DOT/FAA/CT-81/81

Preliminary Software Test for the Bendix Microwave Landing System (MLS) Step Receiver

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Project Plan

U.S. Department of Transportation
Federal Aviation Administration
Technical Center
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1. INTRODUCTION.

1.1 OBJECTIVE.

The objective of this project is to test a new Bendix Microwave Landing System (MLS) Service Test and Evaluation Program (STEP) receiver through comparative bench, instrumented van, and flight tests with an existing Bendix Phase III MLS receiver. Test results will provide performance data for software evaluation before the resident software is finalized and accepted to assure satisfactory receiver performance for use in the STEP program by the Federal Aviation Administration (FAA) and other participants. ACT-100E will provide the Contracting Officer's Technical Representative (COTR) in ARD-320 with the necessary timely feedback pertaining to detected receiver problem areas to facilitate corrective receiver software modifications.

The digital and analog outputs from both units will be compared for relative performance in a proportional guidance region, the clearance (fly left/right) region, and out of coverage region. Comparative data will be collected using a number of different MLS ground systems, each in a different locale, and evaluated against FAA receiver specifications and requirements described in the contract work statement.

1.2 BACKGROUND.

The MLS time reference scanning beam (TRSB) technique has been accepted by the International Civil Aviation Organization (ICAO) for international implementation. Recognizing that the transition from an instrument landing system (ILS) to an MLS environment would be difficult and costly, the National Plan for Development of MLS has, since 1971, specifically provided for an operational evaluation of MLS as a prelude to conducting a full-scale implementation program.

The FAA STEP is designed to provide operational experience during the transition from MLS research and development efforts to actual field implementation. The STEP plan focuses on the following general goals:

a. Conducting an operational evaluation with significant user participation at typical field locations.

b. Demonstrating the ability of MLS to meet the full spectrum of user needs.

c. Developing and refining the standards and procedures needed for flight operations, flight inspection, and maintenance.

During STEP, four prototype ground systems have been deployed in a network comprising Washington National Airport (two sites), Philadelphia International Airport, and Benedum Airport at Clarksburg, West Virginia. The locations were selected principally because of the high volume of commuter operations. The FAA will provide MLS receivers to equip the participating user subject aircraft, which includes Ransome Airlines DHC-7 and Aeromech Airlines Banderante aircraft. Bendix Avionics Division, Fort Lauderdale, Florida, was given a contract to provide 30 MLS STEP receivers which will incorporate changes and improvements necessary to correct deficiencies in the Phase III MLS receivers. The Phase III receivers were used in the final phase of the United States (U.S.) MLS development program. This project will provide receiver performance data in the various coverage regions before the resident software is finalized and the receivers are furnished to the user operators.

1.3 RELATED DOCUMENTATION/PROJECTS.

The primary documents that will be used in this effort are:

a. Bendix Receiver Maintenance Manual, IB 1157C.

b. FAA Engineering Requirement MLS Basic Configuration, FAA-ER-700-01.

c. Bendix Airborne Test Set Maintenance Manual, IB 1157A.

d. A Proposal for MLS Airborne Equipment STEP 1, October 31, 1971.

e. MLS STEP Receiver Factory Acceptance Test Procedures.

f. Service Test and Evaluation Program, February 26, 1979.

g. NAFEC Range Instrumentation Systems, Report No. FAA-NA-79-32, February 1980.

h. FAA Engineering Requirement MLS Small Community Airport Configuration, FAA-ER-700-04.

i. Project Plan, MLS Flight Tests at Washington National Airport, Runway 33, Washington, D.C.

Related projects and contracts include:

a. The Evaluation of STEP Field Sites (Washington National Airport (DCA) Runway 18, Philadelphia International Airport (PHL) Runway 17, DCA Runway 33, and Clarksburg, West Virginia (CKB) Runway 21).

b. The STEP receiver acceptance testing under Contract DTFA01-80-C-10041 at the Bendix plant, Fort Lauderdale, Florida, in October 1981 (to be witnessed by ALG-425 and ARD-321 personnel).

2. SYSTEM/EQUIPMENT DESCRIPTION.

2.1 BENDIX PHASE III MLS ANGLE RECEIVER.

This receiver processes C-band signals generated by the landing site ground stations to provide digital and analog angular data. The aircraft's angular position, with respect to each received ground facility (azimuth (Az), elevation (El)), is determined by measuring the time between the "to and fro" scanning beams. The Bendix Phase III MLS angle receivers delivered in 1976 have been the only receivers used by the FAA to obtain a data base for the ICAO submission. The receiver and its block diagram are shown in figure 1. For the most part, it proved to be a

