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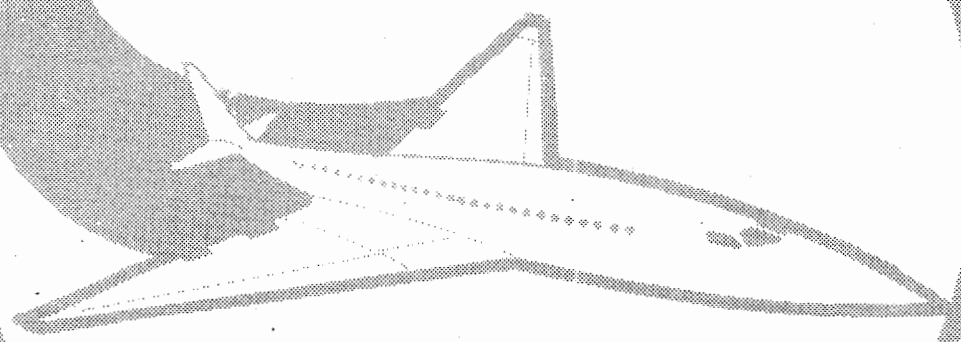
Domestic Applications to Satellite Communications, Phase I Test Plan

William C. Wanner



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16. Abstract

The Federal Aviation Administration (FAA) will be conducting a series of tests on the domestic applications of satellites in helicopters as a new initiative. These tests will use prototype equipment provided by the American Mobile Satellite Corporation (AMSC). This equipment will conform to Aeronautical Mobile Satellite Services Standards (AMSS) when AMSC launches their own dedicated L-band satellites (a total of three) in 1994. These tests to be conducted by the FAA will be separated into three phases. This plan describes the first phase of the project, which will only be concerned with data transmission. Additional test plans for Phases II and III of the project will be written as the additional tests become defined.

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EXECUTIVE SUMMARY

The Federal Aviation Administration (FAA) will be conducting a series of tests on the domestic applications of satellites in helicopters as a new initiative. These tests will use prototype equipment provided by the American Mobile Satellite Corporation (AMSC). This equipment will conform to Aeronautical Mobile Satellite Services Standards (AMSS) when AMSC launches their own dedicated L-band satellites (a total of three) in 1994.

The tests, to be conducted by the FAA, will be separated into three phases. The first two phases will use the International Maritime Satellite (INMARSAT) Marisat F1 satellite. The third phase of the project will use the aformentioned AMSC satellites. The first phase of the project will only be concerned with data transmission. Phase II will still test data transmission, but voice capabilities, using a store and forward technique, will also be examined. The fully operational system will be tested in Phase III of the project.

This test plan contains detailed test descriptions for Phase I of the project. Additional test plans for Phases II and III of the project will be written as the additional tests become defined.

1. INTRODUCTION.

1.1 OBJECTIVE.

The objective of this project plan is to evaluate the potential of the Aeronautical Mobile Satellite Service (AMSS) to provide communication, navigation, and surveillance (CNS) where these services are marginal or non-existent. These tests will be performed in cooperation with the American Mobile Satellite Corporation (AMSC).

1.2 BACKGROUND.

Low altitude helicopter missions, where communications, navigation, and surveillance services can be disrupted, are common in today's helicopter operating environment. Applications of these missions include power/pipeline control, forestry management, emergency medical services (EMS), offshore transport to oil rigs, and air taxi. These missions could derive safety and operational benefit from the AMSS's ability to provide communication, navigation, and surveillance services.

EMS missions, according to a report by Systems Control Technology Inc. (see section 1.3, item 1), are expected to expand (in terms of the number of missions flown) in the future. Therefore, these missions are of particular interest to the helicopter industry. Under the current system, voice and data communications between the helicopter pilot and an accident site or hospital are non-existent or unreliable. The link provided by satellite communication (SATCOM) would give pilots information to conduct EMS missions more safely and efficiently.

Though AMSC presently has a prototype unit, other companies currently provide mobile satellite services. Railstar Inc., through their Scantrak system, provide data services for trucking and helicopter applications. The OmniTRACS system from Qualcomm also provides data services, primarily to the trucking industry.

1.3 RELATED DOCUMENTATION.

Peison, Deborah, Rotorcraft Low Altitude CNS Benefit/Cost Analysis, Draft, System Control Technology, Inc., November 1988.

