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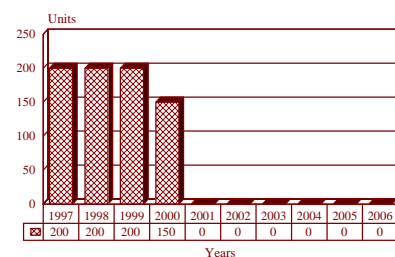
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MLS Avionics - Archived 9/98

Outlook

- Mandatory MLS requirements dropped ICAO
- FAA canceled Cat II/III MLS development
- Limited production has begun to support the users that do exist
- Switch to GPS has impacted MLS market significantly

10 Year Unit Production Forecast
1997-2006



Orientation

Description. Microwave Landing System (MLS) avionics consists of MLS receivers, antennas, and control and display instruments.

Sponsor

Department of Transportation (DOT)

Federal Aviation Administration (FAA)

Washington, DC

USA

(Original Program Manager)

US Air Force

Air Force Material Command

Electronic Systems Center (ESC)

Hanscom AFB, Massachusetts (MA)

USA

(Leader, Tri-Service MLS Program to include

CMLSA and MMLSA development)

US Navy

Naval Air Systems Command (NAVAIR)

Washington, DC,

USA

(Multi-Mode Receiver development)

Contractors

AlliedSignal Commercial Avionics Systems

2100 NW 62nd Street

Ft. Lauderdale, Florida (FL) 33309

USA

Tel: +1 305 928 2100

Fax: +1 305 928 3000

(Civil/general aviation receivers; teamed with

GEC-Marconi on MMLSA Phase II development)

Canadian Marconi Company (CMC) Aerospace

415 Leggett Drive, PO Box 13330

Kanata, Ontario, K2K 2B2

CANADA

Tel: +1 613 592 6500

Fax: +1 613 592 7427

(Commercial MLS receivers; CMLSA (ARN-152) prime contractor development/production for USAF;

teamed with Rockwell/Collins on MMLSA Phase II competition)

GEC-Marconi Electronic Systems Corp

164 Totowa Road, Box 975

Wayne, New Jersey (NJ) 07474-0975

USA

Tel: +1 201 633 6000

Fax: +1 201 633 6167

(MMR Prime: development/production; teamed with

AlliedSignal on MMLSA Phase II development)

Hazeltine Corp

450 Pulaski Road

Greenlawn, New York (NY) 11740-1606

USA

Tel: +1 516 261 7000

Fax: +1 516 261 8002

(MMLSA Phase II competition)

Honeywell Inc

Satellite Systems Operation

PO Box 21111

Phoenix, Arizona (AZ) 85036

USA

Tel: +1 602 436 2311

Fax: +1 602 436 2252

Japan Radio Co, Ltd (JRC)

Tokyo

JAPAN

(Development of low-cost general aviation receivers)

Pelorus Navigation Systems Inc

Calgary, Alberta

CANADA

(Development of low-cost general aviation receiver)

Rockwell International Corp

Collins Avionics & Communications Division

350 Collins Road NE, MS120-130

Cedar Rapids, Iowa (IA) 52498

USA

Tel: +1 319 395 5775

Fax: +1 319 395 5111

(Teamed with CMC on MMLSA Phase II competition)

[The Boeing Co agreed to acquire Rockwell International's defense businesses. Company reorganization may impact parts of this division.]

Telephonics Corp

815 Broad Hollow Road

Farmingdale, New York (NY) 11735

USA

Tel: +1 516 755 7000

Fax: +1 516 755 7644

(Development of NASA Space Shuttle MLS; manufacturer of military/commercial MLS airborne receivers)

Status. Development; limited production.

Total Produced. An estimated 870 receivers were produced through the end of 1996.

Application. Military transports, special-purpose, tactical aircraft, commercial transports; general aviation aircraft.

Price Range. 1994 prices for the following are: MLZ-850, US\$28,978; CMA-2000 "Microlander," US\$28,800; MLS-21, US\$25,615.

Technical Data

Design Specifications. MLS is insensitive to geography and obstructions. At most locations, the full 140° scan coverage would be usable. At particularly difficult sites, the coverage could be reduced to 110°. In addition, the

scan coverage could be adjusted to extend further to one side and less to the other to accommodate special requirements. MLS operates at microwave frequencies; therefore no extensive grading or land purchases would be

required as with the ILS (Instrument Landing System). The existing geography of any airport, large or small, would require little or no modification for the installation and operation of MLS.

Under MLS, multiple approach azimuth and glide path guidance would be simultaneously available to a variety of users. Large command jets, smaller aircraft, STOL aircraft and helicopters could all conduct approaches based on their specific capabilities and limitations, with MLS being especially valuable for the latter two. An increasing number of aircraft now are being equipped with Area Navigation (R-NAV) capability. The MLS signal would provide for much broader and efficient use of R-NAV, using segmented and eventually curved approaches.