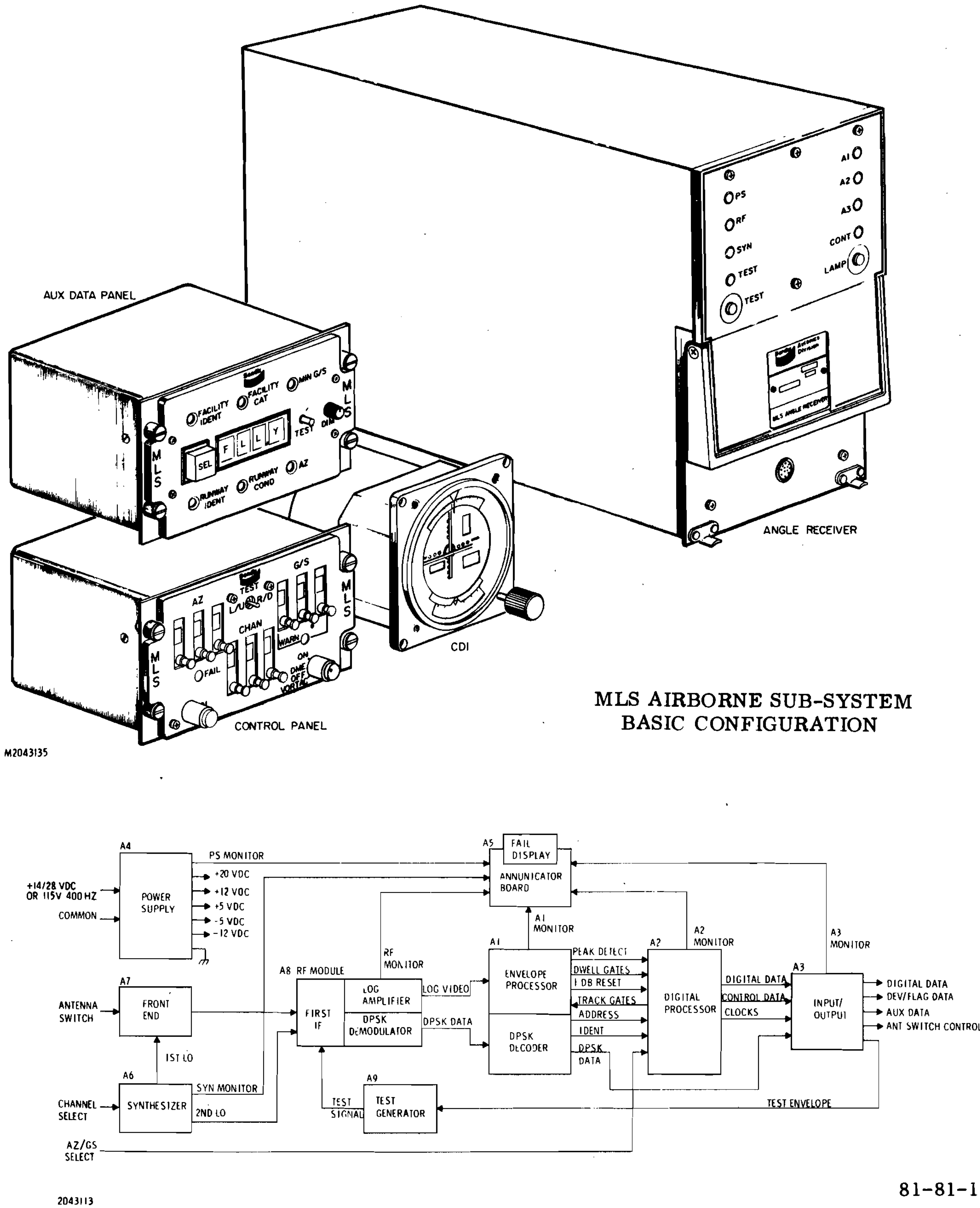

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FIGURE 1. MLS ANGLE RECEIVER AND BLOCK DIAGRAM

valuable tool for evaluating MLS ground stations, but some deficiencies have been discovered during the years of usage. Some of these were corrected as they were encountered through a three-stage improvement program that ran from 1976 through 1978, while others were only documented for use in writing future procurement specifications.

2.2 BENDIX MLS STEP RECEIVER.

This receiver incorporates modifications to the basic Phase III receiver to correct the noted deficiencies. A list of modifications to correct these deficiencies is included in appendix A, but the ones that directly affect these tests are those concerning the digital processor hardware and software (A2 card) and the input/output (A3 card). Figure 1 also represents the physical and functional description of the STEP receiver.

3. DATA COLLECTION.

3.1 LABORATORY TESTS.

Preliminary tests will be performed in a laboratory environment in order to determine that each subject receiver (Phase III and STEP) meets its static test performance specification. Items checked will be: angle accuracy, decoded elevation angle limits, decoded azimuth angle limits, receiver sensitivity (based on 10 percent frame flags), and clearance output. The applicable Phase III and STEP receiver specifications are shown in table 1. The laboratory setup is shown in figure 2.

TABLE 1. MLS RECEIVER SPECIFICATIONS*

	Phase III Receiver	STEP Receiver
Angle Accuracy**		
Mean Az Error	±0.017°	±0.017°
2 Standard Deviations	0.015°	0.015°
Mean El Error	±0.017°	±0.017°
2 Standard Deviations	0.010°	0.010°
Angle Decode Limits		
Az	-59° to +57°	-62° to +62°
El	0.5° to 16°	-1.0° to +20°
Receiver Sensitivity	-103 dBm	-103 dBm
Acquisition time	1 sec	1 sec

*Measured with a standard 1° beam width test signal free of multipath.
**Measured with a -70 dBm signal level.

Note: Sample size = 133 for Az and 400 for El (10 seconds of data).
dBm = Decibels referenced to 1 milliwatt.