2. EQUIPMENT.

2.1 AMSC PROTOTYPE UNIT.

The AMSC avionics used for these tests were developed for Land Mobile Satellite Service (LMSS). The avionics consist of a keyboard with display, RS-232 interface, and an internal LORAN-C board. The transmitting frequency range is 1626.5 to 1660.5 megahertz (MHz). The receiving frequency range is 1530 to 1559 MHz. The unit is powered by a 12 volt, 10-20 amp dc power supply; the transmitted power required is currently 40 watts. In 1994, when AMSC will have launched satellites, the transmitted power will decrease significantly since spot beam technology will be used to transmit and receive messages at the satellite. At that time the AMSC system will be compatible with the AMSS architecture specified in International Civil Aviation

Organization (ICAO) Standards and Recommended Practices (SARPS) and Radio Technical Commission for Aeronautics (RTCA)-SC165.

2.2 ANTENNA.

The AMSC outdoor unit (ODU) will be used for the flight tests. The ODU is an integrated assembly that includes both the antenna and the RF receive/transmit electronics.

2.3 NETWORK OPERATIONS CENTER.

Located at AMSC offices in Washington, D.C., the network operations center is the interface between the ground earth station in Southbury, CT, and the system subscribers. The subscribers access the network operations center through a telephone line.

2.4 SATELLITE.

The International Maritime Satellite (INMARSAT) Marisat F1 satellite, located 106 degrees west longitude, will be used for the first two phases of the project, i.e., until 1994. After 1994, AMSC will launch three dedicated L-band satellites. These satellites will be located at 101, 139, and 62 degrees west longitude. Once these satellites are launched, high speed data and voice can be realized.

2.5 DATA COLLECTION.

Two systems will be used to collect data. The first data collection system records aircraft data, such as altitude, heading, airspeed, etc. The second system will record SATCOM data such as bit error rate, signal-to-noise-ratio, etc.

The data collection system used to collect aircraft data is based on the Motorola 6809 microprocessor package. The package is a combination of an off the shelf data package and FAA designed and built interface boards. The information collected will be stored using a Kennedy magnetic tape recorder.

The second data collection system is for SATCOM data. Bit error rate (BER) and signal strength are the main parameters collected. This data will also be recorded on a Kennedy magnetic tape recorder.

A block diagram of the system is shown in appendix A. Using a Compaq 286 laptop computer, messages will be sent over a phone line to AMSC in Washington D.C. From AMSC, the messages are transmitted via a phone line to the Ground Earth Station (GES) in Southbury, CT. From there the message is transmitted to the INMARSAT Marisat F1 satellite, and finally to the Aircraft Earth Station (AES), i.e., the test aircraft. GPS time will be used to synchronize the data from the two data collection systems.

2.6 HELICOPTER.

The Bell UH-1H helicopter will be used for Phase I of the project. Since the UH-1H is an experimental aircraft, the ODU, which is not flight certified, can be mounted on top of the aircraft.

2.7 TRACKER.

The Department of Defense NAVSTAR Global Positioning System (GPS) will be used to determine aircraft position during the tests.

3. DATA COLLECTION PARAMETERS.

Time (Time code generator and GPS time)
Indicated airspeed
Vertical velocity
Magnetic heading
Barometric altitude
Radar altitude
GPS position
    a. Latitude
    b. Longitude
    c. Altitude
Navigation flags
Vertical gyro
    a. Pitch
    b. Roll
Collective
Cyclic
Bit error rate
Signal strength
LORAN-C position
    a. Latitude
    b. Longitude

4. DATA REDUCTION.

Data reduction is specific for each ground and flight test.

5. DETAILED TEST DESCRIPTIONS.

5.1 LAB TEST.

a. Objective: This test will familiarize project personnel with the AMSC system before it is installed in the test aircraft. The test will also allow project personnel to make all necessary adjustments to system software so the system properly interfaces with the data collection system.

b. Location: The Federal Aviation Administration (FAA) Technical Center, Atlantic City International Airport, New Jersey.

c. Description: Turn on AMSC equipment to test interfaces with data collection system. Any software changes or development needed to make the system compatible with the data collection system will be done during the lab tests. Once the system performs satisfactorily, messages will be sent over the AMSC system.

d. Data Analysis and Reduction: Collect BER and signal-to-noise ratio (SNR) for later comparisons. Plot each of these parameters against time.