Environmental and local siting conditions would not impact the functioning of a microwave landing system, and information would be transmitted at the same high standard. This would provide minimums consistent with other factors such as terminal procedures and aircraft/pilot capabilities.

Operational Characteristics. The microwave landing system (like the instrument landing system) uses the air-derived navigation concept. It uses ground equipment to transmit a signal into space that is interpreted by the aircraft's MLS receiver to determine its position relative to the airport. The aircraft receiver (for angle data) uses the technique of measuring the time difference between passage of scanning beams for angle coding in a time-multiplexed signal format. Because angle information is extracted from scanning beams, the system is self-encoding and requires no signal modulation. The beams

scan rapidly across the approach envelope at a precise rate: back and forth for azimuth and up and down for elevation. Each scan cycle provides two pulses as the beam crosses the path of the aircraft. The aircraft receiver computes aircraft position by measuring the time differential between the two pulses. Digital time-gate tracking logic in MLS avionics minimizes multipath errors, improves signal quality, and allows the transmission of data messages associated with the system operation. Range information is obtained through the use of precision distance-measuring equipment (DME/P).

Airborne MLS systems include antennas, angle receiver-processor, DME, and necessary controls and displays. The processor includes extensive signal acquisition and track validation features to ensure that the angle guidance signal has high integrity and immunity from interference. Automatic self-test using BITE (built-in test equipment) is employed, and an end-to-end check of the unit can be initiated by injecting a Time Reference Scanning Beam (TRSB) signal at the receiver input. DME/P is interoperable with DME/N (Normal DME). The DME/P interrogator can be used for en route navigation with VORTAC; pulse shaping and enhanced signal processing provide the required DME/P accuracy for approach.

Guidance information can be coupled to conventional CDI (Course Deviation Indicator) or ILS indicators, or to an automatic flight control system. Additional information, including facility identification, runway azimuth, landing category, runway identification and condition, and minimum usable glide slope, can be presented on an auxiliary data display panel.

Variants/Upgrades

This is an ongoing development effort that continues to be upgraded/modified to accommodate changing functional needs and technology developments.

Program Review

Background. Beginning in 1975, the USAF conducted a Flight Profile Investigation (FPI) into MLS. This series of tests would determine which flight profiles were feasible with MLS when flown by aircraft having various levels of flight controls and displays, and establish a baseline for identifying the aircraft controls needed to fully exploit the capabilities of MLS. A T-39 Sabreliner, which had flight characteristics representative of executive-type, twin-engine jet aircraft, was used to conduct Time Reference Scanning Beam (TRSB) MLS approaches.

The US Army investigated unique helicopter flight profiles using a UH-1B, while the Navy evaluated the

feasibility of installing airborne MLS equipment on a tactical fighter and its performance during approaches on Navy aircraft carriers. Both efforts were completed in 1977. Various flight test activities continued into the mid-1980s.

With the development of the National Airspace System (NAS) plan in 1981, MLS was incorporated as one of the major system projects, and an MLS implementation strategy was integrated into the NAS plan.

Commercial MLS Avionics (CMLSA) Program. Until 1985, the Air Force role was flight testing various MLS candidates. But that year, Systems Command's Electronic

Systems Division at Hanscom AFB was appointed manager of the DoD MLS program. ESD began to develop a full-scale Tactical Microwave Landing System (TMLS), which would be an air-transportable version of commercial equipment for precision landings in tactical areas. It also set about procuring pre-production commercial grade airborne MLS receivers for about 350 C-130 aircraft, as well as about 300 ground MLS stations for Air Force, Army, Navy, and Marine bases in the US under an FAA contract for civil MLS.

A year later, USAF split off avionics development from the TMLS (now renamed the "Mobile MLS" or MMLS) and established this effort as a separate program called "Commercial MLS Avionics" (CMLSA). CMLSA was conceived as a quick capability procurement, with the emphasis on possible off-the-shelf acquisition. It would require minimum development, while meeting International Civil Aviation Organization (ICAO), Radio Technical Commission for Aeronautics (RTCA), and FAA requirements.

In January 1986, the USAF Systems Command, Aeronautical Systems Division awarded a US\$1.5 million study contract to Oneida Resources Inc (Dayton, OH) to review and analyze commercially available MLS avionics concepts and systems for selection, standardization, installation and retrofit on DoD aircraft. The study focused on comparison of the life-cycle cost/benefits of modifying a commercial MLS receiver, developing the Navy multi-mode receiver (ARN-138, providing both ILS and MLS capability), or designing a military MLS receiver. It established the cost/benefit tradeoffs for integrating these alternatives into DoD aircraft (baseline C-130 and F-16), and for comparing and evaluating alternative ways to provide MLS distance-measuring capability (e.g., using Global Positioning System [GPS] receivers, using DME/P, improving DME/P).