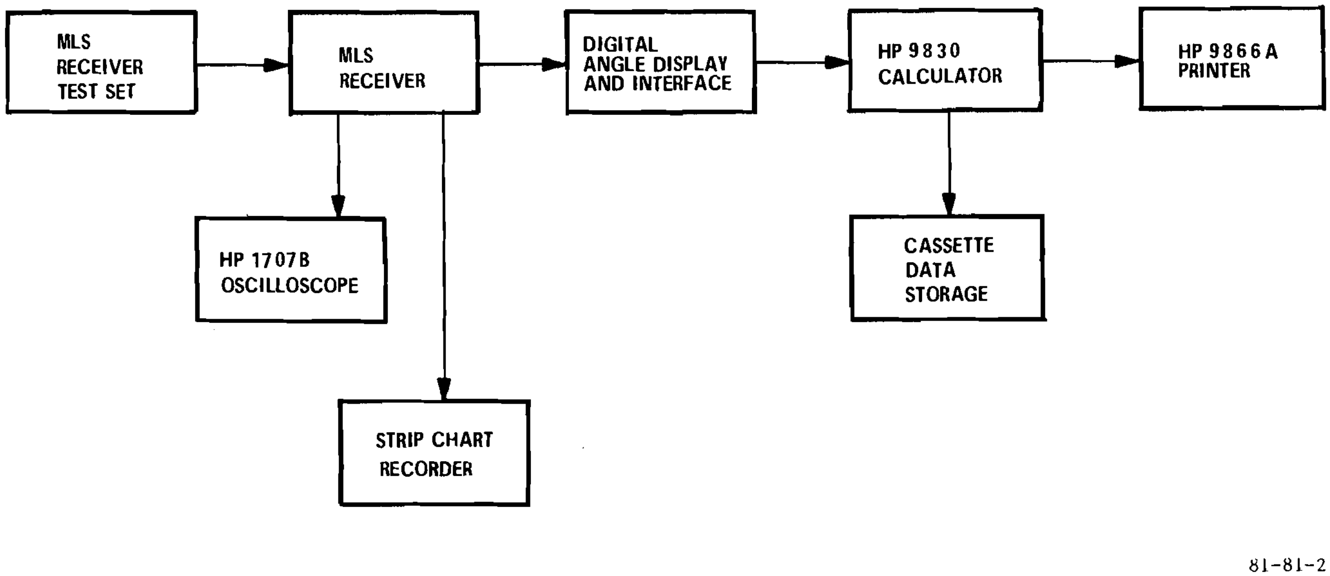

FIGURE 2. LABORATORY MLS RECEIVER CALIBRATION SYSTEM

A 10-second digital angle output data sample will be recorded for each angle shown in table 2 for determining angle accuracy. The decoded angle limits will be found by increasing the test set angle in small increments, from a point below the expected limit until the receiver flags, and then decreasing the angle until the receiver displays an angle, recording both points. To find the receiver sensitivity, the signal level from the test set will be reduced until the receiver flags, and then increased slowly (receiver has a 1-second acquisition time) until the receiver digital output indicates approximately 90 percent valid decodes, determined by a program written for the Hewlett-Packard (HP) 9830 calculator. Static clearance checks will be made by selecting the appropriate test set output (left or right clearance) and observing the analog course deviation indicator (CDI) output for full-scale deflection left or right.

3.2 STATIC VAN TESTS.

Static van tests to compare the digital outputs in the proportional guidance area will be accomplished by positioning the test van's antenna at the desired angle and recording a digital output sample (10-seconds duration) from each receiver. A mean angle, standard deviation, minimum angle, maximum angle, and the number of frame flags will be calculated and recorded for each receiver. A frame flag is a condition where the receiver rejects a particular decoded pair of scanning beams and outputs a calculated angle based on previously received data. It is not the intent here to determine system or receiver accuracy, but to compare digital data from the two receivers using actual MLS ground stations. Only a small number of points on each system will be evaluated. Table 3 indicates the various test angles for each ground system.

TABLE 2. LABORATORY RECEIVER TEST ANGLES

Az Angles (degrees)	El Angles (degrees)
-60	0.5
-40	1
-20	2
-10	3
0	4
+10	5
+20	6
+40	7
+60	8
	9
	10
	15
	20

TABLE 3. STATIC DATA TEST ANGLES

Bendix Test Bed MLS

Az (degrees)	El (degrees)
+60	
+3	1
0	3
-3	6
-60	10
	15
	20

TSC (Meyer's) SCAMLS

Az (degrees)	El (degrees)
+3	1
0	3
-3	6

3.3 DYNAMIC GROUND TESTS.

Dynamic tests using the MLS instrumented van will be performed to determine if the receiver provides proper and continuous guidance throughout the azimuth coverage area under simulated flight conditions. The test van will be driven slowly at a constant speed with the receiving antenna facing the ground station at a height above 1° in elevation (the minimum elevation coverage angle), with respect to the azimuth antenna phase center, through the following azimuth angles for each system:

Test Bed Azimuth	±70°
Transporation Systems Center (TSC) (Meyer's) Small Community Airport Microwave Landing System (SCAMLS) Azimuth	±50°

Although it is desired to cover the entire coverage area in one continuous run at a constant distance from the ground site, there are physical/airport problems in gaining access to some of these areas and probing may be done in segments at different ranges. The data collected will be azimuth analog CDI drive current and flag signals recorded on a strip chart recorder as well as annotated visual observations. Any abnormal indications will be investigated.

3.4 FLIGHT TESTS.

Flight test data collection will be accomplished using the Technical Center's Convair 580 aircraft (N-49), which is presently instrumented for MLS testing. For each receiver, two types of receiver output data, digital and analog, will be collected as well as the logging of any observed problems. The digital data will be recorded on the Kennedy 9832 nine-track digital tape recorder. On tracked flights this data will be time merged (post flight) with ground tracker data to obtain error data. A Brush 481 eight-channel strip-chart recorder will be used to record the analog data. The analog signals, CDI current and flags, are also presented to the pilot's flight director display. Figure 3 shows the existing airborne data collection system in N-49. Table 4 is a listing of the recorded digital and analog parameters.

Four types of data collection profiles will be flown: (1) constant altitude inbound radials which check all elevation angles at one azimuth angle, (2) constant altitude partial orbits which check all azimuth angles within the coverage sector at one elevation angle, and (3) approaches which check the receiver as it will be used operationally. A fourth flight profile, an "S-shaped" constant altitude radial where the aircraft vacillates between the clearance and proportional guidance regions, will be flown on the SCAMLS at Washington National Airport where laser tracking is available. This type profile is designed to reveal any deficiencies in the receiver's scanning beam/clearance transition software. Table 5 is a list of the proposed data collection runs on each MLS ground facility.

Aircraft space position for flights at the Technical Center will be determined by the NIKE-Hercules Instrumentation Radar. As tracking will not be employed at Philadelphia, aircraft position will be estimated from aircraft speed, altitude, very high frequency onmidirectional radio range (VOR) angle, distance measuring equipment (DME) readings, and landmarks.

