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FAA TECHNICAL CENTER LETTER REPORT

DATA LINK DEVELOPMENT
TEST AND EVALUATION PROGRAM

by

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GLOSSARY OF COMMONLY USED ABBREVIATIONS

AACC	Altitude Assignment Clearance Configuration
ACID	Aircraft Identification
ACYALL	AP Command to LPDS Requesting all ETIS Information
ACYGMThhmm	AP Message to LPDS Indicating Greenwich Mean Time in Hours and Minutes
ACYNEW	AP Command to LPDS Requesting Updates of ETIS Information
ADS	All-Digital System
AFS	Flight Standards Service
AFSS	Automated Flight Service Station
AID	Airborne Intelligent Display
AOS	Advanced Operating System
AP	Applications Processor
ARIES	Aircraft Reply and Interference Environment Simulator
ARTS	Automated Radar Terminal System
ATARS	Automatic Traffic Advisory and Resolution Service
ATC	Air Traffic Control
ATCRBS	Air Traffic Control Radar Beacon System
ATCSF	Air Traffic Control Simulation System
ATS	Air Traffic Service
CIDIN	Common International Civil Aviation Organization Data Interchange Network
CRT	Cathode Ray Tube
ELM	Extended Length Messages
ETIS	Enhanced Terminal Information Service
FAA	Federal Aviation Administration

FDB	Full Data Block. Data block of subject aircraft on controller's display. The following codes are used within the FDB:
	ACK — Pilot Acknowledgement of ATC Message Delivery
	D — Mode S Equipped Aircraft
	LA — Low Altitude Alarm
Hz	Hertz
IFR	Instrument Flight Rules
IMP	Instrumentation Micro Processor
I/O	Input/Output
LPDS	Local Processor and Display System
MSAW	Minimum Safe Altitude Warning
NAS	National Airspace System
OSEM	Office of System Engineering Management
RF	Radiofrequency
RVR	Runway Visual Range
SAR	System Analysis Recording
SRDS	Systems Research and Development Service
SSF	System Support Facility
TATF	Terminal Automation Test Facility
TCAS	Traffic Alert Collision Avoidance System
TIPS	Terminal INformatino Processing System
TSC	Transportation System Center
TWRT	Tower Terminal (data link only) ETIS information
UDS	Universal Data Set
WSW	Wind Shear Warning
WX	Weather

1. OBJECTIVES.

The purpose of the data link test program is to determine the functional adequacy of the Mode S data link concepts. This test program will establish a data link test bed, validate that each data link function operates in accordance with defined system concepts and specifications, evaluate the functional performance characteristics of the data link system, and verify the operational application of the Mode S data link system in terminal and en route air traffic control (ATC) environments.

The data link test bed will be configured to interconnect various data sources with airborne terminals via the Mode S data link. Where standard Federal Aviation Administration (FAA) approved subsystems are available, the test bed will be designed to accomodate them. This will permit evaluation of their performance and the performance of the test bed with these subsystems in place. Otherwise, subsystems will be designed and fabricated to perform each function until standard elements become available. The test bed will then serve as a continuing mechanism for testing and establishing requirements for future components and functions.

As standard subsystems are developed and available components are brought on-line, the data link test bed will facilitate evaluation of their performance. Once hardware criteria are satisfactorily established, the data link functions will be tested to measure their impact on the productivity and safety of the air traffic system.

The initial phase of the data link test and evaluation program in this test plan is divided into two specific areas. The first area concerns the verification of the test bed operation and the establishment of performance criteria. The second area pertains to the test and evaluation of ATC operational functions (pilot/controller interface).

The objective is the performance verification of the data link system hardware and software. Tests will evaluate individual components and system characteristics of the test bed capabilities in the areas of message error rates, message delivery delays, and message traffic density capacity.

Objectives of the performance criteria portion of the test effort are to determine the transmission rates, hardware/software limitations, accuracy of delivered data, and the efficiency of data transmission via the Mode S data link.

The second area of tests described in this plan pertains to the minimum safe altitude warning (MSAW) and to the altitude assignment clearance confirmation (AACC) ATC functions. MSAW tests will be conducted in conjunction with the Automated Radar Terminal System (ARTS) all-digital system (ADS) and with air traffic controllers positioned at the terminal automation test facility (TATF). The tests of the AACC function will be conducted in conjunction with the en route Mode S (Build II) software with the controllers operating the system support facility (SSF). The controllers will be requested to provide subjective opinions pertaining to the operational adequacy of the two data link functions at the conclusion of the tests.

2. BACKGROUND.

The requirement for the development of the Mode S data link was identified in the 1969 Department of Transportation Air Traffic Control Advisory Committee Study. The study required modifications to the present Air Traffic Control Radar Beacon System (ATCRBS) which would improve the surveillance accuracy and the reliability of the system. Specifically, a discrete address mode data link function was proposed which would allow digital communications between the aircraft and ground-based automation systems and other data sources.

The Mode S Data Link Applications Development Program began in 1977 when an ad hoc committee was formed by the FAA for the purpose of examining the potential for enhanced safety, productivity, and capacity which could be obtained via the Mode S data link. FAA offices which participated included: Systems Research and Development Service (SRDS), Office of Systems Engineering Management (OSEM), Air Traffic Service (ATS), Flight Standards Service (AFS), the FAA Technical Center, and the Transportation Systems Center (TSC). The committee developed a comprehensive list of data link services and ranked them according to priority and ease of implementation.

The work performed by the committee demonstrated that sufficient potential existed in the near-term applications to serve as the basis for a research and development program. The applications identified were subjected to further analysis and review by SRDS, the FAA operating services, potential users of the services, and industry representatives.

The link design will specifically allow for the interface with a full range of avionics. This will give industry wide latitude to innovate and develop low cost avionics for the full spectrum of users. A national standard will be necessary only to define the services available and how the information is contained in the link transmission.

The near-term services identified for development, demonstration, test, and evaluation are discussed in section 4. The test and demonstration program, together with the expanded avionics development, will more fully define the operational aspects of these data link services. At the same time, the program will study additional enhancement candidates for longer range implementation.

3. RELATED DOCUMENTATION AND PROJECTS.

3.1 DOCUMENTATION.

a. Wisleder, Robert W., Enhanced Terminal Information Services (ETIS) Utilizing the Discrete Address Beacon System (DABS) Data Link-Concept Description, FAA Report, FAA-RD-79-73, July 1979.

b. Canniff, J. and Golab, J., Functional Utilization of DABS Data Link, FAA Report, FAA-RD-78-159, October 1978.

c. Bisaga, John J., DABS Data Link Applications Development Program, SRDS Progress Report, August 1979.

d. Hinkelman, J., Aviation Weather System Integration Program, ibid.

e. Department of Transportation, Report of the Department of Transportation Air Traffic Control Advisory Committee, Ben Alexander, Chairman. Washington, D.C., GPO, December 1969.

f. Drouilhet, P. R., DABS: A System Description, Massachusetts Institute of Technology, Lincoln Laboratory, Contract DOT FA72WAI-261, FAA Report, FAA-RD-74-189 (ATC-42), November 1974.

g. Holtz, Martin, DABS Single Sensor Performance Test Plan, FAA Report, FAA-NA-79-151, July 1979.

h. Jones, Ronnie, An Approach to DABS Data Link Avionics for General Aviation, FAA, Washington, D.C., November 1979.

i. Leeper, J. L. and Kennedy, R. S., DABS Data Link Application Formats (Revision 1), MIT, Lincoln Laboratory, Working Paper, No. 42WP-5083, July 1979.

j. Raudseps, Juris G., Experimental ETIS System Description and Test and Evaluation Test Requirements, Transportation System Center, Technical Memorandum No. 1 (July 1980).

k. System Research and Development Service, Discrete Address Beacon System/Air Traffic Control Facility Surveillance and Communications Message Formats, FAA Report, FAA-RD-80-14, April 1980.

l. System Research and Development Service, Air Traffic Control Facility Hardware Interfaces for Discrete Address Beacon System, FAA Report, FAA-RD-80-38, April 1980.

m. Federal Aviation Administration, Discrete Address Beacon System Engineering Requirement, FAA-ER-240-76, 1976.

n. Federal Aviation Administration, Proposal to Complete Development of the DABS Data Link Test Bed, FAA Technical Center, Memorandom (February 1981).

3.2 PROJECTS.

Program No.	TPD No.	Subprogram/ Project No.	Title	Washington Subprogram Manager/Location
03	03-110	034-241	Experimentation and Test Support for Mode S	D. Johnson, ARD-230
03	03-110	142-176	Terminal Mode S/ATC System Testing	J. Horrocks, ARD-123
12	12-282	142-173	Terminal Information Processing System (TIPS)	B. Wilson, ARD-120
03	03-110	112-115 142-176	Minimum Safe Altitude Warning (MSAW)	S. Smith, ARD-112

Program No.	TPD No.	Subprogram/ Project No.	Title	Washington Subprogram Manager/Location
13	13-251 13-265	132-403	Automated Flight Service Station (AFSS)	E. VanVaanderen, ARD-441
05	05-298	034-242	ATARS	J. Scardina, ARD-252
RD	RD-140	122-115	Interface Development	A. Cioffi, ARD-140

4. SYSTEM/EQUIPMENT DESCRIPTION.

A test bed will be established as part of the data link test program which will consist of ground and airborne equipment. Data will be provided to the data link system from real time sensors, external data bases, controller interfaces, and airborne terminals. The major functional components and the interconnecting data lines are shown in figure 1.

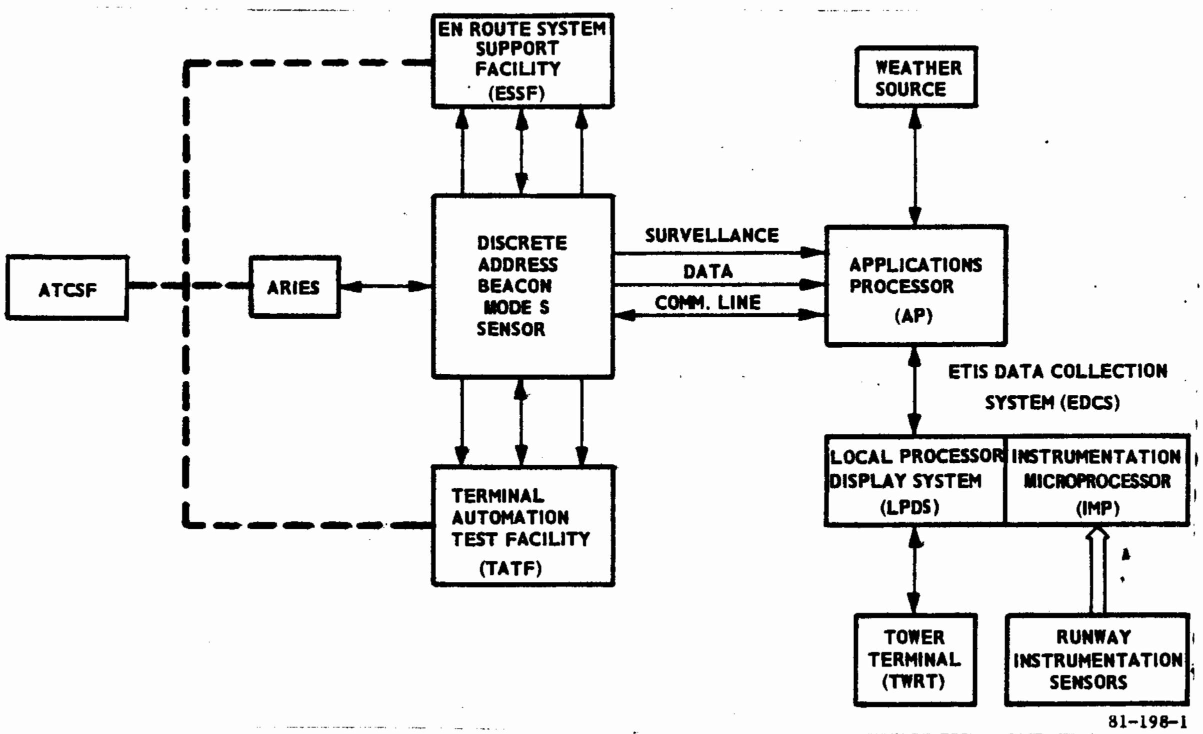

FIGURE 1. DATA LINK TEST BED — MAJOR FUNCTIONAL COMPONENTS

The Mode S sensor performs target acquisition for both ATCRBS and Mode S transponder equipped aircraft. In the case of Mode S targets, the sensor will establish from the reply messages whether the subject aircraft does or does not have data link capabilities. The sensor will maintain surveillance data on each target and transmit the required information to the National Airspace System (NAS) terminal facility and to the application processor (AP). The sensor acts as a message switch for both uplink and downlink messages. The sensor selects the uplink (ground-to-air) data link messages using aircraft address and message priorities, and transmits the message when the target is known to be within the antenna beam.

The downlink (air-to-ground) messages are routed by the sensor to either the NAS facilities or to the AP as determined by the message number. The AP acts as a message switch and will route the downlink request message, in a modified form, to the proper ground facility. To date, two signal sources have been identified for the initial AP configuration: the Enchanced Terminal Information System (ETIS) and the weather product information source.

The ETIS equipment, when interrogated by the AP, will reply with a digital message containing all information pertaining to the particular terminal. If more than one runway is available, the information pertaining to the runway(s) preselected by the controller will be relayed to the AP. Area information such as cloud cover, ceiling, or altimeter setting will be independent of runway selection. Only one runway will be fully instrumented in the ETIS test bed system. Runway Visual Range (RVR) data, for example, will be valid only for runway 13/31 at the FAA Technical Center.

Weather products information will be derived from the MITRE computer in Virginia. The AP will generate the proper interrogation message associated with the type of data requested by the pilot. The AP will identify which aircraft requires the weather information response and will relay the data link message to the Mode S sensor by way of the Common International Civil Aviation Organization Data Interchange Network (CIDIN) interface. To date, four types of weather product messages have been implemented. Future expansion of this vital service is anticipated as the data link application program matures. During ATC functional tests, modified ATC computer programs will be made available for use of the Technical Center's En Route System Support Facility (SSF) and Terminal Automation Test Facility (TATF).