It also provided a feasibility, cost, schedule, and risk study of developing 20,000-hour to 30,000-hour MTBF MLS receivers. The following November, an MLS avionics architecture study recommended modified commercial MLS avionics as the most cost-effective system to meet DoD transport and support aircraft requirements.

According to an October 1986 *Commerce Business Daily* announcement, CMLSA avionics were to be commercial-grade equipment with the capability for a computed straight-in approach to an offset collocated site using TACAN or other DME source, course sensitivity softening, and a MIL-STD 1553 databus and ARINC 429 interface for control. Interoperability with all civil and military MLS ground equipment would be accomplished by means of the ICAO MLS signal format.

In October 1987, Canadian Marconi Co (CMC), Avionics Division, was chosen to supply a modified version of its CMA-2000 Microlander for the CMLSA program. The CMA-2000 is an ARINC-727-compatible MLS receiver. Modifications included a MIL-STD 1553D interface, computed centerline capability using TACAN and DME range inputs, marker beacon outputs and course softening to suit USAF operational siting and guidance requirements. Also required were qualification tests including demonstration of full operation at -55°C to +70°C, and vibration at 5 g. The high vibration requirement was aimed at hard landings for the C-130 as well as Army helicopters. The CMC-2000 receiver has been given the US nomenclature of ARN-152.

In the first phase of the contract, CMC developed and delivered 14 CMLSA equipment shipsets to USAF for evaluation testing. This 18-month effort involved developmental test and evaluation (DT&E) flights on C-130 transport, UH-1 helicopter, Convair-580, and the Navajo scheduled for completion in mid-1993. A decision to proceed with initial low-rate production was made in the summer of 1990, exercising the first of three production options for up to 1,100 CMLSA RPUs. In May 1992, CMC was awarded the final option, with deliveries scheduled to begin in early 1993.

US Military Airlift Command (MAC) C-130s were the first to be equipped with CMLSA, with C-5s, C-141s also scheduled to follow. The new C-17 transport had appeared to be a more likely candidate to receive the MMLSA, as production of the new plane would coincide with production of the Military MLS Avionic receivers. However, then came the FAA's cancellation of the MLS Cat II/III effort: the future of MLS in US service has been sharply curtailed. Relevant USAF documents discuss only C-130 CMLSA installations, with other potential MLS recipient platforms listed only for GPS fits. To reduce airframe down-time and integration costs, MLS would be installed during programmed depot modification scheduling, and, when possible, in conjunction with the Global Positioning System modification schedule. In May 1994, the USAF issued a notice that it planned to procure up to 300 more CMLSA B-kits to complete installations on C-130s. The total C-130B-Ns to receive CMLSA B-kits is listed as 233 Air National Guard, 148 USAF Reserve, and 218 USAF Active Fleet in the FY95 modification documents.

The Navy was expected to procure the CMLSA receivers for its large, land-based ASW, transport and special-mission aircraft such as the P-3, C-130 and EP-3. The Army and the Coast Guard were to follow suit, though their requirements were believed to be smaller. Because the FAA canceled the national MLS effort, further military

installations became less likely as GPS begins to become the preferred navigation and approach method.

In a related effort, USAF contracted Smiths Industries, SLI Avionic Systems Corp (formerly Lear Siegler), for incorporation of revised specifications for integration of MLS with the C-130 SCNS (Self-Contained Navigation System). The SCNS is a fully integrated navigation and communication management system designed to give the C-130 the ability to navigate and accomplish various mission requirements independent of ground-based radio navigation aids. Primary navigation information is provided to the SCNS via a ring laser gyro inertial navigation system, a single Doppler velocity sensor, and various navigation radios all installed on the transport.

The original contract was awarded to Smiths in 1985 for 439 systems, with USAF requirements increased to 547. In September 1988, Smiths was contracted to integrate MLS capability into the SCNS. An FFP contract for US\$5.6 million went to Smith as well, in December 1995, to integrate the dual inertial navigation unit, global positioning system, automatic communication system and microwave landing system into the SCNS on 7HC-130P/N aircraft. This latest contract is expected to be completed in December 1997.

Military MLS Avionics (MMLSA) Program. Nicknamed Melissa, the MMLSA program is the result of the MLS Avionics Architecture Study initiated in FY85 and completed in November 1986. The study recommended that the US Air Force pursue development of a high-reliability MLS/ILS receiver for high-performance aircraft. These would be installed in performance, size and weight-constrained aircraft unable to use the CMLSA.

The Air Force's Electronic Systems Division (now known as Electronic Systems Center) published a notice in the November 1986 *Commerce Business Daily* outlining MMLSA program requirements. The MMLSA's receiver would be capable of both MLS and ILS functions. Designed to fit in the same space as the Rockwell/Collins ARN-108 ILS receiver, the receiver would meet a fighter aircraft's environmental requirements and have a mean time between failures (MTBF) greater than 20,000 hours. The box would be capable of communicating on both MIL STD-1553 and ARINC 429 buses. The receiver, furthermore, would be able to interoperate with all civil and military MLS and ILS ground stations, and would meet Radio Technical Commission for Aeronautics DO-131A, DO-132A, and DO-177. The RFP was issued in February 1987.