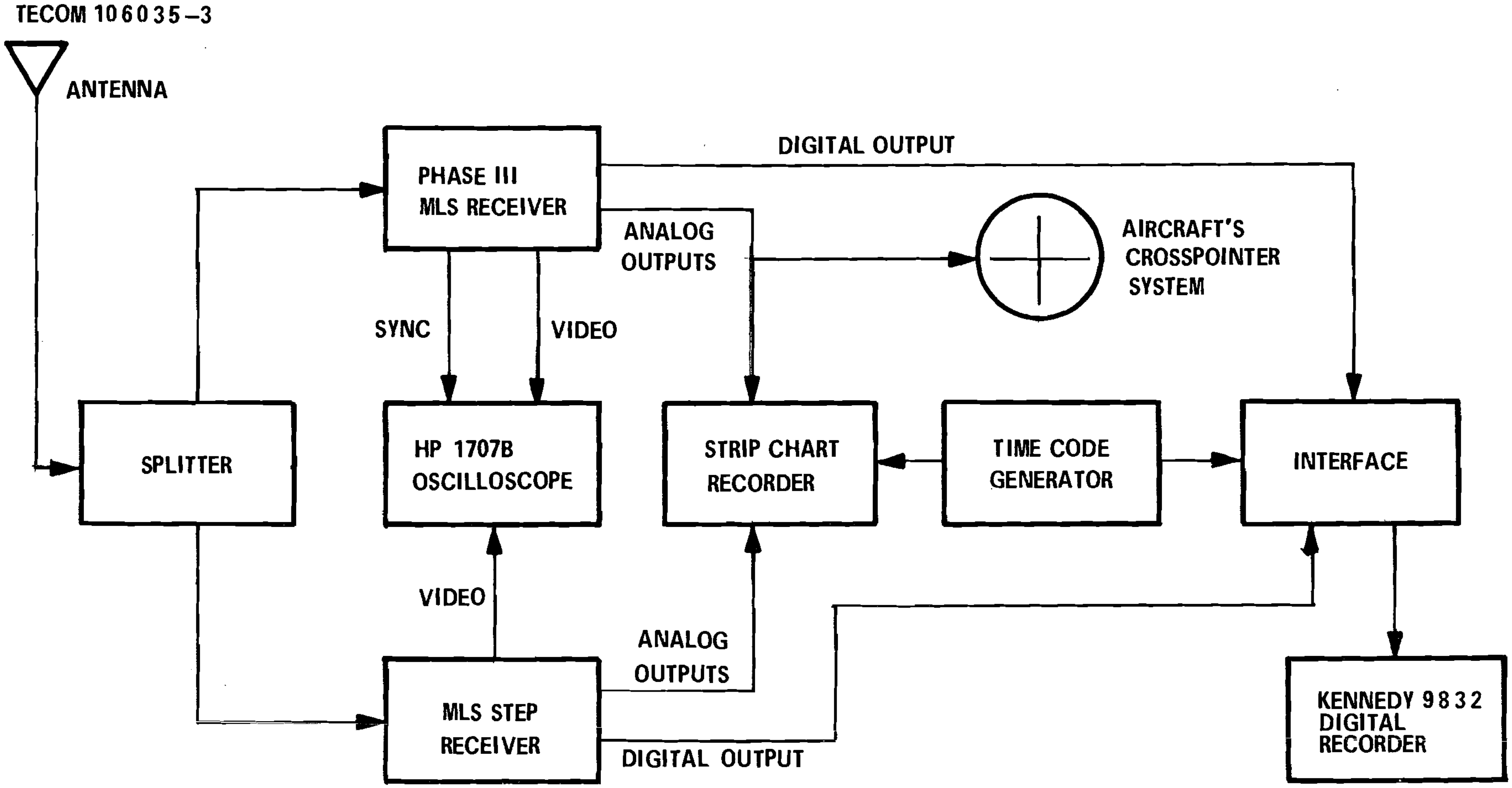

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FIGURE 3. AIRBORNE DATA COLLECTION SYSTEM

TABLE 4. AIRBORNE DATA RECORDED IN N-49

Digital	Analog
Phase III MLS Receiver:	Phase III MLS Receiver:
Az Angle	Az Deviation
Az Frame Flag	Az Flag
Az System Flag	El Deviation
El Angle	El Flag
El Frame Flag	MLS STEP Receiver:
El System Flag	Az Deviation
MLS STEP Receiver:	Az Flag
Az Angle	El Deviation
Az Frame Flag	El Flag
Az System Flag	Time (Irig. B Slow Code)
El Angle	
El Frame Flag	
El System Flag	
Clearance Flag	
Clearance Direction	
DME Range	
DME Flag	
Time (Irig. B)	

TABLE 5. FLIGHT TESTS

1. FAA Technical Center Bendix Test Bed MLS (Runway 31)

   2 - Centerline, 3° glide slope approaches

   2 - 0° radial, 3,000 feet altitude, from 15 nmi

   2 - Clockwise (CW) ±70° partial orbit, 3,000 feet, 9 nmi

   2 - Counterclockwise (CCW) ±70° partial orbit, 3,000 feet, 9 nmi

2. FAA Technical Center Meyer/TSC SCAMLS (Runway 35)

   2 - Centerline, 3° glide slope approach

   2 - Centerline, 6° glide slope approach

   2 - CW ±70° partial orbit, 4,500 feet, 9 nmi

   2 - CCW ±70° partial orbit, 4,500 feet, 9 nmi

3. Philadelphia International Airport T.I. SCAMLS (Runway 17)

   2 - Centerline, 3° glide slope approach

   1 - 360° orbit, 4,500 feet, 6 nmi

4. Washington National Airport (DCA Bendix SCAMLS (Runway 33))*

   1 - 2° left offset, 6° glide slope approach

   1 - 360° orbit, 4,000 feet, 7 nmi

   2 - "S" shaped radials (+12° to +16°), 3,000 feet from 15 nmi

   2 - "S" shaped radials (-12' to -16°), 3,000 feet from 15 nmi

*Flight testing at DCA will be concurrent with the evaluation of the MLS ground facility on runway 33, and data using the STEP receiver will be collected on many of the ground facility test flights (see section 1.3). The runs listed here are the minimum required for the receiver evaluation.

Initially, a flight test will be performed with two Phase III receivers, instead of a STEP receiver and a Phase III receiver, in order to verify that the output of each receiver is not affected by the airborne data collection system and subsequent processing.

The Technical Center's laser tracker has already been transported to the Washington National Airport to support the evaluation of the runway 33 MLS STEP field site. Since the flight profiles proposed for the ground system evaluation include data runs identical to those required for the receiver test, minimal separate flight testing is necessary. Using the existing aircraft data collection package, data for each program can be recorded simultaneously, eliminating the need for duplicate flight tests.

4. DATA REDUCTION AND ANALYSIS.

4.1 LABORATORY TEST DATA.

For each 10-second data sample recorded, a mean angle and 2 standard deviations will be calculated. Mean error will be determined by:

$$\overline{X} \text{ error} = \overline{X} \text{ angle} - \text{test set angle}$$

The mean error, 2 standard deviation, angle decode limits, and the receiver sensitivity will be compared with the specifications in table 1. Failure of the STEP receivers to meet the specifications will result in a suspension of further tests until corrective action is taken by the contractor.

4.2 STATIC TEST DATA.

The static data collected on the two receivers will be presented in a table listing the mean and 2 standard deviation values for each unit at each test angle.