5.2 GROUND TEST I.

a. Objective: Determine the performance of the AMSC hardware without interference from rotor blade motion.

b. Location: The Federal Aviation Administration (FAA) Technical Center, Atlantic City International Airport, New Jersey.

c. Helicopter: Bell UH-1H.

d. Description: With the helicopter sitting on the ramp, turn on the AMSC equipment to transmit and receive fixed messages. These messages will include previously determined messages and position reports via LORAN-C. The helicopter's rotors will not rotate during this test. The ODU will not yet be mounted to the aircraft.

e. Data Analysis and Reduction: Collect BER and SNR for later comparisons. Plot each of these parameters against time.

5.3 GROUND TEST II.

a. Objective: To determine the operating characteristics of the AMSC equipment with the rotor blades moving. This test will determine the effect of moving rotor blades on the radio frequency (RF) signal.

b. Location: The Federal Aviation Administration (FAA) Technical Center, Atlantic City International Airport, New Jersey.

c. Helicopter: Bell UH-1H.

d. Description: The helicopter will be sitting on the ramp with the rotor blades moving. The same messages as Ground Test I will be transmitted and received while the blades are rotating. Once again, the ODU will not be permanently mounted to the aircraft. The ODU may need to be moved to different locations on the fuselage until an acceptable (in terms of the number of errors in the messages transmitted and received) RF signal is transmitted and received. Once an acceptable location on the aircraft for the ODU has been found, it will be mounted to the aircraft in that location.

e. Data Analysis and Reduction: Plot BER and SNR versus time. Compare the BER/SNR plots versus time with the plots from the first test to determine the effect, if any, of rotor blade motion on these parameters.

5.4 FLIGHT TEST I.

a. Objective: Determine the operating characteristics of the AMSC hardware at different headings to test the Doppler compensation of the system. The flightpath chosen will have the helicopter flying toward the satellite, parallel to the satellite, and away from the satellite. This test will also be used to familiarize the pilot, crew, and ground operators, specifically those operating the Compaq 286 laptop computer used to enter messages, with the AMSC system.

b. Location: The Federal Aviation Administration (FAA) Technical Center, Atlantic City International Airport, New Jersey, and surrounding area.

c. Helicopter: Bell UH-1H.

d. Description: Fly the following scenario. This test will will show both the operating characteristics of the AMSC hardware for different headings and the effect of Doppler compensation in the system as well as familiarize project personnel with the AMSC equipment.

Event	Checkpoint	DME	Heading
Start of flight	East pad on FAA ramp Technical Center	----	----
Event 1	Route 30 and Absecon Creek	4.0 nmi	312
Event 2	Absecon Wildlife Management	7.9 nmi	291
Event 3	Abandoned Fish Factory	11.8 nmi	262
Event 4	Parkway Bridge and Mullica River	8.1 nmi	231
Event 5	Wading River and Route 542	9.7 nmi	220
Event 6	Bog next to Absegami Lake	12.0 nmi	223
Event 7	Landing Strip	16.8 nmi	221
Event 8	Oswego Lake	17.0 nmi	203
Event 9	Hog Island	7.8 nmi	208
Event 10	Lennox China Factory	2.2 nmi	162
Event 11	VTOL	----	----
End of flight	East Pad on FAA ramp Technical Center	----	----

Flight time is 53 minutes.

Altitude flown to be determined.

e. Data Analysis and Reduction: Plot BER and SNR versus time, heading, and speed. The BER vs time and the SNR vs time plots can be compared to the ground tests to see how well the system performs during flight. The BER vs heading and SNR vs heading plots will give an indication of how well the system performs with respect to the aircraft's position with the satellite. The pilot will also be asked to give his appraisal of the system in terms of ease of use for the pilot.

5.5 FLIGHT TEST II.

a. Objective: This test will determine to what extent Data Link can augment the existing VHF voice system.

b. Location: The Federal Aviation Administration (FAA) Technical Center, Atlantic City International Airport, New Jersey, and surrounding area.

c. Helicopter: Bell UH-1H.

d. Description: To be determined. It will be a scenario between an air traffic controller or an operations office and a helicopter pilot flying in an area where very high frequency (VHF) coverage is poor or nonexistent. Messages will be transmitted using both VHF voice and the satellite Data Link.

e. Data Analysis and Reduction: To be determined. The analysis will include an appraisal by the pilot on how well the SATCOM system augments the existing VHF system.