USAF's Electronic Systems Division awarded first-phase technology demonstration contracts to five contractors in June 1987: Kollsman; Telephonics Corp; Hazeltine Corp; GEC-Marconi Electronic Systems Corp, with AlliedSignal

Bendix as subcontractor; and Rockwell International Collins Government Avionics Division, with Canadian Marconi Company as subcontractor. This was a 15-month effort. Collins/CMC was the first team to complete the first phase, two months ahead of schedule in September 1988.

An early Rockwell Collins MMLSA product brochure, dated February 1988, expanded on MMLSA capabilities. The Collins/CMC proposal would have a full ILS capability including localizer, glide slope, MIL-E-5400 Class 2 environment, three MLS antennas for curved approaches and MLS area navigation. It would meet ICAO (International Civil Aviation Organization) specifications for rejection of undesired RF signals. Power requirements were 28 Vdc per MIL-STD-704A Category B, Notice 1, 20 watts maximum. Weight was 10 pounds.

Source selections for second-phase full-scale development (FSD) contracts were announced in December 1989. Of the original five competitors, USAF selected three for FSD: Hazeltine (US\$6.46 million), Plessey (US\$9.14 million), and Rockwell Collins (US\$11.6 million). FSD was to be a 30-month effort completed by May 1992. Developmental Test & Evaluation (DT&E) was scheduled to begin in late FY92 with Operational Test & Evaluation (OT&E) scheduled to follow in FY93. A US\$6 million contract was awarded to the team of GEC-Marconi and Allied-Signal in June 1993. The contract was issued for completion of development – a process expected to take about 36 months – and for the production of 30 units to be used for full qualification testing. If options for all three production lots were exercised, the value of the contract could increase US\$43 million and call for a total of 2200 units.

Initial Operating Capability (IOC) was slated for January 1995; however, FY95 budget documents show the MMLSA only beginning IOT&E in FY95. Although MMLSA is primarily intended for fighter and trainer aircraft, future large platforms such as bombers and transports may also be equipped.

Multi-Mode Receiver (MMR) – US Navy. During what was then considered the transition to military MLS, several operational landing aids, some unique to the Navy/Marine Corps, remained in service, requiring the Navy's carrier- and land-based aircraft to be able to interface with these widely divergent ground signal formats. The Multi-Mode Receiver (MMR), nomenclatured as the ARN-138, was developed for interoperation with either the Automated Carrier Landing System (ACLS) or the Marine Corps Remote Area Approach and Landing System (MRAALS), Navy TACAN systems, existing international standard ILS, or the MLS. In the ACLS application only, the MMR provided an Independent Landing Monitor for the

primary system. In other applications, it would be the primary and only precision landing indicator on the aircraft.

The MMR was designed to replace the ARA-63 single-mode Receiving-Decoding Group receiver that is standard equipment on Navy/Marine fixed-wing aircraft. It was intended for installation on Navy/Marine helicopters as well. The MMR capability would allow pilot selection of a mode for interoperability with any of the above-mentioned landing aids as well as provide Navy/Marine aircraft with Category III adverse-weather landing capability.

Additional features of the MMR included both analog and MIL-STD-1553B data bus format outputs, selectable glide slope, course softening, minimum usable glide slope, displays range, range rate, height above touchdown, visual and audio advisories and built-in test. The core MMR ship set consisted of three units for MIL-STD-1553B compatible aircraft: the radio receiver, navigation computer, and the DME coupler calibrator. For not MIL-STD-1553B-compatible aircraft, three additional units could be added: the range/height/rate unit, receiver control unit, and C-Band RF amplifier. In this configuration, the MMR interfaced with the aircraft TACAN system.

GEC-Marconi Electronic Systems Corporation North American Operations, was awarded a US\$15.7 million development contract for delivery of 20 preproduction units in September 1987. The program underwent a major change in mid-1989 when the Navy implemented an engineering modification to a portion of the preproduction lot to make it compatible with the Rockwell/Collins ARN-153, a derivative of its TCN-500 TACAN, a candidate for replacing the older ARN-118 TACAN which had been a Navy standard since the late 1970s. Despite some delays in its development cycle, the ARN-138 completed Technical Evaluation (TECHEVAL) the third quarter of FY90.

Original procurement estimates for the MMR ranged between 3,000 and 4,500 systems. There was some speculation that the US Army would procure a limited number of MMR to equip Special Operations Forces (SOF) helicopters. However, the US Navy shelved the MMR pending further research into alternate landing technologies. Subsequently, OPEVAL and the Milestone III low-rate production decisions were postponed indefinitely, pending the FAA's evaluation of GPS as an alternative landing aid.

