Radio Technical Commission Aeronautics
- SARP - Standards and Recommended Procedures
- TRSB - Time Reference Scanning Beam
- UHF - Ultrahigh frequency
- VHF - Very high frequency
- V/STOL - Vertical Short Takeoff and Landing (aircraft)

INDEX

<u>Subject</u>	<u>Page</u>
Airspace Management	3,7
Curved path approaches.....	3,8
Design limitations (ILS)	1,2
Instrument Landing System (ILS).....	1,2
Joint Tactical Microwave Landing System (JTMLS).....	10-11
Microwave Landing System	
Advantages.....	4-8
Capabilities.....	6-8
Flight instruments.....	6,8
Flight paths.....	6
Ground Equipment.....	4
Future applications.....	10
Missed Approach Guidance.....	6-9
Operational requirements (MLS).....	2-3
Safety features.....	6-9