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**TEST PLAN FOR DALMO VICTOR  
ACTIVE BEACON COLLISION AVOIDANCE SYSTEM  
(ABCAS)**

**E. Glowacki  
E. Quish  
J. Kenton  
J. Warren  
C. Jezierski  
J. Thomas  
H. Banilower**

FEDERAL AVIATION ADMINISTRATION

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**TEST PLAN**

**JULY 1981**

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Prepared for

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## 1. OBJECTIVE.

The purpose of this project is to evaluate the performance of a prototype Active Beacon Collision Avoidance System (ABCAS) manufactured by the Dalmo Victor Corporation. Tests will be conducted to satisfy the following objectives.

a. Verify system compliance with the engineering requirements of contract DTFA01-80-C-10026.

b. Document the performance of the system with respect to the U.S. Aviation Standard for the Active Beacon Collision Avoidance System, October 20, 1980.

c. Document the performance of the system with respect to data collected on the BCAS Experimental Unit.

d. Evaluate the use of proximity warning bearing information derived from directional antennas.

## 2. BACKGROUND.

The FAA has sponsored the development and testing of two active BCAS engineering equipment designs. The first was designed by MITRE and built by the FAA. Two models were built and successfully used to demonstrate active BCAS surveillance. The equipment performance was promising when tested in areas of low-to-medium aircraft densities (up to 6 Mode C Transponder equipped aircraft within a 10-mile radius). Serious deterioration in performance was recorded in the high density area of the Los Angeles Basin.

In particular the FAA built equipment generated "phantom" tracks due to fruit and garble. These "phantom" tracks resulted in false alarms that were displayed as avoidance advisories when none were required.

Lincoln Laboratory was then commissioned to design and build a complete Active BCAS Engineering Unit (BEU) also based on the MITRE design but expanded to include collision avoidance logic. The occurrence of "phantom" tracks is almost nonexistent in the Lincoln Laboratory BEU, and in over 250 hours of test flights the BEU has never displayed a false alarm. The BEU has been tested in 18 metropolitan areas and at over 28 major airports.

Dalmo Victor is currently under a cost-share contract with the FAA to build three prototype ABCAS units that are functionally equivalent to the BEU design, but are packaged for installation in commercial aircraft. The Dalmo Victor units also incorporate aircraft and ground coordination functions that are necessary for BCAS implementation. Directional antennas are included for evaluation purposes only in that they are not presently required by the engineering requirements or the National Standard.

### 3. RELATED DOCUMENTATION/PROJECTS.

#### 3.1 FAA DOCUMENTS.

- a. FAA Contract DTFA01-80-C-10026 and all appendices.
- b. FAA-ER-250-2.
- c. U. S. National Aviation Standard for the Active Beacon Collision Avoidance System, dated October 20, 1980.
- d. Preliminary Evaluation of the Basic Experimental Beacon Collision Avoidance System, FAA-CT-81-25.

#### 3.2 DALMO VICTOR DOCUMENTS.

- a. Initial Design Report ABCAS, R-3711-9618, June 1980.
- b. Initial Design Report (Revision), R-3711-9618A, October 1980.
- c. Acceptance Test Plan ABCAS, Rev. AR-3711-9666A, February 1981.

#### 3.3 RELATED PROJECTS - FULL BCAS, ATARS.

### 4. SYSTEM DESCRIPTION.

#### 4.1 GENERAL.

Two prototype Dalmo Victor ABCAS will be delivered to the FAA Technical Center for flight testing. System 1 will be installed on a Boeing 727 (N78) and will have two direction finding antennas. System 2 will be installed on a Convair 580 (N49) and will use two standard blade omni antennas. Figures 1 and 2 show the locations of the equipment and antennas in N78 and N49, respectively.

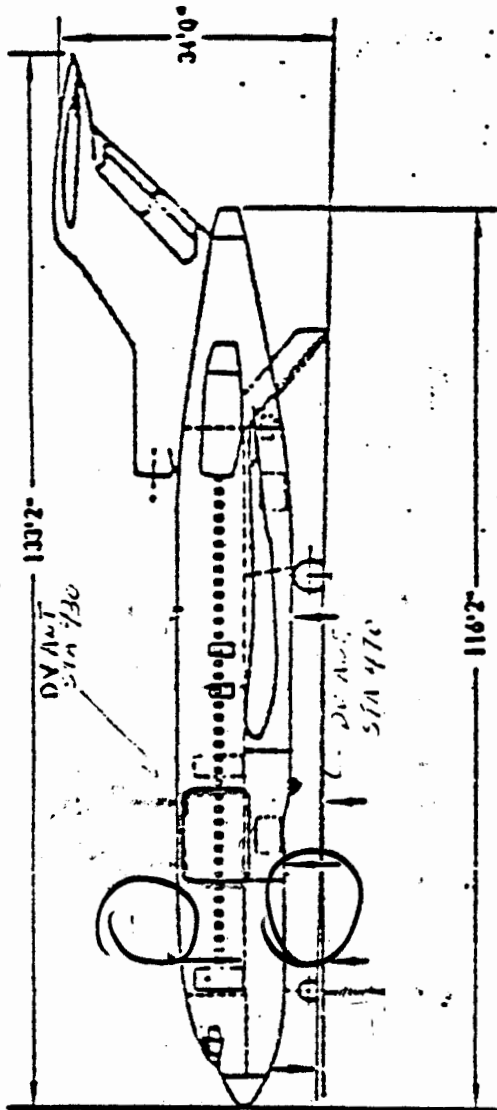
The Dalmo Victor ABCAS System consists of the following hardware units:

- a. Top and bottom antennas.
- b. RF/Processor unit.
- c. A CRT display unit (Dalmo Victor supplied) and an Instantaneous Vertical Speed Indicator Display, IVSI (GFE).
- d. A DABS Transponder (GFE).

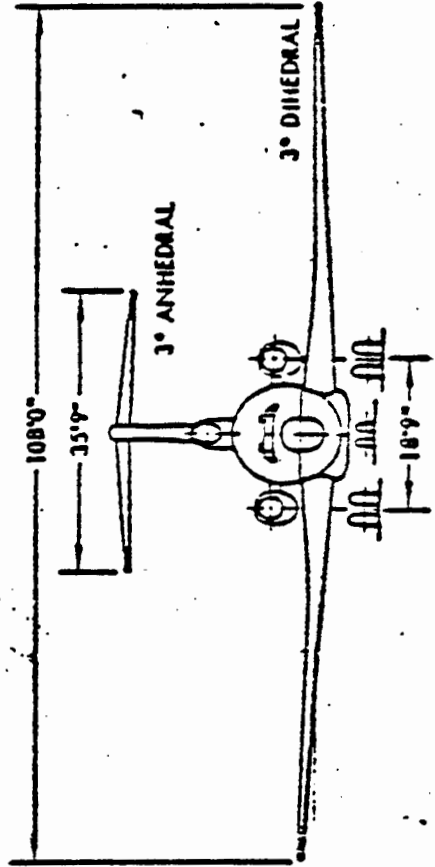
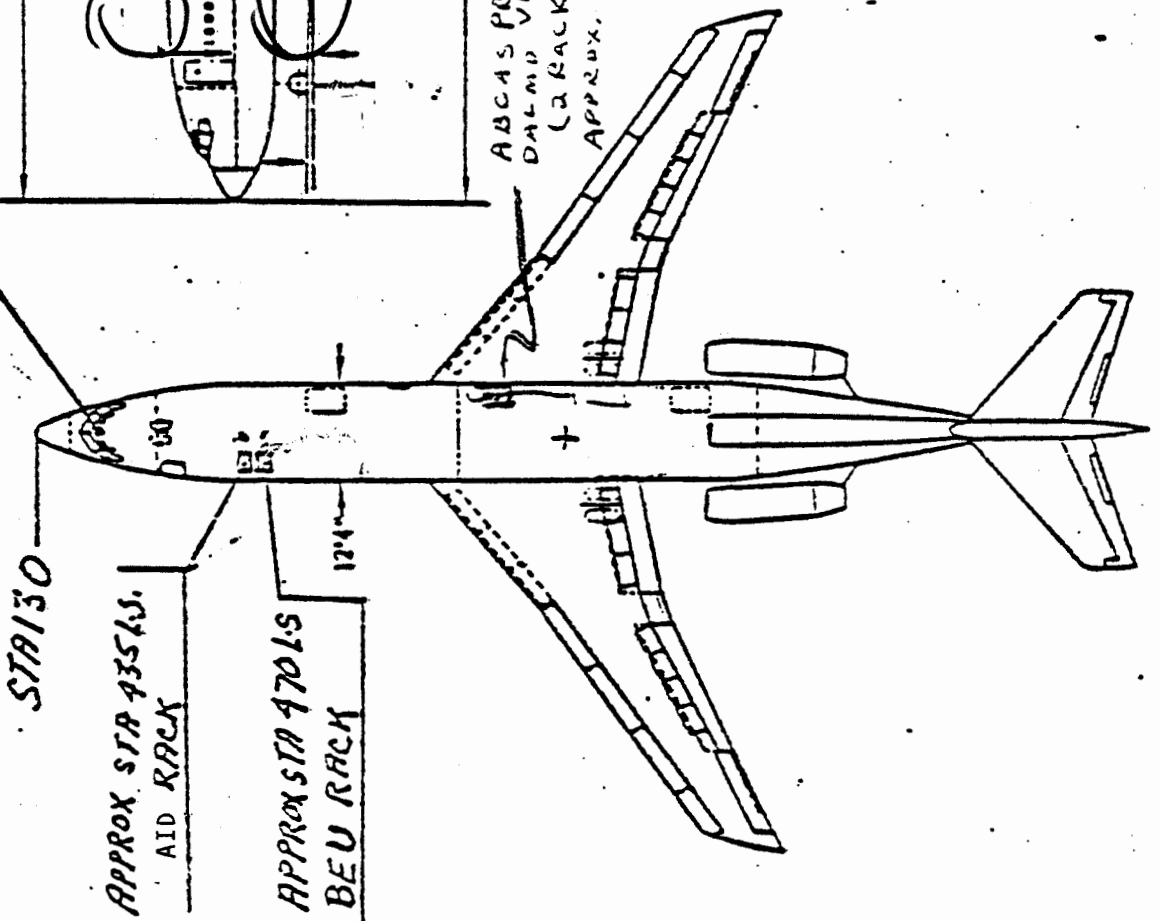
The total flight test system consists of the above units and ancillary equipments required for test and evaluation of the system. The additional equipments are as follows:

AIRBORNE INTELLIGENT DISPLAY INSTL.  
 AIRBORNE SEPARATION ASSURANCE  
 REF 485-1147 (CENTER CONSOLE AREA)

25 1/2



ABCAS PROTOTYPE  
 DAIMIO VICTOR  
 (2 RACKS)  
 APPROX. STA 720-





a. Magnetic tape recorders (9-track).

*Does not detect ECF*

b. Time-of-day clock.

c. Performance monitor.

d. IVSI driver unit.

e. Airborne Intelligent Display (AID).

#### 4.2 HARDWARE SYSTEM DESCRIPTION.

The prototype Dalmo Victor ABCAS consists of four basic units (Antennas, RF/Processor, DABS Transponder, Control/Display) and other supporting equipment for test and evaluation. A block diagram of the system is shown in figure 3.

##### 4.2.1 Basic System.

a. Antennas

1. Directional Antennas. Two amplitude comparing monopulse antenna units are mounted on N78; A top antenna at station location 430 and a bottom antenna at station location 470. Each antenna can provide either an omnidirectional mode or four directional beams. The four directional beams are oriented at 45°, 135°, 225°, and 315° azimuth with respect to the aircraft heading.

2. Omnidirectional Antennas. Two standard ATRBS monopole antennas are mounted on N49. These will be the same antennas that were utilized for the BEU tests. The location of these antennas are shown on figure 2.

b. RF/ Processor Unit. The RF or transceiver section contains a 1030 MHz interrogator, an antenna switching unit, and four 1090 MHz log receivers. The processor section is controlled by a DSA-29B central processing unit with Programmable Read Only Memory (PROM) and Random Access Memory (RAM). Communication with external and internal devices is by Directory Memory Access (DMA) or programmed Input/Output (I/O). The internal devices contained in the RF/Processor unit are the video processor, DABS decoder, ATRBS decoder, Resolution Advisory Register (RAR), transmitter control, aircraft interface, and I/O and mode interface.

c. Display Unit. The display unit consists of a 3-inch CRT driven by a microprocessor and is installed on the equipment rack. The display is capable of showing commands and proximity warning information (PWI) graphics or only PWI graphics. The display unit also contains ATRBS Mode A code selection switches, a self-test control, a sensitivity mode selector switch and it also generates an audio signal.

d. DABS Transponder (GFE). The DABS Transponder is a model TRU-2A. In addition to performing the normal DABS transponder functions, the transponder provides the data link between the ABCAS and the ground based Radar Beacon Transponder (RBX) as well as between ABCAS aircraft.

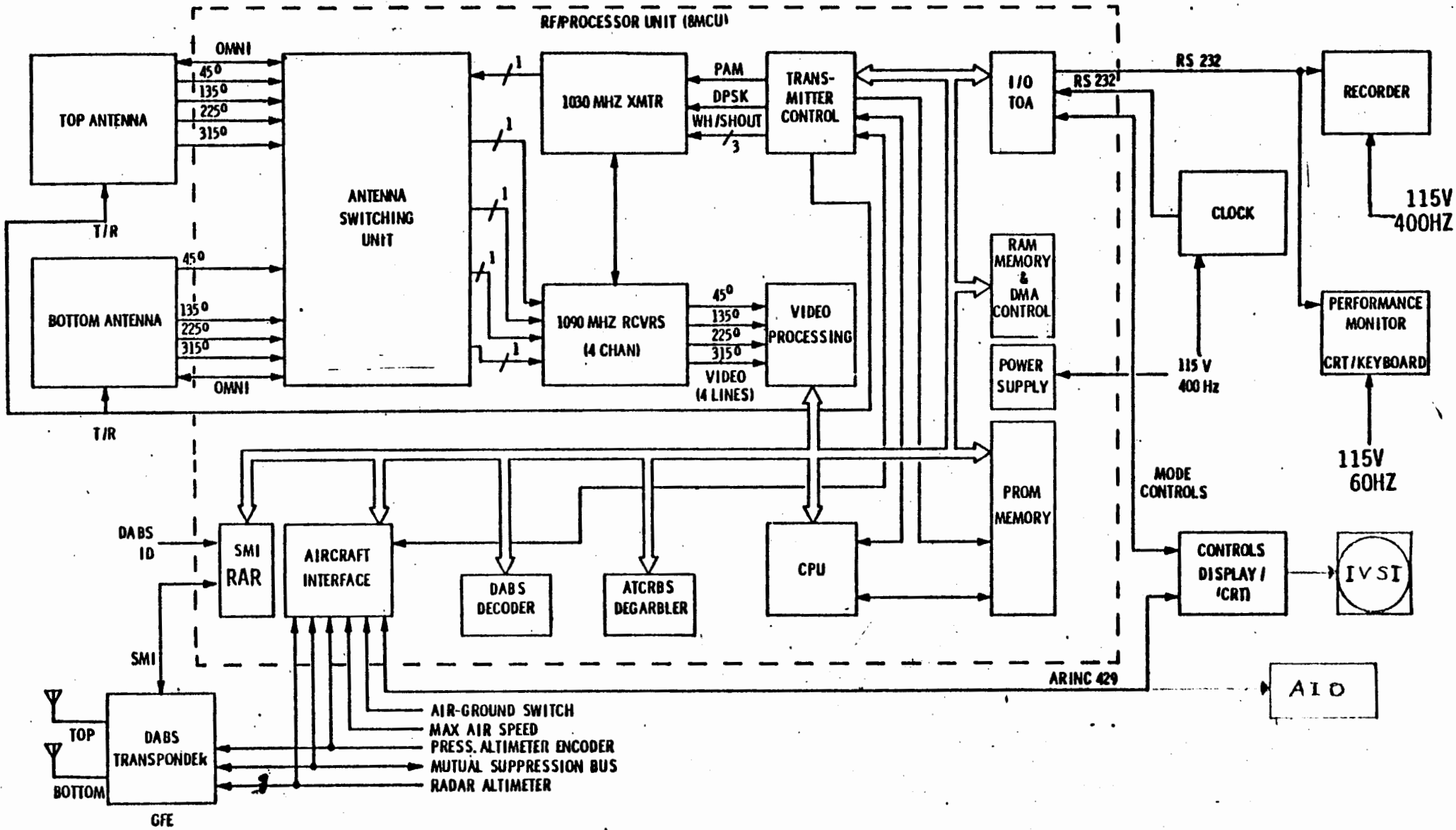


FIGURE 3. ACTIVE BCAS SYSTEM BLOCK DIAGRAM

#### 4.2.2 Support Equipment.

a. Tape Recorder. Pertinent internal ABCAS data is recorded on 9-track magnetic tape in physical blocks of 1024 bytes (512 words). Recording can be either in a continuous mode or in an event driven mode. In the continuous recording mode, all data blocks are continuously recorded provided the data rate is not exceeded. In the event driven mode, certain data blocks are not recorded until a command is initiated and continues for 30 seconds after the command is dropped.

b. Time-of-Day Clock. The time-of-day clock provides the time of day in hours, minutes, and seconds over an RS-232 interface once every second. The clock is used to provide time for data collection and is capable of operating from its battery for 24 hours.

c. Performance Monitor. This unit consists of a CRT display, keyboard and the required electronics to perform the following functions:

1. Real time display of all data being recorded on the 9-track tape recorder.

2. Generation of plots based on the data being recorded.

d. IVSI display. This display is used to present command and advisory information. One unit is installed in the cockpit and a second unit on the equipment track. An audio alarm generator is also installed in the cockpit and is activated when a command is initiated and extinguished after two seconds.

e. Airborne Intelligent Display (AID). This display is installed on N78 only, in the cockpit in the place normally occupied by the aircraft's weather radar display. The actual display is a Bendix weather radar color CRT display reprogrammed to provide information on ABCAS tracked targets. In text, it provides the following information on tracked targets: track number, range to target, range rate, bearing to intruder and altitude difference. This display will be utilized as an evaluation tool for the pilots.

#### 4.3 SOFTWARE DESCRIPTION.

##### 4.3.1 General.

The CPU (Dalmo Victor DSA 20B) controls the operation of the BCAS processor with a system program stored in PROM. The instruction set is similar to that of the ROLM 1650 computer used by Lincoln Laboratories in the BEU and, wherever possible, the software program developed for the BEU is used. Notable exceptions are the additions for processing Angle of Arrival (AOA) information, for providing data to the recorder and monitor, for the addition of the Resolution and Advisory Register (RAR) for BCAS-to-BCAS and ATARS-to-BCAS coordination, and extensive revisions in the Collision Avoidance System (CAS) algorithms.

Under the overall control of the executive module, which acts as a scheduler and interrupt handler, the system software performs four major tasks (see figure 4): ATCRBS and DABS Surveillance, Collision Avoidance, and Coordination. These tasks, and the principal data files which they access are described below.

#### 4.3.2 ATCRBS Surveillance.

A sequence of eight whisper/shout interrogations are scheduled in each one second cycle. Replies are processed and correlated using range, altitude, range rate and altitude rate to form tracks. The next expected range and altitude for each track is predicted. Multiple tracks are merged and false tracks are detected and eliminated. The final result of ATCRBS Surveillance processing is an updated ATCRBS Track File per cycle.

#### 4.3.3 DABS Surveillance.

The DABS Surveillance Task performs the tracking function for DABS targets; it is divided into two subtasks: (1) Squitter, and (2) DABS. The presence of DABS targets is detected by listening for DABS squitters (unsolicited transmissions). If the squitter target is within a relative altitude threshold, an entry in the DABS Track File is created and the target is tracked in altitude. If the target comes within a smaller relative altitude threshold, active interrogations are started to obtain a range track (acquisition phase). Depending on the predicted time to collision, the target is placed in dormancy or is promoted to roll call status. In the latter event, data is passed to the CAS logic for further processing.

#### 4.3.4 Collision Avoidance.

This task is composed of three subtasks: Threat tracking, detection, and conflict resolution.

ATCRBS and DABS track information is received by Collision Avoidance from the Intruder Surveillance Buffer. The threat tracking subtask uses the "raw" range and altitude reports to compute smooth range and altitude and their rates of change. The output of the tracking function is the CAS Track File.

The detection subtask provides a warning time for genuine threats and tries to minimize unnecessary alarms and operational disruptions. In case of a potential threat, the conflict resolution subtask is called to select the appropriate command sense (climb or descent) and type (positive, negative, or Vertical Speed Limit (VSL)).

#### 4.3.5 Coordination.

Interfacing with the resolution function of the ABCAS logic is the coordination function. It handles all messages going to or coming from the RAR to provide external communication and coordinated actions with other BCAS or ATARS equipped aircraft. The Resolution Advisory Display Vector, which represents a composite of all resolution advisories in the RAR is output once each cycle and displayed to the pilot on either the AID or IVSI displays.

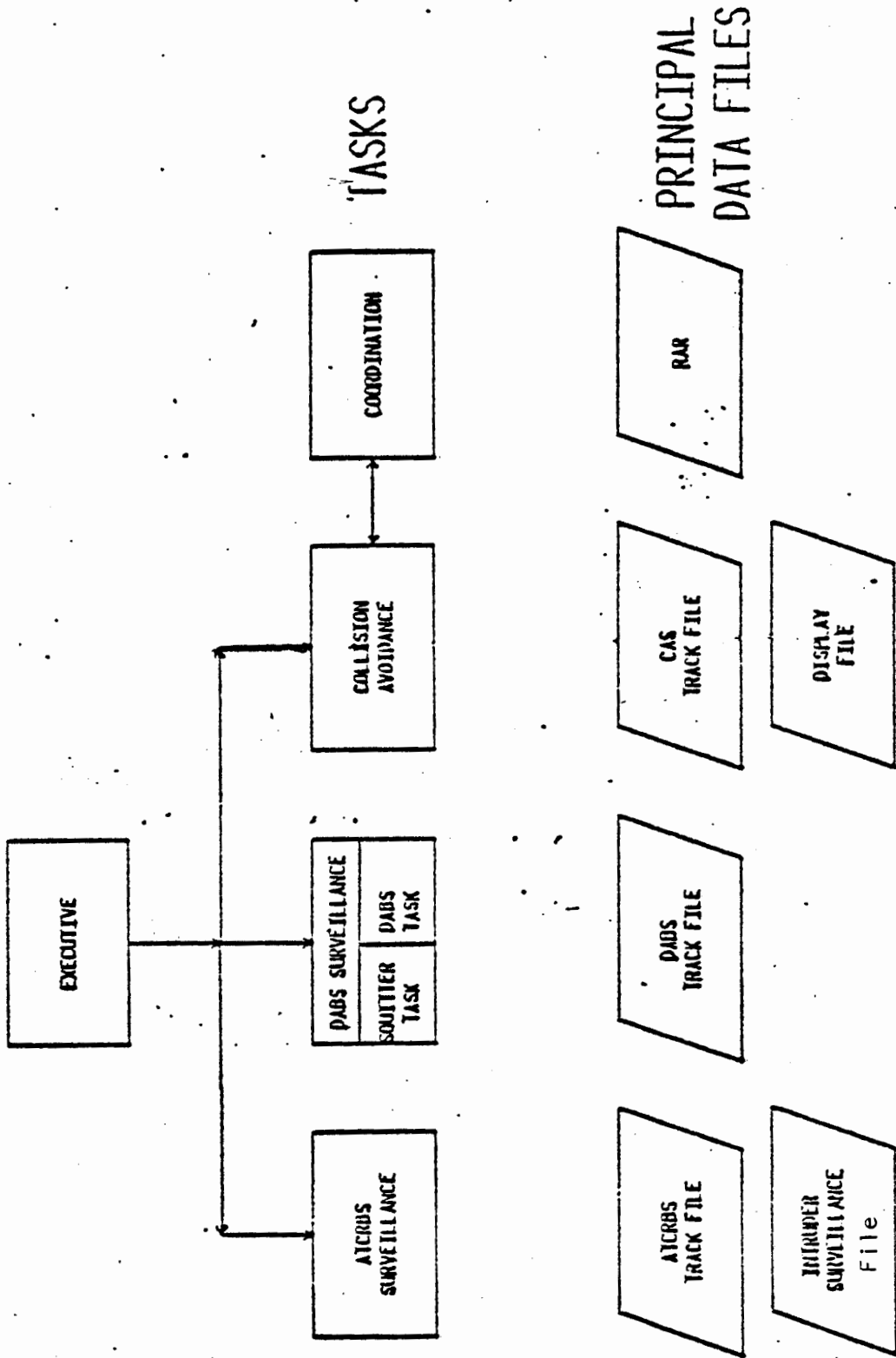


FIGURE 4. ABCAS SOFTWARE FUNCTION ORGANIZATION

#### 4.3.6 Principal Data Files.

There are six principal data files (figure 4). The significant content of these is summarized below.

##### 4.3.6.1 ATCRBS Track File.

This file receives its data from the ATCRBS Surveillance Task and contains the following on each target: Measured range, altitude, time, tracked range, range rate, altitude rate, AOA, track number, consecutive coast count, and number of interrogations.

##### 4.3.6.2 DABS Track File.

There are four file types, or states: Squitter, Dormant, Acquisition, and Roll Call. The format varies depending on the state, but, in general, the file contains track information similar to the ATCRBS Track File along with the threat aircraft's DABS identification code. This file is updated from the DABS Surveillance Task.

##### 4.3.6.3 Intruder Surveillance File.

Whenever a reasonable report can be generated, the appropriate surveillance task (ATCRBS or DABS) sends unsmoothed range and altitude reports, tagged with time, track file number, and aircraft equipage to Collision Avoidance from the Intruder Surveillance File. The Intruder Surveillance File is updated from the DABS and ATCRBS Surveillance Tasks.

##### 4.3.6.4 CAS Track File.

Information is stored for each aircraft on which the Collision Avoidance Task is receiving data from the Intruder Surveillance File. Among the data are tracked range, altitude and bearing along with their rates of changes, intruder equipage, sensitivity level, projected vertical miss distance and time to closest approach.

##### 4.3.6.5 Resolution Advisory Register (RAR).

The RAR is an 84-bit matrix of six columns and 14 rows, and contains the collection of resolution advisories being issued by own BCAS or ATARS. The RAR also contains the complement of resolution advisories of other BCAS aircraft which have been generated against own BCAS (to be used for coordination).

##### 4.3.6.6 Display File.

This file contains own aircrafts resolution advisory display vector which consists of 14 command bits as coded in the RAR, six bits of VSL's, own BCAS operating bit, an audible alarm bit for new resolution advisories, and own BCAS sensitivity level.