Data link services are currently being developed as a supplement to voice communications. At first, ATC services will be largely confirmative ones; i.e., a data link equivalent to an already accomplished voice transaction. Eventually, data link may replace some voice transactions, thereby lowering communications workloads. It is extremely doubtful that voice will ever be completely replaced by data link communications. In situations when an interactive conversation is necessary between pilot and controller, data link (requiring manual inputs of some type) is not the most efficient way to accomplish the interchange of information. The initial package of candidate data link services is being developed to minimize controller and pilot manual interaction with the data link. Reasonable success has been achieved in the initial designs.

The following paragraphs present a brief description of the major subsystems to be used in the data link system test bed.

4.1 MODE S.

The Mode S is a cooperative surveillance and communication system for ATC. Each Mode S transponder equipped aircraft is assigned a unique discrete address which provides a surveillance interrogation and reply protocol that inherently supports data link communications to or from a particular aircraft. A detailed discription of the Mode S is provided in the Mode S engineering requirement (FAA-ER-240-26).

In the data link test bed configuration, the Mode S sensor will be interfaced with the AP in addition to the normal interfaces to ATC facilities and other users such as the system monitor. For a detailed description of the basic interfaces, refer to the Mode S interface document (FAA-RD-80-38).

The sensor to AP interface consist of two 4800 baud unidirectional surveillance data lines and a full duplex communication line. The duplex line conveys digital request and reply messages between the sensor and the AP. Figure 1 shows the interconnections.

4.2 APPLICATIONS PROCESSOR.

The AP is a discrete component of the data link test bed and handles all digital messages between various data sources and the Mode S sensor. The functions of the AP are: (a) to determine which information source (ETIS, weather, or Mode S sensor) is to be interrogated, (b) to determine when the source is to be interrogated, (c) prefilter and compose the message to be sent to the aircraft, and (d) determine when the message is to be relayed to the sensor for efficient utilization of the radiofrequency (RF) link.

Using surveillance data received from the sensors, the AP makes the selection as to which sensor for a given target will receive the messages designated for that aircraft. The AP may determine, from information within an ETIS message, the number of interrogations required for an approaching aircraft when adverse weather conditions are present at the terminal.

Lengthy clear text messages will be segmented by the AP before being retransmitted to insure proper formation by the airborne electronics. Weather warning messages are prioritized by the AP and sent to the selected targets as determined by the present position of the aircraft (derived from the surveillance data) and by the declared destination of the aircraft.

4.3 ENHANCED TERMINAL INFORMATION SERVICE.

ETIS established for the test bed will simulate the information obtainable from future ETIS systems. Some of the future equipments are in developmental stages (such as the ceilometer) and are unavailable at present. Current operational sensors which are available will be utilized for the test bed. The proposed instrumentation microprocessor (IMP) is flexible enough to permit changes as the ETIS system concept evolves. The unavailable sensor outputs will be simulated for the ETIS test bed or, as in the case of the ceilometer, the output of the existing system will be modified by signal conditioning circuits to emulate the outputs of future, improved systems.

The data derived from the instrumentation sensors will represent real-time weather conditions existing at the Technical Center. Specifically, runway 13/31 will have full instrumentation which will derive real-time data for pilots requesting information. This information will be transmitted in response to AP initiated requests.

The major components of the ETIS test bed data collection system are shown in figure 2. Sensor information is conditioned and processed by the buffer circuits of the instrumentation microprocessor. The digitized sensor data are tracked by the IMP. When this data changes by a preselected threshold, the new data are queued for transfer to the local processor and display system (LPDS) through an 8-bit parallel port.

The tower terminal (TWRT), a self-contained microprocessor and display unit, collects keyboard data, such as runway and approach in use and local precipitation, and sends this information to the LPDS through a 300-baud serial port over dedicated telephone lines. The TWRT also receives and displays the ETIS data set currently in effect at the AP. As an additional feature, eight lines of 64 characters each of free text can be edited at the TWRT and transmitted along the same paths as the ETIS data. These free text lines are also echoed at the TWRT printer upon reception by the AP.

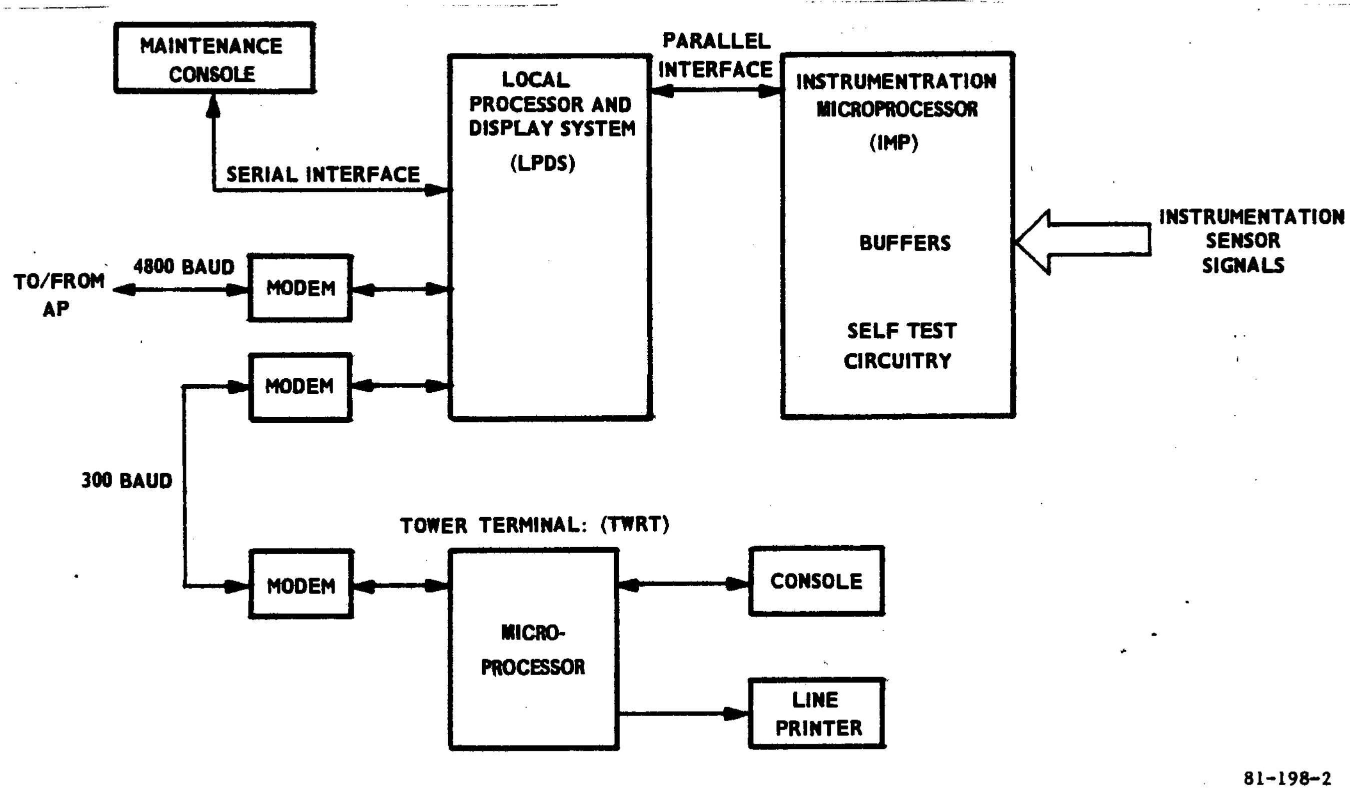

FIGURE 2. ETIS DATA COLLECTION SYSTEM

The LPDS is the communications center of the ETIS data collection system. Information received from the IMP or the TWRT is selected as a response to interrogations from the AP. These new data are transmitted to the AP using a 4800-baud serial port and dedicated communication lines. The data echo messages from the AP are checked for correctness and if an error occurred, the data are retransmitted. Once the data are correctly echoed from the AP, it is queued for display at the local maintenance console and simultaneous transmission to the TWRT display.

4.4 WEATHER PRODUCT SOURCE.

Some of the functions or weather products which are provided by an automated flight service station will be derived from the MITRE computer. The special software which extracts specific information from the data base has been provided by TSC and is being incorporated into the AP by Lincoln Laboratory. The test bed at the Technical Center will utilize the same hardware and software configuration and procedures. The tie-in to the MITRE computer will be made through a dial telephone line and terminal equipment.

4.5 AIRBORNE TERMINAL.

The airborne terminal or airborne intelligent display system (AID) to be used during the data link tests will be provided by Lincoln Laboratory. The information will be displayed on a cathode ray tube (CRT) terminal and printed on paper for permanent records. A keyboard allows request message entries to be made by the pilot. The large memory capacity of the system enables the use of an abbreviated message and its expansion for English text displays and map generation.

The number of characters to be inserted by the pilot for request messages is minimized by limiting the entries to variables once the message type has been selected. The rest of the message is automatically generated by the avionics from memory. For example, when terminal weather information is requested by the pilot, he selects the message type, inserts the three-character terminal code, and depresses the "send" button. The avionics equipment will automatically generate an AP recognizable code designating the message type and insert the handshaking signal for the sensor. Appropriate indications to the pilot will be generated indicating that the request message has been sent, a reply has or has not been received, and when a new request message may be initiated by the pilot. Advisory or warning messages are displayed in clearly recognizable form alerting the pilot to hazards. These messages are displayed in specific areas of the display and/or use different colors to distinguish them from routine message readouts.

4.6 MODE S/ATC DATA LINK FUNCTIONS.

This section describes the MSAW and AACC functional designs to be evaluated in this test activity.

4.6.1 Minimum Safe Altitude Warning.

MSAW is a real-time capability, incorporated into the Automated Radar Terminal Systems (ARTS) III system, which generates an advisory when an aircraft is, or is predicted to be, at an unsafe altitude. MSAW monitors aircraft terrain separation and generates via the Mode S data link, an advisory to the subject aircraft, which is displayed along with an aural alarm on the pilot's AID and the air traffic controller displays. In this activity, the MSAW advisories will be transmitted from the TATF to Mode S via the Mode S/ARTS interface software.

The following events will occur in the Instrument Flight Rules (IFR) room whenever an MSAW advisory is generated:

a. An aural alarm will sound for several seconds (a system parameter).

b. "LA" will be displayed blinking in field 0 of the Full Data Block (FDB) of the subject aircraft on the controller display.

c. The ACID, altitude (or CST), and "LOW ALT" will be displayed in the MSAW display area on the controller scope.

d. The controller will radio communicate the advisory to the simulation pilot; the Mode S sensor will simultaneously uplink the MSAW advisory to the cockpit.

e. When technical acknowledgement is received in ATC from Mode S, "T" will be displayed as a part of the FDB of the aircraft.

f. When pilot acknowledgement (or WILCO) is received by ATC, "ACK" will be displayed in the FDB.

g. When the aircraft is again at a safe altitude, the aural alarm will stop sounding, the "LA" display in the FDB and "LOW ALT" in the MSAW display area will go off, and a "Clear Alert" message will be uplinked to the aircraft via Mode S.

In addition, ARTS will provide a teletype output including the following items:

a. Time of display (including aircraft identification, reported altitude, and aircraft position).

b. Time of message delivery or rejection (based on message delivery notice or message rejection notice from Mode S).

c. Time of acknowledgement.

d. Time of termination of advisory.

The following events will occur in the subject aircraft's cockpit:

a. "MINIMUM SAFE ALTITUDE = XXXX FT" will be displayed blinking on the AID.

b. An aural alert voicing the words "LOW ALTITUDE ALERT" will sound only once in the scan in which the advisory is first received.

c. When pilot depresses the "yes" key to acknowledge (or WILCO) the receipt of the advisory, the display will stop blinking.

d. After 4 seconds (WILCO timeout, a system parameter) the display of the MSAW advisory will go off.

4.6.2 Altitude Assignment Clearance Confirmation.

The Altitude Assignment Clearance Confirmation (AACC) message is an uplink message to the cockpit containing the altitude to which the en route controller has cleared the aircraft. This message provides the pilot with a visual confirmation (on the AID) of the radio communicated voice clearance. The AACC messages are of three types: "Maintain," "Climb to and Maintain," and "Descend to and Maintain."

In this activity, the en route software (which will generate the AACC message in response to a controller initiated keyboard entry) will interface with the Mode S data link system via the Mode S/en route ATC interface software and will provide the following:

a. An indication to the controller which aircraft are Mode S-equipped by displaying the character "D" in field B5 of the FDB.

b. Send an AACC message to the subject aircraft and to the en route controller displays.

The following events will take place at the controller displays:

a. Using the Assigned Altitude Quick Action key the controller will enter the assigned or cleared altitude "ddd" and the flight identification.

For assigning interim altitude, the controller will press the Interim Altitude Quick Action key, make any of the following entries, and enter the flight identification:

1. Tddd (insert interim altitude).

2. Rddd (insert interim altitude and use as reported altitude).

3. T (delete interim altitude).

b. The controller will radio communicate the message to the pilot; the Mode S sensor will simultaneously uplink the message to the cockpit.

c. The FDB of the subject Mode S aircraft will continue to display the character "D" in its field B5 until a technical acknowledgement is received from Mode S.

d. When Mode S technical acknowledgement is received character "A" will replace the displayed character "D" in field B5. If WILCO is not received within WILCO time-out (WILT) time delay, a fixed system parameter measured in minutes, "D" will be displayed in field B5 again.

The following events will occur in the subject aircraft's cockpit:

a. "DESCEND (OR CLIMB) AND MAINTAIN XX,XXX FT" will be displayed blinking on the AID.

b. An aural alert voicing the words "ALTITUDE ASSIGNMENT" will sound only once in the scan in which the message is first received.

c. When the pilot depresses the "YES" key to acknowledge (WILCO) the receipt of the message, the display will stop blinking.

d. After 4 seconds the display of the AACC message will go off.

5. DATA COLLECTION, REDUCTION, AND ANALYSIS.

This section contains a description of specific tests to be performed which will satisfy the data link program objectives.

The Data Link Test and Evaluation program is divided into two specific areas: (a) test bed verification and performance characterization, and (b) test and evaluation of ATC operational functions.

Both simulated and actual operating conditions will be utilized during the tests. For tests with simulated conditions, one or more of the following requirements must be satisified:

a. Test results are independent of actual physical constraints of the antenna, of the aircraft, or of the existing environment.

b. Large numbers of repeated tests are necessary to arrive at a satisfactory conclusion. By simulating the inputs the data rates may be increased to reduce test time.

c. Measurements on a subsystem are to be performed.

d. Controlled environment of the laboratory is necessary to perform repeatable tests.