6. AREAS OF RESPONSIBILITY.

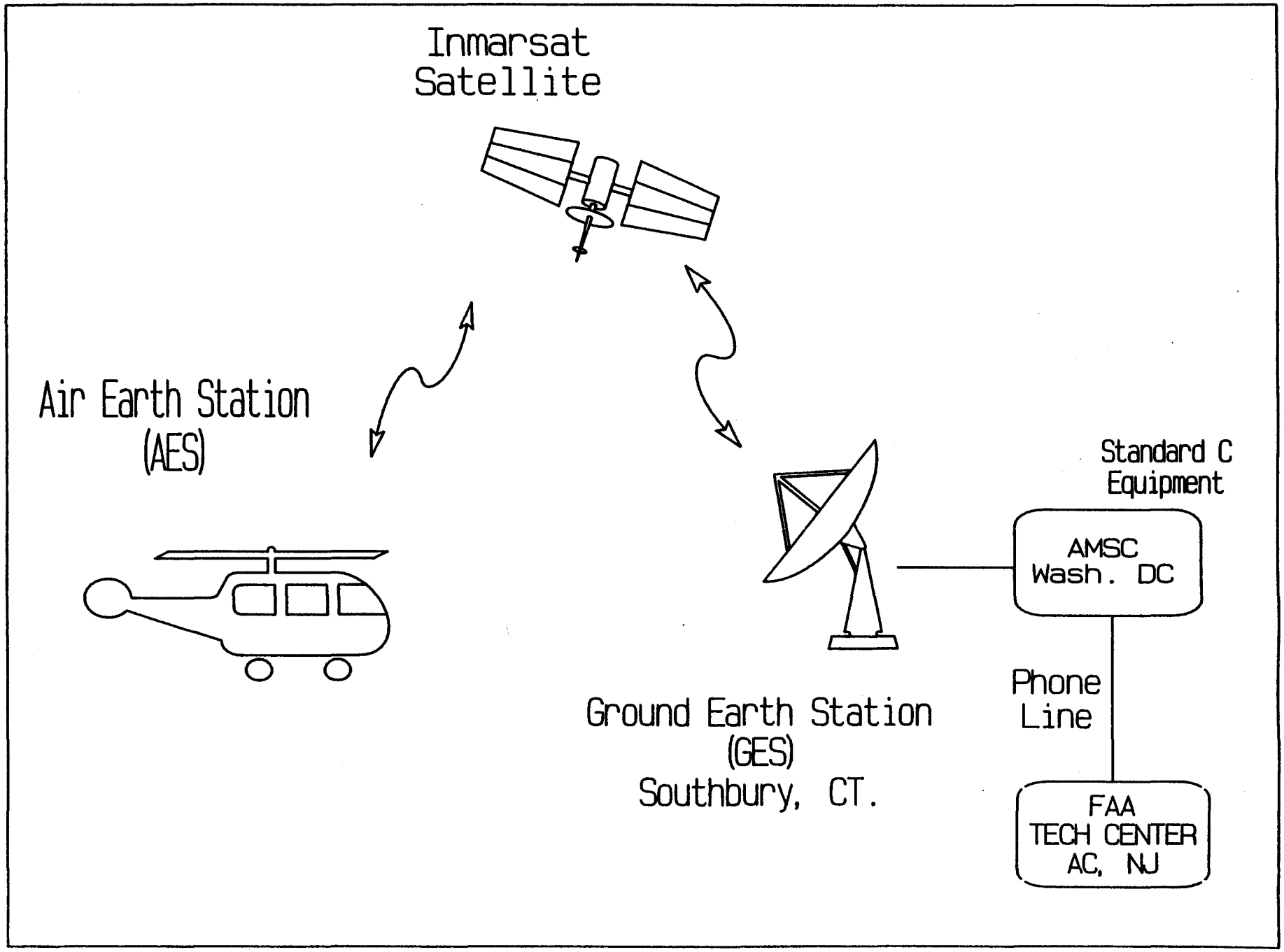
ACN-370: Install ODU on UH-1H helicopter.

ACD-330: Write test plan and perform ground and flight tests.