## 5. TESTING AND DATA COLLECTION.

Three types of tests will be performed: bench, flight acceptance tests, and finally, data collection flights. The philosophy of the test program is as follows:

- a. Verify through bench tests that the equipment is cycling and acceptable for further testing.
- b. Where possible, verify through bench tests correct system operation.
- c. Installation in an airplane with a cursory evaluation of all interfaces and functions.
- d. Exhaustive flight tests.

The bench tests will be broken into three distinct types of tests; acceptance, investigation and verification. The acceptance tests are to verify that the equipment is indeed working and capable of being tested as a system. Failure of these tests may halt the test program. Assuming successful completion of the acceptance tests, the system will enter the investigatory bench testing phase. Here the system will be subjected to detailed tests to verify system performance. A major effort during this phase will be to verify the correct coding of the software through performance evaluation. These tests will continue right through the flight test program. The reason for this is that features will be added while the unit is being flight tested and will require bench verification. Items that will force this additional bench testing are: addition of self test, RBX logic or any software changes that require a new PROM. The third type of bench tests are called baseline verification tests. These are bench tests that will be conducted weekly to verify that the system is still operating as required. These are in addition to preflight tests and will be run when no flight tests are scheduled.

With the conclusion of bench testing, the equipment will be installed in N78 and a one-day acceptance flight test performed. After reduction and analysis of the data from this flight, a decision will be made as to whether to proceed to the data collection flights, which are expected to take approximately four weeks.

In summary, the test program is:

- a. Bench Tests
  - Phase I Acceptance
  - Phase II Investigatory
  - Phase III Verification
- b. Acceptance Flight Tests
- c. System Performance Flight Tests

The tests to be performed during each portion of the test program are contained in table 1 along with a reference to the appropriate performance requirement or specification. Preceding each item to be tested in table 1 is a number. This number is keyed to the following sections where a further description of the item to be tested is contained.

## 5.1 BENCH TESTS.

The purpose of the bench tests are to verify the performance of basic ABCAS system functions and certain subsystem characteristics and to perform those tests which cannot be realized in the flight test environment. Bench testing will also provide Technical Center personnel an opportunity to become familiar with the equipment and operating and maintenance procedures. The data collected will be compared to specifications and will also form a baseline which can be compared to factory tests data, experimental BCAS data, and data collected throughout the test program.

The following sections delineate descriptions of bench tests to be performed. The section numbers are identical to those used in table 1.

### 5.1.1 DABS Transponder.

The DABS TRU 2A transponders to be used on the BCAS aircraft and target aircraft will be bench checked using a DABS Transponder Test Set. Output power, transponder delay time (time from receipt of an interrogation to the transmission of the reply), and receiver sensitivity are the prime measurements. This test will be repeated throughout the flight test program.

NOT MADE YET.

### 5.1.2 ABCAS Self Test Features.

The ABCAS contains six different classes of self tests:

- a. Transmitter Test
  1. Power Test
  2. Two-Level Attenuation Test
- b. Direction Finding Test for Antennas and Receivers.
- c. RAM/ROM Checksum Test.
- d. ATRBS Decoder Test.
- e. DABS Decoder Test.
- f. Display Test.

The pass or fail indication of these tests are shown on the ABCAS display. The tests will be run initially to demonstrate that all functions are operating correctly and subsequently throughout the program to provide a confidence level for the overall operation of the system. Where possible, the self test will be caused to fail in order to determine that the proper indications are given.

TABLE 1. SUMMARY OF TESTS TO BE PERFORMED

Item to be Tested	I	II A	III	B	C	Specification Reference
5.1.1 DABS Transponder			X			ER 3.3.1, ARINC 718
5.1.2 ABAS Self Test Features (6)	X		X			<i>observed</i> F1, F2, F4, D1 FOUR, ANT, ATC, DISAB, D1 RX, DEGRAD, DISAB, DISAB
5.1.3 Performance Monitoring, 4 Functions	X					<i>7/10/88</i> ER 3.5.2 <i>Plane, Format Displayed</i>
5.1.4 Time-of-Day Clock	X		X	X		
5.1.5 Data Recording a. Event Driver b. Continuous	X X			X X		ER 3.5.1 ER 3.7.1
5.1.6 Aircraft Interfaces a. DABS address b. Max airspeed c. Mode A code d. Pressure altitude e. Radar Altimeter f. Air/ground switch g. Suppression Bus	X X X X X X X			X X X X		ER 3.6, N.S.5.3 & 5.1.4 ER Appendix A  PD6 15.0
5.1.7 Transmission Characteristics a. Output power b. Spurious Radiation c. Whisper shout timing d. DPSK Transmissions	X X X X	X X	X X			PD6 1.0 NS 2.1, ER Appendix A 3.3.1, 3.3.4. ER Appendix A.3.3.5.1, N.S.5.1.1 ER Appendix A.3.3.5.1, N.S.5.11.1 PP6 12.0
5.1.8 Receiver Sensitivity	X		X			N.S 2.1 PD6 2.0, 3.0

TABLE 1. SUMMARY OF TESTS TO BE PERFORMED (CONTINUED)

Item to be Tested	I	II	III	B	C	Specification Reference
5.1.9 Cas Display and IVSI a. Manual Switches and Controls b. Command Displays c. Angle of Arrival Display d. System Failure Display	X X X X	X		X X	X X	ER APPENDIX A 3.3.5, 3.3.12 ER APPENDIX A 3.3.5, 3.1.2
5.1.10 ATCRBS Target Test a. Surveillance Tracks b. Missed Threats c. False Threats d. Density e. Popups f. Fruit g. Degarbling h. Sensitivity levels i. Reply probability j. CAS Track quality k. Protection volume l. Command validity	X	X X X X X X X X X X X		X X X X X X X X X X X	X X X X X X X X X X X	ER 1.4.1, 3.4.1.1, N.S.5.2
5.1.11 DABS Target Test a Through l same as 5.1.10 m. Altitude filter		X		X	X	PP6 9.0
5.1.12 RBX a. DABS Interface b. MS6 Format and Protocol c. Comm. and Coordination d. Time out e. Tracking		X X X X			X X X X X	NS 4.5.3, 5.2.3.5, ER 2.4.2 N.s. 4.5 ER Appen. A 3.3.5, 3.3.1.1, NS 5.2.3.5 ER Appen. A 3.3.5, 3.3.1 ER Appendix A 3.3.4.3, N.S. 6.0
5.1.13 RAR a. BCAS to BCAS Coord. b. BCAS to ATARS Coord.		X			X X	ER 3.2.5, 3.4.1.2, N.S. 5.2
5.2.1 Angle of Arrival				X	X	N. S. 5.4, ER 3.4.1

9a

TABLE 1. SUMMARY OF TESTS TO BE PERFORMED (CONTINUED)

Item to be Tested	I	II <sup>A</sup>	III	B	C	Specification Reference
5.3.4 Pilot System Interface						
a. Display					X	
b. Sensitivity Parameters					X	
c. Commands					X	
d. Bearing Information					X	

Legend A. Bench Tests

- B. Initial Flight Acceptance Test
- C. Data Collection Flight Tests
- I. Acceptance Bench Tests
- II. Investigatory Bench Tests
- III. Baseline Verification Bench Tests
- NS. ABCAS National Standard 10/20/80
- PD6. Preliminary Design Guidelines for ABCAS
- ER. Engineering Requirement of Contract DTFA01-80-19026

### 5.1.3 Performance Monitor.

The procedure for using the performance monitor and the data that can be displayed with no target inputs will initially be used to verify the operation of the monitor. Data which can be displayed under this condition are DABS identity and maximum airspeed. Subsequently, the range and altitude vs time plots, and the ability to display any data being recorded, will be tested during the ATCRBS target test, paragraph 5.1.11.

### 5.1.4 Time-of-Day Clock.

The procedures for setting the clock and the time message displayed on the performance monitor will be verified. Operation in the battery power mode will also be checked by dropping the AC power and observing the display.

### 5.1.5 Data Recording.

The procedures for using the recorder and visual indications used to verify its operation will be verified. The continuous operation mode will be selected rather than the event driven mode. The event driven mode will be checked during the ATCRBS target test, paragraph 5.1.11. The message structure will also be examined for correct content and setting of bits. Initially, only the first 13 messages will be evaluated, as others are added they will also be checked. Below is a list of the present utilized messages.

- a. Beginning of Scan
- b. Error Counts
- c. ATCRBS Interrogation Control Table
- d. ATCRBS Reply
- e. DABS Interrogation Control
- f. DABS Reply Buffer
- g. Squitter Reply
- H. DABS Track Record
- i. ATCRBS Track Record
- j. CAS Intruder Track File Record
- k. Display Vector
- l. RAR
- m. Threat File Record

### 5.1.6 Aircraft Interfaces.

The following aircraft interfaces will be verified by observing the correct data on the performance monitor:

- a. DABS identity - prewired code
- b. Maximum airspeed capability - prewired code
- c. ATCRBS Mode "A" code
- d. Pressure altimeter - the altimeter test box will be used to generate the test codes.
- e. Radar altimeter - a closure to ground will be used to simulate the input signal.
- f. Air/Ground switch - a closure to ground will be used to simulate the input signal.
- g. Suppression bus - tested during the ATCRBS target test 5.1.11.

### 5.1.7 Transmission Characteristics.

The transmission characteristics of the Dalmo Victor BCAS will be bench checked to assure compliance with the pertinent specifications cited in the BCAS Engineering Requirement ER-250-2, as well as the ATRBS and DABS National Standards. Although several tests of the transmitter were performed during the Dalmo Victory Factory Acceptance Tests, it is intended that the measurements performed at the Technical Center will go beyond the factory tests in assuring that the spectral requirements of the cited standards are met. Additionally, the timing of the BCAS transmissions will be determined in order to provide one of the checks to be used during the flight tests for indicating nominal system operation. Other tests such as output power, although replicating some tests performed at the factory, will be conducted to provide a basis for determining nominal system operation. The tests to be performed are broken into the following four areas:

- a. Output Power.
- b. Spurious Radiation.
- c. Whisper/Shout Timing.
- d. DPSK Transmissions.

a. Output Power - Output power for the ATRBS and DABS transmissions of the BCAS unit will be measured using the test setup shown in figure 5. For the ATRBS power measurements, the peak transmit power for each transmission in the whisper/shout sequence will be measured at the top and bottom RF antenna ports. This will be done by using the right half of the test setup in figure 5 and will use a spectrum analyser as the measuring device. The power measurements for the DABS transmissions will be performed using both halves of the setup in figure 5. In this test, multiple DABS squitters will be generated by a word generator modulating a 1090 MHz RF source, thereby provoking the ABCAS to interrogate in an attempt to acquire tracks. The use of multiple transmissions will be required to provide sufficient samples of the ABCAS transmissions to provide an accurate power measurement.

b. Spurious Radiation - Using the test setup in figure 5, the various spectral characteristics of the BCAS will be measured. These measurements will include the spectral output when the BCAS is transmitting as well as during periods when it is quiescent. To effect these measurements, a sampling gate will be used to identify the periods during the transmission cycle of concern, i.e., those periods specified in the Engineering Requirement or the BCAS, DABS, or ATRBS National Standards.

c. Whisper/Shout Timing - The relative spacings and pulse widths of the whisper/shout sequence will be measured using the test setup in figure 5. To perform this measurement, the spectrum analyser will be replaced by an oscilloscope. This measurement will become part of the baseline information for the Dalmo Victor ABCAS.

d. DPSK Transmissions - These measurements will be performed using a one-GHz oscilloscope in the test setup in figure 5. It will be the intent of this test to assure that the absolute and relative timing of the DABS

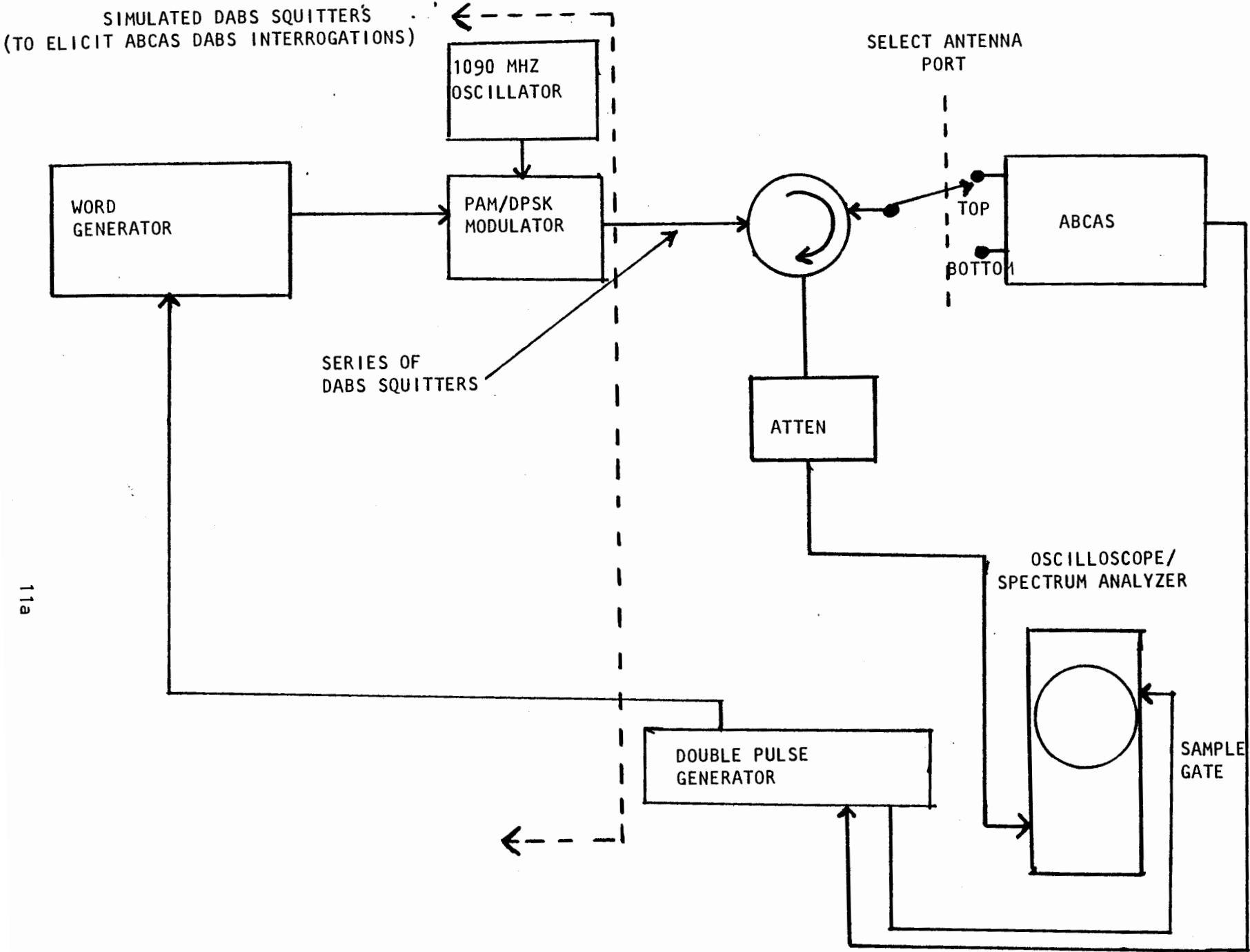


FIGURE 5. ABCAS TRANSMISSION MEASUREMENT TEST CONFIGURATION

waveforms generated by the ABCAS are in compliance with the DABS National Standard. The measurements will include pulse widths, pulse spacings, pulse rise and fall times as well as waveform droop during transmissions to multiple DABS targets. Multiple simulated targets will be required for two reasons. The first is to operate the BCAS transmitter at a high duty cycle while performing the RF droop measurements. The second reason is to provide a somewhat higher sampling rate for determining the waveform characteristics. All pulse spacings will be measured from the leading edge half amplitude point and rise and fall times from the 10 to 90 percent points.

#### 5.1.8 Receiver Sensitivity.

a. ATCRBS - Using the ATCRBS RF test setup in figure 6, a static target will be generated with a range of 5 nmi. This target will be inserted into each of the eight antenna pairs (four top and four bottom) at a level of -77 dBm and will be monitored and recorded.

b. DABS - Using the DABS RF test setup in figure 7, the same test will be repeated with DABS signals.

#### 5.1.9 CAS Display and IVSI.

a. CAS Display - Using the ABCAS target test setup in figure 6 and test scenario in table 2, it will be verified that the proper symbology is displayed for the two different display modes (PWI display only and commands plus PWI).

Target range positioning and bearing angle will be checked on the CRT with the same configuration but using a static target at 2 nmi and 90° bearing. A target at this range will appear on the 2-mile range ring on the 10-mile scale and at the edge of 2-mile scale. The 90° bearing angle is achieved by inserting equal amplitude signals at the 45° and 135° ports. With range constant at 2 nmi, the same inputs will be inserted on the other three pairs of antenna ports (135° - 225°, 225° - 315°, 315°-45°). The target should then appear at 180°, 270°, 360°.

b. IVSI - The IVSI and aural alarm will be verified at power up when all lights on the display are energized and the alarm is sounded.

#### 5.1.10 ATCRBS Target Tests.

The majority of the Phase I and II bench tests shown in table 1 will be accomplished using a single dynamic track for an ATCRBS target. The test configuration for the ATCRBS target is shown in figure 6. The description of the target and BCAS aircraft is shown in table 2. Eight runs will be made with all parameters the same except for the altitude of the target. The target's altitude for each run will be:

Run #1 - 7800'	Run #5 - 7600'
Run #2 - 8000'	Run #6 - 7300'
Run #3 - 8300'	Run #7 - 7000'
Run #4 - 8600'	Run #8 - 7800'

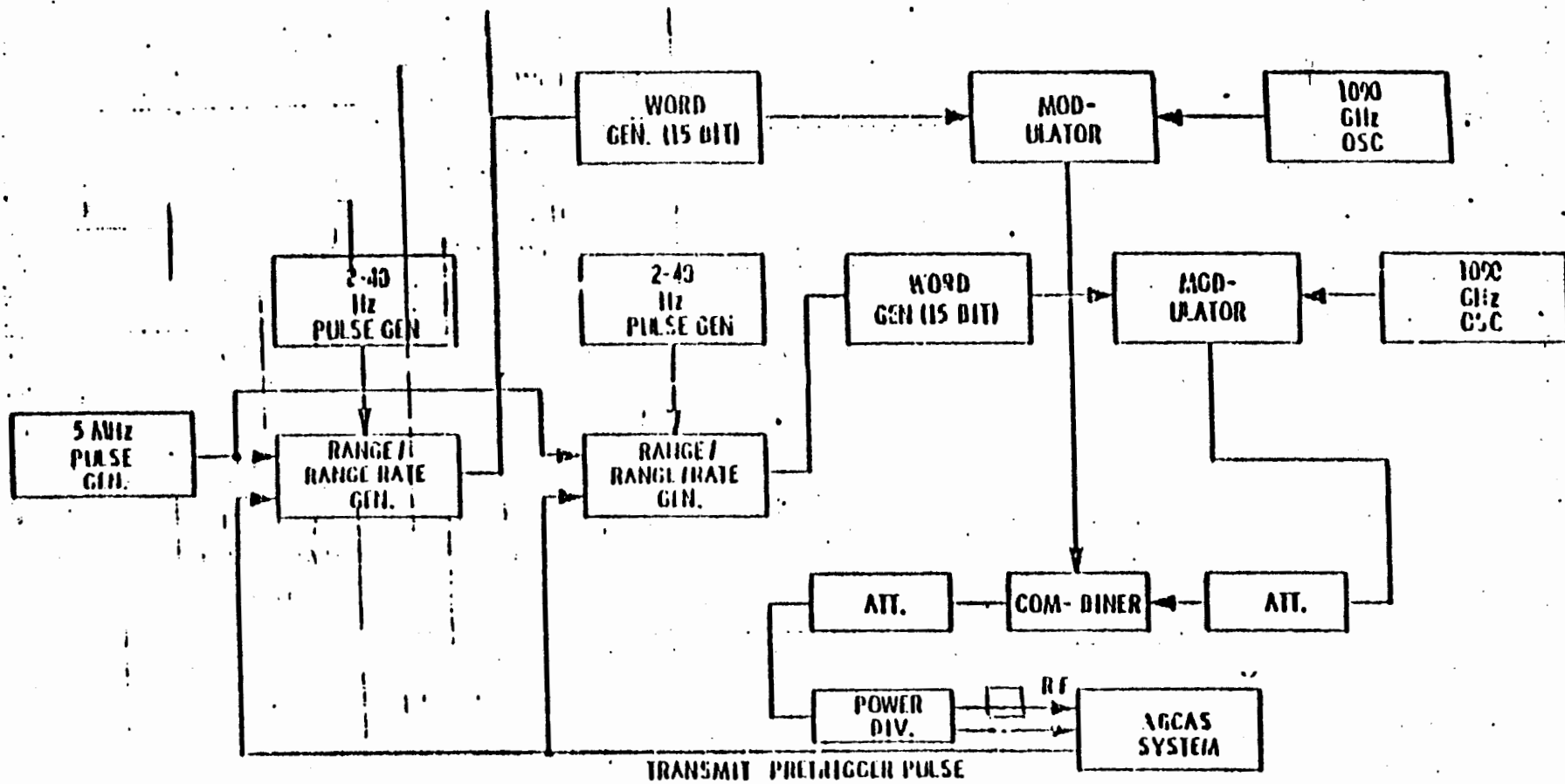


FIGURE 6. ATCRBS TRACKER RF TEST SETUP

12b

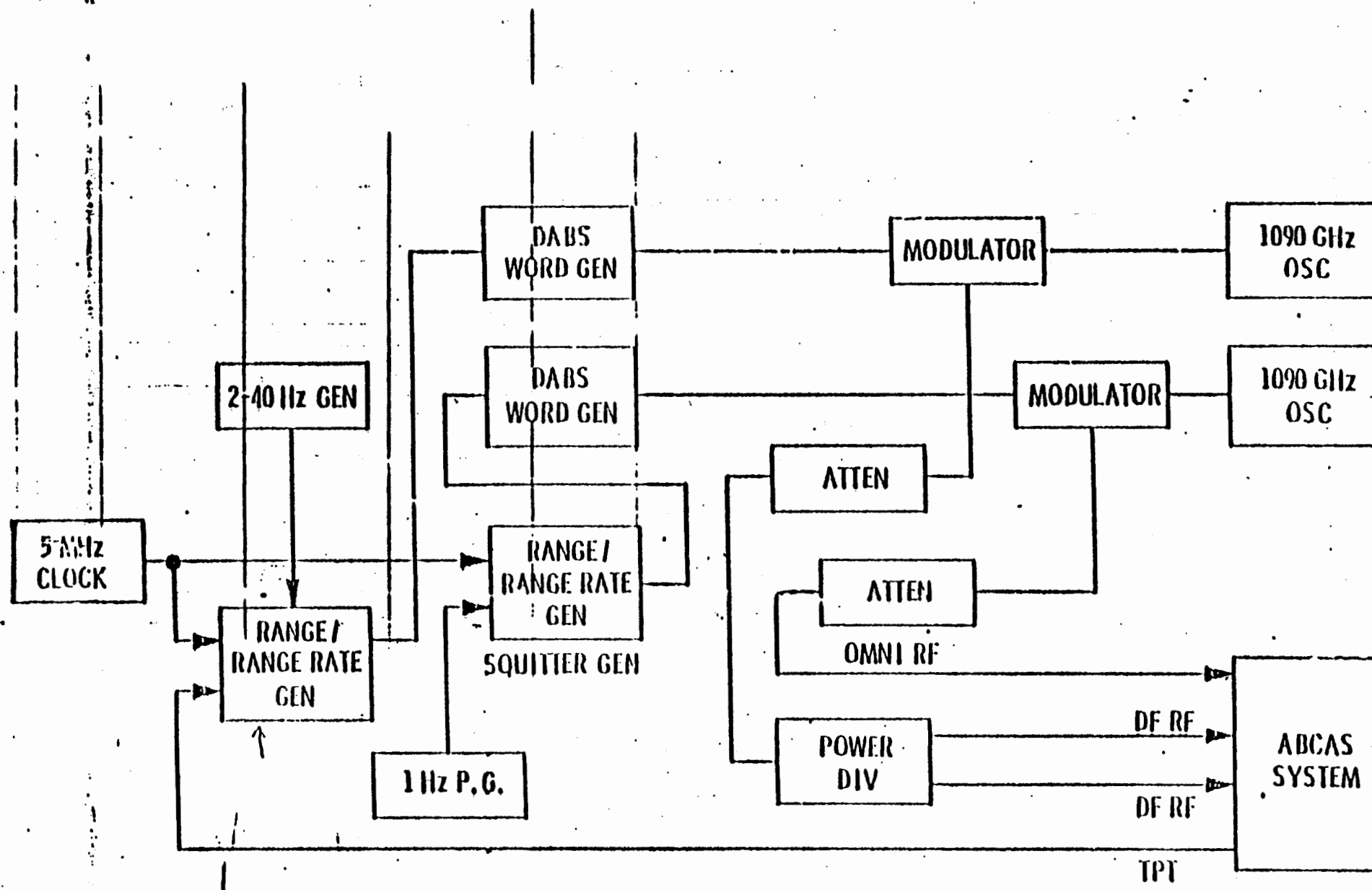


FIGURE 7. DABS TRACKER RF TEST SETUP

TABLE 2. TEST CHARACTERISTICS, CAS DISPLAY VERIFICATION

SCENARIO - Single Dynamic ATRBS Target

a. Target Characteristics -

Range Rate = 400 knots (closing)

Power input to ABCAS antenna ports = -77 dBm

Range = 20 to 0 nmi

Altitude = variable

Equippage = Non-BCAS, non-ATARS

Frequency = 1090 MHz

AOA =  $90^{\circ}$  (ring wing) - equal signals to  $45^{\circ}$  and  $135^{\circ}$  antenna ports

Identity = DABID

b. BCAS Characteristics -

DABS ID = FAA49

Altitude = 7800 ft.

Data Recording Mode = continuous

Performance Level = 3 (manually set)

Data will be recorded in the continuous mode for the first seven runs. For the eight run, data will be recorded in the event driven mode.

The performance monitor will be used to observe data during each run; however, the printouts of the magnetic tape will be the primary means of reviewing the results of the various tests described below. Observations will also be made of the IVSI and CAS Display and all advisories or commands will be noted.

The system functions to be verified in accordance with table 1 are:

Data Recording (5.1.5) - The continuous mode recordings will be examined to verify that the formats agree with those supplied by Dalmo Victor and that no data is being lost. The event driven recordings will be reviewed to verify proper operation.

Performance Monitor Operation (5.1.3) - Will be verified during the runs by selecting each message type, freezing the display and making a hard copy. This hard copy will then be reviewed for correctness. During Run #2, range and altitude versus time plots will be displayed and a hard copy produced for examination.