The average performance of each receiver will be compared, and the mean angles are expected to agree within ±0.017° (see table 1). If the mean differences exceed the specified values in table 1, they will be reported and investigated as appropriate.

4.3 DYNAMIC TEST DATA.

The strip chart data collected in the instrumented van will be manually reduced and polar plots will be prepared to show where the analog flag is on or off as a function of azimuth angle. The analog CDI signal recordings will be analyzed visually and any abnormal occurrences will be investigated and reported to ARD-320. Strip chart sections indicating problem areas will be reproduced and included in the data package.

Upon completion of these tests and consultation with ARD-320, a decision will be made as to whether or not software modifications are required before proceeding with further testing.

4.4 FLIGHT TEST DATA.

Flight test data will be presented on two types of plots, rectangular and polar. Rectangular plots obtained from ACT-750 (CALCOMP Plotter) for tracked flights will show the path following error (PFE) and control motion noise (CMN) in degrees on the Y axis plotted against distance or azimuth angles from the azimuth antenna phase center on the X axis.

PFE includes the steady-state bias and cyclical error components of low enough frequency for the aircraft to physically track and have a measurable effect in terms of deviations from the desired track. The transfer function of the low-pass filter used to extract this error from the data is:

$$H(s) = W_n^2/(s^2 + 2W_n s + W_n^2)$$

where

$W_n = 0.78$ radians/second for Az and $W_n = 2.34$ radians/second for El.

CMN encompasses errors that are generally of a frequency too high for the aircraft to physically track, but low enough for the control system to respond to. This results in rapid, small amplitude control surface wheel and column motions and is undesirable because it diminishes flight crew confidence by presenting them with a "shaky stick." The transfer function of the high-pass filter used to extract CMN from the data is:

$$H(s) = \frac{S}{S + W_1}$$

where

$W_1 = 0.3$ radians/second for Az and $W_1 = 0.5$ radians/second for El.

PFE and CMN plots will be presented for each receiver for visual comparison using only noticeable differences as the performance criteria. Error magnitudes will not be considered because they are mostly attributable to the ground system.

The analog data will be checked to see that continuous guidance is provided throughout the coverage region (±60° test bed and ±40° SCAMLS). Particular attention will be given to the 10° to 14° SCAMLS region where a smooth scanning beam to clearance guidance transition is required. A system flag or CDI guidance loss in this area is unacceptable.

5. INSTRUMENTATION AND FACILITIES.

5.1 TRACKING FACILITIES.

a. Precision Tracking Radar: Time correlated position information during the flight tests at the FAA Technical Center will be obtained from the Center's NIKE-Hercules instrumentation radar. This X-band tracking radar provides azimuth, elevation, and slant range to maximum range of 200 nautical miles (nmi). Slant range accuracy is ±6 meters; angle accuracy (azimuth and elevation) is ±0.25 milliradians.

b. Laser Tracker: Aircraft space position during the flight tests at the Washington National Airport will be determined by the FAA Technical Center's precision automated Laser Tracking System. It will be located at DCA to support the flight testing of the SCAMLS installed on runway 33. The mobile tracking facility uses an invisible laser beam to illuminate and automatically track a retroreflector installed on the test aircraft (N-49). Accuracy tests performed on the laser tracker by the Technical Center indicate 2-sigma estimate of error of 0.017° in azimuth, 0.026° in elevation, and 5.2 feet in range (at 6 nmi). The report describing the accuracy tests is listed in the references under section 3, "Related Documentation/Projects."

5.2 MLS GROUND STATIONS.

a. The Bendix Test Bed MLS is located at the FAA Technical Center on runway 31. It has 1° scanning beams which provide coverage of ±60° Az and 1° to 20° El.

b. The Meyer TSC SCAMLS is located on runway 35 at the Technical Center. It has 3° Az and 2° El scanning beams and proportional guidance coverage at ±10° Az and 2° to 14° El. Azimuth clearance is provided to ±40°.

c. The Texas Instruments SCAMLS, which serves runway 17 at Philadelphia International Airport, has 3° Az and 2° El scanning beams. It provides ±10° Az proportional guidance with azimuth clearance to ±40°, and coverage from 1° to 15° El. The system is designed to conform to FAA Engineering Requirement FAA-ER-700-04.

d. The Bendix SCAMLS located at Washington National Airport on runway 33, provides the same coverage as the Texas Instruments SCAMLS, and is also designed to provide guidance, as specified in FAA-ER-700-04.

5.3 MLS ANGLE RECEIVER TEST SET.

The MLS Angle Receiver Test Set shown in figure 4 is a self-contained unit designed to generate the full range of signals required to completely test the functional capability of the MLS angle receiver. The test set contains its own carrier frequency reference and provides full channel coverage (500-699) at "C" band. Front panel controls provide for wide range flexibility in the selection of the various functions contained in the MLS format. A detailed description is contained in the Bendix MLS Test Set Maintenance Manual, IB 1157A.