Program Restructuring. The focus of this USAF program was originally on developing the microwave landing system for worldwide adoption. It was drastically redirected. Its goal became the development of a replace-

ment for ILS to support precision landing capability until GPS becomes available.

Multi-Mode Receiver (MMR) — USAF. While the Navy's MMR had very limited usage, the USAF has been developing one that could be used for many years, at least until GPS/Glonass precision landing technology is perfected. Through a Cooperative Research And Development Agreement (CRADA) with GEC Marconi, the USAF Electronic Systems Center has been managing development of a multi-mode receiver fitted with not only ILS and MLS capability but with GPS capability as well. The new MMR was the result of an evolutionary process which began with the Air Force's MMLSA receiver. The Military Microwave Landing System Avionics receiver, with ILS and MLS capability, was modified to become a Precision Landing System Receiver (PLSR). To this PLSR, GEC Marconi has added (at its own expense) a Trimble six-channel GPS receiver. The resulting multi-mode receiver's avionics box measures 10.16 x 5.02 x 3.76 inches, weighs 9.8 pounds, and fits in F-16 and other fighter aircraft. It is the same size as the ARN-108 ILS unit now installed in the F-16. Designed to sustain high g-forces, it is intended to be used in a wide variety of USAF aircraft, especially transport aircraft.

Successful flight trials were performed on a C-135C aircraft at Hanscom AFB in October 1995 and on an FAA Sikorsky S-76 at the FAA Technical Center (December 1995). Preliminary accuracy results indicated that the MMR performed well within Category I performance standards. Testing was, at that time, limited to Category I, as the Air Force's transport fleet aircraft operate to Category I minimums. According to GEC Marconi, test pilots reported little difference in the "guidance feel" between the three modes as they flew more than 45 precision runway approaches. The test activities were funded by US\$125,000 provided to the Electronic Systems Center by the GPS Joint Program Office at Los Angeles AFB, CA. Testing was also supported by ARINC Inc, Annapolis, MD, which provided a ground-based D-GPS station, and Textron Systems Division whose mobile microwave landing system developed for the Air Force was also used.

The USAF's MMR program is entering the final phase of engineering and manufacturing development. An engineering change proposal calls for the MMR's production system to use kinematic carrier phase tracking techniques to provide Category II or III accuracy. It should be ready for production following testing by late 1997. No formal requirement for a multi-mode receiver has been announced by the Air Force. However, Electronic Systems Center officials believe it will be needed by military aircraft flying into other countries' civil airfields.

Since mandatory MLS installation has been dropped and no single precision landing system has been endorsed by the ICAO, airports worldwide will be equipped with different types of systems, with some even issuing their own system compliance regulations. The crash which killed US Commerce Secretary Ron Brown in the Balkans indicates the hazards inherent with using indigenous systems are used. This was not an MLS situation, but old navigation equipment, unfamiliarity with procedures, and approach deficiencies combined to cause the disaster.

Multi-Mode Receivers – Civil Aircraft. A multi-mode receiver providing ILS, MLS and GNSS (Global Navigation Satellite System) capabilities for commercial use is being developed by Rockwell's Collins Air Transport Division. Designated the GLU-900, the new multi-mode receiver was designed to meet the needs of commercial airlines worldwide as they prepare to transition to GNSS sometime in early 2000.

This transition period could last as long as 20 years. Meanwhile, US airlines are installing GPS capability, while in Europe many services will retain ILS as long as operationally feasible (or until 2010, ICAO's deadline for replacement of ILS) and others will need to install MLS capability. The ILS nav aids of Amsterdam's Schiphol airport and London's Heathrow, for example, are experiencing quality degradation to the point that they are expected to be among the first to install Category III MLS or the equivalent. Amid these differing strategies, airlines soon will be flying into airports with different landing systems.

A multi-mode receiver such as the Collins GLU-900 could be the most cost-effective solution for many airlines. They would continue to have ILS capability many European fields will eventually have GNSS capability, which the US is promoting as the ultimate precision-landing system; and they would have the MLS capability at some "austerely located" airports will have to adopt to be able to achieve Category II or III landings. GNSS worldwide will be limited initially to en route and nonprecision approaches.

ILS and GNSS functions are basic to the GLU-900 receiver, while the MLS function is categorized as an option. Two configurations of the system will be available: the GLU-900, an Arinc 710 replacement; and the GLNU-900, an Arinc 547 replacement which also includes the VOR function. Both are compatible with existing ILS interfaces, racks and wiring. Such a system would not only expand airlines' capabilities, but also the number of airports served.