Surveillance Track (5.1.10A) - Data will appear in message 9 for ATRCBS and message 8 for DABS and will be reviewed for correctness (see section 5.1.5 for various message types).

Missed Threats (5.1.10B) - A threat should be indicated on the IVSI for all runs except Runs #4 and #7.

False Threats (5.1.10C) - For all runs only one track should exist and except #4 and #7 a single command or coherent series of commands.

Density (5.1.10D) - An ATRCBS target/fruit generator that exists at the FAA Technical Center is being modified to aid in Electromagnetic Compatibility (EMC) testing with the ABCAS system. It will be capable of generating multiple targets, ATRCBS and DABS, at various ranges. This unit will be used to generate an aircraft density of .02 aircraft/nmi<sup>2</sup> and a test target track. This track will be examined for reply detection, coasts, acquisition range, proper commands, timeliness of commands, etc. BCAS-to-BCAS communications (RAR request and reply messages) will not be simulated.

Fruit (5.1.10F) - The ATRCBS target/fruit generator, described above, is also capable of producing fruit replies from 20 per second to 40,000 per second. Various fruit levels will be continued with the replies from a single dynamic target. The ABCAS data recordings will be examined to determine the effects on reply detection, CAS tracking, and command generation.

Degarbling (5.1.10G) - The purpose of this test is to verify that the system is capable of degarbling three overlapping replies. Three independent static ATRCBS targets will be used at approximately the same range and with power levels of -40 dBm, -43 dBm, and -37 dBm. The percentage of overlaps of an individual coded or framing pulse will be varied in four steps; 100%, 50%, 25%, and 0%. The ATRCBS reply buffer message will be examined for decodes and garbled bits.

Sensitivity Levels (5.1.10H) - This test will use the same configuration (figure 6) and test scenario (table 2) except the altitudes of ABCAS and target will be changed together with the performance levels selected on the manual switch.

<u>Run No.</u>	<u>PL Switch</u>	<u>Own Altitude</u>	<u>Target Altitude</u>
1	Standby	7800'	7800'
2	PL2	7800'	7800'
3	PL3	7800'	7800'
4	PL4	7800'	7800'
5	Auto	7800'	7800'
6	Auto	20000'	20000'
7	Auto	32000'	32000'

Message 11 (Display Vector) of the recorded data will be examined for the current system sensitivity level. Message 1 contains the sensitivity level selected by the pilot. The performance level is shown on the CAS display and will be recorded during the tests.

Reply Detection Probability (5.1.10I) - The ATCRBS single target test setup shown in figure 6 and the Scenario in table 2 will be used. Eight runs will be made using different pairs of antenna ports (45° and 135°, 135° and 225°, 225° and 315°, 350° and 450°), first on the top antenna inputs and then the bottom antenna inputs. Data will be continuously recorded and message types 3 and 4, ATCRBS Interrogation Control and ATCRBS Reply Buffers, will be reviewed to compare interrogations made to replies received.

For DABS, messages 5 and 6 (DABS Interrogation Control and DABS Reply Buffer) will be reviewed to compare numbers of interrogations made and replies received. Message type 7 will reviewed to verify the number of squitters received by ABCAS.

During the test runs, the performance monitor will be used to observe messages 3, 4, 5, 6, and 7. A hard copy will be made of selected plots.

CAS Track (5.1.10J) - Data will appear in message 10 and will be reviewed for correctness.

Protection Volume (5.1.10K) - At command or advisory times the range TAU and altitude TAU will be reviewed for reasonableness.

Command Validity (5.1.10L) - The commands received on the IVSI and in message 11 will be reviewed for reasonableness.

A cursory examination will be made of all other messages with particular attention to error counters (message 2) acquisition ranges, processor loading, etc.

#### 5.1.11 Dabs Target Tests.

Tests A thru L will be tested using the configuration in figure 7, and will follow the identical procedure as described in Section 5.1.11 for ATCRBS.

Altitude Filter - Test runs will be made using figure 7 and the scenario in table 2. In Run #1, the target altitude will be 5100' and no track should be established. In Run #2, the target altitude will be 2900' and a track should be generated. In Run #3, with zero vertical rate, and an altitude of 3000' no track should be generated.

#### 5.1.12 RBX Tracking.

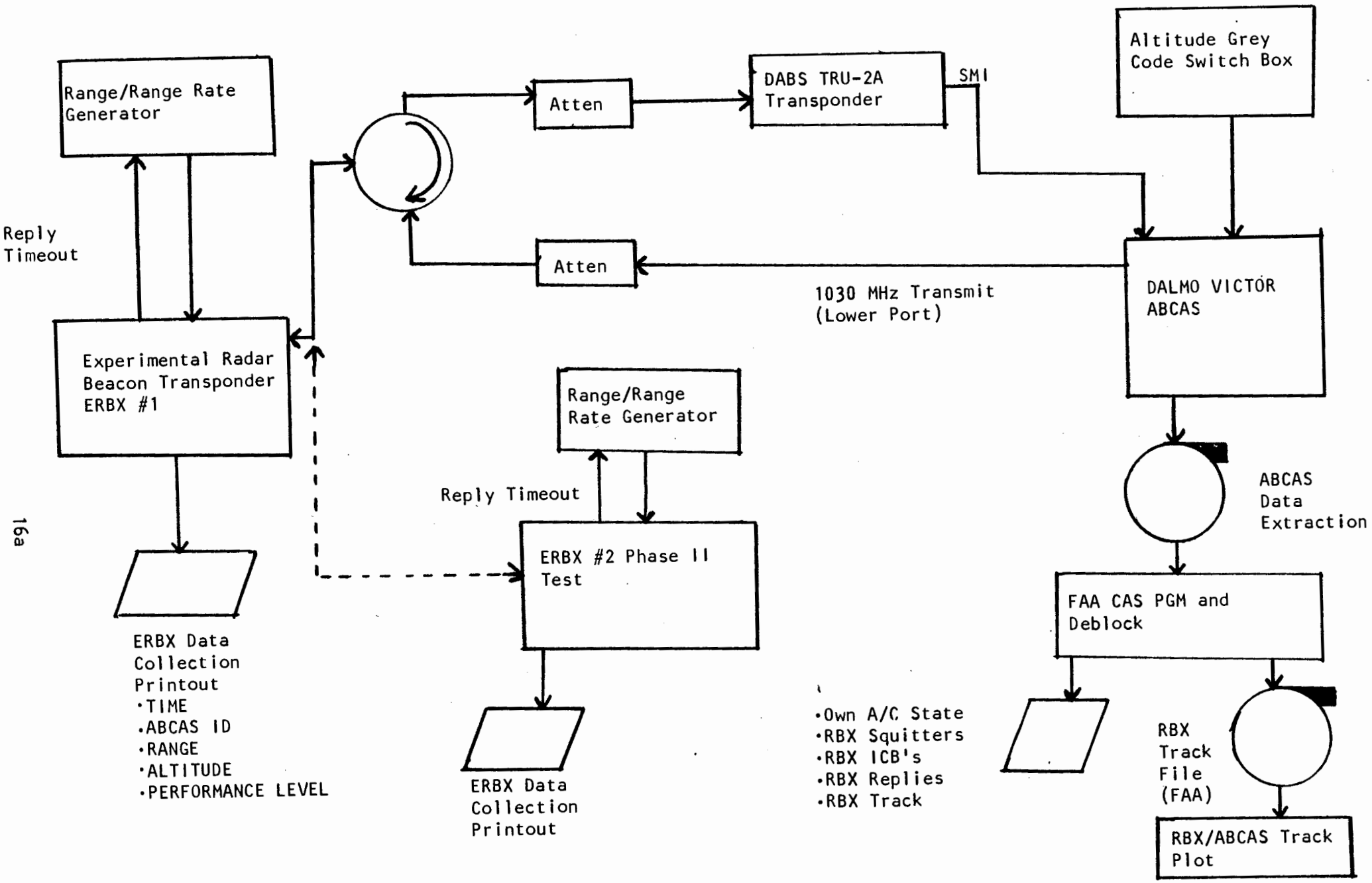
The testing to be conducted under this heading will involve both bench tests (the subject of this section), and flight tests (covered in Section 5.3.2).

The bench tests to be performed for RBX tracking will determine if the ABCAS tracks and correctly interacts with an RBX. In verifying the ABCAS/RBX protocol it should be understood that the RBX software implemented in the Dalmo Victor ABCAS will be functionally different from the RBX software (version 7) used in the Lincoln Laboratory BCAS Experimental Unit (BEU). The major functional difference will be the implementation in the RBX of a hysteresis function for setting the ABCAS performance levels, the purpose of which is to minimize multiple performance level changes when ABCAS is near a performance level boundary. This section is based on the premise that the RBX tracking software in the ABCAS is equivalent to that in the BEU's. Sufficient flexibility will be retained in the test setup, figure 8, to permit adaptation for any differences that arise. In accomplishing this the bench tests will be divided into a Task I (immediate bench tests) and a Task II (requiring modifications to existing equipment).

a. Task I - The ABCAS will be operated with one of the experimental RBX's (ERBX) developed at the FAA Technical Center. In this configuration the ABCAS will be equipped with a switch box (closures to ground) as a source of simulated altitude gray codes. In order to simulate movement towards and away from the ERBX, a range/range rate generator will be used to delay the reply time out trigger of the ERBX. (The reply time out trigger is a switch selectable delay time in the ERBX used for establishing the turn around times for the ERBX replies to ABCAS interrogations.) The test scenarios to be followed are shown in table 3.

During the tests the range boundaries will be held fixed while the altitude boundary between performance levels PL 4 and 5 will be varied. This variation is to allow verification that the ABCAS will not enter PL 5 below 10,000 feet, but can be held in PL 4 above 10,000 feet by the ERBX. The ascending and descending portions of the scenario will be used to confirm that ABCAS will implement the correct performance level at the correct time while traversing through present altitude and range boundaries.

One additional step in the scenario will be performed to confirm the automatic increase in the ABCAS performance levels when the ERBX track is dropped. To test this function the ABCAS will be set to 1,500 feet (via the altitude switch box) at which time the ABCAS will, at close range, be in performance level 1. At that point, the ERBX will be stopped from replying. This will, in turn, cause the ABCAS to increase its performance level one step every 14-16 seconds. Although the ERBX will not reply, it will continue to record the number and content of the interrogations received from the ABCAS and their times. This will be examined to confirm that the ABCAS performed at least two interrogations every 4 seconds to reacquire the ERBX.



Reply Timeout

16a

- ERBX Data Collection Printout
- TIME
  - ABCAS ID
  - RANGE
  - ALTITUDE
  - PERFORMANCE LEVEL

- Own A/C State
- RBX Squitters
- RBX ICB's
- RBX Replies
- RBX Track

FIGURE 8. RBX TRACKING TEST

TABLE 3. RBX TRACKING TEST SCENARIOS

Performance Level Boundaries

	PL1 - PL2	PL2 - PL3	PL3 - PL4	PL4 - PL5
Range (nmi)	1	2	10	15
Altitude (100's feet)	2.0	3.0	5.0	8.0 (scenario 1), 12.0 (scenario 2)

TARGET CHARACTERISTICS AND PERFORMANCE LEVEL RESULTS INBOUND AIRCRAFT SPEED - 400 KTS

	<u>Target Altitude (1000's feet)</u>	<u>Expected Performance Level</u>
Scenario 1	1.5	1 (no BCAS interrogations)
	2.5	2 (BCAS interrogates RBX only)
	4.5	3
	5.5	4
	9.0 (PL 5 Boundary at 8.0 K')	4 RBX can't command PL 5 below 10 K'
	11.0 (PL 5 Boundary at 8.0 K')	5 BCAS goes to PL 5 at 10 K'
Scenario 2	9.0 (PL 5 Boundary at 12.0 K')	4
	11.0 (PL 5 Boundary at 12.0 K')	4 BCAS still held in PL 4 by RBX above 10 K'
	2.0 - 12.0 (ascend)	1 - 5 Performance levels delayed 16 sec.
	12,9 0 2,9 (decend)	5 - 1 Performance levels used immediately
	1.5 (stop RBX replles)	1 - 4 ABCAS Performance level increases automatically from PL1 to PL4 below 10 K'

Data collection in this phase will come from the ABCAS data extraction tape, the ERBX data collection function (hard copy output) and possible the ABCAS performance monitor. During the testing the time-of-day clocks of both the ABCAS and the ERBX will be synchronized to assure ready correlation of the data tape of the ABCAS with the printouts of the ERBX. The extraction tape from the ABCAS will be processed via the "CASPGM" and "DEBLOCK" data reduction and analysis programs at the Technical Center, from which a listing of the ABCAS records pertinent to the RBX track function will be produced. Additionally, a second program, "RBX/ABCAS TRACT PLOT", will be used to generate plots of the aircraft track versus performance level boundaries. This information will be used to determine the performance level changes with respect to the performance level map.

b. Task 11 - These tests will be performed at a later date in the ABCAS testing program. The purpose of this testing will be to verify the correct functioning of the ABCAS when tracking two RBX's. In order to execute this task, the second ERBX at the Technical Center will be modified to operate with the revised DPSK waveforms (figure 9) required by the TRU-2A transponder with which the ABCAS will be equipped. The testing will be identical to that performed under Task 1 with the exception that both ERBX's will have altered turn-around times. One of the turn-around times will be set at the nominal 500 microseconds (usec) expected by the ABCAS, while the second ERBX will have a turn-around time of 530  $\mu$ s. This will result in an apparent range difference between the two ERBX's of 2.43 nmi.

The data will be correlated and reviewed to ascertain what priorities that the ABCAS established for the ERBX's and also what performance levels are adopted by the ABCAS when conflicts arise between commands between multiple ERBX's.

#### 5.1.13 Resolution and Advisory Register (RAR).

When two systems are available they will be interconnected as in figure 10. Each system will be forced to generate commands. The correct exchange of these commands via the RAR function will be monitored via message 12. The data exchange will be verified for timeliness and correctness.

### 5.2 FLIGHT ACCEPTANCE TESTS.

As described below, this testing will be performed in two parts: a static angle of arrival test and a flight test. Each test is scheduled for one day duration. All tests should be completed within two days.

#### 5.2.1 Angle of Arrival Static Test.

Static tests will be performed with the Directional ABCAS system installed on the Technical Center's Boeing 727 (N78). Although upper and lower antennas are used in the Dalmo Victor ABCAS, the antenna of primary concern in this test will be the array mounted on the top of the fuselage. The objective of these tests is to determine the bias error in the azimuth angle and the stability or standard deviation of the angular errors at various points. The procedure will be to use a van with a variable mast (5 ft. to 55 ft.) and an ATCRBS transponder that can be interrogated by the BCAS aircraft. The van and aircraft will be positioned on the ramp about 100 feet apart (figure 11). Exact ( $\pm 1$  ft.) measurements of the aircraft and the van will be made with an HP3801A Total Station. This is

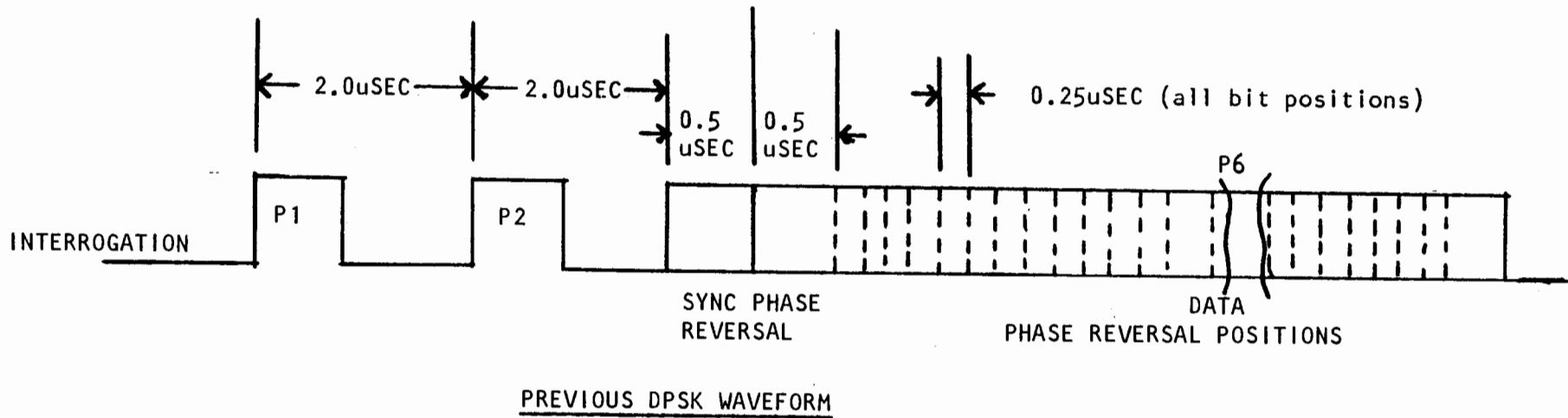
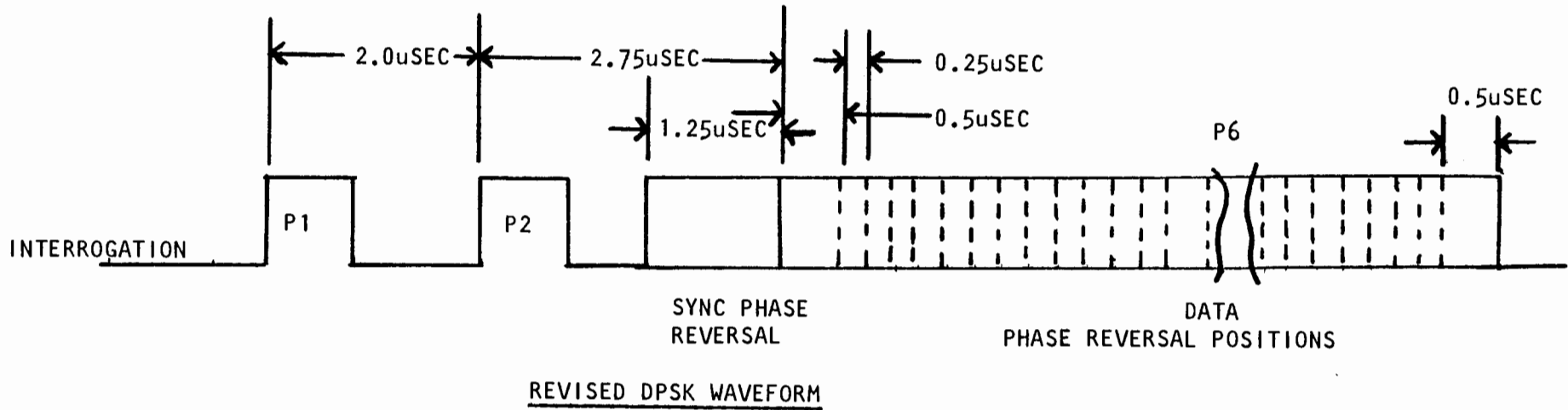


FIGURE 9. DPSK MODULATION WAVEFORM

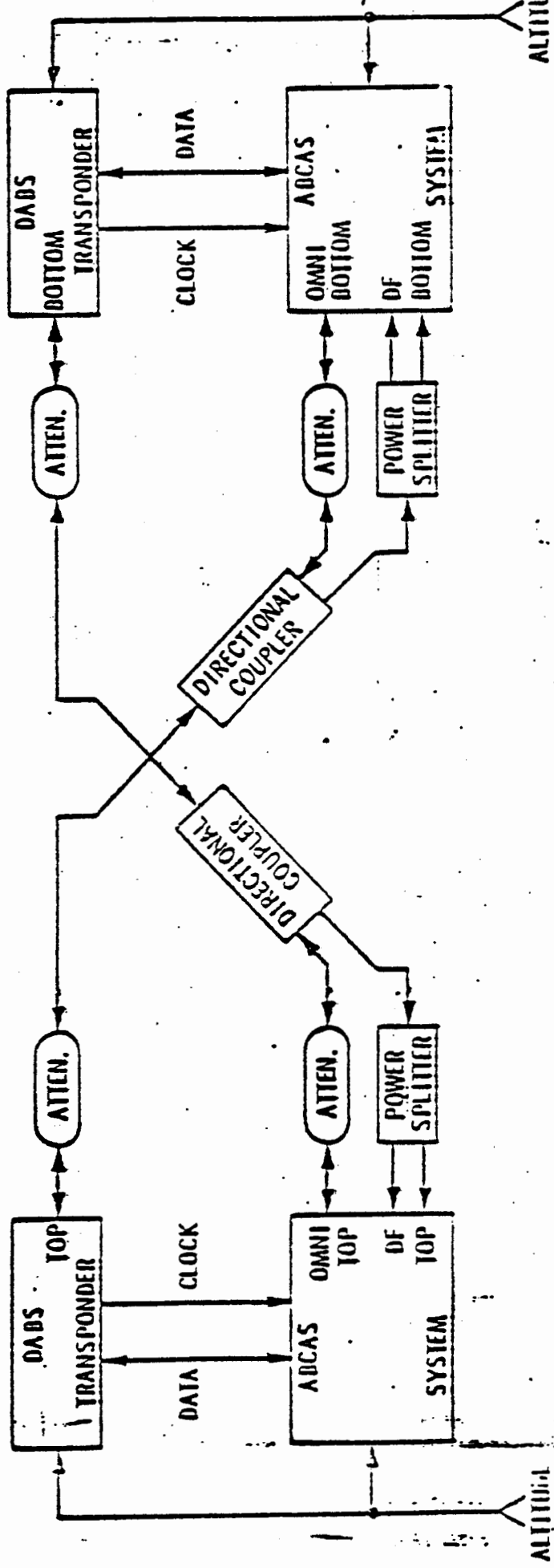


FIGURE 10. RAR COORDINATION TEST CONFIGURATION

STATIC TEST I  
MILSVAN & SURVEY

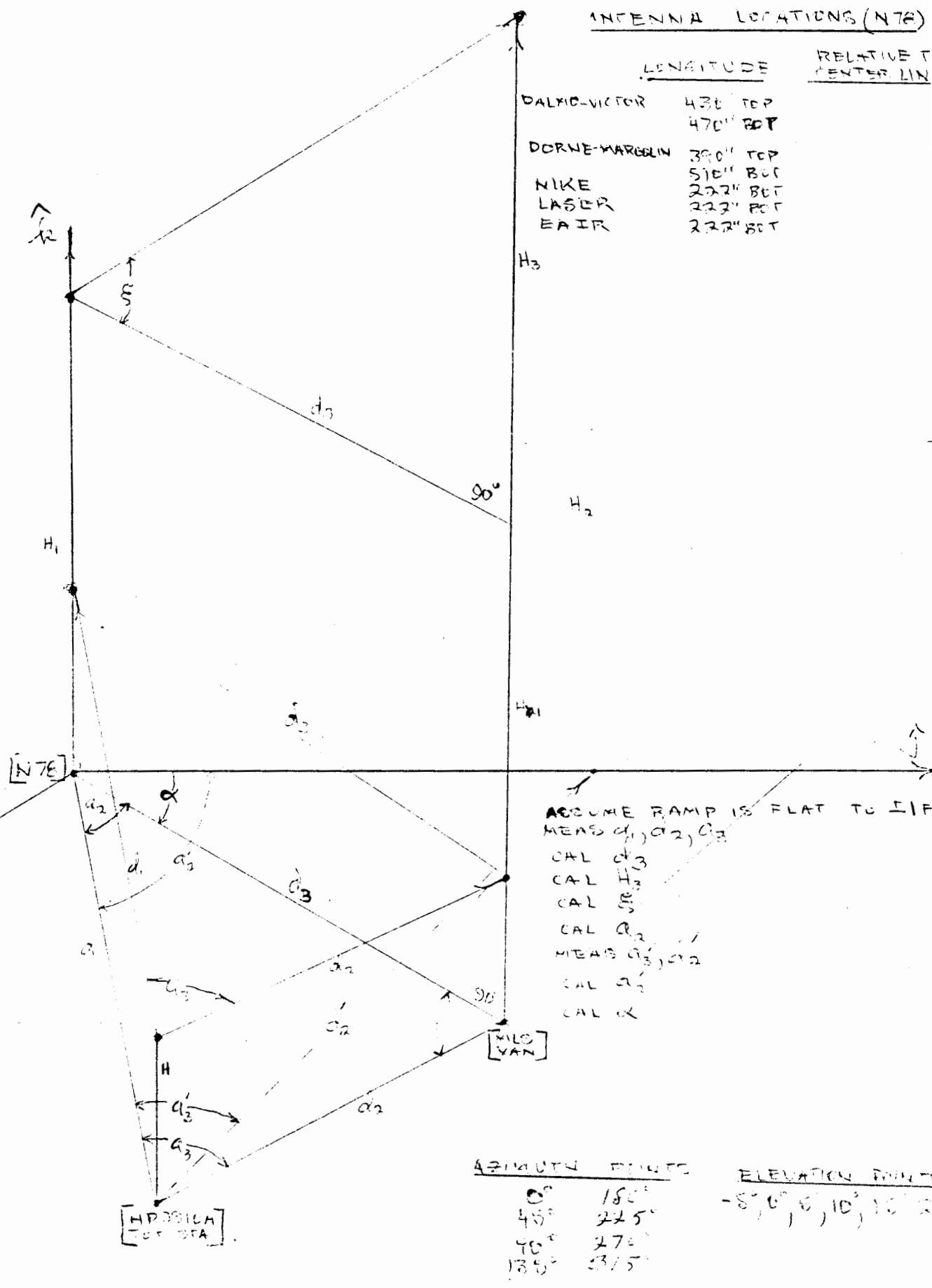


FIGURE 11. AOA STATIC TEST CONFIGURATION

an infrared surveying device which provides distance, azimuth, and elevation data. The azimuth and elevation of the bottom and top D. F. arrays to the ATRCBS van antenna will be calculated by utilizing antenna locations above the ramp, two measured points on the bottom of the fuselage (heading information) and a single measured point on the antenna mast. Due to the blockage of the landing gear, precise bias and angular error data on the bottom array will not be obtained. However, a cursory examination of the array performance will be obtained by moving the van around the aircraft and observing the displayed (BCAS) output. Any phenomenon observed will be examined during the subsequent flight test. Also, the maximum angular blockage of the bottom array due to maximum flaps will be determined for use in the flight tests. The top antenna will be examined for mean and standard deviation errors at specific points. The azimuth angles selected are  $0^{\circ}$  to  $315^{\circ}$  in  $45^{\circ}$  increments. At each of these points the elevation angle will be varied between  $-5^{\circ}$  and  $+20^{\circ}$ . Errors due to signal blockage by the horizontal and vertical stabilizer and the rudder will also be determined. The minimum power at the antennas will also be determined by reducing the ATRCBS power until the Dalmo Victor system does not respond. The data collected on the aircraft will be stored on 9-track tape.