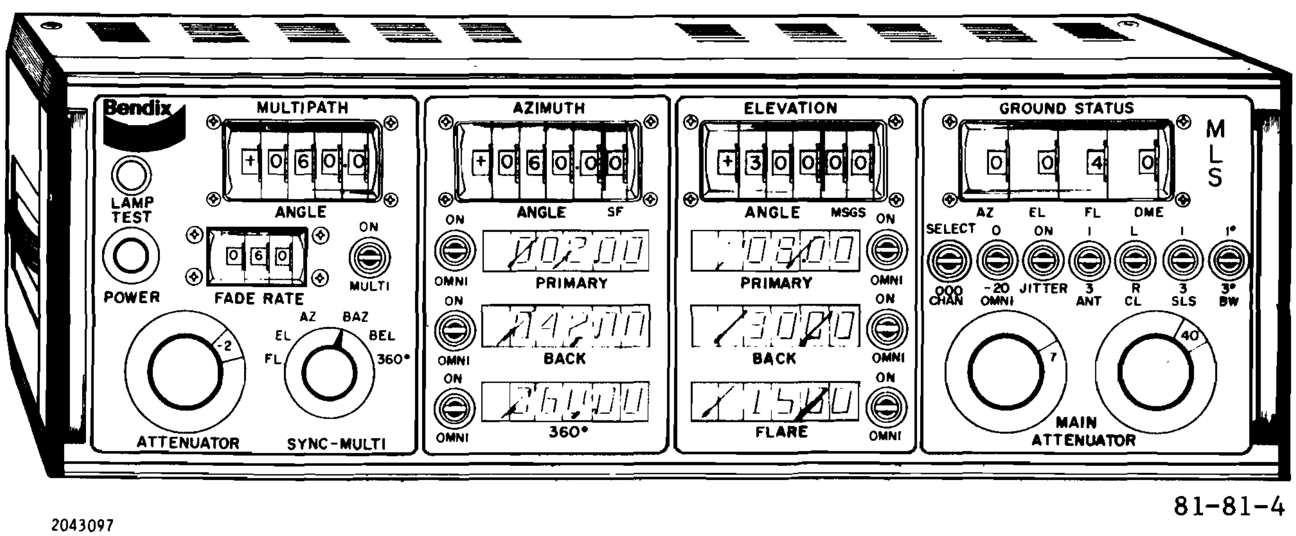

FIGURE 4. MLS AIRBORNE TEST SET

5.4 INSTRUMENTED VAN.

The MLS Test Van (figure 5) is a self-propelled instrumented mobile laboratory with an integral extendable mast capable of positioning a receiving antenna from 5 to 51 feet above the airport surface. Antenna height is displayed with 0.01 feet resolution on a digital read-out inside the lab area. A block diagram of the MLS test van data collection system is shown in figure 6.

6. COORDINATION AND AREAS OF RESPONSIBILITY.

a. ACT-100E will schedule all of the necessary facilities, maintain the Technical Center's MLS ground equipment, provide the necessary manpower for data collection, and write a letter report.

b. ACT-100 personnel will handle all coordination with Air Traffic Control (ATC).

c. ACT-600 will supply the aircraft and pilots for flight testing.

d. ACT-750 will calibrate and operate both the laser tracker at Washington National Airport and the NIKE-Hercules Instrumentation Radar at the Technical Center. They will perform all digital flight data processing which includes processing and merging the airborne and tracker tapes, supplying tape listings, and provide error and diagnostic plots.

e. The MLS and DME ground equipment at the Washington National Airport will be maintained by Bendix personnel throughout the tests.

f. The MLS and DME ground equipment at the Philadelphia International Airport will be maintained by Texas Instruments personnel throughout the tests.