TILS II. Telephonics has been involved in the development and production of MLS airborne receivers, as well as ground stations, since the late 1960s. It has supplied the NASA Space Shuttle Microwave Scanning

Beam Landing System (MSBLS), the ARA- 63 C-Scan receiver for the US Navy, and the ARQ-31 MLS Tactical System Airborne Set for the US Army. Its latest MLS receiver product is the TILS II receiver now in production as part of an US\$11 million follow-on contract in 1993 from Saab for the Swedish Air Force JAS.39 Gripen. The TILS II is a MIL-STD-1553B compatible receiver designed for high reliability, with a service life of 5,000 hours over a 20-year period. TILS II may be used with any Ku- band MLS ground station. Telephonics is also developing a newer version, the TILS IIB, which will provide both MIL-STD-1553B and analog interfaces to the aircraft.

Civil/General Aviation Receivers. The FAA categorizes MLS airborne receivers used in US civil aircraft into three classes: high-end general aviation (also known as cabin class), low-end general aviation, and air carrier.

High-end general aviation receivers are generally installed in commuter or corporate aircraft (twin piston and turboprop aircraft as well as jets). These more sophisticated receivers are often interfaced with area navigation and flight director systems that permit a variety of approach procedures. Honeywell and AlliedSignal Bendix are the major US suppliers of cabin class MLS receivers. Typical unit prices based on previously known sales or manufacturers information are provided below; however, FAA adds that it should be understood that prices are ultimately determined by the manufacturer and may be affected by competition, size of order, features desired, and installation.

Honeywell MLZ-900. Originally developed by Hazeltine as the Model 2800, this receiver is produced under license by Honeywell. It is FAA TSO 104 certified. Major production was completed in 1987, with about 100 systems produced and almost all purchased by the FAA for flight evaluations of MLS. Honeywell continues to produce spares to support FAA MLZ-900s.

Honeywell MLZ-850. The estimated list price of this receiver, uninstalled, is US\$28,978. Its current production series is available in two versions: as a subsystem of Honeywell's new Primus II integrated communications/navigation radio system for business and commuter class aircraft, or as a stand-alone system for retrofit into existing cockpits. The MLZ-850 is FAA TSO C104 certified, and has a 200 ICAO channel capability, standard rotary knob controls, and an LCD display. It is ARINC 429 compatible and provides analog outputs to ADI, HSI, FCS. The unit has a CSBD digital interface and 2X5 DME channeling, and is updatable to future ICAO magnetic course reference. Its power requirements are 18-32 Vdc and weight is 6.15 lb. Price includes tray

and installation kit. The price for Primus II configuration is US\$19,520; weight is 5.5 pounds.

Bendix/King MLS-20A. This receiver is FAA TSO C104 certified. It features standard rotary knob controls and LCD display. It also features ARINC 429 compatibility and 200 ICAO channel capability. It is compatible with analog flight control instruments as well. Its power requirements are 28 Vdc at 1.5 amp, and weight is 8.9 pounds.

Bendix/King MLS-21A. The list price of this receiver, uninstalled (including installation tray, kit, and two antennas), is US\$25,615. It is FAA TSO 104 certified, has 200 ICAO channel capability, standard rotary knob controls, and LCD display. It is ARINC 429 compatible, PDME compatible and EFIS compatible, and features ICAO magnetic course reference. Power requirements are 28 Vdc at 0.75 amps, and weight is 8.7 pounds.

Low-End General Aviation Receivers. These are panel-mounted receivers, generally installed in light, single-engine, general aviation aircraft. Although some development activity has been reported, no US-manufactured low-cost general aviation receiver has been marketed, nor is any likely to be, because of the cancellation of the mandatory MLS program. However, Japan Radio Co (JRC) announced that it had completed two production prototype panel-mounted receivers. These prototypes were tested at the FAA's Technical Center in Atlantic City, New Jersey. The estimated price was about US\$3,500 – assuming the market would develop more fully and quantity production would provide economies of scale. However, the potential size of the market has now shrunk drastically.

Pelorus Navigation Systems Inc of Calgary, Alberta, Canada has been carrying out development work for a prototype, low-cost MLS receiver. The company held discussions with JRC over possible collaboration on low-end MLS receivers, but no actual agreements were announced.

Air Carrier Receivers. These are designed to meet ARINC specifications (MLS Characteristic 727) for air carrier aircraft applications involving Category I, II, and III approaches. Canadian Marconi Company (CMC) offers the advanced CMA-2000 Microlander receiver system, which is built to the ARINC-727 specification for commercial, commuter, and business aviation use. The CMA-2000 was certified by the FAA and Transport Canada in late 1986. The CMA-2000 serves as the basis for the US Air Force's Commercial MLS Avionics (CMLSA) program (see above). The CMA-2000 was selected for installation on the two Boeing 747-200B aircraft that serve as the new Air Force One for the president and senior members of the executive branch. Boeing has reportedly completed certification of the CMA-2000 equipment, with McDonnell Douglas planning to type-certify the CMA-2000 on the MD-11 transport.