### 5.2.2 Flight Tests.

The purpose of these tests will be to verify basic system performance, installation, and to provide familiarization to the flight test crew. A day of encounters is planned. A list of these are contained in table 4 with the actual profiles to be flown contained in figure 12 thru 16. The encounters will be tracked with the Technical Center's Nike Hercules tracking radar. It is planned to record and reduce selected data for each encounter. These tests will enable verification of the installation and provide sufficient performance information to proceed to the next phase full scale data collection flight tests.

### 5.3 SYSTEM PERFORMANCE FLIGHT TESTS.

The objective of this set of tests is to provide a basis for evaluating the operational performance of the Dalmo Victor ABCAS units with respect to the BCAS National Standard (October 20, 1980) and Engineering Requirement FAA-ER-250-2.

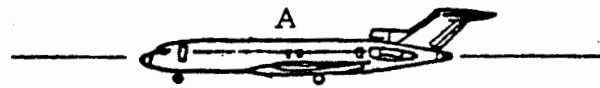
This operational flight test program will provide the data required to compare the performance of the Dalmo Victor ABCAS in both the ATRCBS and DABS configurations in the Technical Center airspace and higher density airspace such as Washington, D.C., and New York. In addition, testing will include parallel flight response, vertical warning time, vertical tracker performance, and pilot system interface performance. Upon delivery of additional prototype units, multiple encounters will be conducted using two and possibly three aircraft in various equipment configurations. The first unit will additionally undergo flight tests which will determine the systems capability to interface with the RBX (Section 5.3.2) and the accuracy of its bearing information (Section 5.3.3).

#### 5.3.1 Performance Flight Tests.

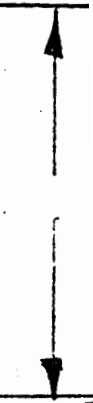
Performance in accordance with Engineering Requirements and the National Standard will be achieved by assuring that the prototype unit equals the ap-

TABLE 4. SUMMARY OF FLIGHTS - ACCEPTANCE TESTS

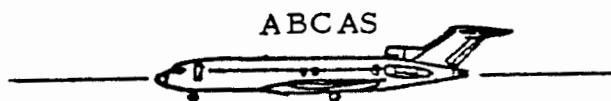
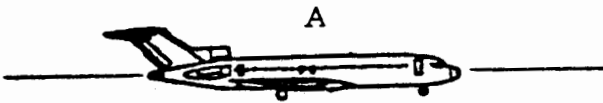
Run	Type of Test	Pattern No.	ABCAS Altitude	Target Altitude	Target
1	Head on encounter	A	12,000	11,200	ATCRBS
2	Head on encounter	B	11,600	12,000	ATCRBS
3	Head on encounter	A	12,000	11,600	ATCRBS
4	Head on encounter	B	8,200	9,000	ATCRBS
5	Head on encounter	B	8,700	9,000	ATCRBS
6	Head on encounter	A	8,300	8,000	ATCRBS
7	Head on encounter	A	8,300	8,000	ATCRBS
8	Head on encounter	B	8,700	9,000	ATCRBS
9	90° encounter	C	8,300	8,000	ATCRBS
10	90° encounter	D	8,300	8,000	ATCRBS
11	45° encounter	E	8,300	8,000	ATCRBS
12	135° encounter	F	8,300	8,000	ATCRBS
13	135° encounter	G	8,300	8,000	ATCRBS
14	45° encounter	H	8,300	8,000	ATCRBS
15	Tail Chase	I	8,300	8,000	ATCRBS
16	Tail Chase	J	8,700	9,000	ATCRBS
17	500 ft/min Descent Head on encounter	K	9,500 to 8,500	8,000	ATCRBS
18	1000 ft/min Descent Head on encounter	K	9,500 to 8,500	8,000	ATCRBS
19	2000 ft/min Descent Head on encounter	K	9,500 to 8,500	8,000	ATCRBS
20	Head on encounter	A	8,300	8,000	DABS
21	Head on encounter	B	8,700	9,000	DABS
22	Head on encounter	A	8,300	8,000	DABS
23	25000 ft/min Descent Head on encounter	L	9,500 to 4,500	4,000	ATCRBS



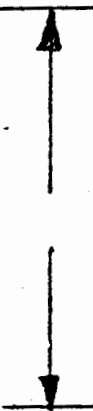
TBA



PATTERN A

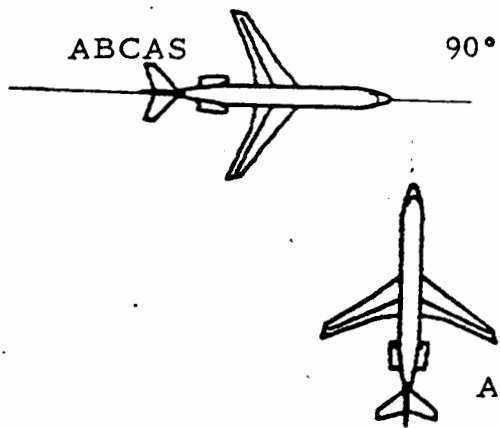


TBA

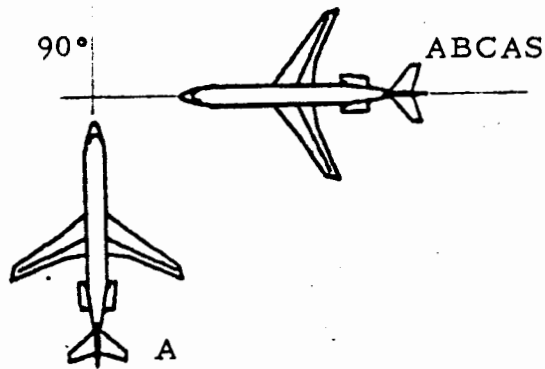


PATTERN B

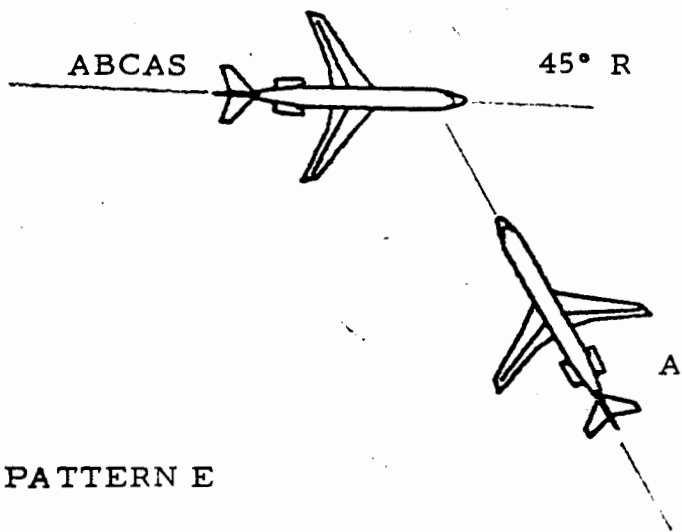
FIGURE 12. FLIGHT PROFILES ACCEPTANCE TESTS



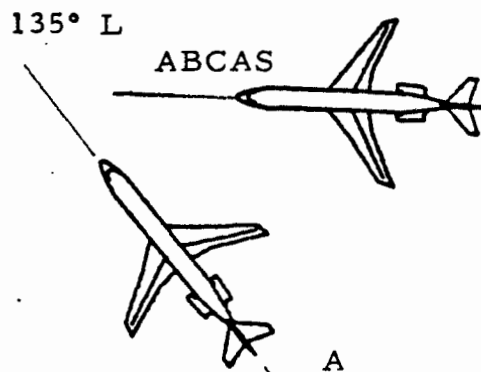
PATTERN C



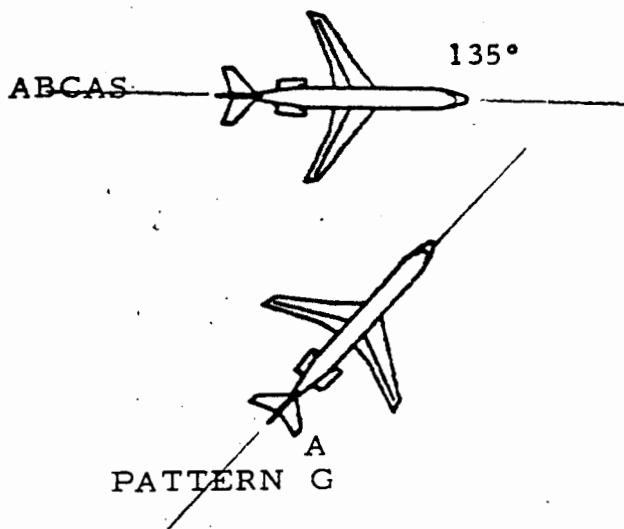
PATTERN D



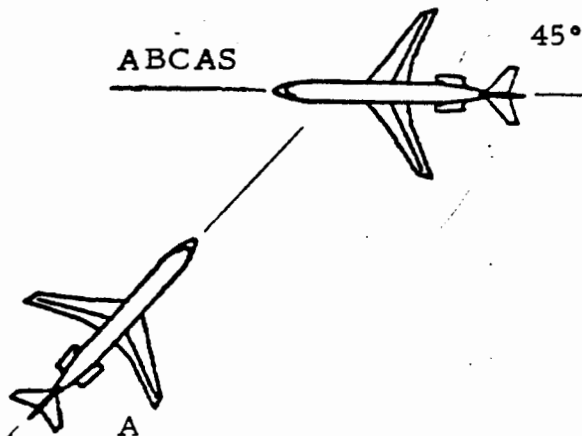
PATTERN E



PATTERN F

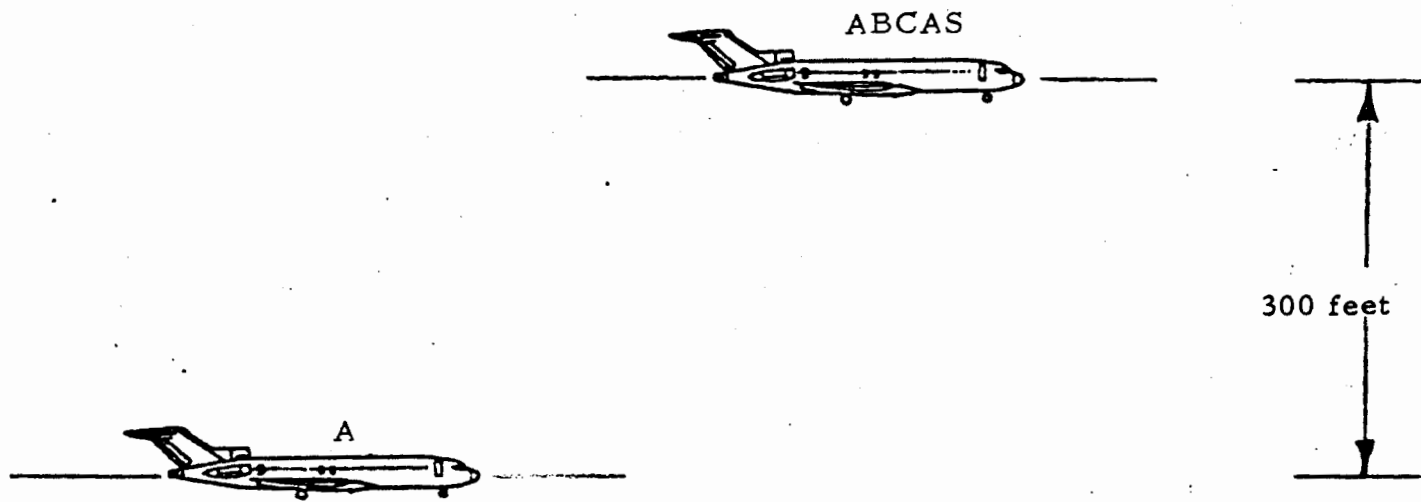


PATTERN G

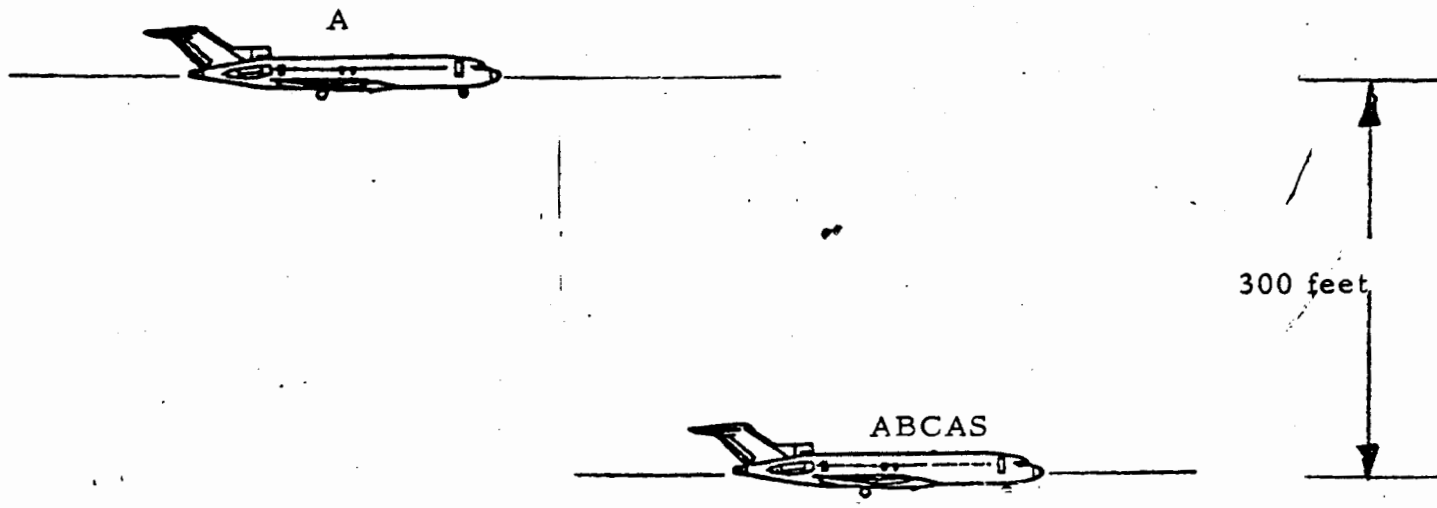


PATTERN H

FIGURE 13. FLIGHT PROFILES. ACCEPTANCE TESTS



PATTERN I



PATTERN J

FIGURE 14. FLIGHT PROFILES. ACCEPTANCE TESTS

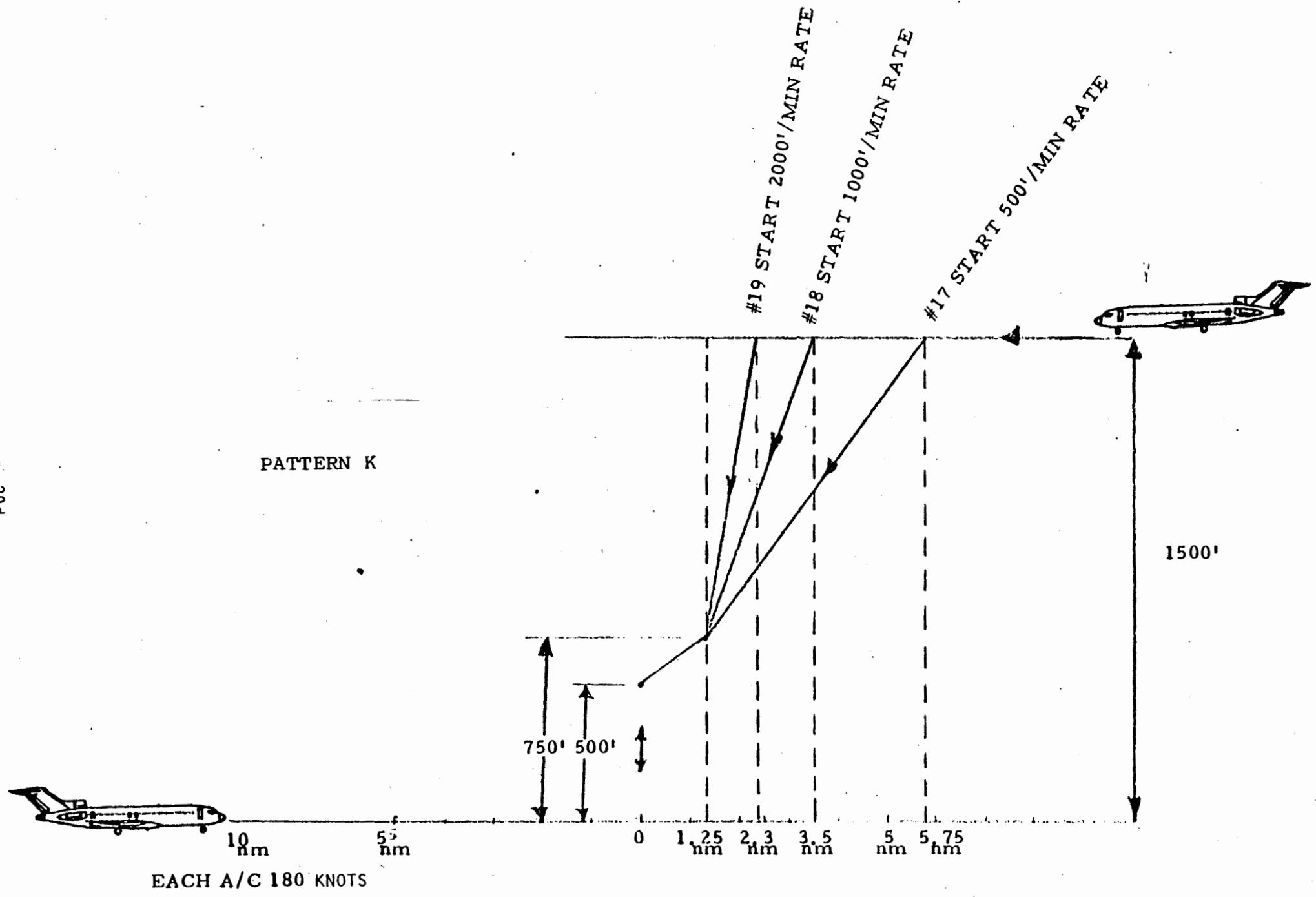


FIGURE 15. FLIGHT PROFILES, ACCEPTANCE TESTS

PATTERN L

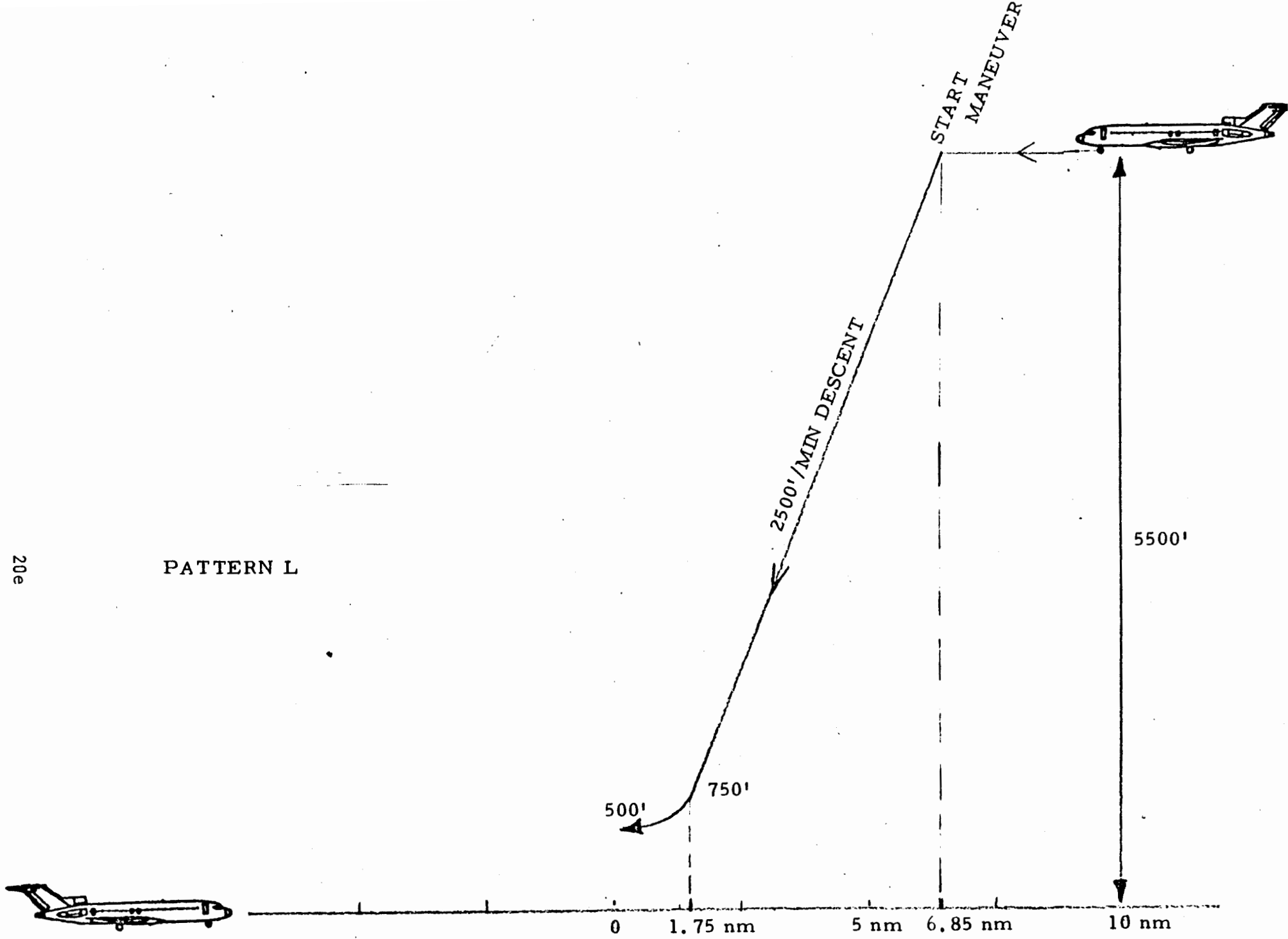


FIGURE 16. FLIGHT PROFILES ACCEPTANCE TEST

plicable the basic BEU performance and that the multiple target logic, and air-to-air coordination perform properly. Additional testing will be conducted which will provide data relative to critical parameter performance and the pilot-system interface. The flight profiles for these tests are contained in Appendix A and the test program has been categorized into the following phases:

- a. Comparison to basic BEU performance - 2 aircraft
- b. High Density Performance
- c. Additional Performance Evaluation
- d. Pop-up Target and Two BCAS Equipped Performance
- e. Multiple Encounter Performance

The information provided by the specific test phases will provide for evaluation of ATRBS and DABS performance relative to the following:

- a. Track coasting percentage
- b. Track coast probability
- c. Acquisition range
- d. Warning times (protection volume)
- e. Advisory correctness
- f. Missed alarms
- g. False alarms
- h. Fruit and density effects upon performance
- i. Pilot response time and related separation at the point of closest approach.
- j. BCAS versus Ground Radar Tracking Accuracy
- k. BCAS versus Ground Radar Bearing Accuracy
- l. Vertical tracker performance
- m. Parallel flight (DMOD) performance
- n. Pop-up target performance
- o. Multiple encounter response

p. Air-to-air coordination

The various phases of the flight test program will not be discussed in detail. Each phase will address the number of encounters, type and expected duration. The order of these phases is also a priority order. Phase A will be completed before phase B is undertaken.

Phase A - Comparison to basic BEU Performance

This phase will address the ABCAS performance at the Technical Center against another target. As this is the primary test in assessing performance, it is quite lengthy and is expected to require 4 days of flight time.

Flight 1 - ATRCBS Target, Performance Level 4

<u>Profile No.</u>	<u>Type</u>	<u>Number of Encounters</u>
4	Tail Chase	4
5	Tail Chase	4
1	Head On	4
2	Head On	4
11	Turning Head On	4
3	Head On	4
		<u>24</u>

Flight 2 - ATRCBS Target, Performance Level 4

<u>Profile No.</u>	<u>Type</u>	<u>Number of Encounters</u>
6	Tail Chase (225° climbing encounter)	2
7	Tail Chase (225° descending encounter)	2
8	Head On (45° climbing encounter)	2
9	Head On (45° descending encounter)	2
19	90° encounter	1
20	90° encounter	1
21	270° encounter	1
22	270° encounter	1
23	45° encounter	1
24	45° encounter	1
25	225° encounter	1
26	225° encounter	1
10	Climbing Head On	4
		<u>20</u>

Flight 3 - DABS Target, Performance Level 4

<u>Profile No.</u>	<u>Type</u>	<u>Number of Encounters</u>
1	Head On	4
2	Head On	4
12	Climbing Tail Chase	4
13	Descending Head On	2
14	Climbing Head On	2
15	Turning Head On	2
16	Turning Head On	2
		<u>20</u>

Flight 4 - ATCRBS Target, Performance Level 5

<u>Profile No.</u>	<u>Type</u>	<u>Number of Encounters</u>
1	Head On	4
2	Head On	4
12	Climbing Tail Chase	4
13	Descending Head On	2
14	Climbing Head On	2
15	Turning Head On	2
16	Turning Head On	2
		<u>20</u>

Flight 4 ATCRBS Target, Performance Level 5

<u>Profile No.</u>	<u>Type</u>	<u>Number of Encounters</u>
1	Head On	4
2	Head On	4
3	Head On	4

Performance Level 3

1	Head On	4
2	Head On	4
3	Head On	4
		<u>24</u>

Phase B - High Density Performance (Washington, D.C., and New York)

The Technical Center airspace generally provides an environment of low level aircraft density and fruit. DABS and ATCRBS encounters will be flown in Washington, D.C. and New York airspace in order to provide higher levels of fruit and aircraft density, in order to determine their effects on system performance.

Phase C - Additional Performance Parameter Evaluation

Although information relative to DMOD, vertical TAU, and the vertical tracker, will be obtained during other parts of the flight program, specifics are the goal of these flights. The flights are designed to specifically evaluate the level 3, 4 and 5 DMOD parameters, generate commands which are vertical TAU dependent, and stress the vertical tracker. These tests will require two flights with the vertical tracker and levels 4 and 5 DMOD tests on one day and the vertical TAU and level 3 DMOD tests on the second day.

Flight 1- Vertical Tracker and DMOD (Levels 4 and 5)

<u>Profile No.</u>	<u>Altitude Separation (Ft.)</u>	<u>Performance Level</u>	<u>Number of Encounters</u>
17	300	4	3
17	300	5	3
18	300	4	3
18	300	5	3
13	2000	5	4
14	2000	5	4
			<u>20</u>

Flight 2 - Vertical TAU and DMOD (Level 3)

<u>Profile No.</u>	<u>Altitude Separation (Ft.)</u>	<u>Altitude Rate</u>	<u>Number of Encounters</u>
27	1500	500	2
27	1500	500	2
27	1500	1000	2
27	1500	1000	2
27	1500	2000	2
27	1500	2000	2
17	300	0	3
18	300	0	3
			<u>18</u>

Phase D - Pop-up Target and Two BCAS Equipped Performance

The purpose of the pop-up target encounter is to observe system warning time (TAU) performance when a target's transponder is turned on within the protective volume. The BCAS versus BCAS Co-Altitude and maneuvering encounters are designed to test the RAR coordination logic. One flight will be devoted to these performance measures.