5.1 TEST BED VERIFICATION AND PERFORMANCE CHARACTERIZATION.

The primary purpose of these tests is to determine the adequacy of the individual components of the Mode S/data link test bed. While quantitative data are collected, these tests are not meant to provide the data for an exhaustive numerical analysis of the operation of all components. These tests are intended to verify the operation of the myriad functions of the test bed components. In addition, the characteristics of the ETIS data collection system will be thoroughly and numerically analyzed in this test segment. The test bed weather source will also be characterized to a lesser degree.

The Mode S/data link system test bed will be evaluated to determine the operating characteristics of the individual components and their interactions in order to determine the characteristics of the system as a whole. The immediate components to be tested are the ETIS data collection system (comprised of TWRT, LPDS, IMP, and intercommunications thereof), the area weather source computer link, the AP and its ancillary operating software, those functions of the Mode S sensor relating to data link capacity not previously tested under other programs, and the handling capability of the prototype airborne transponder and display (COMM-C). The enumeration of the test bed system characteristics is imperative to allow the analysis of the Mode S/data link system concept tests to be quantitatively meaningful.

Specific objectives of these tests are to measure the accuracy and data delivery time delays induced by the various hardware and software components of the test bed system.

This section is divided into the following tests:

a. AP/ETIS tests.
b. AP/weather source tests.
c. AP communications capability.
d. ETIS data acquisition tests.

5.1.1 AP/ETIS.

This analysis will be comprised of two tests. The first will determine the characteristics of the communications link between the two systems. The second will be to determine the response characteristics of the operational ETIS data acquisition subsystem (LPDS, IMP, and TWRT) and will require test software packages within the AP. The test software packages will operate in FORTRAN 5 under Advanced Operating System (AOS) to simulate the input/output (I/O) characteristics of the operational AP software. Hence, the compiler and operating system overheads will be considered as part of the communications interface. Figure 3 shows the test configuration.

a. Interface Test.

1. Intent: The goals of this test are the measurement of the time required to complete a fixed interrogation-reply transaction between the AP and the LPDS and the detection of errors on the line. An error here is defined as one error regardless of the number of bits in error in the combined interrogation-reply transaction. An error-free transaction is defined as a transaction with a one-to-one correspondance on the bit basis between interrogation and reply.

2. Technical Approach: The operational message for time code transfer is of the form "<cr ACYGMThhmm" where "<cr" is a carriage return and "hhmm" is the event time. The test software package will use these four data characters to carry a hexadecimal message number. The LPDS software will reply with the message "GMTACYhhmmnl <nl" using the same four character message indicator. Thus, the interface test will be comprised of many repetitions of this interrogation/reply transaction. Each transaction is assigned its own distinct message number. If no reply is received, the interrogation can further characterize message performance by isolating uplink versus downlink and protocol versus message content errors.

3. Data Collection: The test software in the AP will keep a running sum of interrogations sent and the total correct replies received. The high, low, and average values of the I/O time between the first transmission of an interrogation and the reception of a correct reply will also be tracked.

4. Data Analysis: The message delivery success rate will be determined by the number of correct replies received as a function of the total number of interrogations transmitted. The time required to successfully complete a message transaction will be considered the response time of the interface; the high, low, and average values of the response times will be calculated and stored during the test.

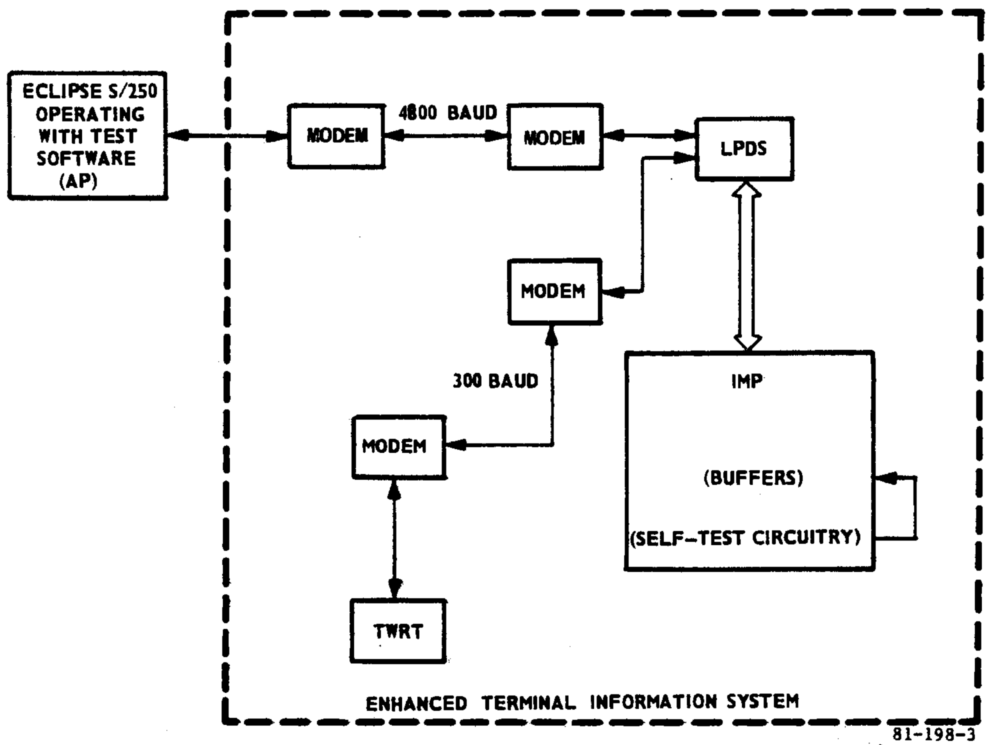

FIGURE 3. AP/ETIS COMMUNICATIONS LINK TEST CONFIGURATION

b. Software.

1. Intent: Message delivery times related to LPDS software implementation will be recorded. The aim of this test will be to measure worse case time delay occurring when the entire data base is updated and the LPDS must accomodate communications with the IMP and the TWRT. By limiting the AP operation to the single function of interrogating the LPDS, adequacy of the LPDS software for timely delivery of ETIS data will be observed. Test results will be used to gauge requirements for future designs of ETIS systems. Message delivery delay times attributed to other subsystems of the test bed will also be derived; accumulated data will form the data base for statistical analyses. Verifications of software performance in recognizing and implementing report priority, precedence, and sequence will be observed and recorded.

2. Technical Approach: An AP test software package will be used to simulate the operational software while collecting data. To assure maximum loading on the LPDS, this test will be run simultaneously with the transmission of eight full lines of free text from the TWRT and transmission of a repeatable backlog of data from the IMP. The test procedure is as follows:

(a) The LPDS will be placed in its keyboard command executive mode to ignore IMP data transfer requests. The IMP will be reset to generate a repeatable backlog of data for transfer. The test operator will allow approximately 10 minutes to elapse for the accumulation of this backlog. Then, simultaneously, the

LPDS will be returned to operational status to resume processing IMP inputs and the transmit free text buffer command will be issued to the TWRT. The test run will be executed at the AP.

(b) This test run will issue the "send all" interrogation to the LPDS, and then receive and echo replies according to the operational protocol sequence, terminating with the transfer to the LPDS of the appropriate terminator message (ACYQUT). Next, the "Mode S sensor off" message is sent, followed by the Mode S sensor "on" transaction. The reception and echoing of replies are repeated up to the termination ("ACYQUT") at the end of the sequence. The "send all" sequence is then repeated. This test should exercise all message formats defined for the AP/ETIS interface.

(c) Information echoed correctly back to the LPDS is transmitted to TWRT. This information is printed upon reception at the TWRT, resulting in a printed log of the data update information. Both the number and content of ETIS updates sent to the TWRT during the test run will be available for later analysis.

3. Data Collection: During each test run, a log will be kept of the content of all transmissions and receptions of messages, along with the event times of these messages. In addition, the total number of interrogations sent will be maintained as a running sum. Also, the number of times the LPDS fails to reply to an interrogation will be recorded. The number of replies with detected errors will be recorded, and the number of replies that the LPDS retransmits (indicating a data reception or echo error) will be stored. The high value, low value, and average value of the total I/0 time to successfully complete each interrogation/reply transaction will be collected. In addition, the total output to input time which elapsed between the start and end of a protocol sequence will be recorded for each sequence. This period starts with the transmission of the "send all" or "send new" interrogations, and ends with the reception of the correct "time code" echo.

4. Data Analysis: The accuracy rate will be determined from the total number of interrogations sent minus the number of replies with detected errors, the number of replies that were repeated, and the number of times the LPDS failed to reply. This value, given as a ratio per number of interrogations sent, indicates the percentage of accurately completed interrogation/reply transactions.

The high, low, and average values of I/0 time required at the AP to complete each transaction will be considered as the response time since this period includes the LPDS operational software delays. This test scenario is intended to submit the LPDS to its heaviest expected normal load, so the message data transfer capacity can be taken from the total I/0 time required to complete each test sequence.

The priority resolution capability will be checked by verification of the correct and consistent ordering of the LPDS replies, as recorded on the AP communications log. The ETIS updates to the TWRT display will be verified by comparison of the AP communications log to the ETIS data reception log of the TWRT.

c. ETIS Link Operating Characterization. The following test will be used to determine the operational characteristics of the ETIS source (LPDS) to AP communications link.

1. Intent: This test will be used to determine the adequacy of system parameters and provide data for recommending changes in parameter values necessary to preclude system degradation. The test will also be used to log character error rates on the communications link where an interrogation-reply transaction error has been found and recorded. Parameters fixed in the software that will be evaluated include frequencies and limits of generating and repeating interrogation commands.

2. Technical Approach: The bidirectional communications between the AP and the LPDS will be monitored by a test microprocessor which will collect the data and, as CPU time permits, perform data reduction. The LPDS will use the same test data source which was used in the hardware test of the interface to supply known and repeatable sets of ETIS data. The configuration for this test is shown in figure 4. The AP will be executing its operational software package during this test.

3. Data Collection: The items to be recorded are the periodicities of the transmission of the "ACYALL" and the "ACYNEW" interrogations. The occurrence of erroneous replies, and the rate of incorrect data echoes for each of these items will be logged along with their relative event times.

4. Data Analysis: The data reduction for this test will be performed by the test microprocessor during the run of the test and by a development microcomputer supplied with the log tape from the test run afterwards. The reduced data will show the peak, average, and variance of the frequency of occurrence of each type of logged event. The periodicities of the interrogations will enable the calculation of the ETIS data update rate at the AP. The communications character errors will be plotted cumulatively as error frequency throughout the test run.

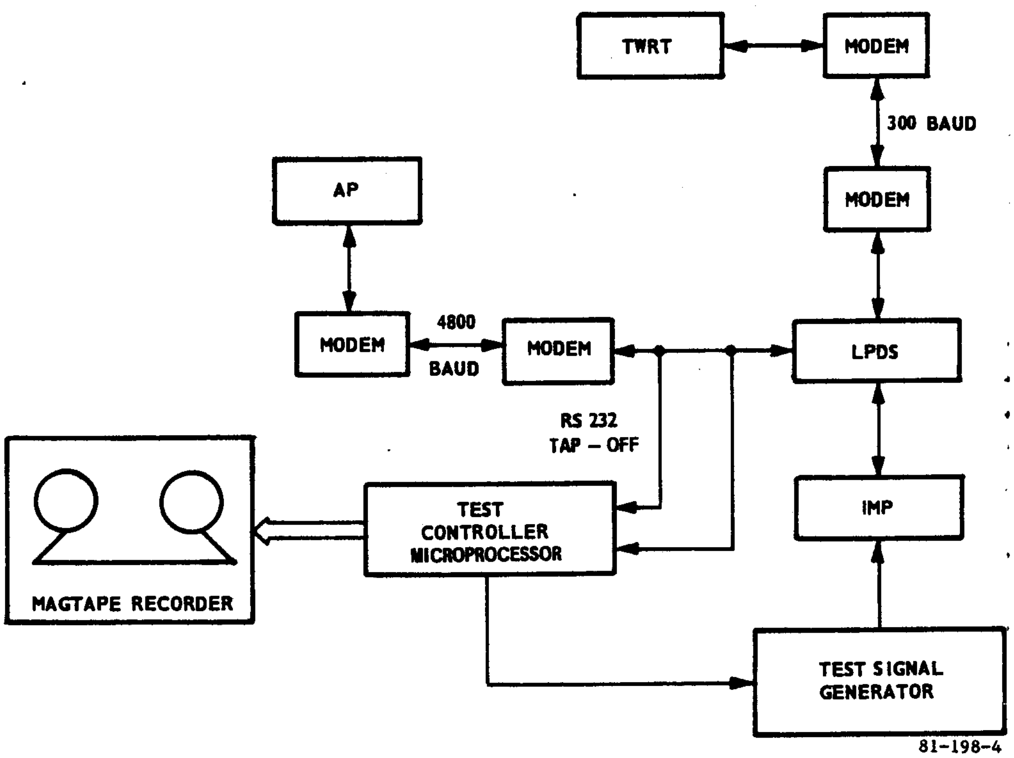

FIGURE 4. TEST CONFIGURATION — ETIS LINK OPERATING CHARACTERIZATION

5.1.2 AP Weather Source Tests.

The test described below will be used with the MITRE computer information for weather products. This configuration is identical to that used by Lincoln Laboratory using a "Bell System Data Set 212A" modem over commercial land lines.

The configuration may be changed to use the Technical Center Automated Flight Service Station (AFSS) facility, provided time permits and the AFSS facility at the Technical Center becomes available for such incorporation into the test bed. If the test bed is configured with the AFSS, the AP software will be modified to interrogate and accept messages from the facility. Also, interface hardware will be fabricated and the information will be transmitted over dedicated telephone lines using modems identical to the modems used by the Mode S system.

a. Weather Source Characterization. For the AP to weather produce source link test, the data will be collected by the S-250 (AP) minicomputer running under the control of special test software, which will generate messages, collect the test data, and calculate the results.

1. Intent: During this test only contributions to delay time by weather sources will be considered. The goal is to determine the adequacy of the implementation of the weather function in future systems. The error rate from a given interrogation and reply transaction and the time to transaction completion will be measured. Time to completion includes all reiterations of the total transaction until acceptance without error. For this test, the errors caused by interference or noise on the line will be separated from delays due to data source characteristics.