Honeywell Sperry planned to offer an air carrier MLS receiver, tentatively designated as the MLZ-9000, but subsequently decided not to pursue these plans. The company felt that developments in three-dimensional GPS could "leapfrog" MLS before the system was fully operational. FAA action on MLS in mid-1994 has justified this conservative approach.

CDC CMA-2000 Microlander. This receiver's estimated list price is US\$28,800. It offers 200 ICAO channel capability; standard rotary dial controls; LCD display; full compliance with ARINC 727 and ICAO specifications; analog and ARINC 407, 410, 429 interfaces; manual and fully automatic self-test; and auto/manual angle modes. Power requirements are 115 Vac at 400 Hz, 50 Va nominal, or 28 Vdc: 50 W (non-ARINC option). The system weighs 17.85 pounds. It has three antennas.

The CMA-2000 Microlander is actually a series of airborne MLS receiver designs developed by CMC. To date, CMC has qualified two series, known as Phase I and Phase II, and was in the process of TSO qualification of a third (Phase III) design.

Funding

There is limited information available on civilian funding. Details on USAF funding for its efforts are contained in the ATCALS Market Intelligence Report.

Recent Contracts

Contractor	Award	
	(\$ millions)	Date/Description
Smiths	5.6	Dec 1995 — FFP for integration of the dual inertial navigation unit, GPS, automatic communication system, and microwave landing system into the self-contained navigation system on 7HC-130P/N

aircraft. To be completed December 1997. (F09603-95-C-0872)

Timetable

	1967	RTCA Special Committee 117 (SC-117) formed to develop ways to overcome limitations of ILS
	FY71	National Plan for Development of MLS
	FY75	FAA Flight Tests, Bendix Phase II Equipment
	FY76	DoD designated Army Lead Service for JTMLS program
	FY78	Revised National Plan for development of MLS
	FY86	Commercial MLS Avionics (CMLSA) demonstration contracts awarded
	FY87	MMR development award. MMLSA demonstration award to five contractors
Dec	1990	MMLSA Full-Scale Development Contract Award to three contractors
May	1992	CMC awarded full-production contract for CMLSA
	FY93	CMLSA IOC. MMLSA EMD Phase II contract awarded
Jun	1994	FAA announces cancellation of Cat II/III MLS ground station development
	FY95	MMLSA IOT&E
Jan	1995	ICAO drops mandatory MLS requirement
Jan	1998	Official date by which MLS was to become international standard – rescinded by ICAO at April 1995 COMM-OPS Meeting
	2010	Earliest date by which ILS must be replaced by new precision landing system (no system yet endorsed by ICAO)

Worldwide Distribution

The CMLSA, MMLSA and MMR receivers that were originally the focus of this program are unique to **US** military aircraft. A variety of other systems are in international use.

Forecast Rationale

MLS's potential as the world's preeminent precision-landing system has been almost totally eclipsed by the rapidly advancing technology of GNSS (Global Navigation Satellite System). In June 1994, the FAA halted the development of Category II and III MLS and canceled development contracts. Then, at its April 1995 COM-OPS meeting in Montreal, ICAO announced that it would drop its former mandate on MLS implementation by international airports by January 1, 1998.

No worldwide precision approach/landing strategy has yet been endorsed – although ICAO issued a nonbinding statement recommending that a five-year warning be given prior to decommissioning existing

landing systems. For the present, ILS (Instrument Landing System) will be maintained, although it must be replaced by the year 2010. GNSS technology (the US's GPS and Russia's Glonass), however, will not be able to meet Category I standards before the 2005-2010 time frame; the more rigorous Category II and III standards will not be met until 2015. In the meantime, GNSS developers and builders can refine their systems to meet ICAO's rigorous standards for accuracy, continuity, availability and integrity. Those ILS-equipped international airports unable to meet ICAO criteria, such as Schiphol airport in Amsterdam and Heathrow in London, can replace their old systems with MLS.

While MLS's ability to do what it promises remains unquestioned, its technical prowess cannot compete with the lower-cost, higher-flexibility, and easily implemented GNSS. Yet, MLS has strong adherents, especially in Europe. MLS evaluations continue in the UK and elsewhere. MLS can contend with such factors as the congested skies in many European cities, which necessitate multiple approach patterns, as well as the high density of FM radio. GPS poses a thorny problem for the international community as a whole: reliance on the US military, which has control of the GPS satellites, leading to the possibility that access could be denied in time of war, for example. US release of the more-precise military modes to the general public will ease some of these concerns.

Russia's Glonass system does not feature this "selective availability," as the Pentagon calls its right to degrade the GPS's signal. Glonass users then have somewhat greater reliability on their system. Glonass can be used in conjunction with GPS to achieve global coverage. Each system comprises 24 satellites. Glonass was provided with its final two satellites in December 1995 and became operational in early 1996. Both systems require "augmentation" to achieve ICAO-approved levels of accuracy in Category I, II and III landings. As Russia's system already meets the accuracy needs of many civil users, the country has been slow in developing accuracy-enhancing differential correction techniques. But such development work is now progressing in earnest.