Phase D - Pop-up Target and Two BCAS Equipped Performance (cont.)

<u>Profile No.</u>	<u>Intruder Equipage</u>	<u>Number of Encounters</u>
3	ATCRBS	2
3	BCAS	2
28	BCAS	4
1	ATCRBS	2
1	BCAS	2
4	ATCRBS	2
4	BCAS	2
19	BCAS	2
23	BCAS	2
		<u>20</u>

Phase E - Multiple Encounters

Multiple encounters will be conducted in various combinations of BCAS, and ATCRBS, equipped aircraft. The encounters are listed below and are expected to take three days due to the number of aircraft involved.

<u>Profile No.</u>	<u>Type Encounter</u>	<u>Aircraft Combinations</u>	<u>Number of Encounters</u>
29	Tail Chase	1 BCAS, 2 ATCRBS	2
30	Tail Chase	1 BCAS, 2 ATCRBS	2
31	Tail Chase	2 BCAS, 1 ATCRBS	3
32	Tail Chase	2 BCAS, 1 ATCRBS	3
33	Tail Chase	2 BCAS, 1 ATCRBS	3
34	Tail Chase	2 BCAS, 1 ATCRBS	3
35	Tail Chase	3 BCAS	2
36	Tail Chase	3 BCAS	2
37	Head On	1 BCAS, 2 ATCRBS	2
38	Head On	1 BCAS, 2 ATCRBS	2
39	Head On	2 BCAS, 1 ATCRBS	3
40	Head On	2 BCAS, 1 ATCRBS	3
41	Head On	2 BCAS, 1 ATCRBS	3
42	Head On	2 BCAS, 1 ATCRBS	3
43	Head On	3 BCAS	2
44	Head on	3 BCAS	2
45	Head On	1 BCAS, 2 ATCRBS	2
46	Head On	2 BCAS, 1 ATCRBS	2
47	Head On	3 BCAS	2
			<u>46</u>

5.3.2 ERBX Test Flight.

In order to verify that the Dalmo Victor ABCAS and the RBX properly interact in a dynamic situation, a test flight will be performed at the Technical Center. It will be the purpose of this flight to exercise the ABCAS/RBX logic from takeoff to landing. Part of this flight will also entail the generation of a maneuver intent by the ABCAS to assure that it will be relayed to and recorded by one of the Technical Center's experimental RBX's (ERBX).

Although the ABCAS will be capable of tracking multiple RBX's, it is not intended at this time to exercise this logic during the flight test. The "RBX Tracking Tests" do, however, cover this function of the ABCAS in the Bench Test Section of this document.

The flight will consist of a takeoff, a landing (both performed with the ABCAS active), a climb, a dive, and a simulated encounter with another aircraft. The simulated encounter will be performed with a ground based mode-C transponder preset to report a non-zero altitude when interrogated. The climb and dive portions of the flight will be such as to cause the ERBX to change the ABCAS performance levels through each of the five possible values.

The flight conditions for this test are shown in table 5 along with the performance level map that will be loaded into the ERBX.

During the flight the ERBX antenna will be located on the roof of the Technical Center's Technical and Administrative Building. In this location the antenna will be approximately 60 feet above and 2000 feet from the main runway (13-31) at the Center.

During the flight the automatic performance level control lines for the ABCAS will be disabled to preclude their interaction with the performance levels transmitted by the ERBX. These lines include the landing gear switch and the radar altimeter trip lines. (It will be necessary to disable these lines in order to ascertain that the ABCAS performance level setting comes from the ERBX.)

Data collection and processing during the flight will be similar to that performed during the "RBX Tracking" Bench Tests. The data sources and processing flow are shown in figure 8. In addition to the ABCAS data extraction tape and the ERBX printouts, a third source of data will be the NIKE Instrumented Radar. Data from this will be correlated with the ABCAS data tape to determine the tracking accuracy.

Results of the test flight will be examined to determine the correct performance level control with respect to the performance level map, as well as, the transmission of the ABCAS maneuver intent to the ERBX during the simulated encounter.

### 5.3.3 Angle of Arrival.

Three types of flight patterns denoted YAW, pitch, and roll, will be flown in order to provide enough data, on conjunction with previous static tests, for a feasibility analysis of the angular errors. (see appendix B). It will be necessary to use the NIKE tracker for both aircraft during these tests. Diagrams of these patterns are shown in figure 17. The pitch pattern will be flown in order to vary the elevation angle and keep the azimuth angle constant. The YAW pattern will be flown in order to vary the azimuth angle and keep the elevation angle constant. Both patterns will be flown with flaps up. The roll pattern will be an elliptical pattern that will result in a variation of both azimuth and elevation angles. The intruder aircraft will come up from behind, to the right, and below the BCAS aircraft

TABLE 5. ABCAS/RBX FLIGHT TEST

Performance Level Boundaries:

	Boundary			
	FL1-PL2	PL2-PL3	PL3-PL4	PL4-PL5
Range (nmi)	1.0	2.0	10.0	15.0
Altitude (1000's feet)	2.0	3.0	5.0	12.0

Flight Conditions:

\*ABCAS on from takeoff to landing

\*Aircraft Speed - 250 knots

<u>Scenario</u>	<u>Altitude (feet)</u>	<u>Range (nmi)</u>
Takeoff	0-200	25
Climb	2000 - 12,000	
Dive	12,000 - 2000	
Landing	2000 - 0	25

FLIGHT TESTS

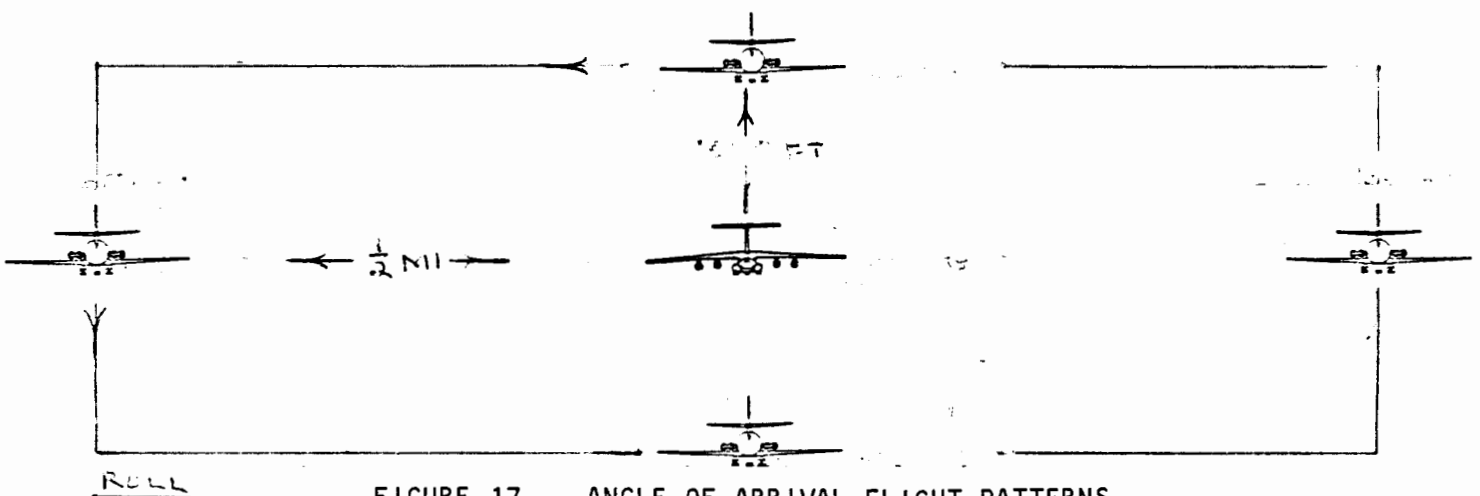
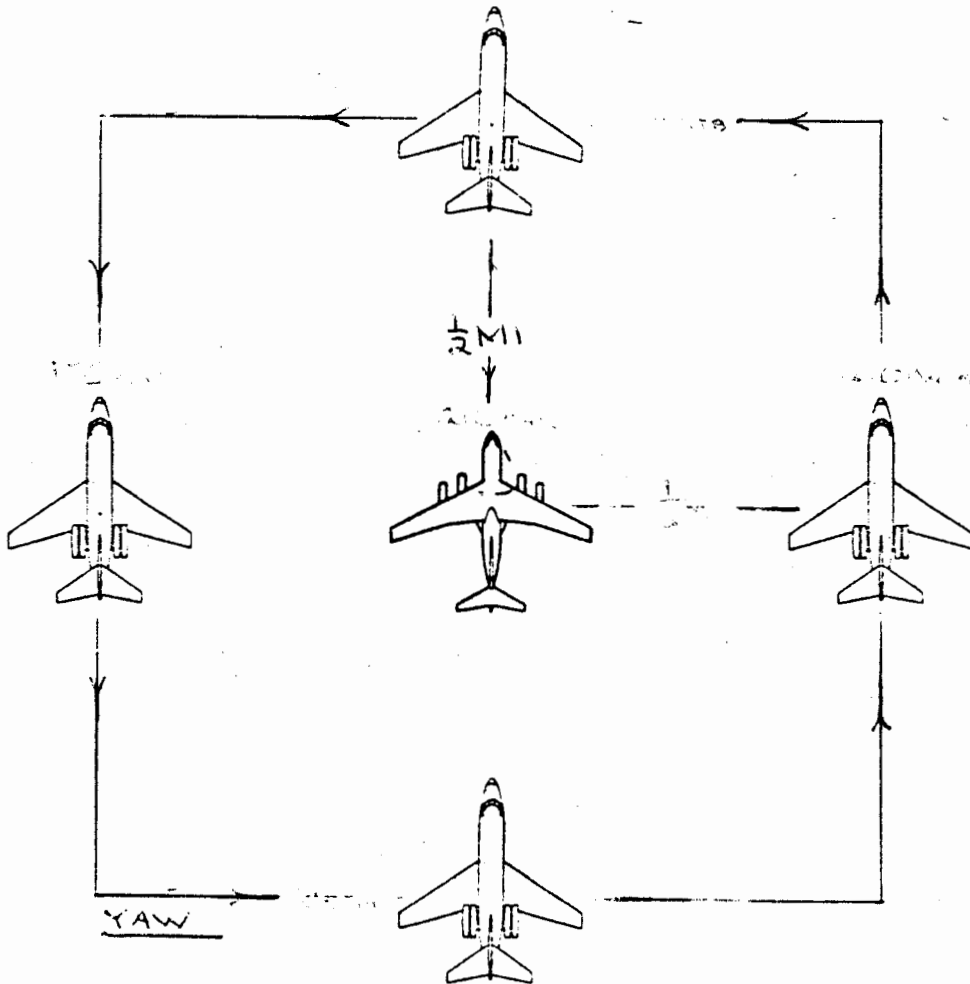
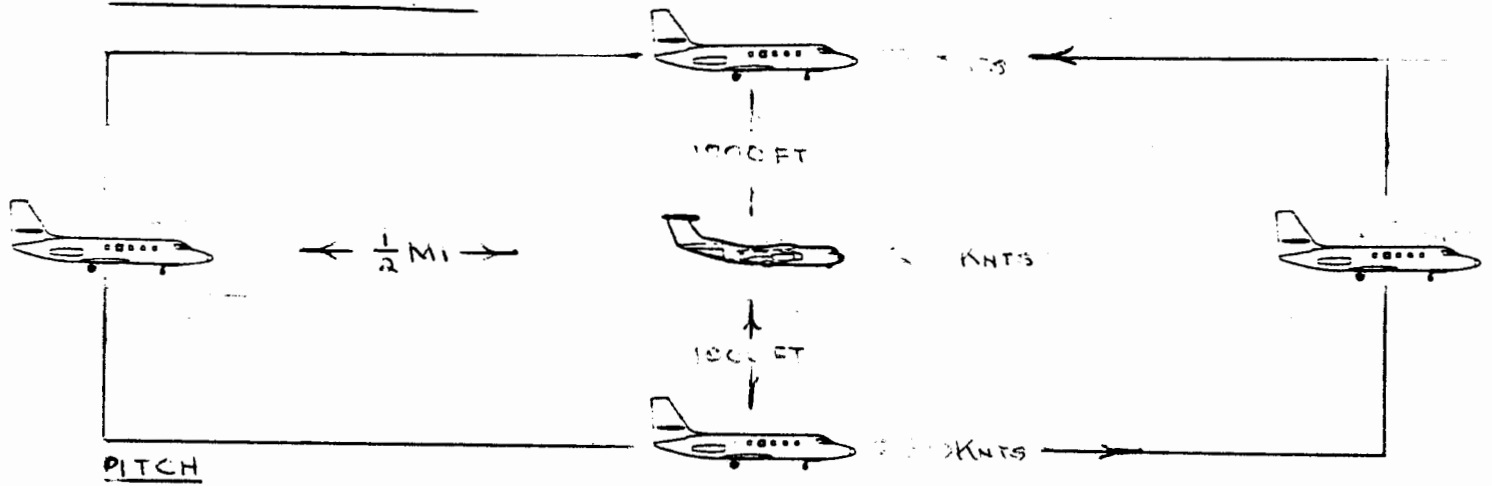


FIGURE 17. ANGLE OF ARRIVAL FLIGHT PATTERNS

then around to the top, left, and front, and then return to its initial position. This pattern will also be flown with full flaps down on both (BCAS = N78, INTRUDER = N49), in order to provide maximum distortion.

Specific areas of interest, such as zones-of-silence, will be defined from the flight tests. The duration of these tests will be one flight with each pattern being repeated twice.

#### 5.3.4 Pilot System Interface.

The human factors portion of this test plan will evaluate the system man-machine interface. Of primary concern is the pilot's ability to recognize, interpret and process an advisory, with the ultimate output being the mechanical motion of the appropriate aircraft controls to accomplish a maneuver commensurate to the advisory. Our aim in this test effort is not to characterize the complex human channel of senses, perception and motor movement, but rather to evaluate the channel performance from display to pilot action using parameters we can readily measure. Of chief concern is delay time, that is how long does it take the displayed information to be perceived by the pilot and the pilot take a meaningful action? The delay time should always be much less than the system TAU for a successful maneuver to be completed.

The pilot delay time is taken as a measure of the display interface performance. The overall delay data is available from data tapes recorded during the test flight (accurate to about one second). The data collection system does not record the individual delay times associated with recognition, perception, interpretation and motion. This will make it difficult to quantitatively evaluate specific display characteristics and is an inherent limitation to this study. It is assumed, for the purposes of this test that the deviation in motion times will be small and independent of the higher order cerebral delay times. Evaluation of specific display characteristics will be accomplished using questionnaires to obtain subjective data.

Accuracy of display interpretations is another important parameter; we must evaluate the display's capability to convey the advisories in a clear, unambiguous manner. The measure of this will be the rate at which the subject pilot performs inappropriate evasive maneuvers. This data is readily available from the encounter plots.

It is not expected that scenarios performed under this test plan will produce typical numbers of display interpretation errors due to the high degree of training and motivation of our subject pilots. It will, however, produce baseline "best case" data from which future evaluations can draw.

Another important parameter is the overall efficiency of the man-machine interface. Ideally, the system should perform its function in a totally transparent mode until an advisory is given. The alert for the advisory should be presented in a manner that minimize reaction time and disruption to other critical tasks being performed at the same time. With this in mind, we are seeking the following kinds of data:

- a. Is there sufficient information transmitted?
- b. Is there an over abundance of non-essential data?
- c. Is there an increase in communication?
- d. Is the pilot workload extended beyond his means?
- e. Is there wasted energy or motion?
- f. Are there nuisance alarms?
- g. Is the automatic sensitivity adjustment adequate?
- h. Does the system help in sighting the conflicting aircraft?

This data will be collected by a trained observer in the cockpit using a formatted questionnaire (appendix B). That data will then be correlated with data obtained on the subject pilot debriefing questionnaire.

We will evaluate the three display subsystems subjectively with specific criteria in mind. Below are descriptions of the subsystems and the kind of data that is desired:

a. Aural Alarm. This aural alarm is expected to be the primary means of alerting the pilot to an advisory. The aural alarm in this system is a sequencing one where each transition to a higher level of advisory is worked by a tone. This feature is intended to reduce pilot workload (fewer visual samples of the IVSI are needed) without producing nuisance alerting of transitioning to lower levels of advisory. We seek to evaluate the aural alarm in the following ways:

1. Does it prompt the pilot?
2. Does it decrease response time?
3. Does it create added workload?
4. Does it distract or annoy the pilot?
5. How effective is the sequencing? Is it an improvement over the single tone system?
6. Is there confusion between this alarm and other cockpit alarms?
7. Is the alarm timely?

b. IVSI Display. The primary means of indicating advisories to the pilot is by the IVSI display. Past evaluation have revealed problems with both color and method of display. We seek to evaluate the IVSI display in the following ways:

1. Does the display wash out in daylight?
2. How is the cockpit location?
3. Are the colors used appropriate to the function?
4. Are the distinct advisories discernible?
5. Is there confusion as to which advisory is being displayed?
6. Does the display enhance pilot confidence?
7. Is the alarm timely?

c. AID Display. The AID display is intended to give ancillary data such as target altitude and position within the protected volume. It is the means by which angle-of-arrival information can be transmitted to the pilot. We seek to evaluate the AID display in the following ways:

1. Is the information displayed in a useable manner?
2. Does it give an indication of aircraft separation?
3. Is the screen visible and clear.
4. Are the alpha- numerics legible?
5. Is there sufficient data?
6. Is there too much data?
7. Does the information presented help in sighting conflicting aircraft?
8. Does the novelty of the display cause distraction?
9. Are the colors appropriate?
10. Is relative position helpful?
11. How often does the pilot observe the display?
12. Does the display enhance pilot confidence?

The questionnaire is constructed to allow the subjects to rate numerically on a scale of 1 to 10. The numbers will then be used to generate statistics (means, variance, distributions) on each subjective category linking similar questions.

No special tests will be scheduled for this effort. All data collected will be from flight tests designed for other purposes. It is expected that if special demonstration tests are run data relevant to this area will also be collected.

## 6. DALMO VICTOR DATA ANALYSIS.

Due to the extensive flight program, Active BCAS multiple participants, (ARINC, Dalmo Victor, MITRE, etc.) and system performance reporting in support of the National Standard and airline flight program, the data analysis is being conducted in the three phases.

Phase I will support the decisions on flight schedules. Phase II will provide the performance data which will permit interested parties to obtain a data base to assess preliminary system performance.

Phase III will provide the in-depth analysis which will result in a final report on the performance of the system based on the overall test program.

In order to provide an official record of the test flight process, a mission report (see appendix C) for each flight will be generated. This report will include information relative to flight objectives, resources, data records, observed problems, and other pertinent activities.

### 6.1 PHASE I - QUICK LOOK ANALYSIS.

The flight test program is primarily going to be conducted on a schedule of three flights per week. In order to provide a level of assurance that the flights are fulfilling their intended design goal, a quick-look flight data analysis will be conducted. This analysis will consist of inputs from hard copies of the performance monitor display, pilot and technical personnel debriefings, and airborne Dalmo Victor 9-track data tapes.

The Dalmo Victor system has a performance monitor which permits data displays on a Tektronix 4052. Subsequently, the displayed data can be hard copied on a Tektronix 4631. During the test flight, technical personnel will constantly monitor system performance and obtain hard copies of pertinent target performance data, and range and altitude versus time plots.

After the flight, a debriefing will consist of discussions relative to system performance and will include subjective and performance data evaluations. Based on inputs from all participants, a qualitative evaluation of the flight will be made. From this evaluation, a preliminary determination will be made relative to the advisability of repeating the test sequence or conducting the next flight and its time of occurrence.

Concurrent with the debriefing, the 9-track flight data tape will be duped and submitted for processing on the Technical Center's Honeywell computer. Successful processing of the tapes will result in creating data files and listings of selected data messages which will be available the morning following the flight. The listings will provide detailed performance data which will permit evaluation of aircraft tracks, command timeliness, and appropriateness of command sense. The created files will be transferred from the Honeywell to a Tektronix 4052 which will be used to create plots of the total flight tape. These plots will consist of altitude and range versus time together with the command sequence (see appendix D, figure D-2).

A consensus of flight success will be established on the basis of listings and a sample of Tektronix plots from the 9-track flight data. This consensus will then be evaluated relative to the previous debriefing consensus and a final flight decision will be made.

Based on the performance monitor hard copy data, debriefings, and 9-track listings and plots, the quick look data summary will provide, as a minimum, the following information relative to the next flight decision process:

Quality of intruder and own trackers,  
Appropriateness of command sense,  
Acquisition range,  
Timeliness of commands,  
Angle of arrival performance and,  
Link performance.

## 6.2 PHASE II - INITIAL DISSEMINATION OF DATA.

The purpose of this phase is to provide an early indication of system performance to the external community (SRDS, MITRE, Lincoln Laboratories) following each flight test. Barring unforeseen delays, the Phase II outputs will be made available for distribution as early as 48 hours after the flight. Included in this package will be,

- a. Encounter summaries
- b. CAS logic plots
- c. Angle of arrival plots

The content and method of producing each of these is described below.

Each encounter will be summarized on a single sheet of paper. These will be compiled manually from flight logs and from formatted listings of BCAS data records (#1, 10, and 11) that were created during the quick look phase. The summaries will contain:

- a. Type of encounter,
- b. Aircraft attitudes,
- c. CAS performance level,
- d. Resolution advisory sequence,
- e. Comments,
- f. Times of:

Acquisition  
First and last resolution advisory,  
First and last traffic advisory and,  
Closest point of approach.

At each of the times (see preceding page, item f.) the following data will be tabulated:

Relative range,  
Relative altitude and bearing,  
Altitude and bearing rate,  
Horizontal TAU,  
Vertical TAU and,  
Predicted vertical miss distance.

The plots in Phase II will consist of a series of six plots for each encounter. These plots will be used to determine whether the CAS logic is functioning according to specification, and, if so, to assess the performance of the design.

The inputs to this plot program are a file, created during Phase I, of certain BCAS recorded data, and intruder track numbers and encounter start and end times which are determined manually from the quick look listings.

A list of the six plots to be provided are shown below. Examples of these plots are contained in appendix D, figures D-3 to D-8. The AOA plot will be a range and bearing plot of an intruder aircraft relative to our own aircraft. All resolution advisories will be indicated as well as closing speed, CPA separation, etc. If during an encounter both aircraft are being tracked, plots 1 through 6 will be duplicated with the information provided by the ground tracker.

- Plot 1 Range and Range Rate versus time
- 2 Own and intruder altitude versus time
- 3 Own and intruder altitude rate versus time
- 4 Altitude difference (own and intruder) and project vertical miss distance versus time
- 5 Modified horizontal and vertical TAU versus time
- 6 Angle of arrival and range versus time.

### 6.3 PHASE III - IN-DEPTH ANALYSIS.

Two hundred and sixty (260) aircraft performance flight tests utilizing two or three aircraft will provide the data upon which the in-depth analysis will be conducted. The performance flight tests include head-on, tail chase and various angular encounters in both level and maneuvering flight patterns. These patterns have been chosen to provide the basis for previous basic BEU comparisons, evaluation of the multiple target logic, air-to-air coordination, critical parameter performance, and pilot/system interface. The tests include aircraft in various equipment configurations which include ATRBS and DABS targets, BCAS versus BCAS, and BCAS versus combinations of equipments in three aircraft encounters.

#### 6.3.1 Tracking Performance.

##### 6.3.1.1 Acquisition Range and Track Continuity.

In order to assure that adequate warning against intruder aircraft is provided, the intruder must be acquired at a great enough range. Once the intruder is acquired and a track has been established, track continuity must be maintained in order for the threat to be evaluated.

Whether or not a target report is provided the CAS tracker, each second of time is a measure of how well the track is maintained. When a target report is not provided, track is maintained by coasting the existing track through that period of time. If a target report is not provided for six consecutive seconds for an ATCRBS track, or ten consecutive seconds for a DABS track, the CAS track will be dropped. Track coast percentages will be provided for each encounter and will be categorized in accordance to position above and below the BCAS equipped aircraft, range from the BCAS equipped aircraft, and prior to and after closest point of approach. In addition, the probability of remaining in track will be estimated for both ATCRBS and DABS targets.

#### 6.3.1.2 False and Missed Tracks.

False tracks are undesirable for two reasons: First, they can make the choice of a correct maneuver for conflict resolution impossible by obscuring a real threat and, second, they can result in overloading track files to the extent that the BCAS degrades. These tracks are caused by Mode A/Mode C conversions, multipath on interrogations and replies, and other phenomena. As a minimum, ARTS tracks in the Technical Center environment will be compared with BCAS tracks over a one hour period. A percentage of track correlations between the independent systems will be established. This correlation effort will include a false and missed track evaluation for uncorrelated tracks. The correlations will be limited to within 10 nautical miles of the BCAS equipped aircraft.

#### 6.3.2 CAS Logic.

The threat detection and resolution capability of the CAS logic will be determined by evaluating range and altitude warning times (TAU), command correctness, missed and false alarm characteristics, and pilot response effects on vertical missed distance.

##### 6.3.2.1 Warning Times (TAU).

The flight paths of the BCAS and target aircraft are designed to generate alarms. Each encounter will be analyzed to determine the time of the alarm and the proximity of the aircraft when the alarm occurs. The applicable range and altitude warning times (TAU) will be determined and the distribution of the TAUs will be histogrammed and averages, standard deviations, and confidence limits will be calculated. Since the encounters are designed to generate alarms, an evaluation of missed alarms will be made. In addition, all alarms generated by the BCAS will be evaluated to establish the characteristics of the intruder causing the alarm. All alarm occurrences will be evaluated to establish the causes of missed expected alarms or the validity of unexpected alarms.

##### 6.3.2.2 Command Correctness.

The encounter flights include aircraft which are above, below, and at co-altitude with the BCAS equipped aircraft. For those encounters in which the aircraft are above or below, the command sense can be anticipated

beforehand and the correctness of the sense can be established. For encounters which are at co-altitude, the correctness of the command sense can only be established as a result of post flight analysis. Summaries will be established relating the type of encounter and the command sense outcome. For those encounters which are flown at co-altitude, those that result in command sense opposite to that anticipated and those that are unplanned, the flight data will be extensively evaluated to determine command characteristics. In addition, the flight data will be input to the BCAS surveillance and CAS logic software, which has been established for use with the Technical Center's Honeywell computer. The results of the Honeywell CAS logic will be compared to the Dalmo Victor systems CAS logic results for evaluation and verifications purposes.