2. Technical Approach: The tests on the link will use live data from the weather computer center. Without known input, the test will generate its own reference data (i.e., a manual interrogation, such as the Atlantic City weather forecast, will be inputted into the AP as the acceptable reply message). Automatic interrogations will be generated by the AP and the replies will be compared bit by bit to the stored reference. Since the weather source computer is an undedicated signal source, the number of interrogations in each test run will be a relatively low number (about 100 interrogations). A number of test runs will be made randomly to establish delay times.

3. Data Collection: Data will be obtained for each weather product type defined at the start of the test program. As in the case of the ETIS link, the number of good replies and the time delay will be recorded. Reinterrogation delays, when no reply was generated in response to the original interrogation, will be included in the computation of the running average delay times. Maximum delay time and an average delay time will be determined and recorded during the test.

4. Data Analysis: The minimum delay time will be calculated, assuming that the MITRE computer is instantaneously available for this service, and the calculated minimum value will be compared to the measured minimum value.

An acceptable maximum delay time will be established for the facility; values exceeding this value will not be used in calculating the average value, but the reply delay will be measured and printed out for each occurrence. Excessively long delays will be assumed to be caused by higher priority programs within the MITRE processor, preempting the AP's requests, and will be assumed to be improbable occurrences using a dedicated computer in a nationwide, automated flight service station network.

The results of the data reduction will be presented as the error rate (percentage ratio of total messages received with errors to the total number of messages received), and the maximum, minimum, and average reply delay. The error rate required for the test bed is less than 1 percent. As long as this figure is met, no further analysis of delays will be necessary. The average delay times will be used during the data reduction of the data link system test to determine delays introduced into the delivery times of each message type by the weather source software due to competing messages. The average delay times and error rates on this link will be used to determine the effectiveness and accuracy of the software and processing hardware of the Mode S data link beyond the input port of the applications processor.

b. Weather Source Link Operating Characterization. The following test will be used to determine the operational characteristics of the weather source to AP communication link.

1. Intent: This test will evaluate implementation of weather source software and verify request message storage capacity. Sequencing of reply messages according to a predetermined priority scheme will also be verified.

2. Technical Approach: The bidirectional RS-232 communications link between the AP and the MITRE computer, used as the weather source for the test bed, will be monitored by a test microprocessor which will collect data and, as CPU time permits, perform data reduction. Figure 5 shows the configuration for this test. The test will be performed while the AID is requesting continuous updates on the weather in a given area. The AP will function using its operational software during this test.

3. Data Collection: The items to be collected are the occurrences of weather requests from the AP to the weather source computer, the number of occurrences of replies from the MITRE computer, the elapsed times between requests and replies, the occurrences of character errors in the weather request messages, and the occurrences of character errors in the reply messages.

4. Data Analysis: The reduced data will include the periodicity of requests for various information, the percentage of replies occurring in response to requests, the average response time of the weather sources during the run, and the frequency distribution of incorrect characters on both the interrogation and reply communications lines. This information will result in the calculation of the weather data reliability and approximate average update rate of the AP.

Since the MITRE weather product source computer is not dedicated to the test bed alone, the reply delays are not critically important, provided that they do not average longer than the installation threshold as determined by the time-out period of the AP software.

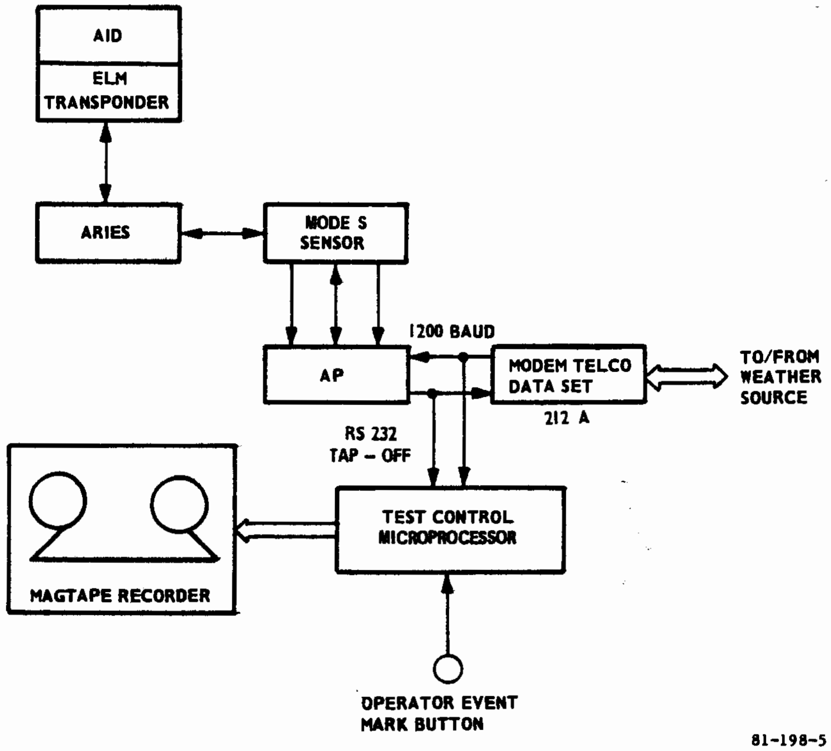

FIGURE 5. TEST CONFIGURATION——WEATHER SOURCE LINK OPERATING CHARACTERIZATION

5.1.3 AP Communications Capability Tests.

A Bendix transponder equipped with the extended length message (ELM) capability will be interfaced with the Aircraft Reply and Interference Environment Simulator (ARIES) to establish Mode S sensor to transponder communications. The transponder will be inhibited from replying by removing the power supply voltages to the RF output amplifier. In this test, the ARIES will provide the reply messages which simulate a target having a predetermined flightpath. The external ELM transponder will receive the same RF signals and will have the same address as one of the simulated ARIES target. Since the address of both targets will be identical, the ELM transponder will accept the uplink messages and, by inhibiting the RF output of the transponder, only the ARIES target will generate reply messages. The data outputs of the ELM transponder will be connected to the AID system for display generation. Through a special interface, described in section 6 of this document, the altitude of the ARIES target may be controlled by the test operator.

a. Weather Communications. A test microprocessor, equipped with a 60-cycle time source and an operator controlled epoch mark button, will be used to simulate the AP's weather source. The test microprocessor will record messages sent by the AP over the channel assigned to the weather source interface and will reply with known, repeatable messages in the standard formats used by the weather source computer. In addition, the test device will record elapsed times by means of the operator controlled epoch mark button. See figure 6 for the configuration for this test.

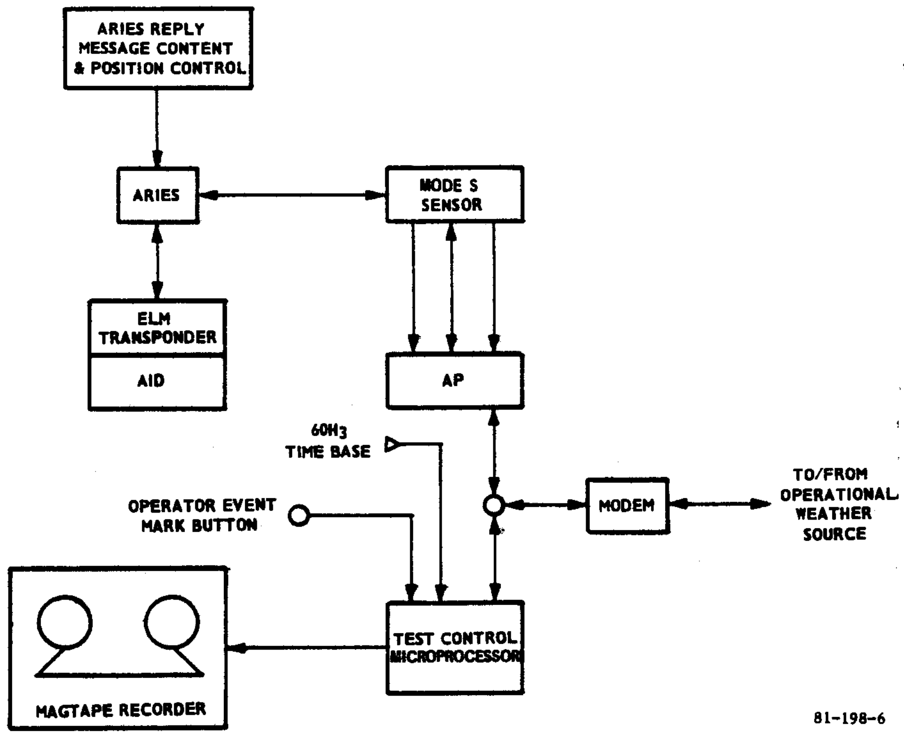

FIGURE 6. TEST CONFIGURATION — AP COMMUNICATIONS CAPABILITY VERIFICATION; WEATHER FUNCTIONS

1. Intent: The test is designed to determine time delay for the weather functions measured from the input of the AP to the AID display, and the delay time from AID keyboard entry to the generation of the request message by the AP. Also, through predetermined message content, the accuracy of data processing through the system will be verified.

2. Technical Approach: The test operator will enter a request for area weather for a specific location into the AID keyboard. The operator will then simultaneously depress the AID's "send" key and the "mark" button on the test control microprocessor unit. The test unit will assign this event as time zero. When the AP issues a weather request to the weather source, the test unit will record the elapsed time and will reply with a fixed set of data to the AP. The operator will again depress the test microprocessor's "mark" button when the data set is dislayed on the AID's display, causing the event time to be recorded. The operator will then verify the message content for accuracy as compared to the known set of data supplied by the test unit.

The test microprocessor will also record the event times of successive weather requests by the AP in response to the AID's request for updates. After a specific elapsed time, the test microprocessor will change the data set being replied to the AP. When this update is received and displayed at the AID, the operator will again depress the "mark" button on the test unit to record the event time.

3. Data Collection: The data collected will include the elapsed times between the initiation of the weather request at the AID and the reception of the weather product request from the AP at the weather source simulator and the delay time between the change of data sets and the update display at the AID. However, the data of primary concern here is the occurrence of character errors in the data displayed at the AID as compared to the data set generated by the test control microprocessor as it simulates the weather product source to the AP.

4. Data Analysis: The test microprocessor will reduce the collected data to obtain the request turnaround times, update sampling period averages, and will store this information on magnetic tape for later printing.

The event times collected on this verification test run will be approximate due to the low resolution of a 60-cycle derived time base and the operator's response lag. However, for the sole purpose of verifying the AP's communication capability, these times will be sufficiently accurate.

Within the short-term limits of this verification test, no character errors are expected. If erroneous displays do occur, the event will be logged by the test operator. Statistical data on error occurrences will be presented only if errors are frequent enough to provide a sufficient basis for analysis.

b. LPDS Communications. The configuration for the test of the AP communications capability from the LPDS as source is shown in figure 7. A test signal generator will provide the IMP with known, repeatable data signals under the control of a test controller microprocessor. The operator will communicate with the test controller from a video data terminal connected via modems to the RS-232 serial data link in the controller microprocessor. The test controller will maintain a 60-cycle derived time base and will be equipped with a magtape data storage capability.

The verification test will consist of three parts, each testing a different aspect of the AP's ETIS-related functions.

1. Requested ETIS Delivery (with updates): This portion of the verification is concerned with the AP's ability to supply ETIS information to a transponder upon request from the transponder.

(a) Intent: The objective of this test is to determine ETIS-related system delays without contention for processing time by a higher priority data link function. The test will be conducted while all other inputs to either the AP or the sensor are inhibited. Delay time will be measured from the IMP input to the display of the information at the AID; processing time of the request message will be measured from the AID keyboard to the delivery of the requested message at the LPDS. From known input data, the accuracy of the delivered messages will be verified.

(b) Technical Approach: Upon initialization command from the operator, the test controller will cause the issuance of a fixed set of data to the IMP from the test generator. This data will be allowed to flow through the system from

IMP to LPDS to AP to LPDS again and, finally, to the controller display at the TWRT. The operator will enter a request for ACY ETIS information with updates on the keyboard of the AID. The operator will then simultaneously depress the "send" key at the AID and send a "mark" character to the test controller microprocessor. The control microprocessor, upon receipt of this character, will initialize an event elapsed time counter. The test operator will send another "mark" character to the test controller unit upon receipt of the requested ETIS data at the display of the AID. The test controller will record the approximate elapsed time. The operator will also verify the display context by comparison to the known data sent to the LPDS.

The operator will then send a control character to the test controller to start the measurement of the update throughput delay time, and to cause the issuance of a different, known, repeatable set of data to the IMP. When this update is displayed at the AID, the operator will again send a mark character to the test control microprocessor and verify the update content. The test control unit will record the throughput delay time for the update data.

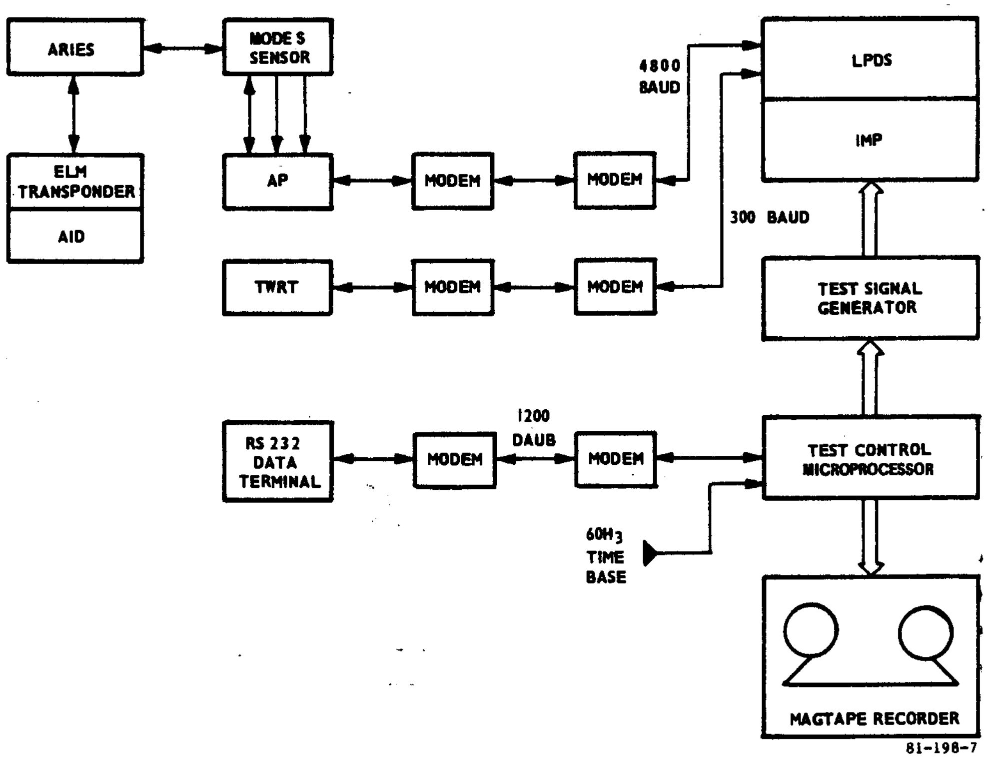

FIGURE 7. TEST CONFIGURATION — AP COMMUNICATION CAPABILITY VERIFICATION; LPDS FUNCTIONS

(c) Data Collection: The test control microprocessor will, during the execution of the test run, record the elapsed turnaround time between the issuance of the ETIS request at the AID and reception of the data with its subsequent display, and the throughput delay time between the generation of a new set of ETIS signals at the IMP and the display of this update at the AID. The data of primary concern is the display of the erroneous data.