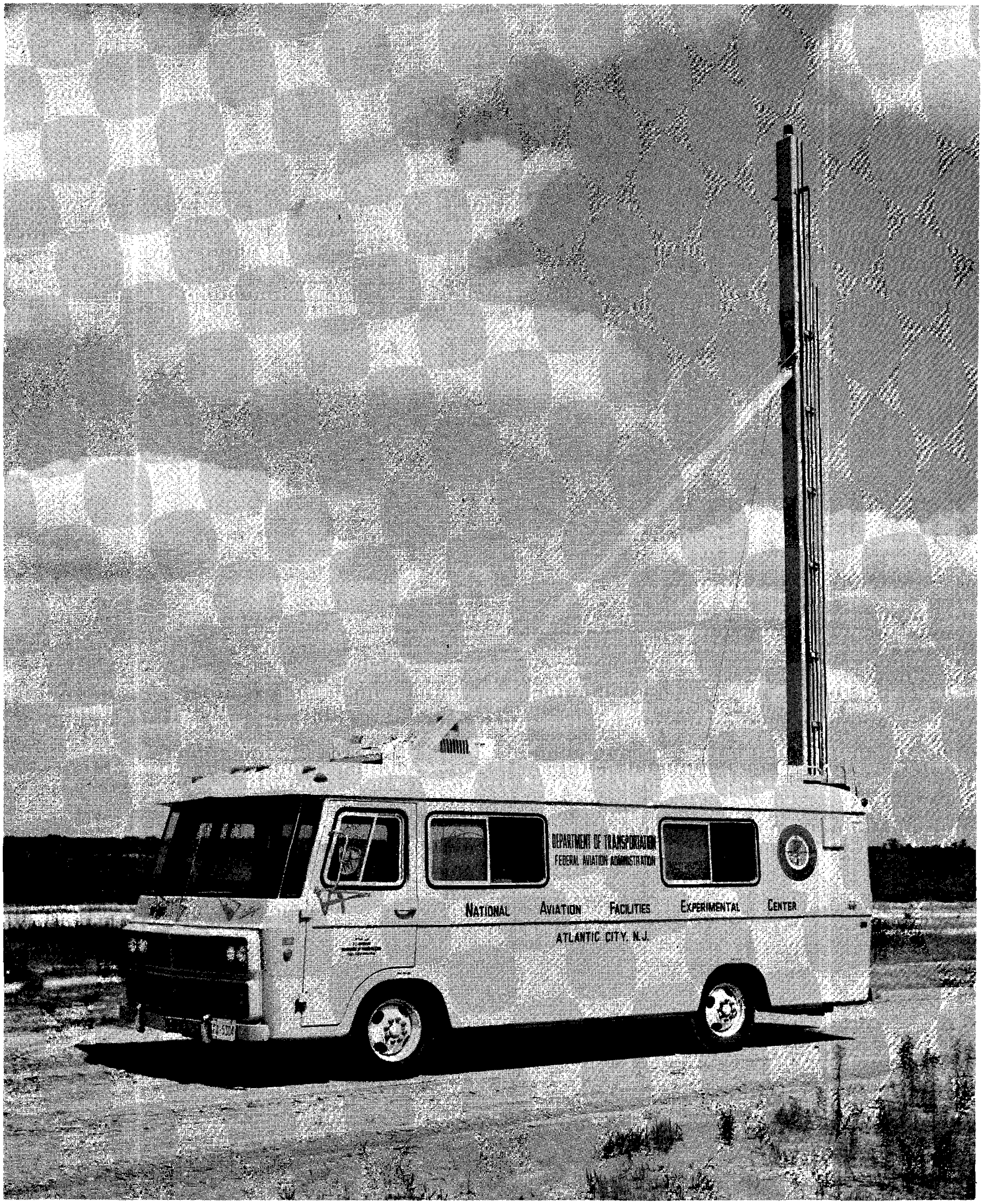

FIGURE 5. MLS TEST VAN

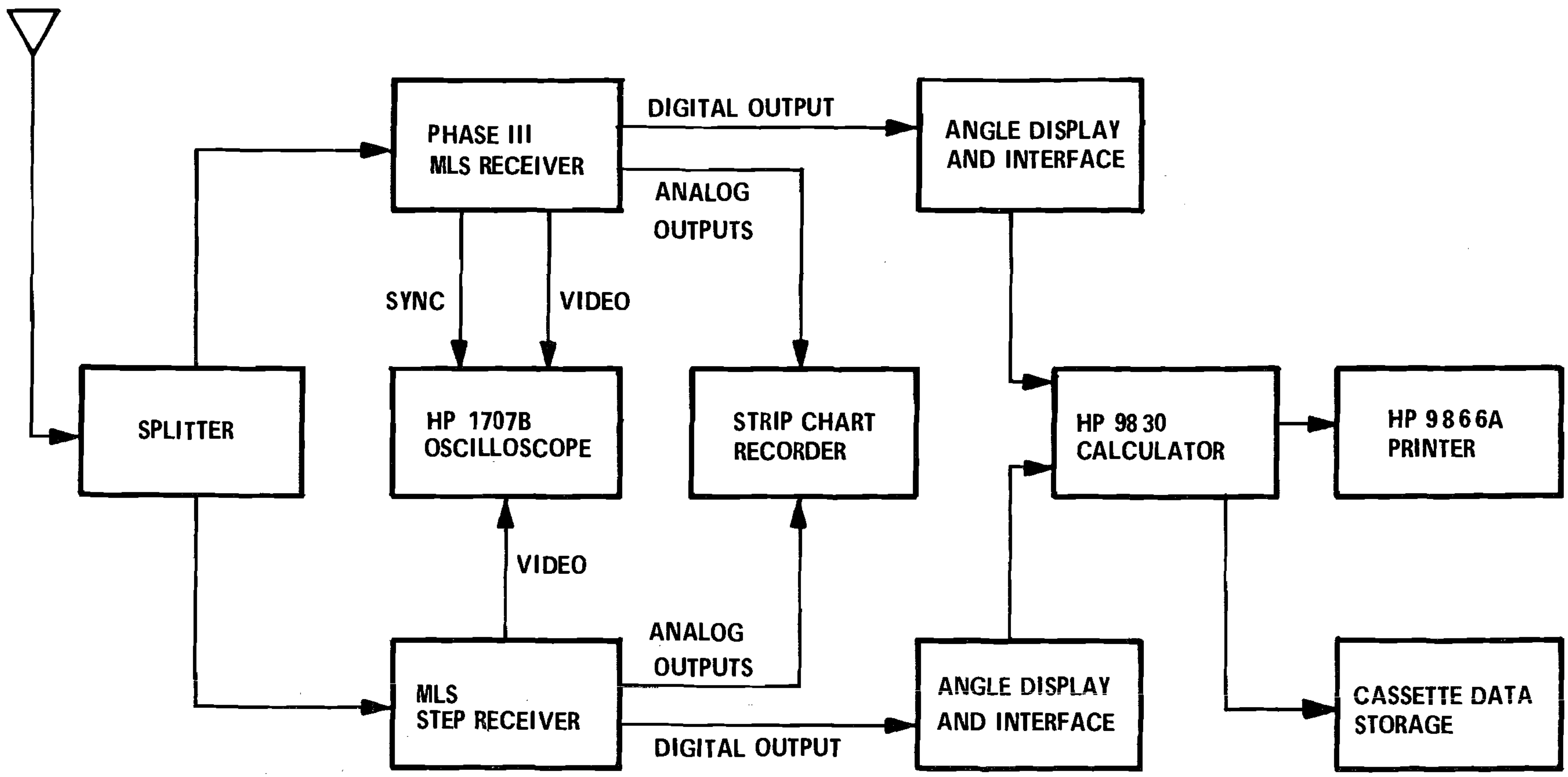

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FIGURE 6. MLS TEST VAN DATA COLLECTION SYSTEM

7. SCHEDULE.

MLS STEP Receiver Delivery*

Laboratory Tests

Static and Dynamic Ground Tests (Technical Center)