### 6.3.3 Fruit and Density.

The basic BCAS engineering unit flight test plan established a measure of aircraft density and fruit density. The aircraft density was defined as all Mode A and Mode C transponders and DABS transponder equipped aircraft within 10 miles of the BCAS aircraft over a one minute period. The perceived fruit density was defined as follows:

$$\text{Perceived Fruit} = \frac{\text{Replies-Density}}{(\text{Number of interrogations}) (\text{Listening interval})}$$

The present flight program will include encounter flights at the Technical Center, Washington, D.C., and New York City. These flights will include both DABS and ATRBS targets. BEU evaluations have indicated that fruit levels increase significantly from low at the Technical Center to high at New York City. The results of the encounters at the three areas will be evaluated to determine if the higher levels of traffic affect the Dalmo Victor prototype performance.

### 6.3.4 Range and Bearing Accuracy.

Encounter flights involving two or more Technical Center aircraft will be tracked by multiple tracking radars. The ground tracking data will then be compared to identical data generated by the prototype units. Comparisons will be made of radar versus BCAS range, altitude rate, and range rate. Attempts will be made to establish BCAS error as a function of BCAS range. Average and standard deviation statistics will be calculated for range, range rate, and altitude rate errors. The prototype units provide bearing on target aircraft. Although this information is not used for threat evaluation and resultant maneuver commands, it does provide a basis for establishing intruder clock position. By using ground tracking information in conjunction with aircraft pitch, heading, and roll (see appendix F), an independent bearing measurement is available for prototype bearing comparisons. The encounter flights are designed to provide data for which multiple BCAS bearing positions can be compared to ground trackers. Attempts will be made to obtain a measure of prototype bearing accuracy and to establish statistical estimates. In addition, comparisons will be made to the accuracies established in the Angle of Arrival Tests of paragraph 5.3.3.

### 6.3.5 Multiple Encounters and Air-to-Air Coordination.

A number of three aircraft encounter profiles will be flown. The profiles, which are exhibited in appendix A, consist of BCAS versus two ATCRBS, two BCAS and one ATCRBS, and three BCAS equipped aircraft. The profiles are designed to check the ability of the logic to limit the rate of climb or descent of a single aircraft in conflict with one of two other aircraft and to reverse the command, generated as a result of resolving the first aircraft, when encountering the second aircraft. Other profiles are designed to limit the single aircraft to no climb/no descent commands. Various combinations of commands will be generated on similar encounters and are dependent upon the equipage of the various aircraft. Post flight analysis will evaluate the appropriateness of the encounter resolutions.

Two aircraft encounters and a number of three aircraft encounters contain two BCAS equipped aircraft. These encounters will be used to evaluate the reliability of air-to-air conflict coordination. A post flight analysis of the recording from the BCAS equipped aircraft will be accomplished to determine the content and sequence of coordination messages, and the displayed alarms and commands. Measures of reliability will be the percentage of conflict coordinations initiated and completed, the number of interrogations required to effect coordination, and the delay in issuing alarms due to coordination requirements.

### 6.3.6 Specific Tests.

Three specific groups of tests have been developed to evaluate the DMOD parameter, the pop-up target warning time, and the vertical tracker. Since each of the tests have limited numbers of flights, the evaluations will result mainly in generalizations.

The pop-up target tests are designed to evaluate the system's warning time performance when a target's transponder is turned on within the protective volume. Evaluations will include the time required to establish track and subsequently resolve the threat, range TAU, correctness of the command, and the time remaining to closest point of approach.

The vertical tracker tests are basically designed to recreate the August 4, 1980, Canton, Ohio, unplanned encounter upon which extensive analysis was performed. These analyses provided added impetus to the development of the present tracker. The evaluations will consist of encounter resolution characteristics and the time required for the tracker to recognize aircraft flight path changes. These encounters will be verified in the Honeywell CAS logic.

The DMOD tests are designed to evaluate the performance of the system in parallel flight just outside the DMOD zone and subsequently turning into the zone. Evaluations will consist of all the characteristics associated with a threat resolution such as range TAU and correct command. The real time track data will be run through the Honeywell CAS logic software for verification purposes.

## 7. INSTRUMENTATION AND FACILITIES.

The flight test program and directional antenna ground evaluation will require up to three aircraft and various combinations of ground support facilities. These ground support facilities will be utilized to obtain the BCAS equipped and threat aircraft flight positions, to support ground evaluations of the directional antenna, and to verify targets of opportunity at terminal areas and the Technical Center. The specific ground support equipment are the following:

Extended Area Instrumentation Radar (EAIR) - A C-Band tracking radar used in the beacon tracking mode for obtaining aircraft position data.

Nike Hercules - An X-Band radar tracking system, capable of independently tracking two aircraft, used for obtaining aircraft position data.

Automated Radar Terminal System (ARTS III) - A beacon tracking system which will be utilized to verify the presence and position of tracked aircraft.

HP3801A Total Station - A short range, automatic, direct reading, electro-optical distance and angle measuring instrument utilizing an infrared light source. The station will be used to obtain distance, azimuth, and elevation data during the angle of arrival static tests.

MLS Van - A vehicle containing a built-in power generator and an automatically controlled MAST whose height can be varied from 5 to 55 feet. The van will be used in the angle of arrival static tests and will be equipped with an ATCRBS transponder, 1 GHz antenna, variable attenuator and 18 volt power supply.

## 8. COORDINATION AND AREAS OF RESPONSIBILITY.

The management of the Dalmo Victor prototype test program at the Technical Center is the responsibility of ACT-100J of the Systems Test and Evaluation Division. The responsibilities described below are specifically related to the flight program and reflect Technical Center activities with respect to its implementation and resultant evaluation. Program coordination is required with the Separation Assurance System Branch, ARD-240, which is responsible for the overall management of the prototype Active BCAS Program for the FAA. Interfacing is required with the Massachusetts Institute of Technology Lincoln Laboratory for surveillance functions, MITRE-METREK for CAS/RAR logic, ARINC for the Piedmont Test Program, and Dalmo Victor for support and maintenance of the prototype software and hardware.

Although many Technical Center organizations are responsible for conducting a successful flight program, primary contributors to conducting the flights, evaluating the resultant data, and generating the reports are the Reports Processing Section, Analysis Branch, Aviation Facilities Division, Range Programming and Analysis Branch, and the Air Traffic Control Tower. In addition to these Technical Center organizations, a private contractor, Input/Output Computer Services provides measurable inputs to the program.

#### 8.1 ACT-100J BEACON COLLISION AVOIDANCE SYSTEM PROGRAM.

Coordinates all Technical Center organization and outside activities relative to the flight program. Develops and participates in conducting flight programs. Reduces and analyzes test results and generates reports relative to system performance.

#### 8.2 ACT-220 ANALYSIS BRANCH.

Provides system support relative to surveillance and RAR logic to all participants. Assists in evaluating test results and performance inconsistencies. Develops software for flight data inputs to RAR logic.

#### 8.3 ACT-750 RANGE, PROGRAMMING AND ANALYSIS BRANCH.

Provides mathematical and software support for development of software programs to reduce and analyze flight data. This includes developing production type software, mathematics and software to support statistical and error analyses, and software to visually display, via plots, the analyses. Provide and operate ground support facilities (NIKE, EAIR) and aircraft interfaces. Assist in processing ground facility data tapes and developing hardware and software for airborne ground tracking data recording.

#### 8.4 ACT-600 AVIATION FACILITIES.

Responsible for providing an aircraft test bed, maintaining aircraft and interfaces with project equipment making available and scheduling aircraft and supplying a crew to fly and maintain aircraft during flight programs at the Technical Center and other test areas. Assist project personnel in developing flight programs and subjective analysis of flight results.

#### 8.5 ATC - AIR TRAFFIC CONTROL TOWER.

Provide the clearances and coordination necessary to conduct a flight test program in the Technical Center airspace.

#### 8.6 INPUT/OUTPUT COMPUTER SERVICES (CONTRACTOR).

Maintains primary responsibility to reduce flight data to useable analysis formats. Develops software to extract and format data from airborne tapes, creates data files, reduces, accumulates, plots, and displays data on CRTs and hard copy printouts. Interfaces with all other software and data analysis participants in order to assure a coherent software development and analysis effort.

9. SCHEDULE.

Unit 1 delivery at Technical Center.	5/81
Bench acceptance test completed.	7/81 (No RBX)
Bench tests completed.	10/81
Flight acceptance test completed.	7/81
Unit 2 delivery.	8/81
Airborne data collection started.	8/81
Unit 3 delivery.	8/81
Airborne data collection completed.	10/81
Draft coordination report.	11/81
Published final report.	12/81

APPENDIX A

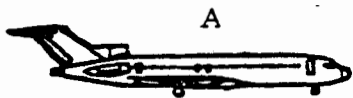
AIRCRAFT PROFILES WHICH WILL BE UTILIZED DURING  
THE DATA COLLECTION FLIGHT TESTS



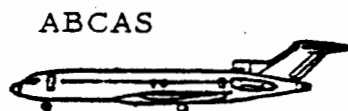
300 feet



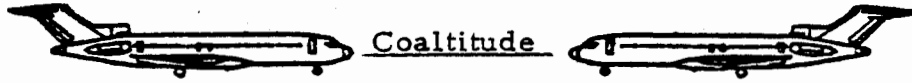
PROFILE 1



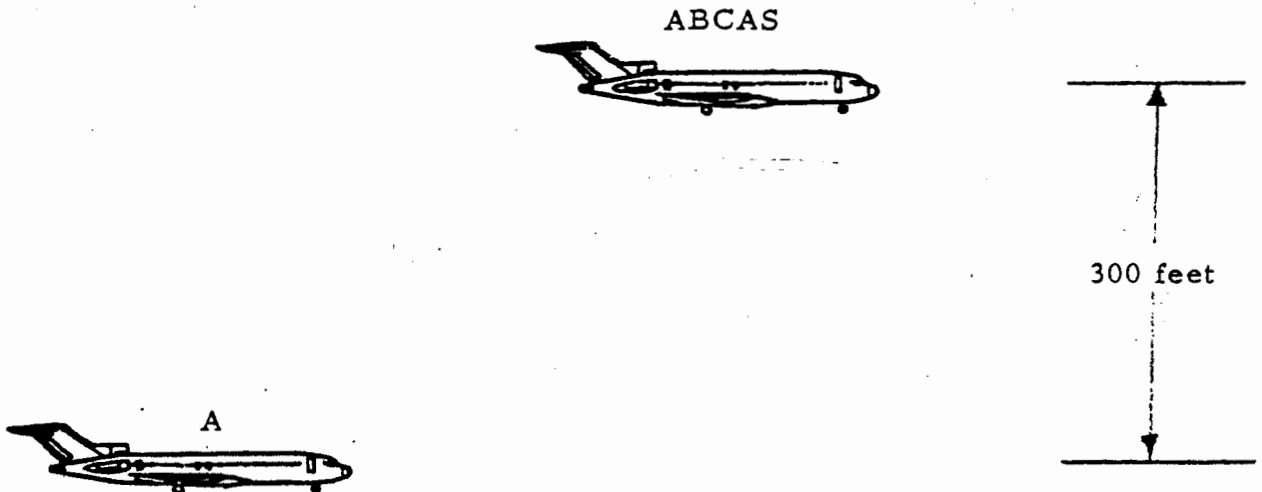
300 feet



PROFILE 2

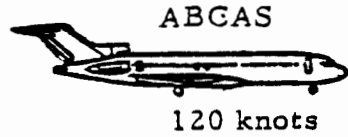
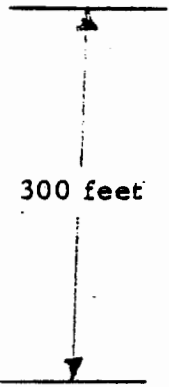
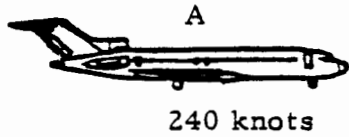


PROFILE 3



PROFILE 4

A-2

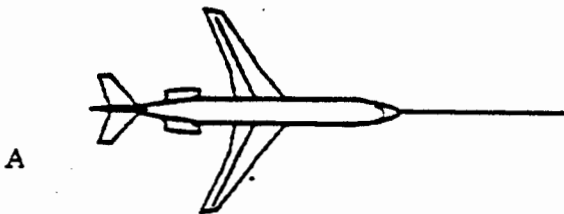
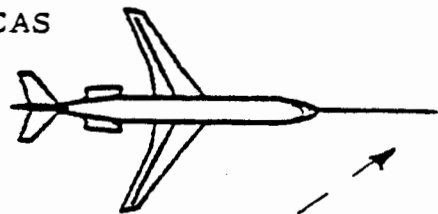


PROFILE 5

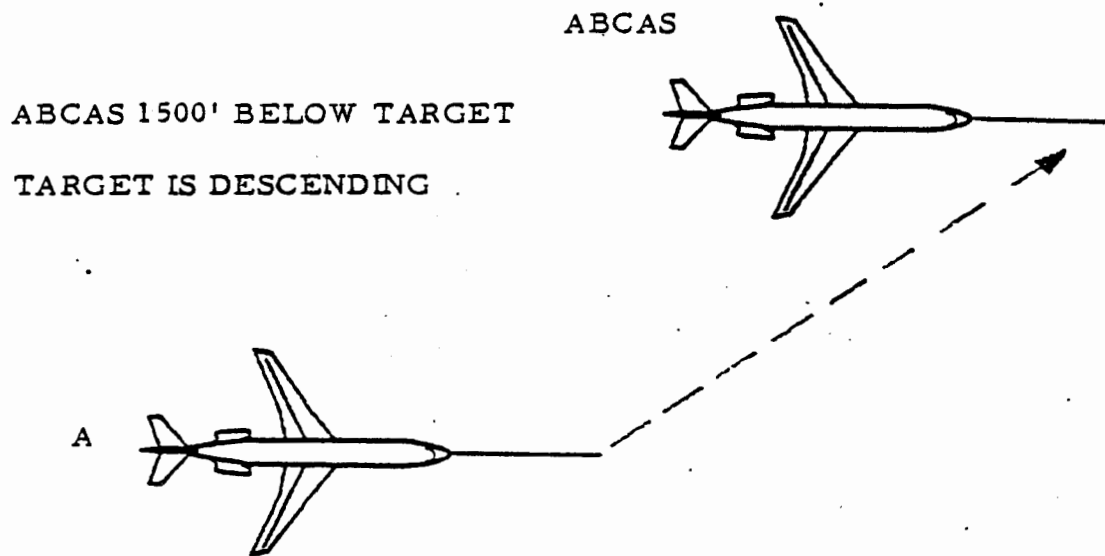
ABCAS 1500' ABOVE TARGET

TARGET IS CLIMBING

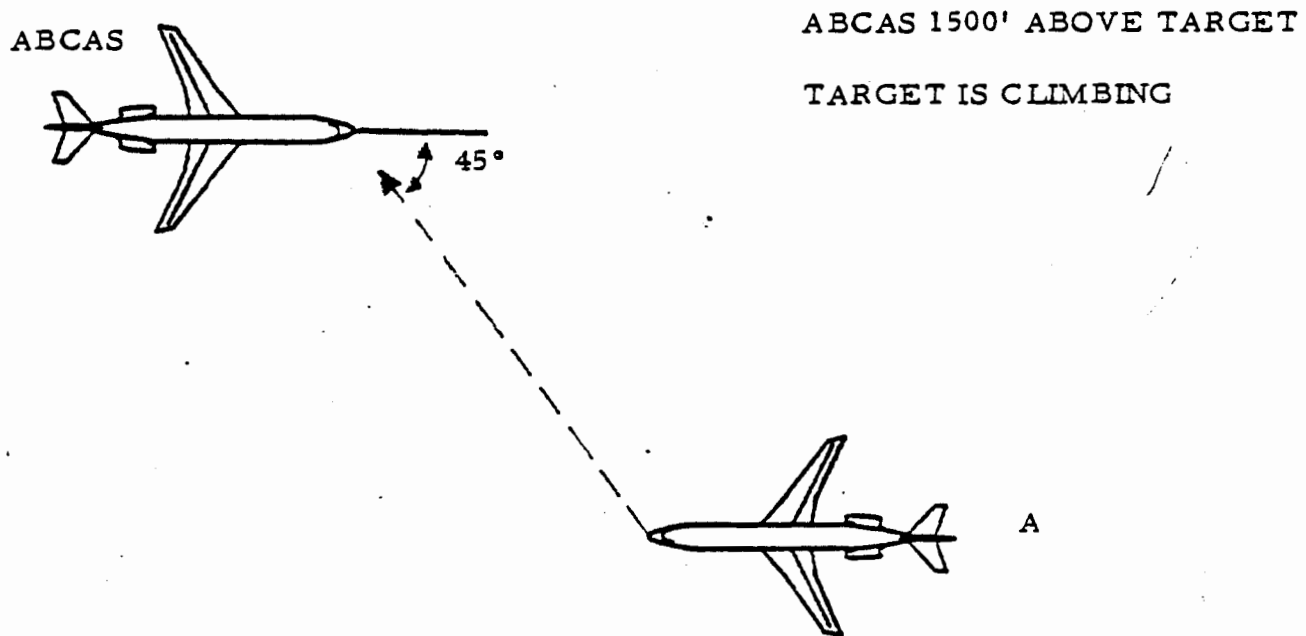
ABCAS



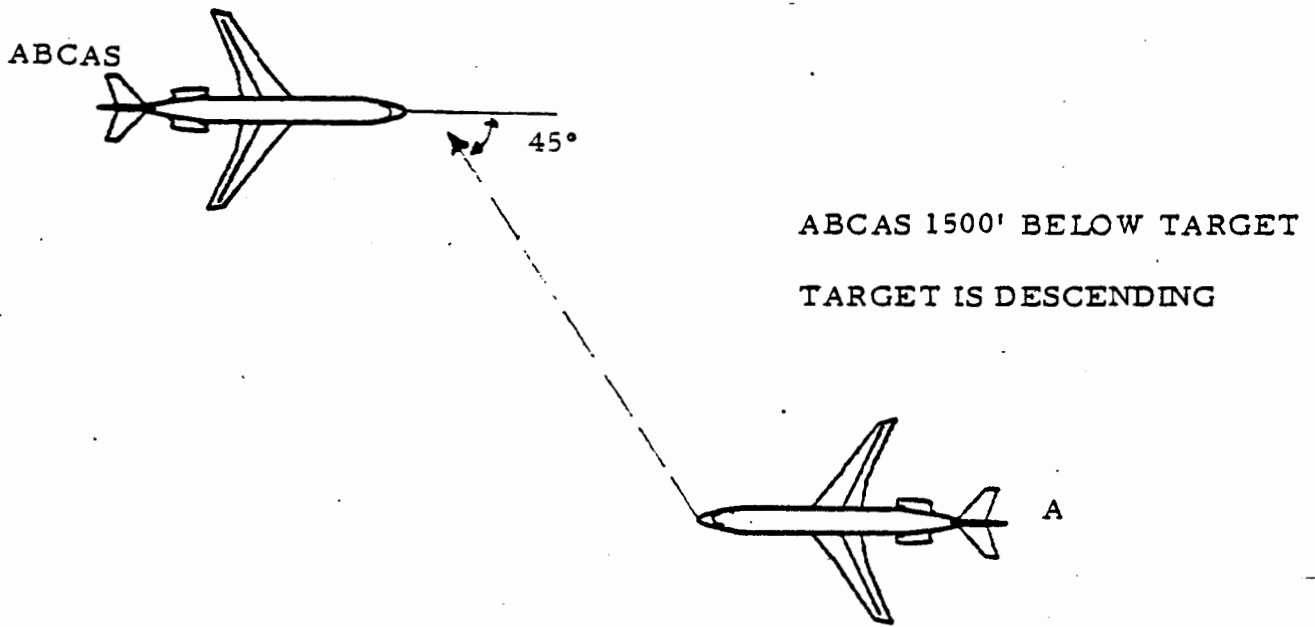
PROFILE 6



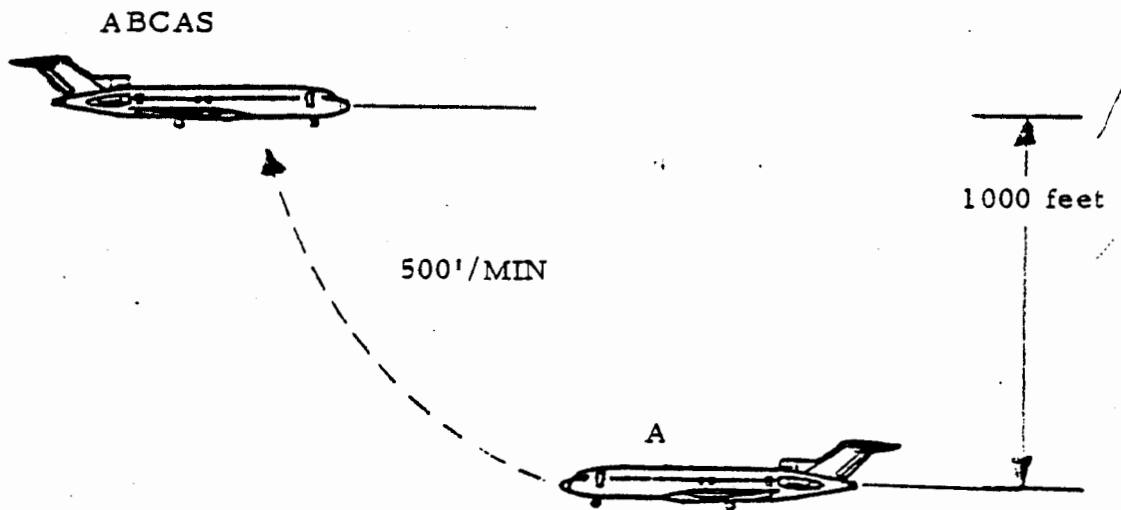
PROFILE 7



PROFILE 8

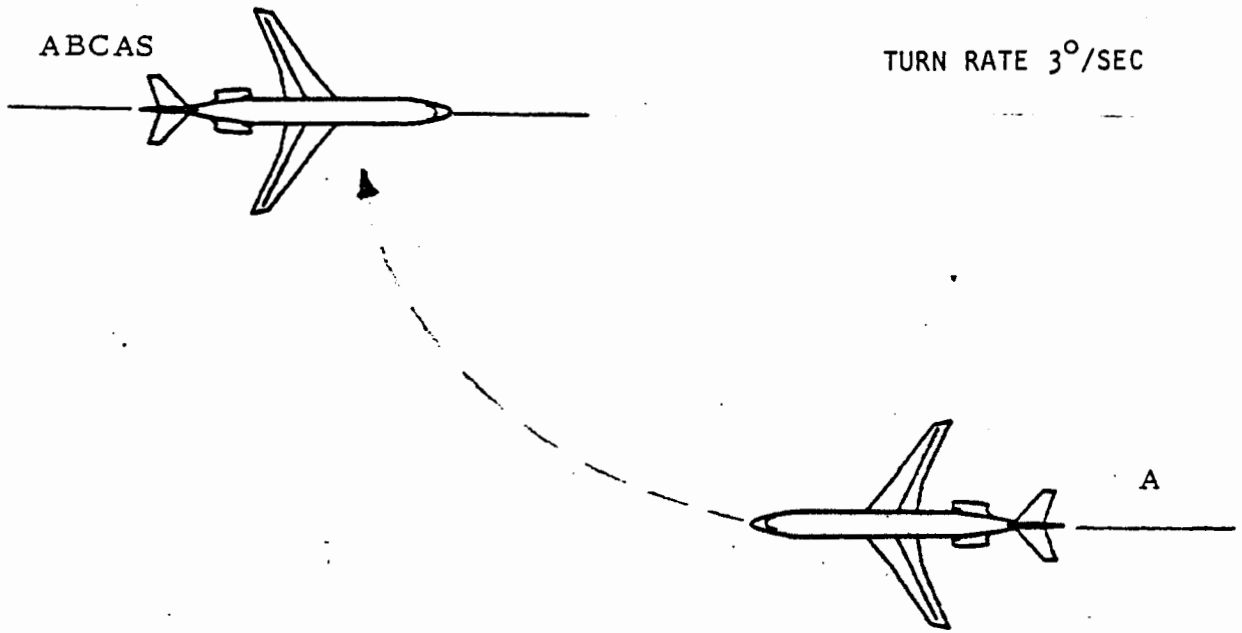


PROFILE 9

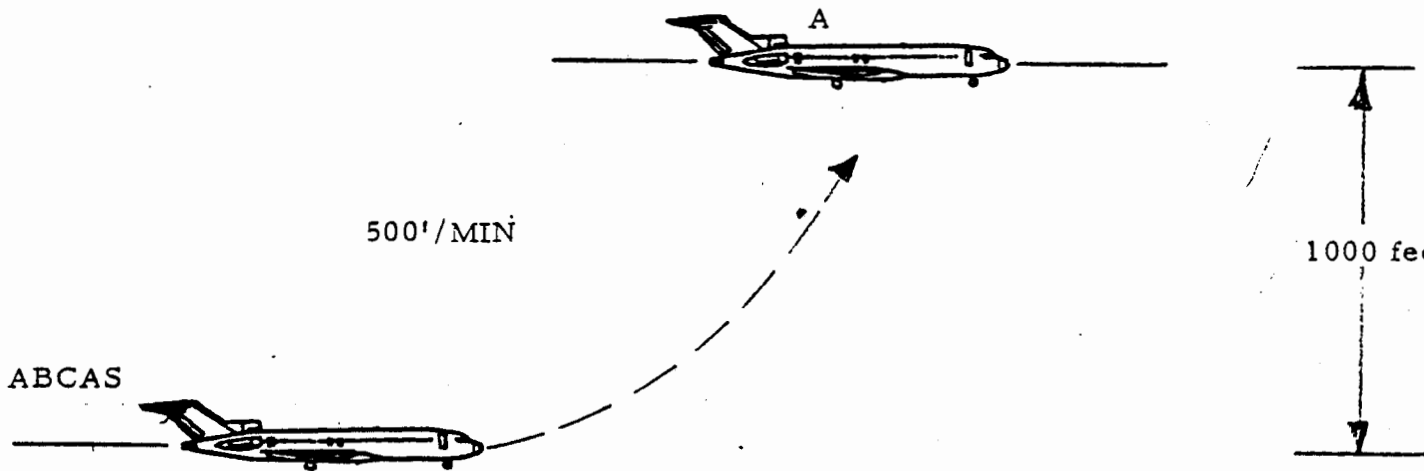


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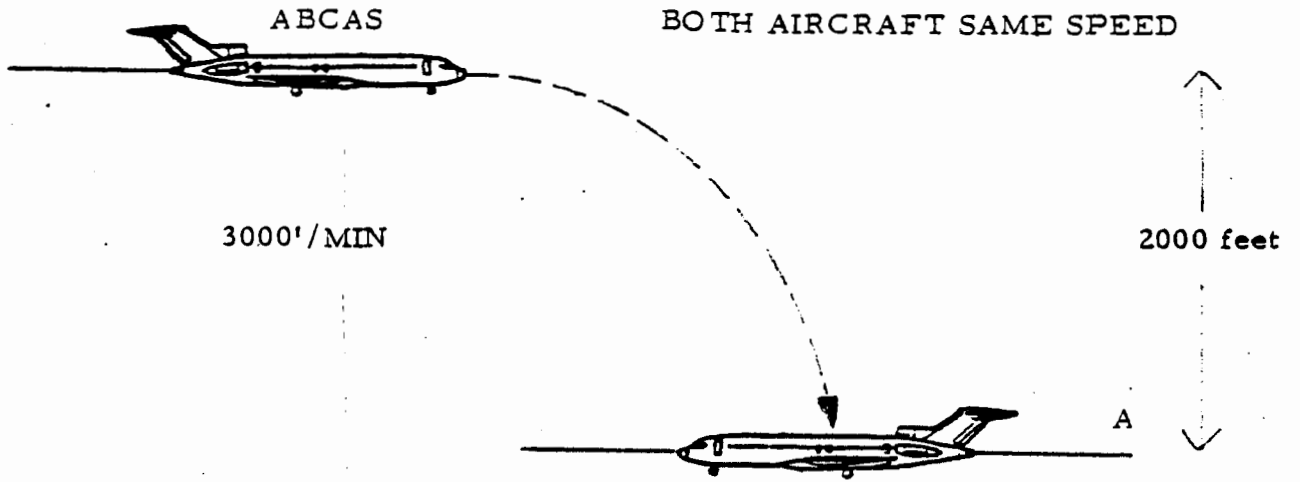
A-5