(d) Data Analysis: The data reduction of this phase of the verification test will involve printing of the recorded values of the AID's ETIS request turnaround time and the update delivery throughput delay time derived from the test controller microprocessor's runtime log tape. Statistical analysis of these values will not be performed at this time. These values will be used to produce an approximation of the propagation delays induced by the combination of the AP, the Mode S sensor, and the transponder/AID subsystems for reference when the individual throughput delay times are determined for each subsystem in later phases. As in the verification of the weather product delivery, the primary concern here is the confirmation of the AP's ability to supply the transponder with accurate ETIS data. Again, statistical enumeration of error rates will be presented only if the error density warrants such analysis.

2. Final Approach ETIS Delivery. This portion of the verification is concerned with the ability of the AP to deliver the proper ETIS data automatically to aircraft entering the defined final approach zone.

(a) Intent: The test objective is to determine the accuracy of the delivered data and to measure the time delay between occurences of the triggering condition and the display of the final approach ETIS message on the AID. Tests will be repeated to obtain data for statistical analysis and association with reasons for delay.

(b) Technical Approach: A known set of ETIS data will be stored into the system as in the requested ETIS delivery test. The "mark" character will be sent to the test controller microprocessor, coinciding with the adjustment of the altitude of the ARIES target to bring the simulated aircraft flightpath into the final approach zone. The real-time, operator controlled positioning of ARIES targets will be accomplished through the special control interface of the ARIES system described in section 6 of this document. When the target is within the landing zone, the final approach ARIES message will be transmitted to the AID by the AP via the sensor and ELM transponder. The message will be "marked" and verified by the operator upon reception and displayed at the AID. The test microprocessor will record the approximate elapsed time involved for final approach determination and message delivery.

(c) Data Collection: As previously mentioned, the data from this test will be collected by the test control microprocessor, with the exception of the message content verification performed by the operator upon display of the final approach ETIS message. The value to be recorded by the test controller unit is the combined delays involved in the AP's reacting to the transponder's "entry" into the final approach zone and in the delivery delay of the message itself.

(d) Data Analysis: A preliminary value of the AP's response time in servicing final approach ETIS targets will be determined from the measured values from the individual test runs. These measured values are of low resolution due to operator response lag, but are sufficiently accurate for this verification of the AP's final approach determination algorithm. Message content errors will be evaluated on a per case basis.

3. Wind Shear Alert Delivery. This portion of the verification test is concerned with the ability of the AP to deliver wind shear alerts to final approach aircraft by way of the Mode S COMM-A message to the transponder's standard message interface.

(a) Intent: The goal of this test is the measurement of elapsed time between deliveries of the update messages. Messages will be generated with a timing accuracy of a 60 hertz (Hz) clock so as to obtain more accurate measurements than obtainable previously. With fixed aircraft flightpaths simulated, time delays will be measured for increasingly severe windshear conditions.

(b) Technical Approach: A set of ETIS data which contains a "no wind shear" condition will be initialized through the test bed data collection system and allowed to stabilize. The operator will then simultaneously depress a mark character on the test controller microprocessor interfaced with the video data terminal and start the test scenario on the ARIES unit. The flightpath of the simulated ARIES target will provide for transition into the final approach zone of the Technical Center's airfield at a predetermined speed.

The test controller microprocessor, having waited a specific elapsed time after the reception of the mark character from the operator, will then cause a second set of ETIS data to be generated to the IMP for subsequent transfer to the AP through the LPDS. This set will contain a single-point wind shear alert. After another predetermined period of time has elapsed, the test controller will cause the generation of yet another ETIS data set, containing a multiple-point wind shear alert. While the test controller maintains this multiple-point alert, the ARIES unit will introduce a second aircraft into the final approach zone.

(c) Data Collection: Both the ARIES unit and the test controller microprocessor will generate data logs of the test run on magnetic tape for later correlation. Event times will be compared relative to the synchronization mark issued to both units by the test operator at the start of the test run. The data log of the ARIES unit will record the COMM-A message content along with their respective reception times. The test controller microprocessor log will contain event times for the generation of the various data sets to the ETIS data collection system of the test bed.

(d) Data Analysis: The data analysis from the log tapes of the two test units will verify the delivery and context of the COMM-A windshear alert messages from the standard message interfaces of the ARIES transponder units. The scenario is designed to verify delivery of both existing wind shear alerts by the AP to aircraft entering the final approach zone and newly occurring windshear alerts to aircraft already within the final approach zone. Comparison of the generation times from the test controller log and the reception times and position reports from the ARIES log will permit the calculation of approximate elapsed times for wind shear alert delivery from generation (or occurrence) or from aircraft entry into the final approach zone. These approximate elapsed times are of low resolution due to the synchronization errors induced by the operator's lack of simultaneity at the start of the test run and by the use of independent time bases for event timing during the test run. However, these accuracies are sufficient for the purposes of this communications verification test.

5.1.4 ETIS Data Acquisition Test.

The characterization of the IMP to LPDS to AP data path being complete, the actual ETIS data acquisition process will be verified. The items of interest are: the delay time between new data occurrence and the data reception at the AP, the instrumentation data reliability at the AP, and the minimum separation of two new data values resulting in the transmission of both values to the AP. The tests will be conducted under the worse case or highest load conditions for the LPDS.

The configuration for the data collection test is shown in figure 8. The IMP, LPDS, and TWRT will be operating with their respective operational software packages. The AP will operate using test software and will be the controlling unit. A hardware test data/signal generator will be connected to the IMP instrumentation inputs and will provide the instrumentation signals to generate several different predetermined sets of data. A test control microprocessor will be used to drive the IMP/LPDS reset control and the test data generator. The controller will derive its control timing from the AP by listening on the 4800 baud AP/LPDS communication line. The AP will address the controller as a receive-only LPDS with the identification code "CTL" as opposed to the LPDS identification code "ACY." The AP will also control the TWRT keyboard entries via the serial interface of the AP driving the TWRT console communications line.

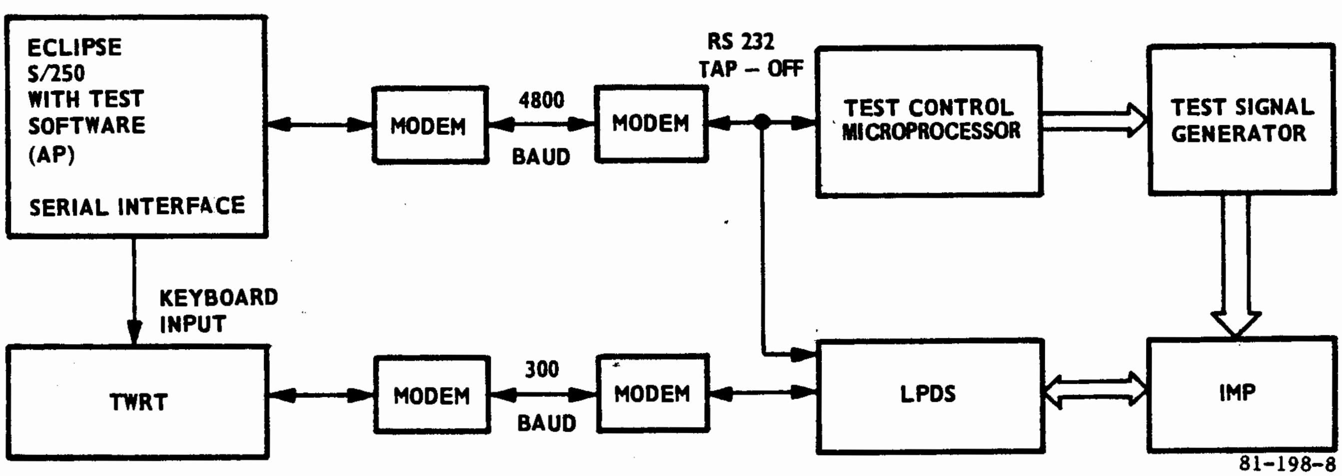

FIGURE 8. TEST CONFIGURATION — ETIS DATA COLLECTION TEST

a. Intent: The test is designed to measure ETIS delivery time of messages through the data link system with a forced maximum rate of change on the inputs. Constraints imposed by the system will be identified.

b. Technical Approach: Each test run will consist of the transfer of two full sets of instrumentation data from the test data driver and, to assure repeatable LPDS loading, eight lines of free text from the TWRT. The separation time between the two sets of instrumentation data will be varied under control of the AP.

For each test run, the AP sends the test controller the separation time between the two sets of instrumentation data in terms of the 60 Hz clock cycles. Upon receipt of this information, the controller stores the separation time in a count-down register, then sends the reset pulse to the LPDS and the IMP to establish a consistent data origin. After a pause to allow post-reset stabilization of the LPDS, IMP, and TWRT system, the proceed signal is issued to the controller. The controller then strobes the trigger pulse to the test data driver, which generates the first set of data and enables the clock interrupt input to start the count-down to the trigger of the second set. The AP, meanwhile, sends the transmit free text command over the TWRT keyboard. The AP then initiates continuous data interrogation sequences to the LPDS.

The separation time between the two sets of instrumentation data is progressively shortened until the first set is overwritten with the second set before transfer to the AP.

c. Data Collection: For each test run, the system time at which the proceed message is issued by the AP will be recorded for derivation of the data change times. As each data item is received, the system time will be logged together with the value received. The order in which the items are received will be logged in association with the reception time. The separation time between the two data sets, as sent to the test controller module, will be stored along with the final number of complete data sets received.

d. Data Analysis: To assure sufficient data base size, data will be collected from many test runs. The minimum, maximum, and average values of the delay time between the new item value and its reception at the AP will be derived for each time from the data change times and the reception times as taken from the system clock. Since the data generated by the test data generator is both repeatable and known, data reliability can be determined on a per item basis in terms of percentage of accuracy by comparison of the generated and received values for many transferred sets of data. The minimum separation time between two instrumentation data sets, which results in the transfer of both sets to the AP, will be determined directly during the test runs by confirming the reception of two complete sets of data for each separation time. Data reduction will be performed within the AP by test software.

5.2 TEST AND EVALUATION OF ATC OPERATIONAL FUNCTIONS.

The tests will be conducted with a single (non-netted) Mode S sensor interfaced with the ATC test facilities at the FAA Technical Center. Only one test facility (TATF or SSF) will be connected to the sensor at any given time, depending on which data link function is being tested. The aircraft will be simulated, using scenarios with the air traffic control simulation facility (ATCSF) or the ARIES. The Mode S sensor will transmit the surveillance data to the AP and to the ATC test facilities. Based on the Mode S surveillance information, the simulated aircraft data blocks will be displayed to the controller. The data link messages will be transmitted by the ATC facilities whenever an MSAW advisory or an AACC message is generated for the simulated aircraft. On receipt of these uplinked messages, the MSAW advisory or the AACC messages will be displayed on the AID in the cockpit.

In MSAW tests, ETIS messages (i.e., RVR and wind shear warning (WSW) messages) will be automatically generated as COMM-A's in the terminal approach zone. The display of ETIS and MSAW information, and any contention between these messages when they are generated simultaneously, will be observed and evaluated. In addition to RVR and WSW messages, which are automatically generated, ETIS and weather (WX) messages will be transmitted as COMM-C messages at the request of the pilot. These COMM-C messages will be generated in both the MSAW and AACC tests to introduce a background data link load on the system. The controller will be unaware of the generation of these messages and they will only be displayed on the AID. Both the controller displays and the AID's will be used for the verification of the display of MSAW and AACC functions during the tests.

This test activity will proceed in two phases: test bed verification and operational tests. In the test bed verification phase, a test will be conducted to ensure the operation of the overall system and to validate the ATCSF scenarios. This test will be conducted prior to the operational tests which will involve air traffic controllers participation. In the operational tests, generation of the MSAW and AACC messages will be demonstrated, and their operational acceptability to the controllers will be subjectively evaluated.

During the operational tests, two to four controllers will be required to man the TATF and SSF displays for approximately 1 week. During the test bed verification and the operational tests, the traffic environment will be simulated by using the ARIES/ATCSF interface, which is currently under development. The ATCSF will provide the simulated aircraft positional data to the ARIES via a telephone line interface, and will update this information every scan. These simulated aircraft will be maneuvered by the simulator pilots as instructed by the controllers.

The tests to be conducted are divided into two categories: MSAW and AACC tests. The following is a description of the tests.

5.2.1 MSAW Tests.

A total of three tests will be conducted: one test bed verification test and two operational tests (see table 1).

a. Test Bed Verification.

1. Intent: The objectives of this test (T-1 in table 1) are to ensure the proper operation of the overall system and to validate the ATCSF scenarios. This test will be conducted prior to the operational tests which will involve controller participation.

TABLE 1. MINIMUM SAFE ALTITUDE WARNING (MSSW) TESTS

Test Phase	Test No.	Test Configuration	Test Objectives
Test Bed Verification	T-1	Figure 9	To ensure proper operation of the overall system and to validate the ATCSF scenarios.
Operational Tests	T-2	Figure 10	To demonstrate the generation of MSAW advisories and to assess the operational acceptability of the MSAW data link to controllers.
	T-3	Figure 9	To demonstrate the generation of MSAW advisories; to observe the contention for display on AID between the ETIS messages (RVR and WSW) produced in the terminal approach zone and the MSAW advisories; and to assess the operational acceptability of the MSAW data link to controllers.