Data Reduction and Analysis

Technical Center Flight Tests

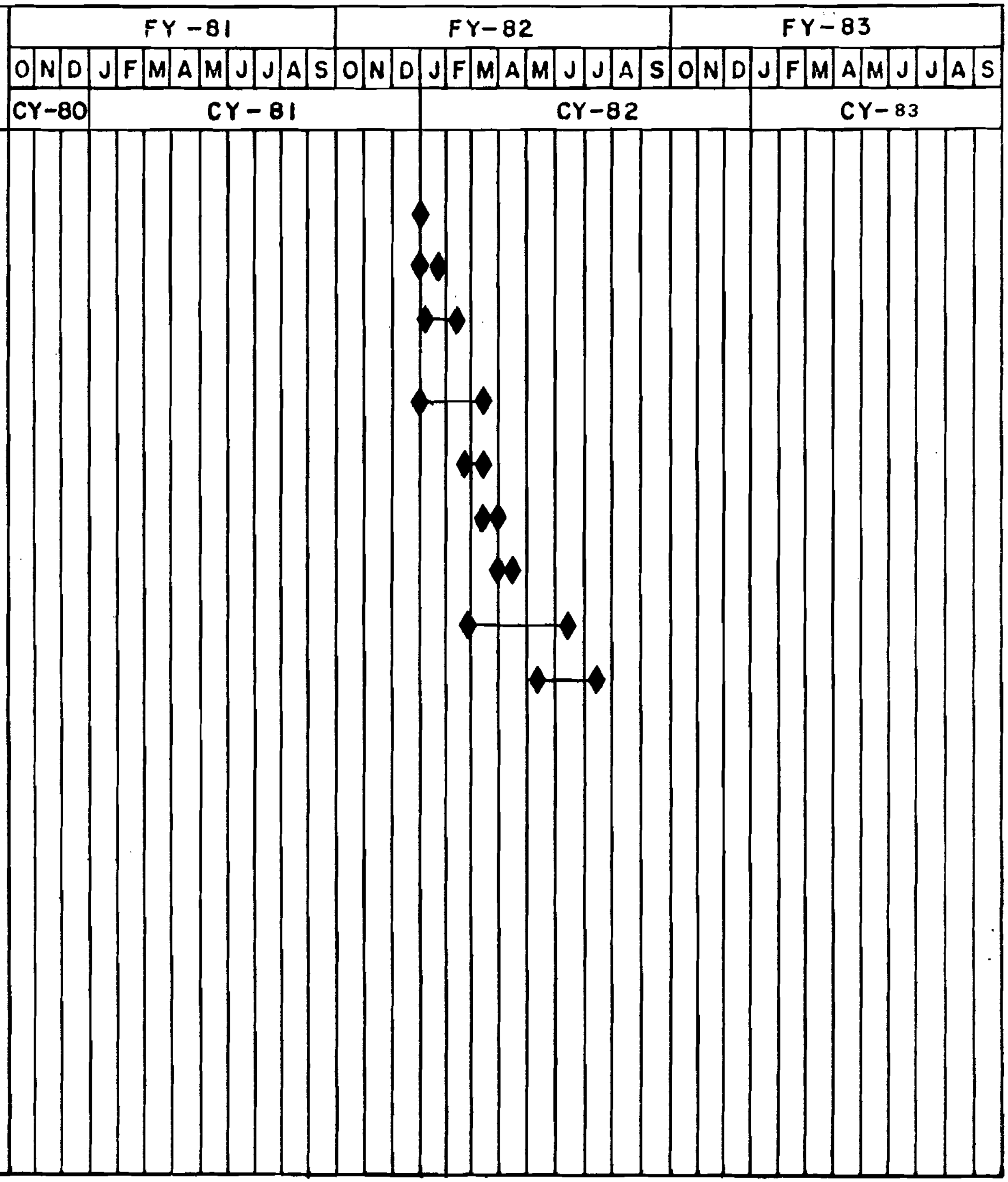
Philadelphia Flight Tests

Washington National Flight Tests

Data Reduction and Analysis

Letter Report

*Testing based on MLS STEP Receiver Delivery



APPENDIX A

RECORD OF MICROWAVE LANDING SYSTEM (MLS) ANGLE RECEIVER DESIGN CHANGES

The contractor shall incorporate into the units all design improvements made to the Phase III Basic Narrow Angle receivers furnished under contract DOT-FA72WA-2801 (see Bendix internal memo dated February 24, 1978, revision November 2, 1978, "MLS Phase III Angle Receiver Improvement Program").

ADDITIONAL DESIGN IMPROVEMENTS

In addition to the above changes, the following design improvements shall be incorporated into the angle receiver.

SYNTHESIZER.

1. The temperature compensated crystal oscillator shall be replaced by temperature controlled crystal oscillator. This change will result in improved reliability, less critical alignment, and will permit the use of standard rather than selected components.

2. The voltage controlled oscillator (VCO) shall be replaced by a modified standard unit to reduce sensitivity to vibration, extreme temperatures, high frequency drift, and component aging.

3. The layout of the digital circuit board shall be revised to eliminate jumpers and accommodate improvements in the failure annunciator circuitry.

4. The synthesizer shall be characterized for compliance with applicable Technical Standard Order (TSO) requirements, e.g., instrument landing system (ILS).

RF MODULE.

1. The third local oscillator shall be repackaged to eliminate radiation interference.

2. A high level double balanced mixer shall be employed to reduce all spurious outputs to at least -60 decibels referenced to 1 milliwatt (dBm).

3. The frequency response of the first intermediate fix (IF) amplifier shall be changed for compatibility with synthesizer changes, thereby unblocking all operating channels.

4. The printed circuit board shall be revised to incorporate functional changes, shield the log amplifier, and provide extra ground terminals.

DIGITAL PROCESSOR (A_2 BOARD).

1. A clearance beam indication on the 32-bit data word shall be incorporated to indicate proportional guidance in a clearance zone.

2. A "watchdog" circuit shall be added to sense and, if possible, reset the inoperative microprocessor under adverse conditions.

3. The card layout shall be revised to incorporate increased memory without jumpers.

INPUT/OUTPUT (A_3 BOARD).

1. The card shall be redesigned to use multiwire or multilayer techniques rather than a double sided board with bus strips.

2. The course deviation indicator (CDI) drive circuits shall be redesigned to provide stable drive offsets with individual setting for high or low level.

3. The flag circuits shall be revised to accept an input from the microprocessor watchdog circuit to ensure that no false courses are indicated without flags.

4. The super flag driver circuits shall be redesigned to improve mean time between failure (MTBF).

CONTROL PANEL.

1. The power supply shall be redesigned to add fail-safe protection for the +5 volt supply.

2. The track thickness of both circuit boards shall be increased to reduce voltage drop and facilitate the replacement of integrated circuit packages.

3. Snap locks shall be added to the rear panel connector and its mate to secure the connection.

4. The minimum glide slope data message shall function as follows: the receiver shall always provide and display a valid output, meaning the higher angle of either the selected glide slope angle or the minimum glide slope selectable angle. A discrete warning (light) shall result when the selected angle is below the minimum selectable glide slope.

ANTENNA SWITCHING MODIFICATION.

The loss or disconnect of one antenna in dual antenna aircraft installation shall not have any adverse effect on the functioning of the remaining antenna.

RECEIVER ANALOG OUTPUT CHARACTERISTIC.

A 12-bit digital-to-analog converter shall be provided for the analog deviation output.

OUT-OF-COVERAGE INDICATIONS FLAG CONTROL.

The receiver processing shall provide for averaging of the OCI levels over a period of 1 second.

SCANNING BEAM/OCI/CLEARANCE ALGORITHM AND CLEARANCE.

The following algorithms shall be incorporated into the receiver:

1. Compare the relative levels of the clearance, OCI, and beams.

2. Process both clearance and beams for all scans.

3. Output both independently to the 32-bit digital word output.

4. Output the larger averaged function to the CDI. Allow a 1-second transition to prevent rapid switching.

5. The left clearance to be valid, must exceed the OCI and must exceed the right clearance by 6 dB. This statement also applies to the right clearance.

6. In the event of more than one valid function, the CDI output priority shall be azimuth scanning beam, azimuth clearance, back azimuth scanning beam, back azimuth clearance.

MAXIMUM AZIMUTH AND ELEVATION ANGLE.

The receiver shall be capable of processing an angle to ±61° for azimuth and -1.0° to 20° for elevation.