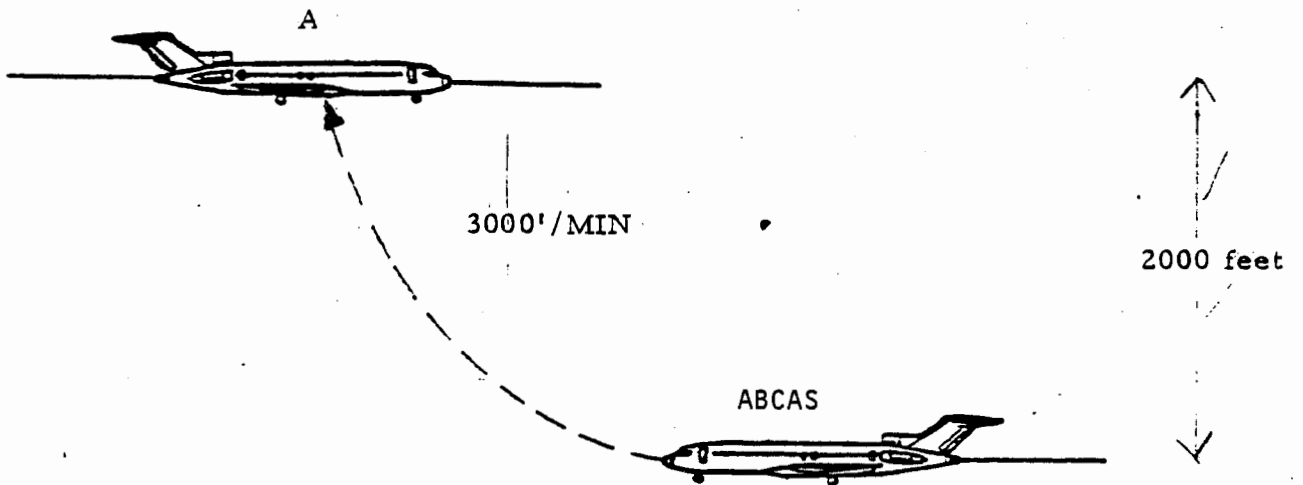
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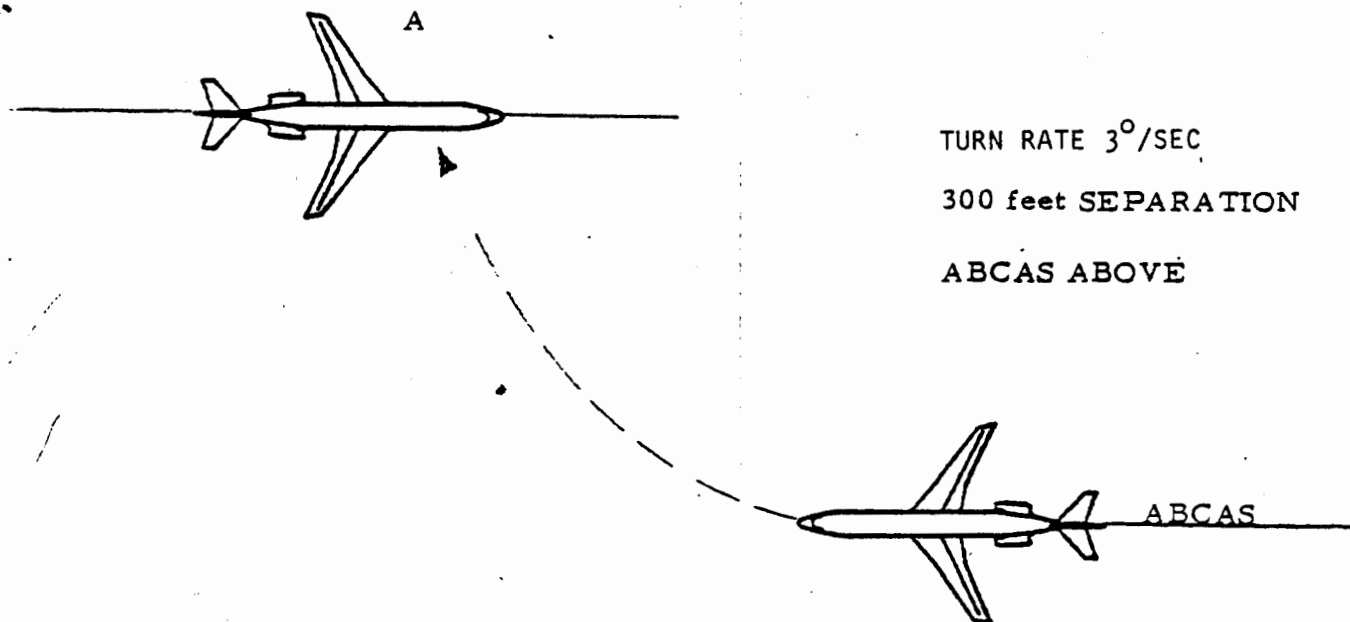
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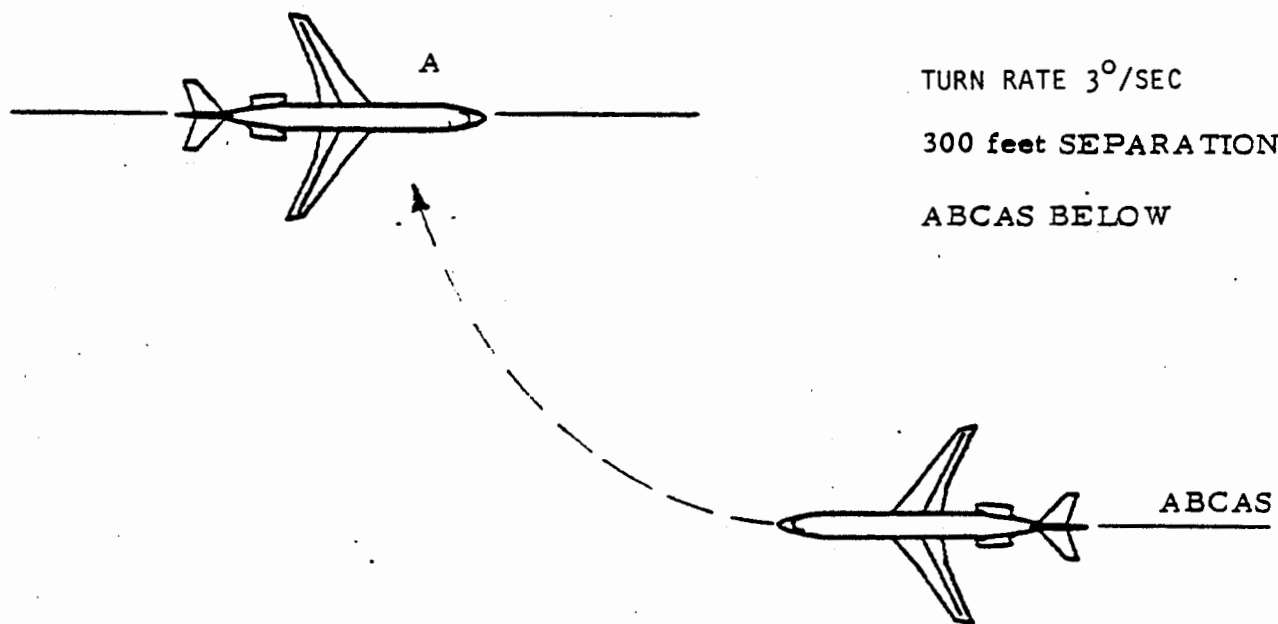
PROFILE 13



PROFILE 14



PROFILE 15

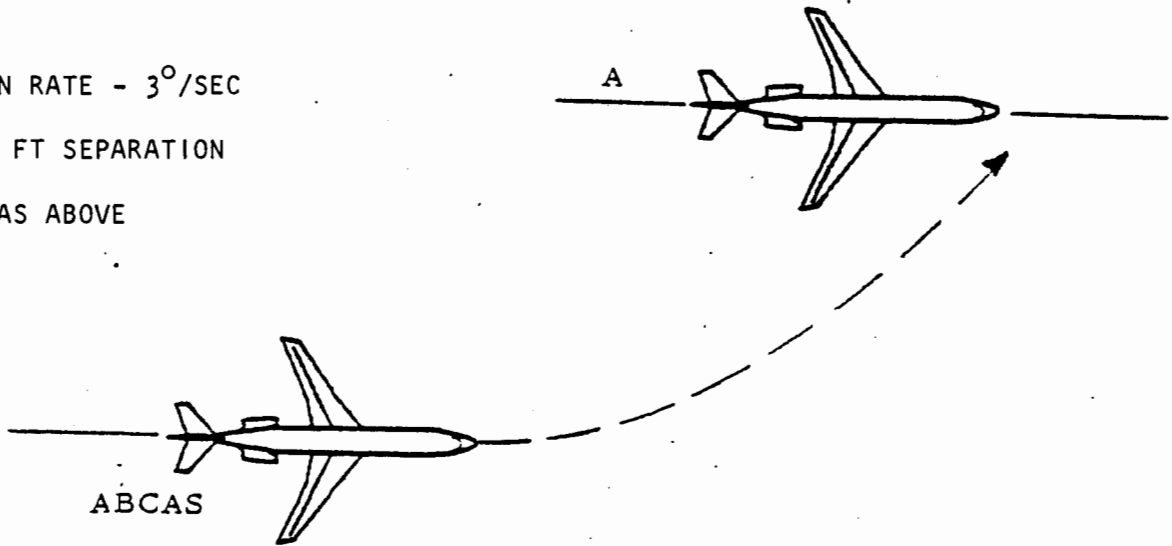


PROFILE 16

TURN RATE -  $3^{\circ}/\text{SEC}$

300 FT SEPARATION

ABCAS ABOVE

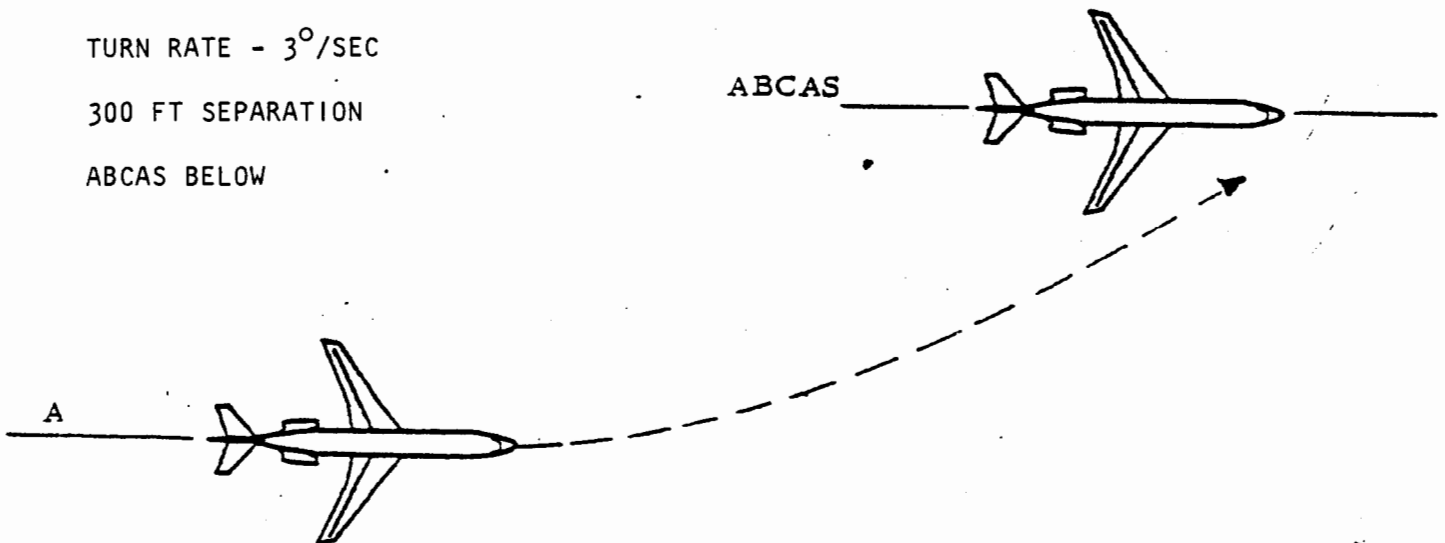


PROFILE 17

TURN RATE -  $3^{\circ}/\text{SEC}$

300 FT SEPARATION

ABCAS BELOW

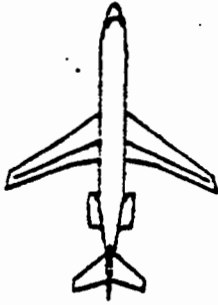


PROFILE 18

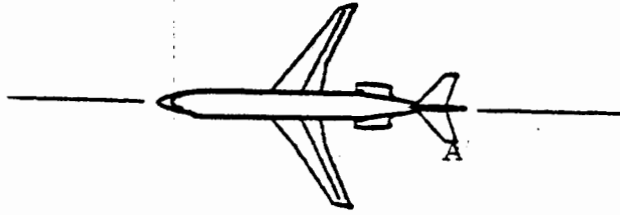
90° ENCOUNTER

300 feet SEPARATION

ABCAS ABOVE



ABCAS

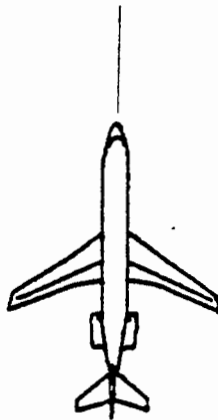


PROFILE 19

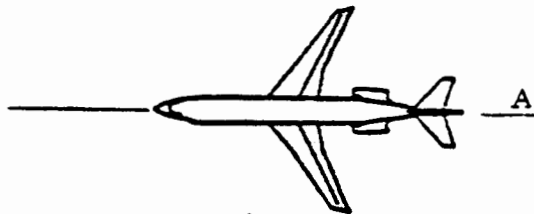
90° ENCOUNTER

300 feet SEPARATION

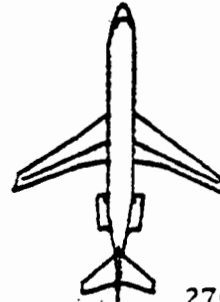
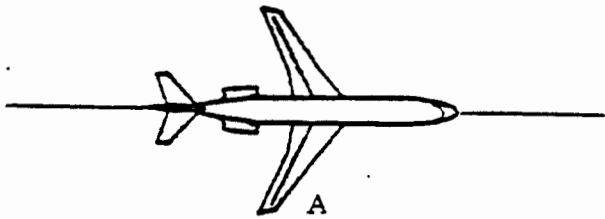
ABCAS BELOW



ABCAS

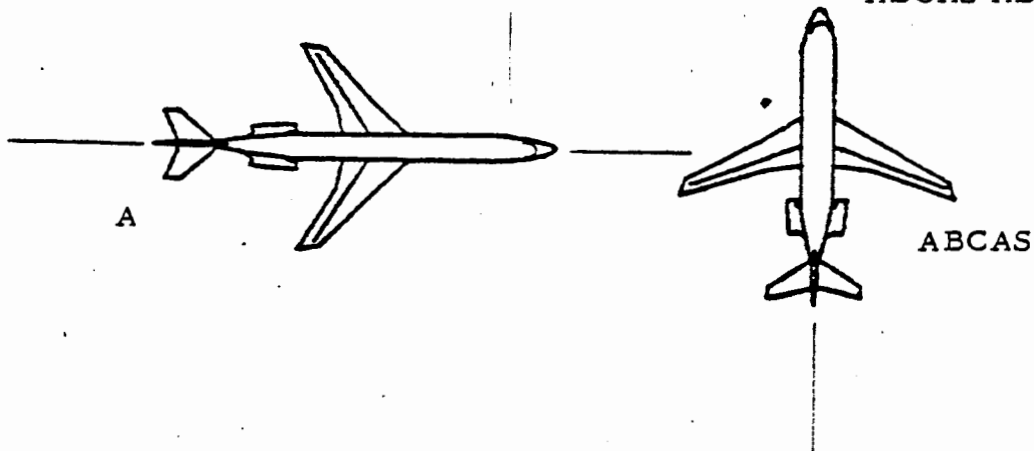


PROFILE 20



ABCAS  
270° ENCOUNTER  
300 feet SEPARATION  
ABCAS BELOW

PROFILE 21

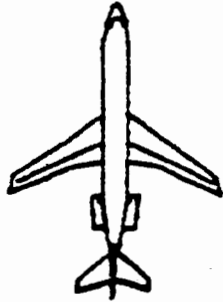


270° ENCOUNTER  
300 feet SEPARATION  
ABCAS ABOVE

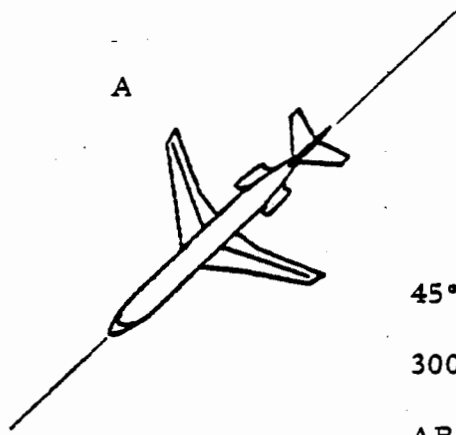
PROFILE 22

A-11

ABCAS



A



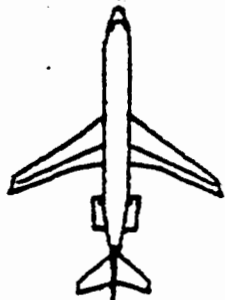
45° ENCOUNTER

300 feet SEPARATION

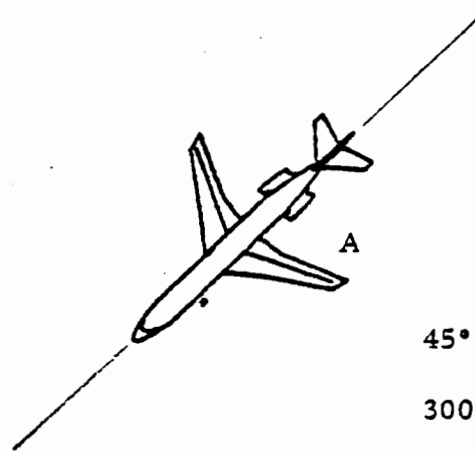
ABCAS ABOVE

PROFILE 23

ABCAS



A

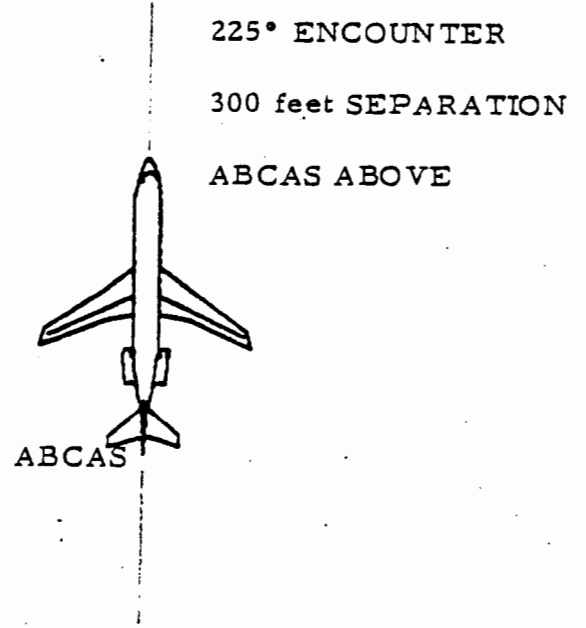


45° ENCOUNTER

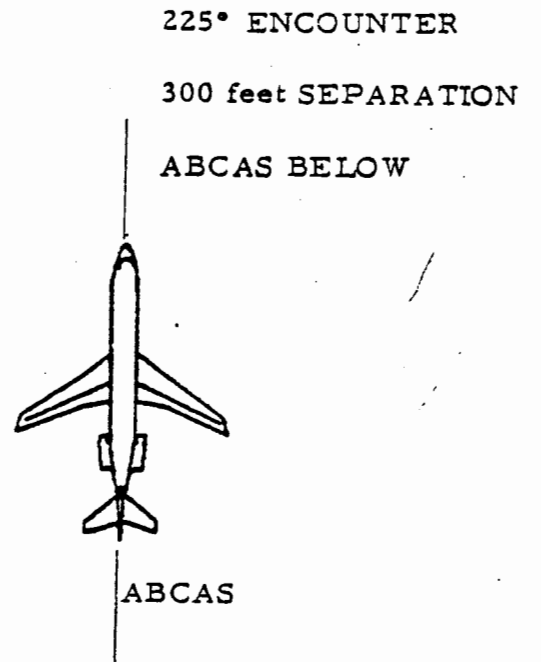
300 feet SEPARATION

ABCAS BELOW

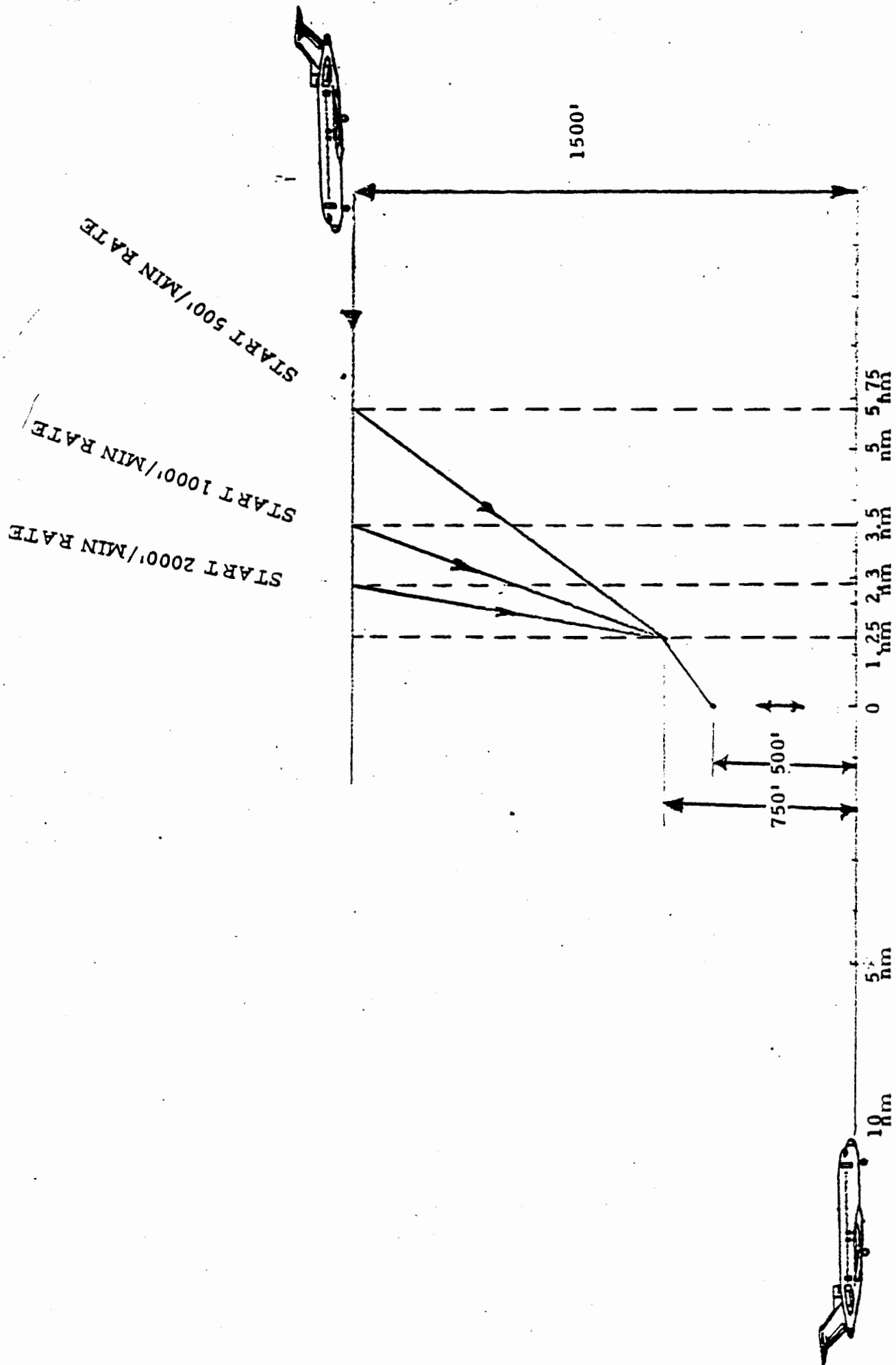
PROFILE 24



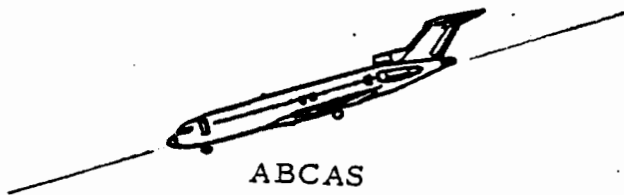
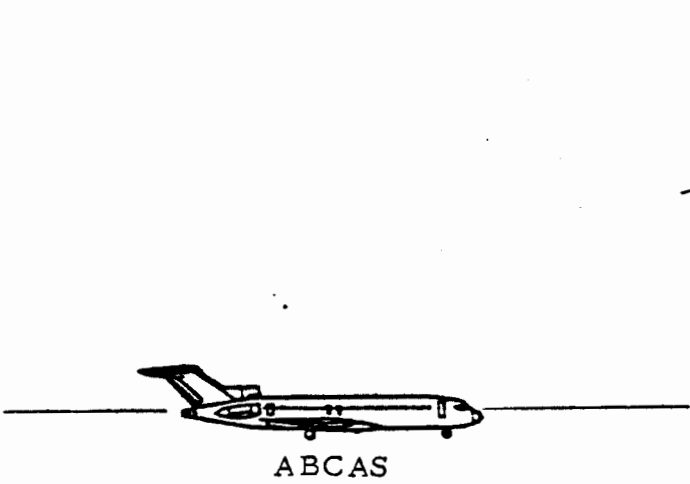
PROFILE 25