2. Technical Approach: During this test (T-1), the ATCSF will simulate the traffic environment and provide the aircraft positional data to ARIES every scan. The Mode S sensor will receive the ARIES inputs and generate surveillance messages for the simulated traffic, which will be transmitted to both the AP and the TATF (see figure 9 for test configuration). Based on the surveillance information, the simulated aircraft tracks will be displayed to the controller. An MSAW advisory will be generated by the TATF when a simulated aircraft flies at a low altitude, with respect to the terminal area MSAW adaptation. In addition to MSAW advisories (COMM-A messages), RVR and WSW messages will be automatically generated as COMM-A messages in the terminal approach zone. There will be occurrences of contention for display on the AID when several of these messages are generated simultaneously. Such occurrences will be observed and evaluated. ETIS and WX messages will also be generated by the AP at the request of the pilot, and will be uplinked (via Mode S) as COMM-C's to the subject AID. The TATF controller will be unaware of the generation of ETIS and WX messages as they are displayed only on the AID. The MSAW advisories will be displayed on both the TATF controller displays and the AID's. Only six AID's will be available during testing. The simulator pilots will maneuver only six aircraft, and the MSAW, ETIS, and WX messages will be simulated for the six aircraft selected for demonstration. These six aircraft will be simulated as a part of the ATCSF scenarios described in table 2.

The following software, some of which are currently under development, will be required for this testing:

(a) Mode S/terminal ATC interface software with the capability to data link MSAW advisories.

NOTES:

a. AIR TRAFFIC CONTROL FACILITY:

TATF FOR MSAW FUNCTION TESTS
SSF FOR AACC FUNCTION TESTS

b. DATA EXTRACTION:

ARTS DATA EXTRACTION TAPES FOR MSAW FUNCTION TESTS
SYSTEM ANALYSIS RECORDINGS (SAR) FOR AACC FUNCTION TESTS

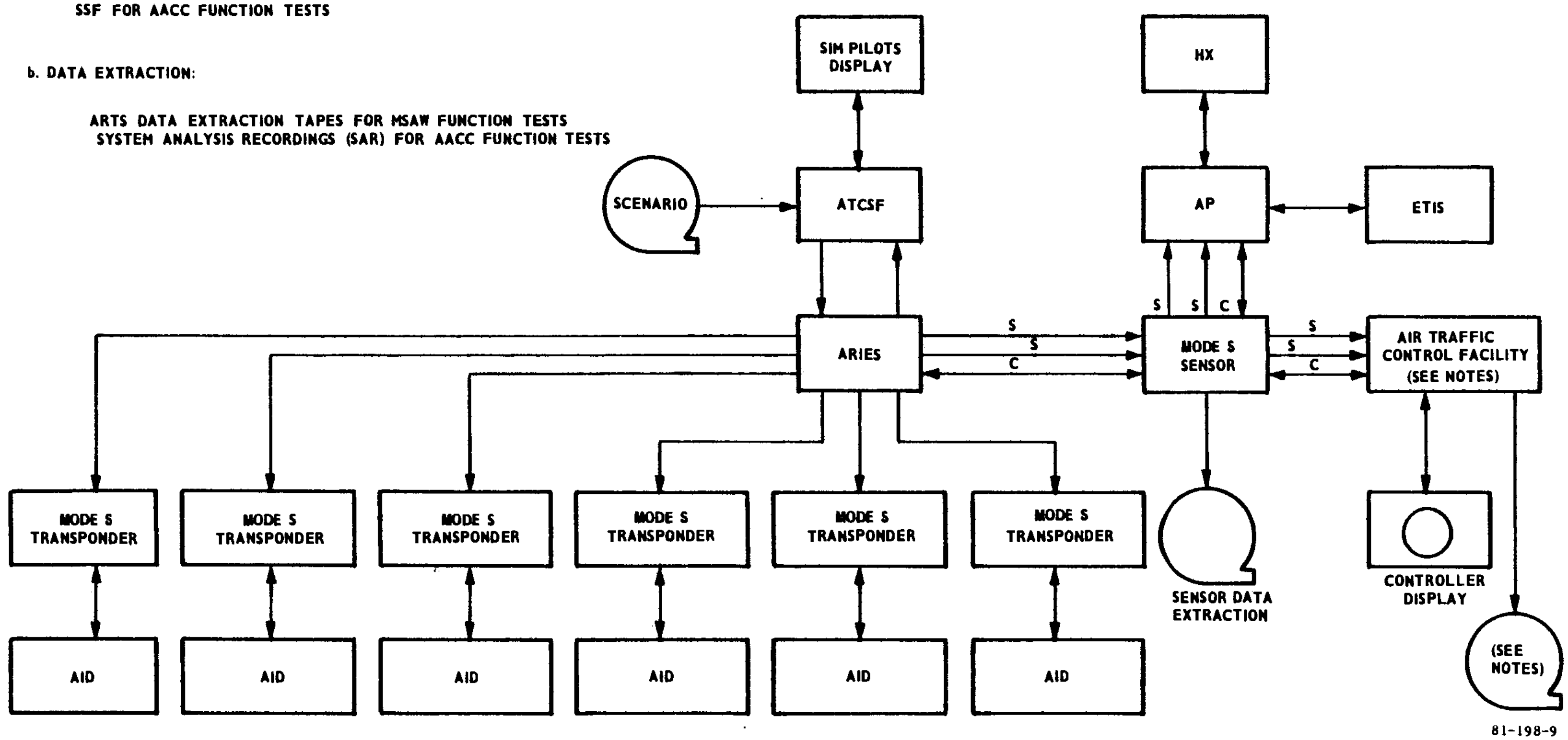

FIGURE 9. TEST BED CONFIGURATION — ATC FUNCTION TESTS WITH INCLUSION OF TERMINAL AND WEATHER DATA SOURCES

TABLE 2. SCENARIOS FOR MSAW TESTS

Test Phase	Test No.	ATCSF Scenarios
Test Bed Verification	T-1	A realistic scenario with aircraft load and traffic patterns the same as in the Philadelphia terminal adaptation will be developed. Six Mode S aircraft in the scenario will be simulated and maneuvered by simulation pilots such that MSAW advisories are generated by the TATF at the rate of approximately one advisory per aircraft every 6 minutes. In addition, several COMM-A messages will be sent to other aircraft by the COMM A/B Driver software resident in one of the Mode S computers. These messages will provide additional data link load on the system. Six aircraft (same as above) will also send downlink requests alternately for ETIS and WX information at the rate of one request per minute.
Operational	T-2	Same as in test T-1 except that the six aircraft in the scenario will not send downlink messages requesting ETIS and WX information.
	T-3	Same as in test T-1

(b) Mode S/AP interface software with ETIS and WX software modules.
(c) ATCSF/ARIES interface software.
(d) Data collection software for the Mode S sensor and the ARTS.
(e) ATCSF scenarios.
(f) COMM A/B driver scenarios.

The following test facilities will be required for testing:

(a) Mode S sensor at the FAA Technical Center.
(b) TATF.
(c) ATCSF.
(d) ARIES.
(e) Six AID's.
(f) AP integrated with ETIS and WX systems.
(g) ATCSF/ARIES interface.
(h) ARIES/AID interface.

3. Data Collection: During the tests both surveillance and communication data will be collected using the Mode S and ARTS data extraction. Observer logs will be filled out by the test observers manning the TATF displays and the AID's. Any anomalies or problems observed during the tests will be noted along with the time of occurrence, description of the event, and the estimated severity of the problem. Samples of the observer logs are shown in tables 3 and 4.

4. Data Analysis: A subjective evaluation of the MSAW verification tests will be made on the basis of the visual observations of the TATF controller displays and the AID's. The data collected on the Mode S and the ARTS data extraction will be used for post-test investigation of any problems encountered during the tests. The visual observations of the TATF controller displays, the AID's, and the observer logs completed during testing will be used to formulate conclusions regarding the validity of the scenarios and the readiness of the overall system for operational testing with air traffic controllers.

b. Operational Tests.

1. Intent: The objectives of the tests conducted in this phase are to demonstrate the MSAW data link function and to subjectively assess its operational acceptability to controllers. In addition, any possible contention between the display of ETIS (i.e., RVR and WSW messages) and MSAW information, when these messages are generated simultaneously, will be observed and evaluated.

2. Technical Approach: Two tests (T-2 and T-3 in table 1) will be conducted in this phase. In both tests, the traffic environment will be simulated using the ATCSF. Air traffic controllers will be stationed at the TATF to control all but six simulated aircraft. These six aircraft will be monitored by the controllers, but no control actions will be taken until an MSAW advisory is generated automatically. On display of the MSAW advisory, the controller should radio communicate the advisory to the simulator pilots. On receipt of the advisory, the simulator pilots in the ATCSF will maneuver the aircraft selected for demonstration by making a keyboard entry. During these tests, several COMM-A messages will also be sent to aircraft, other than the six selected for demonstration, by the COMM A/B driver software resident in one of the Mode S computers. These messages will not be displayed to the controllers or to the AID observers.

TABLE 3. TATF OBSERVER LOG

Display Symbol _____ Observer Name ________________________

Time	MSAW Message Generated	MSAW Display Terminated Prior To WILCO	MSAW Display Terminated After WILCO	Anomalies/ Problems Observed	Comments
00:15:00					
00:16:00					
00:17:00					
00:18:00					
00:19:00					
00:20:00					
00:21:00					
00:22:00					
(until end of scenario)					

TABLE 4. AID OBSERVER LOG

AID-General Aviation ______ Commercial ______

Time	Messages Generated MSAW	Messages Generated AACC	Messages Generated ETIS	Messages Pending Yes	Messages Pending No
00:15:00					
00:16:00					
00:17:00					
00:18:00					
(until end of scenario)					

Aircraft Address Identification ________ Observer's Name ____________

No. Of Messages Pending	Anomalies/ Problems Observed	Comments

They will only be simulated to provide an additional data link load on the system. The software and the test facilities required in these tests will be the same as in the test bed verification test (T-1).

In test T-2, only MSAW advisories will be generated as a result of the aircraft maneuvers simulated by the ATCSF scenario and the simulator pilots. The ATCSF scenario characteristics are described in table 2. See figure 10 for test bed configuration. The ETIS and WX messages will not be generated during this test. Whenever an MSAW advisory is produced by the TATF, it will be uplinked to the subject aircraft via Mode S. Simultaneously, the controller will radio communicate the advisory to the ATCSF "pilot" maneuvering that aircraft.

The data-linked MSAW advisory will be displayed on the AID, but not on the ATCSF simulator pilot display, and will be acknowledged by the test observer at the AID. On receipt of the acknowledgement at the TATF, the MSAW advisory will go off and a "clear alert" message will be generated. In case the simulator pilot maneuvers the aircraft to a safe altitude in response to the ratio communication from the controller and before the pilot acknowledgement is generated, the MSAW advisory should be terminated automatically.

In test T-3, the MSAW advisories will be generated along with the ETIS and WX messages. The test configuration will be the same as that for test T-2, except for the addition of the AP connected with the ETIS system and the weather source as indicated in figure 9. The AP will provide ETIS (i.e., RVR and WSW) messages generated automatically in the terminal approach zone as COMM-A's. The ETIS and WX messages will also be generated by the AP at the request of the pilot and will be uplinked via the sensor as COMM-C messages to the appropriate aircraft. During the test the controller will be unaware of the ETIS and WX messages because only the MSAW advisories will be displayed at the controller position in the TATF. All three (MSAW, ETIS, and WX) messages will be displayed on the AID's. Therefore, any contention between the ETIS messages (RVR and WSW) sent as COMM-A's and the MSAW advisories will be observed on the AID's.

As in test T-2, the controller will radio communicate the MSAW advisories to the ATCSF "pilots," and the advisories will be simultaneously uplinked via the Mode S sensor. On receipt of the acknowledgement at the TATF, the MSAW advisory will go off and a clear alert message will be generated. If the aircraft maneuvers to a safe altitude before the pilot acknowledgement is received, the MSAW advisory will be terminated automatically.

To verify the MSAW message display at the controller scopes, four different situations will be simulated by specifying the actions of the simulator pilots and the AID observers. The four situations are:

(a) WILCO is received (from AID) by the controller and the aircraft changes its flightpath simultaneously to comply with the advisory.

(b) WILCO is received by the controller but the pilot ignores the advisory.

(c) The aircraft changes its flightpath in response to the advisory before the controller receives the WILCO.