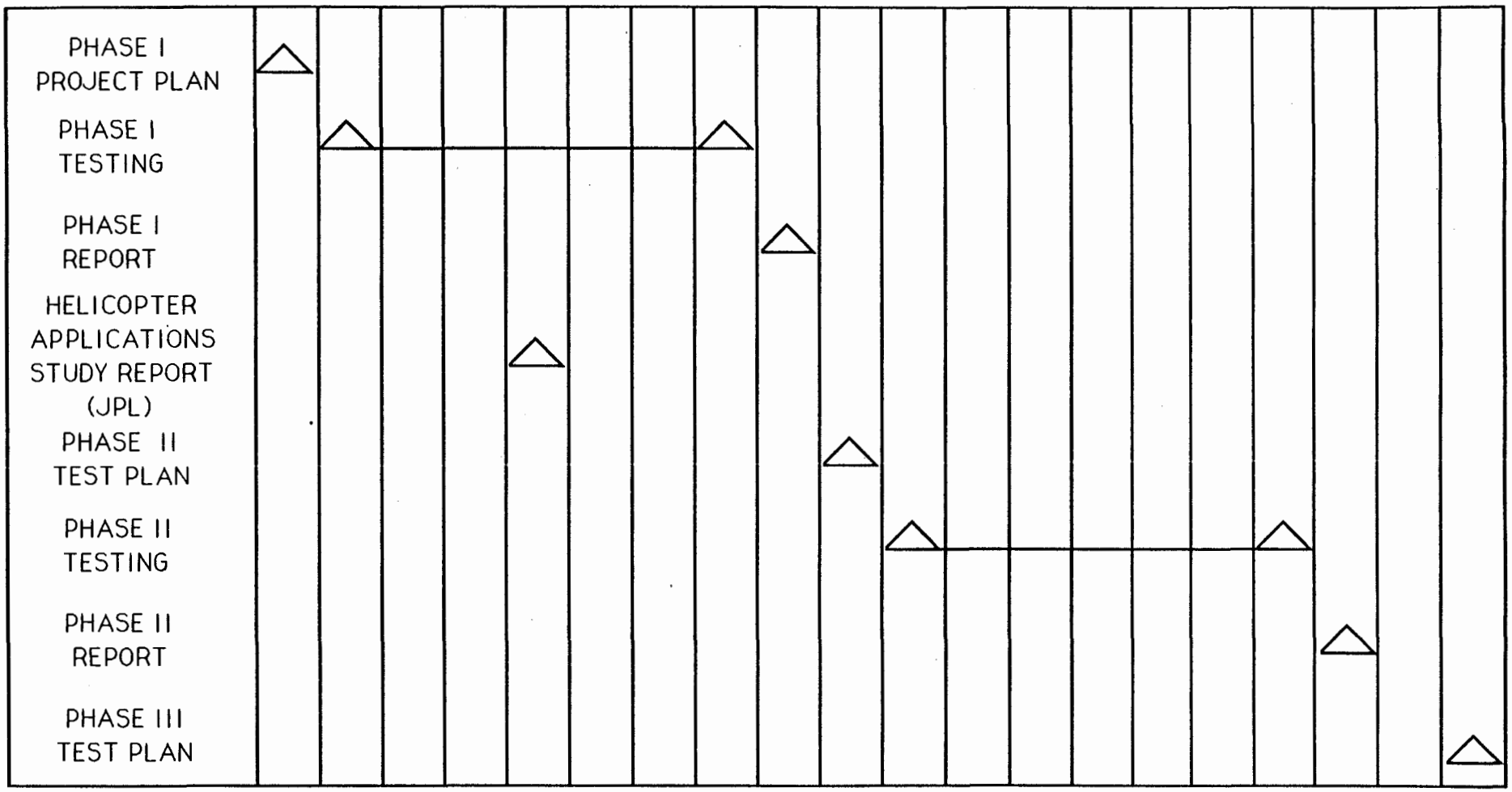
AMSC: Provide Standard-C equipment and coordinate with COMSAT for use of INMARSAT satellites.

APPENDIX A

SYSTEM BLOCK DIAGRAM


Inmarsat
Satellite
Air Earth Station
(AES)
Standard C
Equipment
AMSC
Wash. DC
Phone
Line
Ground Earth Station
(GES)
Southbury, CT.
FAA
TECH CENTER
AC, NJ

APPENDIX B

SCHEDULE

DOMESTIC APPLICATIONS OF SATCOM SCHEDULE