To meet ICAO's stringent standards for accuracy, the US favors a differential correction technique called the Wide-Area Augmentation System (WAAS). Wilcox Electric received a US\$475 million incentive-fee contract from the FAA to develop and produce its WAAS, which is to make the global positioning system usable for all phases of civil flight through Category I approach operations. The FAA has yet to determine whether the GPS/WAAS can provide the accuracy needed for precision approaches to Category IIIB (auto-pilot landings). The WAAS is expected to be operational by 2001; the FAA believes it to be a precursor to a worldwide satellite-based navigation system. The FAA hopes, furthermore, to expand WAAS coverage to Canada and Mexico. The system's use in Europe is also being considered; however, the Europeans have other ideas.

At the June 1995 Paris Air Show, Europe announced its own program to build a satellite navigation/surveillance program that would be administered by Europeans. Under the European Satellite Navigation Plan (ESNP), transponders would be fitted to Inmarsat-3 satellites launched in 1996 to

provide more precise fixes than the current GPS/Glonass service. ESNP would employ local differential techniques by means of ground stations rather than the FAA-favored wide-area augmentation system. However, the US military balked at such a move on the grounds that it would provide accurate targeting capabilities to enemies of the US.

The world community is far from reaching a unified approach on implementing GNSS. For some countries, GNSS may not be feasible for some time. Some will need to implement MLS as their old ILS structures degrade beyond safe use and adverse weather conditions make Category III service necessary, as has happened in Amsterdam and the UK. MLS technology is extremely expensive, which is one big reason it has been overtaken by GNSS. If a nation invests now in MLS, how will it be able to afford to convert when GNSS becomes fit for use in all categories?

MLS still has a valuable role to play in worldwide precision landing/approach technology, at least for the next 20 years. In the US military, the CMLSA continues to be installed on C-130 aircraft to meet a specific short-term precision landing mission requirement for tactical airlift. The Air Force has noted a requirement for MLS to assist aircraft operations in austere locations and remote northern and southern areas of the globe where disturbances to satellite signals are more frequent. The USAF multi-mode receiver, developed with GEC Marconi, could fill this need. A deployable microwave landing system developed by Textron Defense Systems for the Air Force could be a good candidate. This mobile MLS has aroused interest among some European users, both military and commercial. In tests conducted in Scotland, the MLS demonstrated that it could be employed in the same location and at the same time as ILS without suffering disruption from the other system.

As the world's airlines transition to GNSS, manufacturer Rockwell Collins continues to promote its multi-mode receiver as providing "a seamless shift to GPS landing systems." Collins' GLU-90 could be a good choice for European lines, which will need not only MLS systems for quite some time, but ILS systems as well. The multi-mode receiver developed by GEC Marconi with the USAF ESC would serve important US military needs. As explained by an article in *Aviation Week & Space Technology* (December 4, 1995), "A multi-mode receiver would allow a US Air Force aircraft deploying to the Middle East via Europe to use MLS or ILS when landing in Britain, ILS or D-GPS [differentially augmented GPS] when landing in Africa, and then either D-GPS or MLS in the Middle East. A

mobile MLS ground station could be deployed to airfields where GPS signals were being jammed."

The forecast was prepared with a view to the inevitable worldwide adoption of GPS/Glonass, and the virtual abandonment of MLS, except for limited use. There is continued need for precision approach systems, though, and room for a multi-mode (combined ILS/MLS/GPS) receiver on the market. It would probably find most uses among air carriers flying into European cities involving Category II and III approaches. However, airlines and corporate fleets are amenable to a multifunction receiver only if the price is right.

The conversion to GPS means that ILS will be around longer than had been expected. ILS technology, though, has advanced to the point that severe compromises will not be required. The FAA is actively pursuing upgrades to its ILS systems, and Rockwell's Collins Avionics division, for example, has invented an interesting solution in the form of ILS and VOR avionics immune to VHF FM broadcast interference, an increasingly pressing concern even in the US due to the proposed 1998 increase in the broadcast power of commercial FM radio stations. Collins offers both a new series of avionics and retrofits for existing models.

Ten-Year Outlook

		ESTIMATED CALENDAR YEAR PRODUCTION											
		High Confidence				Good Confidence				Speculative			
		Level				Level							
Designation	Application	thru 96	97	98	99	00	01	02	03	04	05	06	Total
MLS AVIONICS	CMLSA (USAF)	495	0	0	0	0	0	0	0	0	0	0	0
MLS AVIONICS	MLS RECEIVERS												
	CIVIL/GENERAL AVIATION												
	(VARIOUS)	275	100	100	100	50	0	0	0	0	0	0	350
MLS AVIONICS	MMLSA (USAF/USN)	100	100	100	100	100	0	0	0	0	0	0	400
Total Production		870	200	200	200	150	0	0	0	0	0	0	750