NOTES:

a. AIR TRAFFIC CONTROL FACILITY:

TATF FOR MSAW FUNCTION TESTS
SSF FOR AACC FUNCTION TESTS

b. DATA EXTRACTION:

ARTS DATA EXTRACTION TAPES FOR MSAW FUNCTION TESTS
SYSTEM ANALYSIS RECORDINGS (SAR) FOR AACC FUNCTION TESTS

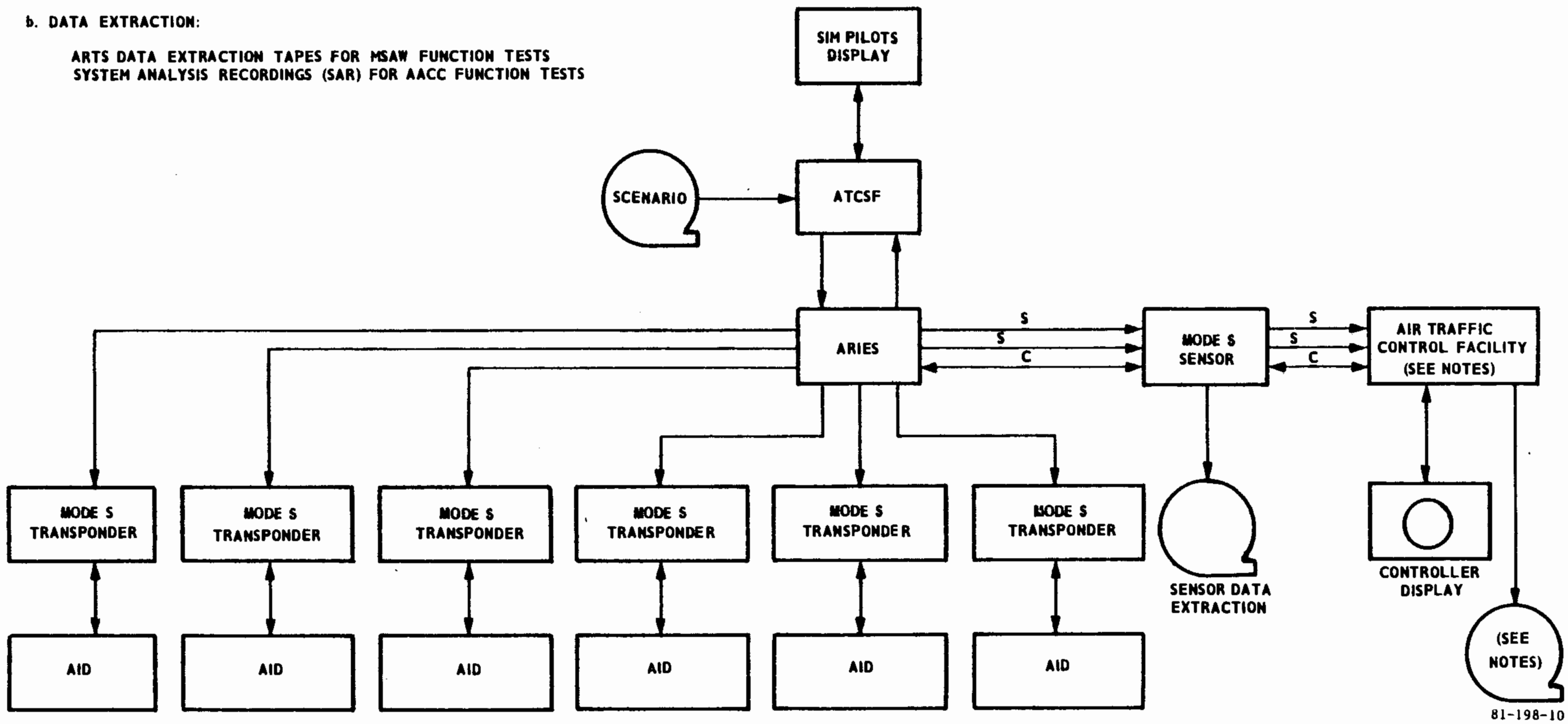

FIGURE 10. TEST BED CONFIGURATION — TESTING OF ATC FUNCTIONS

(d) Neither WILCO is received nor does the aircraft respond to the advisory.

Examples of the scripts that will specify simulator pilot and AID observer actions are shown in tables 5 and 6. During these tests, two to four air traffic controllers will be required at the TATF displays.

3. Data Collection: During tests T-2 and T-3, the TATF controllers will be asked to record from their observations of the display such information as the number of scans after which the technical acknowledgement is received, the number of scans after which the WILCO is received, and the number of scans after which the display is terminated. The controllers and observers at the AID's will also fill out observer logs (shown in tables 3 and 4). Any anomalies or problems observed during the tests will also be noted along with the time of occurrence, description of the problem, and the estimated severity of the problem. In addition, both the surveillance and communication data will be collected on the Mode S and ARTS data extraction tapes. The radio communication between the controllers and the pilots will be recorded on voice tapes; photographs of AID's and controller displays will be taken.

After the tests are completed, special debriefing questionnaires will be used to obtain the subjective opinions of controllers and the AID observers pertaining to the operational acceptability of the data link function. Questions (such as those shown below) will be included in the debriefing questionaires:

(a) Is the display format acceptable?

(b) Is the display attention getting?

(c) Are the message contents enough to indicate suitable action?

(d) Are the keyboard entries distracting, confusing or easy to work with?

(e) Are the keyboard entries acceptable?

(f) Is the technical acknowledgement to a data link message received immediately, after some time, or after a long time?

(g) Do the MSAW and AACC data link functions improve safety?

(h) Does the data link function have the potential to reduce the controller work load?

4. Data Analysis: A subjective evaluation of the MSAW operational tests will be made on the basis of the visual observations of the controllers and the AID observers. These observations will be supported by the following:

(a) Films of AID's and controller displays.

(b) Voice tape recordings of the radio communication between the controllers and the simulation pilots.

TABLE 5. SCRIPT FOR SIMULATION PILOTS — MSAW TESTS

Approx. MSAW Advisory Receive Time (hr:min:sec)	MSAW Advisory Received Aircraft No. 1	2	3	4	5	6	Advisory Comply	Advisory Ignore
00:15:00	X						X	
00:16:00		X						X
00:17:00			X				X	
00:18:00				X				X
00:19:00					X		X	
00:20:00						X		X
00:21:00	X							
(until end of scenario)								

TABLE 6. SCRIPT FOR AID OBSERVERS — MSAW TESTS

Approx. MSAW Advisory Receive Time (hr:min:sec)	MSAW Advisory Received Aircraft No. 1	2	3	4	5	6	WILCO Immediately	WILCO Delay	WILCO No.
00:15:00	X						X		
00:16:00		X					X		
00:17:00			X					X	
00:18:00				X					X
00:19:00					X			X	
00:20:00						X	X		
(until end of scenario)									

(c) Observer logs completed during the testing.

(d) Debriefing questionnaires and verbal comments.

A review of the films, voice tapes, observer logs, notes from verbal debriefing, and the debriefing questionnaires will be conducted to formulate conclusions pertaining to the acceptability of the MSAW data link function. The results of the tests will be compiled into a final report.

5.2.2 Altitude Assignment Clearance Confirmation Tests.

A total of three AACC tests will be conducted: one test bed verification test and two operational tests. A test matrix is shown in table 7.

a. Test Bed Verification Test.

1. Intent: The objectives of this test (E-1, see table 7) are to ensure the proper operation of the overall system and to validate the ATCSF scenarios. This test will be conducted prior to the operational tests which will involve controller participation.

TABLE 7. ALTITUDE ASSIGNMENT CLEARANCE CONFIRMATION TESTS

Test Phase	Test No.	Test Configuration	Test Objectives
Test Bed Verification (without controllers)	E-1	ATCSF/ARIES/AID/Mode S/ AP/SSF (figure 9)	To ensure proper operation of the overall system and to to validate the ATCSF scenarios.
Operational Tests	E-2	ATCSF/ARIES/AID/Mode S/ SSF (figure 10)	To demonstrate the generation of AACC messages and to assess the operational acceptability of the AACC data link function to controllers.
	E-3	ATCSF/ARIES/AID/Mode S/ AP/SSF (figure 9)	To demonstrate the generation of AACC messages when ETIS and WX messages are also generated, and to assess the operational acceptability of the AACC data link function to controllers.

2. Technical Approach: Test E-1 will be conducted in the same configuration as the MSAW test bed verification test except that the SSF will be used in place of TATF in this test (see figure 9).

The traffic environment will be simulated by the ATCSF scenario (see table 8 for description). The Mode S sensor will transmit the surveillance data to both the AP and the SSF. The simulated aircraft data will be displayed to the controllers on the SSF displays.

During the tests, AACC messages will be initiated by the test operators at the SSF and the ETIS; WX messages will be generated by the AP whenever a simulated downlink request is received for such information. The ETIS and WX messages will be generated to provide a background data link load. Quick-action keys such as the Assigned Altitude key and the Interim Altitude key will be used by the test operator to assign an altitude (or interim altitude) to an aircraft. When a keyboard entry is made, the AACC message will be displayed on the controller displays and the Mode S will uplink the message to the subject aircraft for display on its AID. The ETIS and WX messages will only be displayed on the AID and at the controller scope in the SSF. Observations will be made at both the controller displays and the AID's to verify the operation of the system and to validate the ATCSF scenarios.

TABLE 8. SCENARIOS FOR AACC TESTS

Test Phase	Test No.	ATCSF Scenarios
Test Bed Verification (without controllers)	E-1	A realistic scenario with aircraft load and traffic pattern the same as in the Universal Data Set (UDS) adaptation will be developed. Six Mode S aircraft in the scenario will send downlink requests alternately for ETIS and WX information at the rate of one request per aircraft per 6 minutes (see table 4). (The same six aircraft will receive AACC messages from SSF controllers.) In addition, several COMM-A messages will be sent to aircraft, other than these six, by the COMM A/B driver software resident in Mode S.
Operational	E-2	Same as in test E-1, with the exception that the six aircraft in the scenario will not send downlink messages requesting ETIS and WX information.
	E-3	Same as in test E-1.

3. Data Collection: During test E-1, both surveillance and communications data will be collected on the Mode S data extraction and the System Analysis Recording (SAR) function of the en route system. Observer logs will be filled out by the test observers manning the SSF displays and the AID's to record specific questions and any anomalies observed. Table 9 shows a sample of the SSF observer log; an AID observer log is shown in table 4.

4. Data Analysis: Based on the visual observations of the SSF controller displays and the AID's, the AACC test bed will be evaluated to determine the readiness of the system and the scenarios for operational tests. No data analysis will be conducted other than the evaluation of opinions of the test observers. The data collected on the Mode S data extraction and the SAR tapes will be used for post-test investigation if problems are encountered during the tests.

b. Operational Tests.

1. Intent: The objectives of the tests (E-2 and E-3 in table 7) conducted in this phase are to demonstrate the AACC data link function and to subjectively assess its operational acceptability to controllers.

2. Technical Approach: Two tests (E-2 and E-3) will be conducted in this phase. The configurations for these tests will be the same as for MSAW operational tests except that the SSF will be used in place of the TATF. Figures 9 and 10 show the test bed configurations. In both tests, the traffic environment will be simulated using the ATCSF scenarios (see table 8). The controllers at the SSF will control the simulated aircraft and will send AACC messages to at least six aircraft in the scenario. These messages will be originated by the controllers in accordance with a script that will be provided to them. An example of the script required for these tests is shown in table 10.

To initiate an AACC message in accordance with the script provided, the controller at the SSF will radio communicate the altitude clearance to the simulator pilots and will make a keyboard entry (see section 4.6.2 for details). In response to this controller input, the AACC message will be displayed on the controller scope and will be uplinked to the subject aircraft via Mode S. The uplinked AACC message will be displayed on the AID, but not on the ATCSF simulator pilot display, and will be acknowledged (WILCO) by the test observer at the AID. Upon receipt of the acknowledgement at SSF, the display of the AACC message will be terminated. In case the simulator pilot maneuvers the aircraft to the assigned altitude in response to the radio communication from the controller, the AACC message display in the SSF will be terminated even if the WILCO is not received. A script will be provided to create different situations such as: prompt receipt of WILCO, or receipt of WILCO after aircraft maneuvers to the assigned altitude, or no receipt of WILCO. Expamples of scripts that will specify such actions are shown in tables 3 and 4.

In test E-3, the AP, interconnected with the ETIS and weather information sources, will interface with the Mode S system. The AP will provide ETIS and WX messages via the Mode S sensor to an aircraft in response to request messages. Reply messages containing ETIS and WX information will be addressed to simulated aircraft which are equipped with AID systems. The other simulated aircraft in the test scenario will receive COMM-A messages to provide near capacity communications loading for the Mode S system. The background COMM-A messages will be derived from the COMM A/B driver software resident in the Mode S sensor.

TABLE 9. SSF OBSERVER LOG

Display Symbol _____ Observer's Name _______________

Time	AACC Message Generated	AACC Display Terminated Prior To WILCO	AACC Display Terminated After WILCO	Anomalies/ Problems Observed	Comments
00:15:00					
00:16:00					
00:17:00					
00:18:00					
00:19:00					
00:20:00					
(until end of scenario)					

TABLE 10. SCRIPT FOR SSF CONTROLLERS

Time (hr:min:sec)	AACC Message Sent To Aircraft No. 1	2	3	4	5	6	Message
00:15:00	X						Descend and maintain
00:16:00		X					Climb and maintain
00:17:00			X				Maintain
00:18:00				X			Climb and maintain
					X		
						X	
(until end of scenario)							

Only the AACC messages will be displayed on the SSF displays for the controllers. The uplink AACC, ETIS, and WX messages addressed to a particular target will be displayed on one of the six AID systems associated with the selected aircraft address.

3. Data Collection: During tests E-2 and E-3, the SSF controllers will be asked to record from their observations of the display such information as the number of scans after which the technical acknowledgement and the WILCO is received and the number of scans after which the displays are terminated. Also, the controllers and the test observers at the AID's will be requested to fill out observer logs (shown in tables 4 and 10). In addition, both the surveillance and communication data will be collected on the Mode S and SAR data extraction tapes. The radio communication between the controllers and the pilots will be recorded on voice tapes, and films of AID's and controller displays will be taken. After the tests are completed, special debriefing questionnaires will be used to obtain the subjective opinions of the controllers and the AID observers pertaining to the operational acceptability of the AACC data link application function.

4. Data Analysis: Only a subjective evaluation of the AACC tests will be made on the basis of the visual observations of the controller displays and the AID's. No quantitative data analysis will be conducted. The data collected on the Mode S and SAR data extraction will be available for post-test investigation of any problems encountered during the tests.

A review of the films, voice tapes, observer logs, notes from the verbal debriefing, and the debriefing questionnaires will be conducted to formulate conclusions pertaining to the operational acceptability of the AACC function. The results of the tests will be compiled into a final report.

6. SPECIAL INSTRUMENTATION.

Special instrumentation requirements for characterization of the test bed, verification tests, and ATC tests are described in this section. The essential test equipment for these tests are the components of the data link test bed itself. In addition, some special purpose devices will be fabricated.

A test signal generator will be constructed to supply known, repeatable instrumentation signals to the IMP in lieu of the real-time signals of the runway instrumentation. These signals will be selectable as data sets to be generated to the IMP. This selection will be available manually by means of front-panel switches or remotely from data line buffer-interfaces.

A microprocessor test controller will also be configured as shown in figure 11. The unit will include two asyncronous, serial communications interfaces, a parallel interface to drive a 9-track magnetic tape data recorder, another parallel interface to drive the data select lines of the test signal generator described above, a 60-cycle time base input, an operator controlled event mark push-button, 1 kilobyte of static random-access memory, and space for 4 kilobytes of erasable, programable, read-only memory. The firmware for this microprocessor will vary with the applications to which the unit is used in the various test configurations.

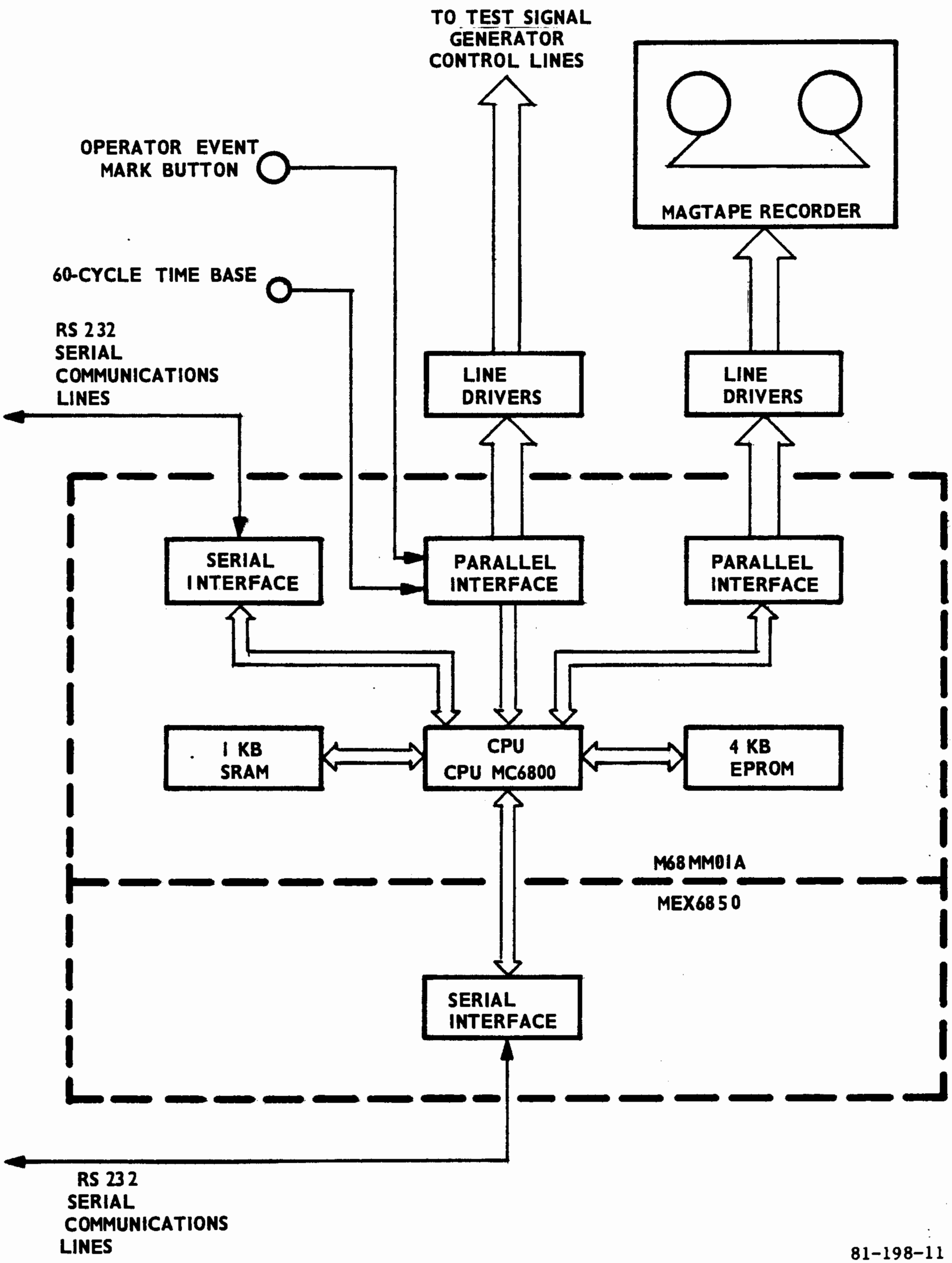

FIGURE 11. MICROPROCESSOR TEST CONTROLLER CONFIGURATION

For some tests, special software packages will be written for use in the data general S/250 computer in order to drive devices operationally interfaced to the AP. These software packages will operate under the AOS which will be used for the AP's operational software package. Modifications to the test bed software are required to conduct the operational testing of the MSAW and AACC data link functions. An ARIES/ATCSF interface needs to be developed for simulating the traffic environment. With this interface, the ATCSF will provide the aircraft positional data to ARIES and will update this information every scan. In addition, the simulator pilots will be able to maneuver the aircraft dynamically.

For the ETIS communications tests described in section 5.1.3, the ARIES interface will be driven by an external hardware module emulating the ATCSF signals for two targets. Only two targets will be used to reduce requirements for the ARIES/ATCSF interface emulator. Also, the limited capability of the emulator is sufficient to verify operation of the ETIS function. The emulator will generate control messages for two targets under three conditions: neither of the targets placed within the approach zone, one of the targets inside the zone, and both within the zone. The selection of the scenario will be generated under manual control of the test operator. The information is communicated to the ARIES unit through 12 serial 16-bit words for each target.

Modifications to the ATCSF software will also be required for simulating downlink messages requesting ETIS and WX information. These messages will be generated in response to the scenario inputs and will be transmitted to the ARIES. As a result, the ARIES will receive both the positional updates of the aircraft and the downlink requests for ETIS and WX information.

An ARIES/AID interface will be required for simulating the cockpit display receiving ATC messages. The ARIES will be modified to provide acknowledgement (or WILCO) to the ATC of the receipt of the MSAW or AACC messages at the AID. This capability will allow simulation of the complete cycle an ATC data link message goes through before its termination.

In addition to the software modifications, an arrangement to setup AID and controller displays side by side will be required. This will facilitate instantaneous comparison of the displayed information. The photographic equipment to record AID and controller displays and the controller/pilot voice tapes recording equipment will also be required during the tests for data collection purposes.

7. COORDINATION AND AREAS OF RESPONSIBILITY.

The various areas of responsibility and coordination requirements are distributed as follows:

System Research and Development Service.

ARD-100: Overall plans relative to operational ATC testing are coordinated with this organization. ARD-100 will provide all software modifications to incorporate the data link ATC functions.

ARD-220: Overall management of the data link development program including test planning, scheduling, contract dollars, and special support requirements.

ARD-400: Participate in the planning and implementation of the weather products into the data link utilization program. Provide inputs to the conceptual design of the ETIS link. Coordinate weather sensor design and acquisition.

AAT: Provide inputs to the conceptual design of the ETIS and data link operational procedures. Coordinate initial operational procedure concepts for ATC functions.

Massachusetts Institute of Technology Lincoln Laboratory: Responsible for hardware and software development of the interfaces between the AP, the Mode S sensor, and the MITRE computer. Responsible for the definition of message formats for all functions. Coordination of AP related work performed by TSC and the Technical Center.

TSC: Responsible for software development within the application processor and the establishment of the weather data base interface with the Technical Center test bed, the development of the overall ETIS concept, the initial concepts for the ETIS subsystem of the Technical Center test bed, and the AP software for the ETIS function.

FAA Technical Center.

ACT-100A: Overall responsibility for the test and evaluation effort including establishment of the test bed, construction of special hardware for data collection, the design of data reduction and analysis software, test conduction and final report preparation. Implementation of the interface between the ETIS sensors and the AP, including the construction and development of interface equipments which perform data reformatting. Coordination of the aircraft avionics installations and the instrumentation requirements for the aircraft installations. Scheduling of facilities for testing and arranging for simulator pilots and air traffic controllers during the testing of ATC functions.

ACT-200: This organization will provide the simulation facilities, personnel to support facility operation, and both simulation pilots and controllers during the ATC function tests.

ACT-410: Acquisition, installation, and maintenance of the ETIS sensors and providing the sensor outputs at a single common point for interfacing with the data collection equipment.

ACT-600: All requirements for test aircraft, aircraft modification, special installations, and pilots.

ACT-700: This organization will provide programming support, computer facilities for data collection/analysis, and assist in maintaining and testing the data link software.

MITRE: Will provide systems engineering support throughout the test effort on the ATC data link functions. Such support will include development of the test procedures, development of scenarios, scripts and observer logs, participating in the test activities, analyzing the data collected, and preparing parts of the final report pertaining to the ATC functions (see section 5.2).

8. SCHEDULE.

The data link test program for the initial group of services to be evaluated is scheduled to run for 18 consecutive months (as shown in figure 12). The start of the test program is contingent upon the completion of the test bed. Time allotted to subtasks delineated in the plan are indicated as months of elapsed time from the starting date. The smallest quantum of elapsed time in the schedule is one-quarter of a month. The program will start with the design and construction of special test equipment, software, and interfaces necessary to perform the task.

Design and testing efforts are staggered and arranged in chronological sequence corresponding to the outline of the test plan. The test plan was organized in a logical sequence where the results of previously performed tests are prerequisites for subsequent tests. For example: the ETIS data requisition tests (section 5.1.4) have to be proceeded by the operational verification of the individual subsystems which comprise the ETIS function. Since ETIS messages are used during ATC function tests, the ETIS tests have to be performed prior to verification of the ATC functions.

Completion of the test bed is a prerequisite for starting the test program. This requirement implies that the ATC software modules have been installed in TATF, SSF, and ATCSF facilities. Also, all operational hardware and software modules for the test bed must have been completed and have undergone limited testing to demonstrate system operation.

The last 2 months of the test program are devoted to final report preparation which will start when all data has been collected and analyzed. ACT-100 will have overall responsibility for final report preparation. MITRE will author those portions of the report which pertain to the ATC data link function evaluation.

9. MANPOWER AND FACILITY REQUIREMENTS.

The data link group will consist of two engineers, a programmer, and a technician. This group shall design and fabricate all special hardware and software modules necessary to achieve the objectives of the test program described in this plan. The same group of individuals will be responsible for performing the tests, data reduction, and data analysis. Additional ACT-100A personnel are required to assist in the operation of the Mode S sensor and ARIES.

MITRE support during scenario generation, questionaire and test script design, performance of tests, data analysis, and report preparation is estimated to total 24-man months. An estimated 5-man months of ACT-410 support is required prior to and during the test runs to insure operation of all terminal sensors and instrument interfaces. The manpower requirements and system utilization estimates are summarized in table 11.

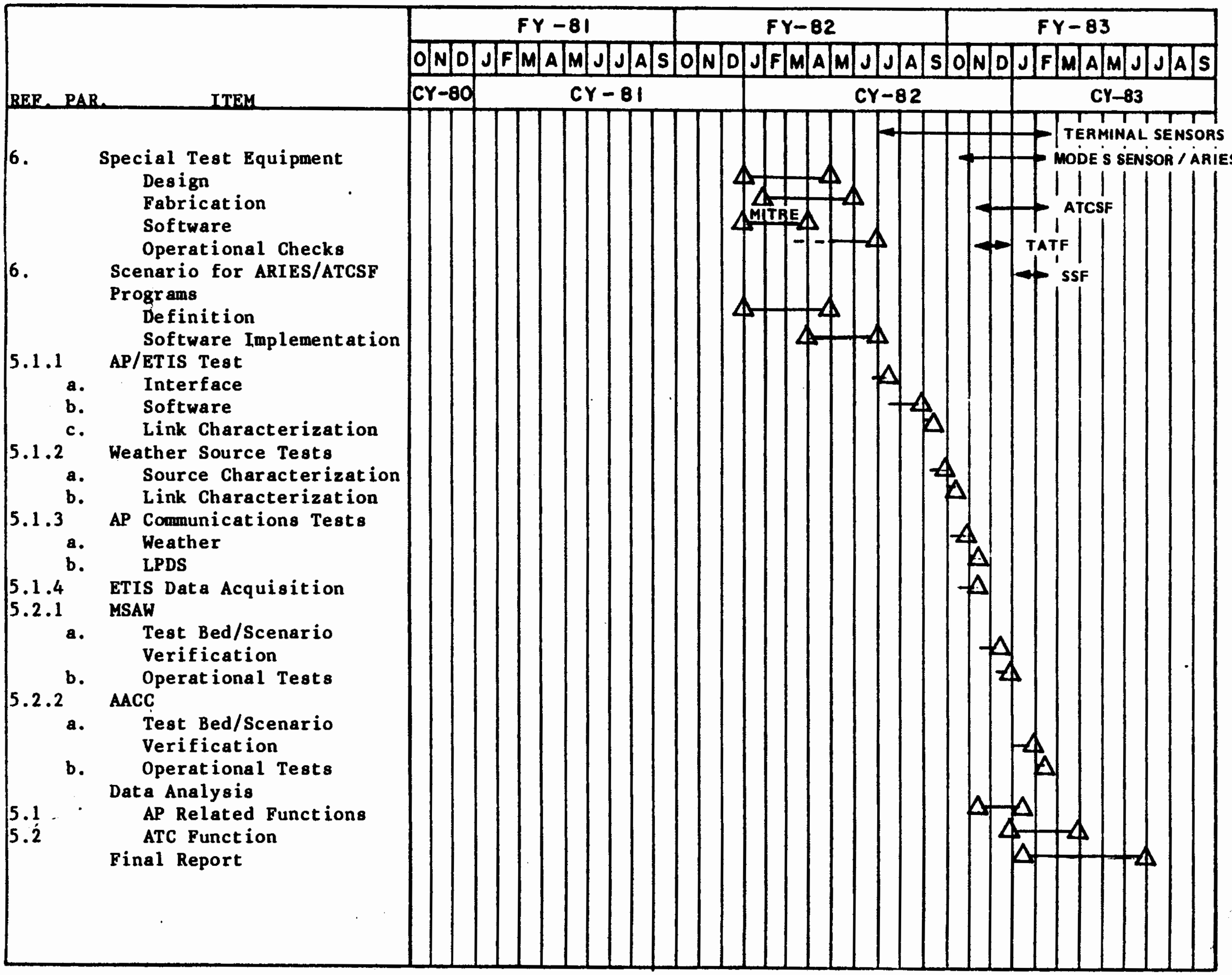

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FIGURE 12. SCHEDULE

TABLE 11. MANPOWER AND FACILITY REQUIREMENTS

Activity	Manpower In Man Months					
	Field Controller	Tech. Center Controller	Engineer	Programmer	Technicians	Simulator Pilots
ACT-100 Data Link Group			36	18	18	
ACT-100 Facility Operators			4	4	12	
ACT-400 Terminal Sensor Maint.			2		3	
ACT-200 Simulation Facility (ATCSF)						18
ACT-200 TATF		3				
ACT-200 SSF		3				
ACT-100 Responsibility	3					

Facility	Use In Month	Estimated Utility In %
Mode S Sensor Tech. Center	4	25
Terminal Sensors Tech. Center	7.5	50
ATCSF	3	25
TATF	1.5	25
SSF	1.5	25
AP, LPDS, and Weather Data Source	7.5	80