PROFILE 26

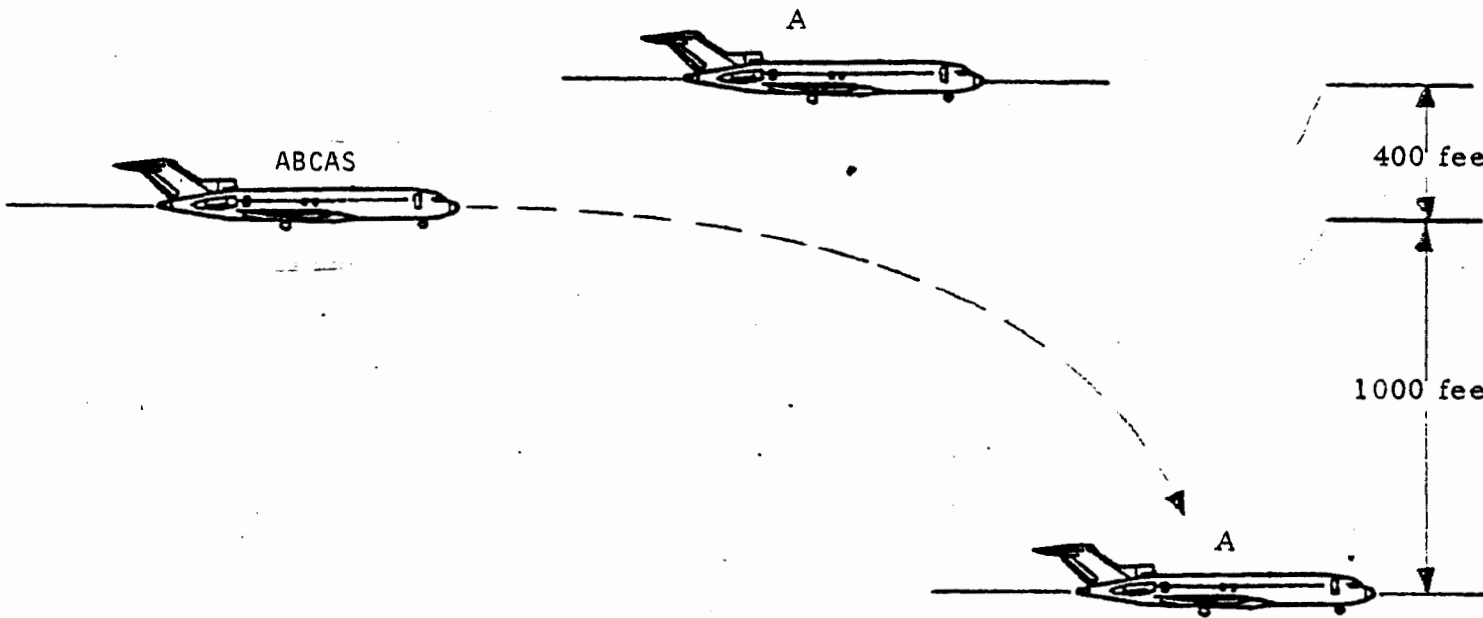


PROFILE 27

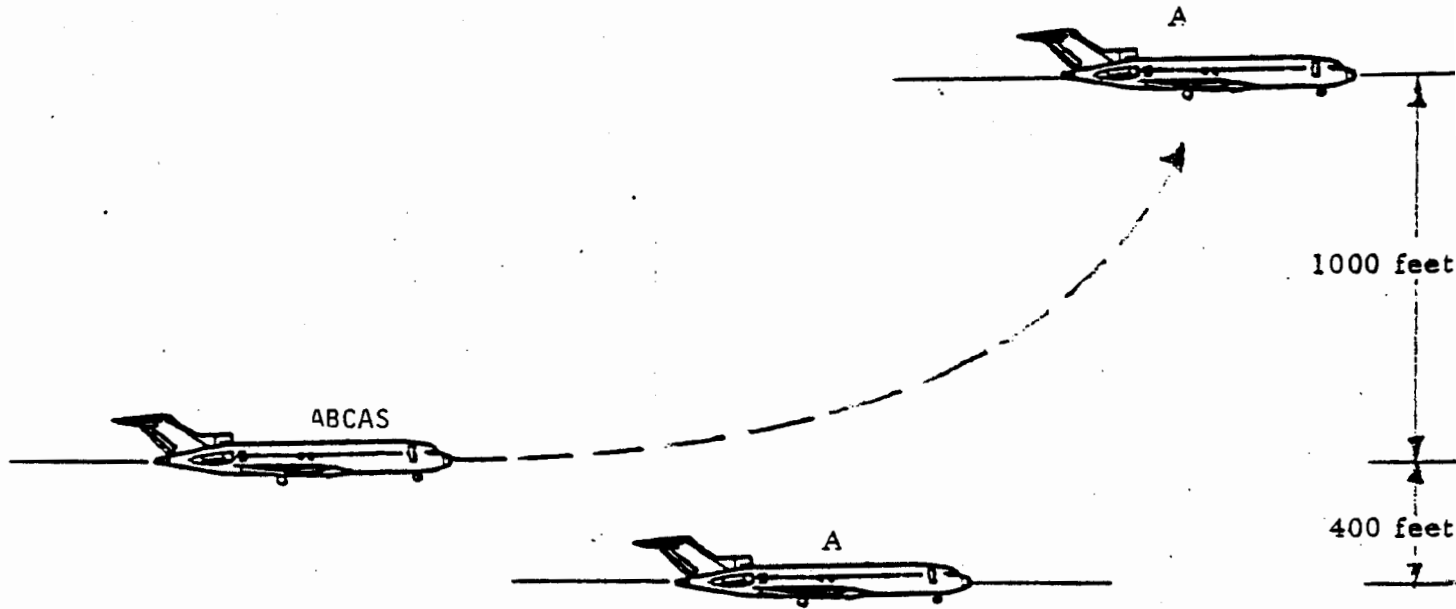


RATE OF DESCENT  
2000 feet/min.

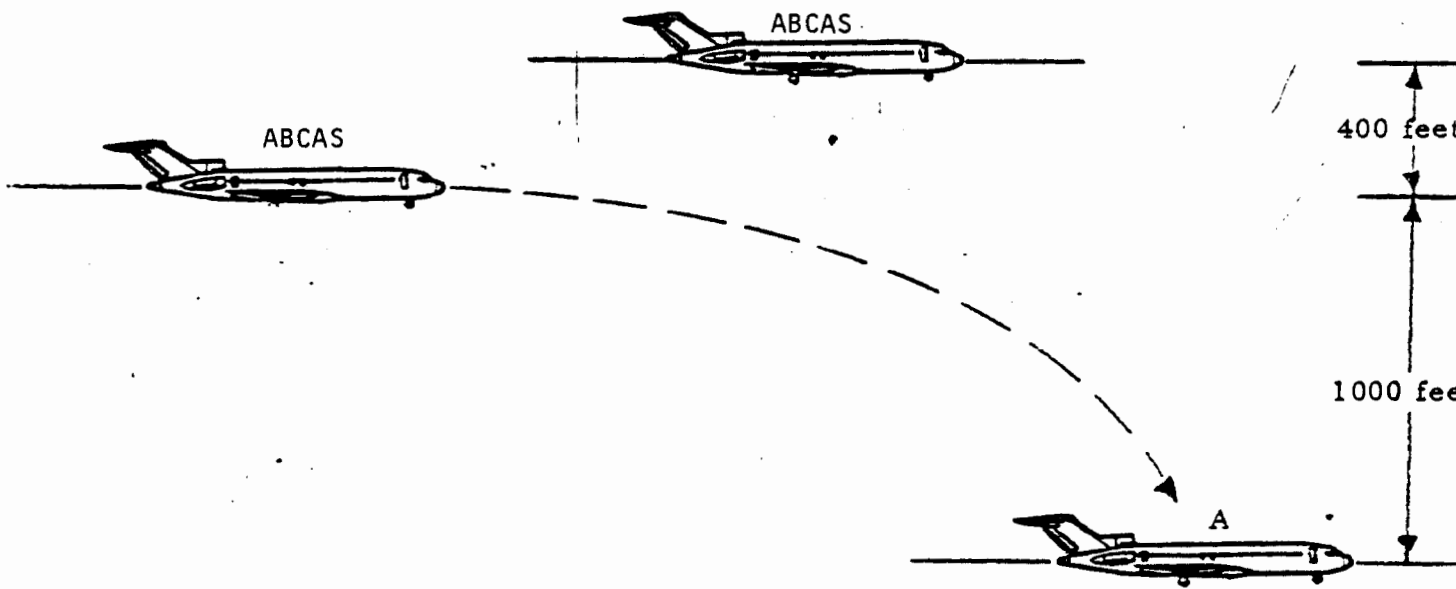
PROFILE 28



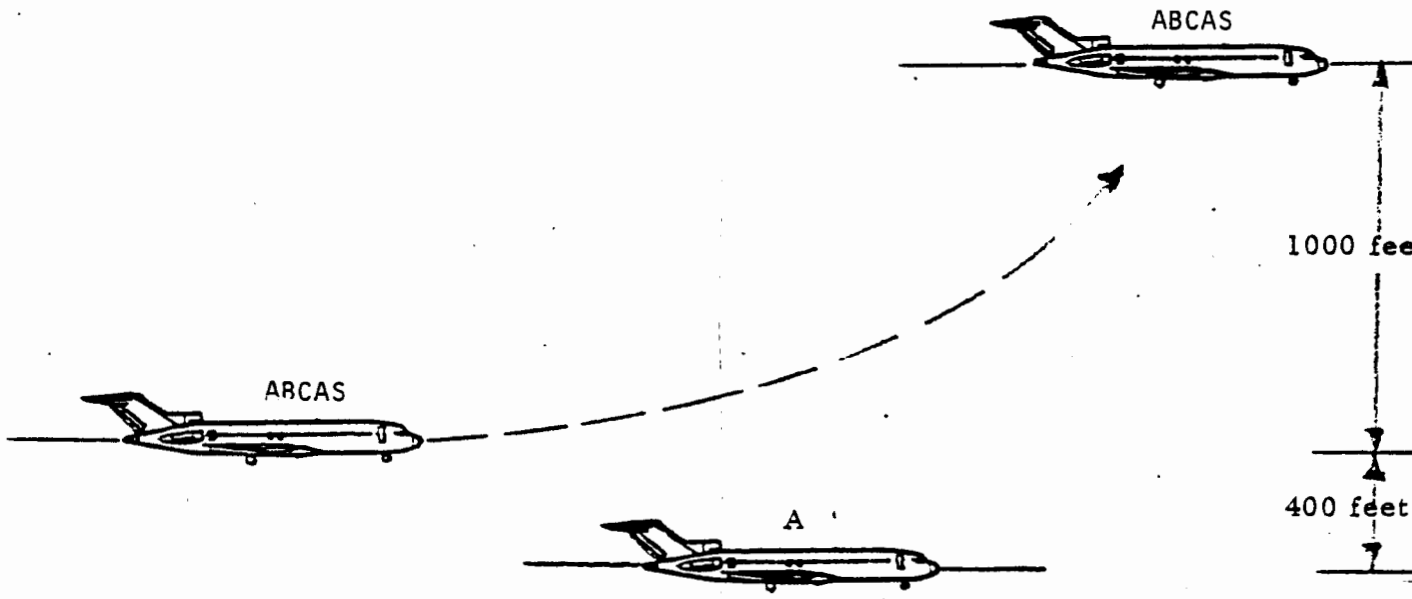
PROFILE 29



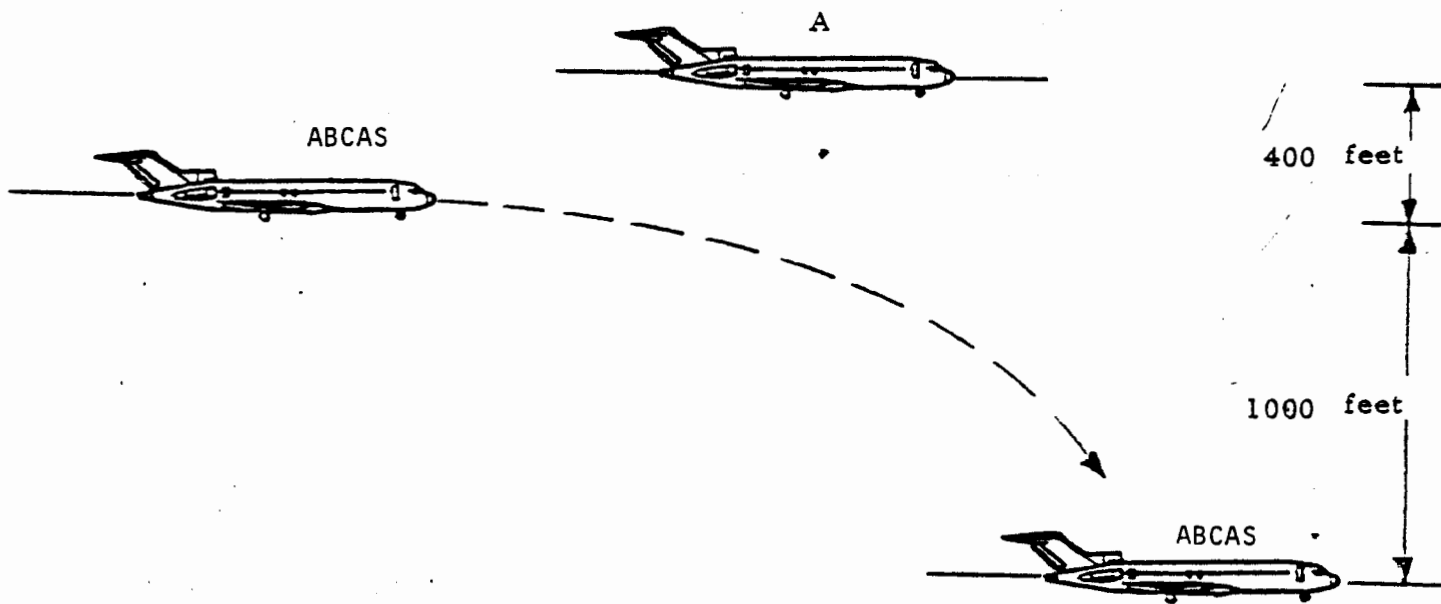
PROFILE 30



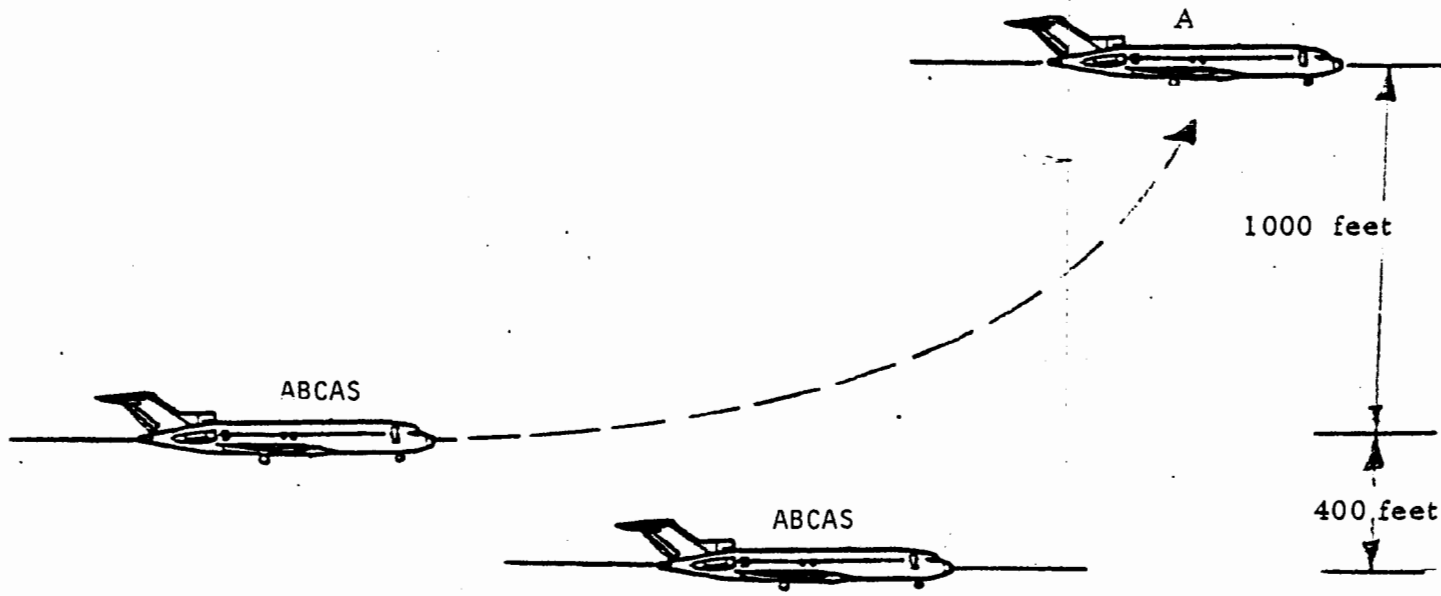
PROFILE 31



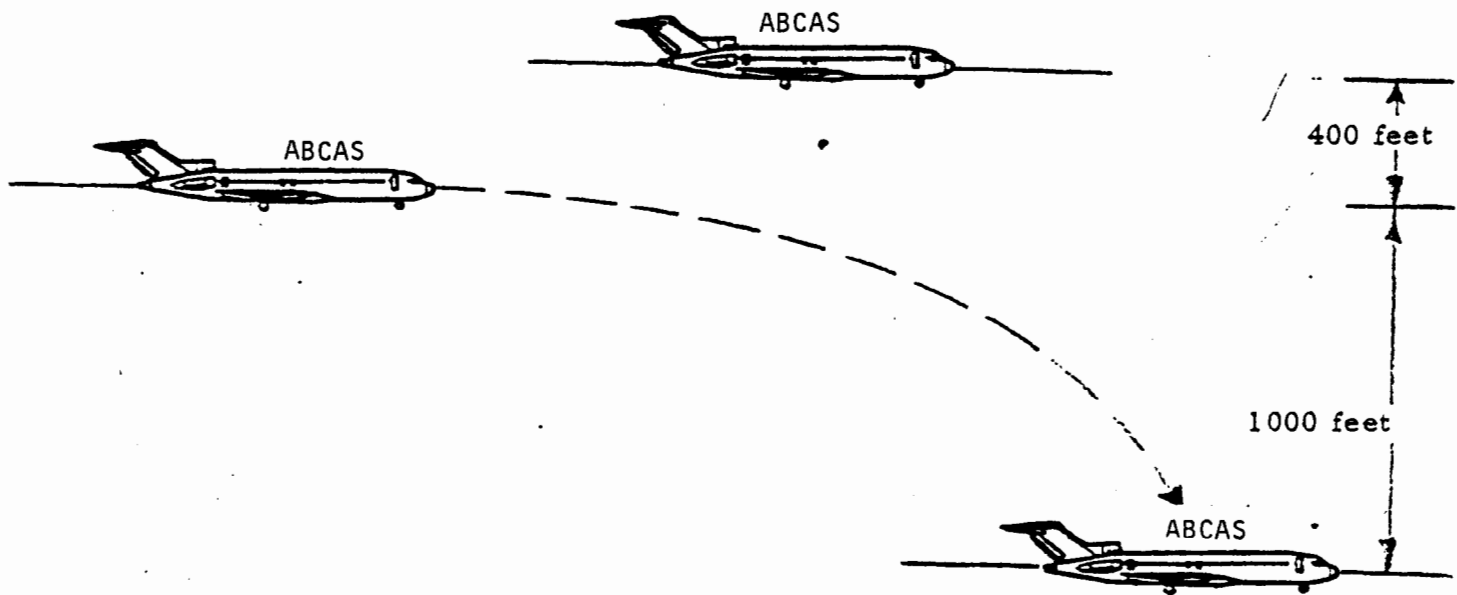
PROFILE 32



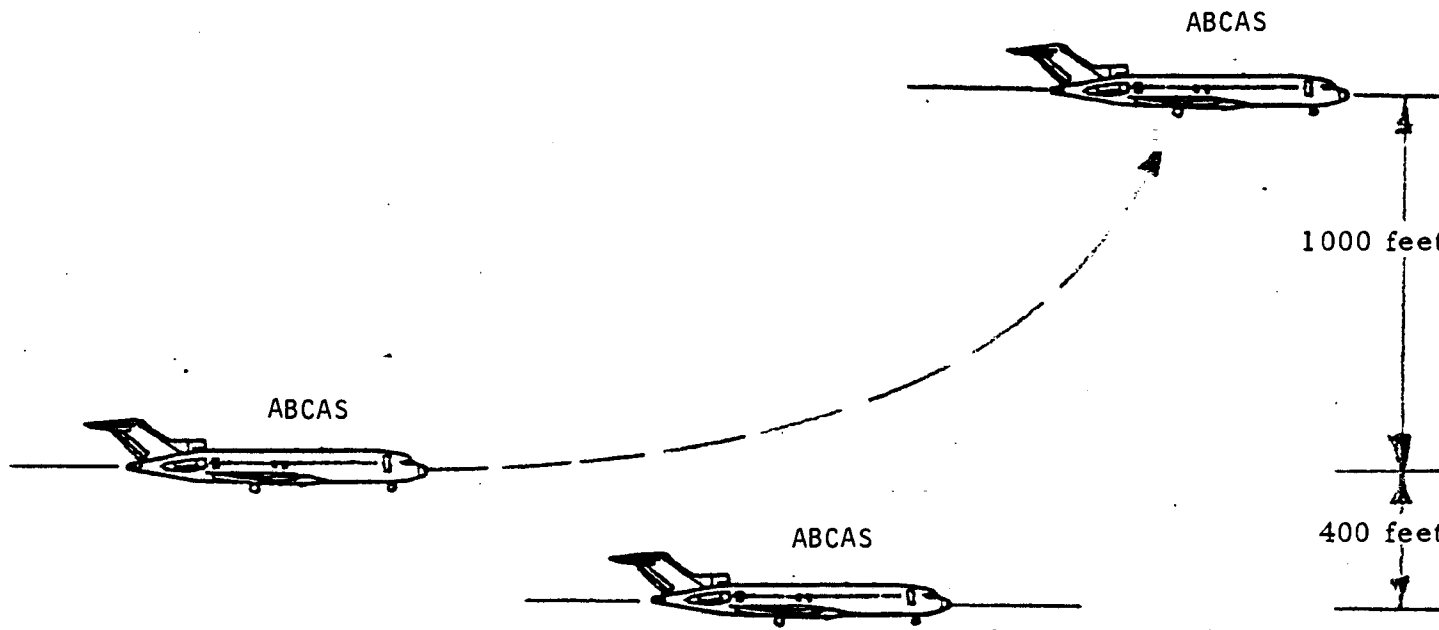
PROFILE 33



PROFILE 34

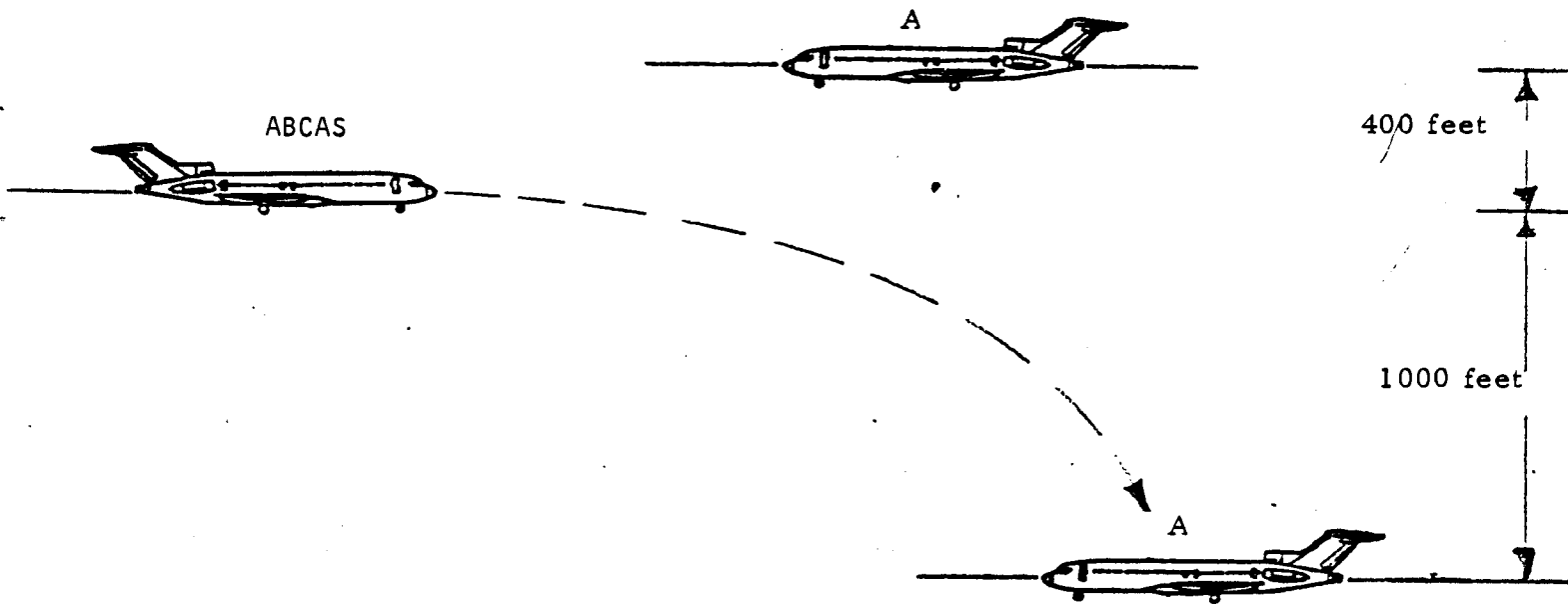


PROFILE 35



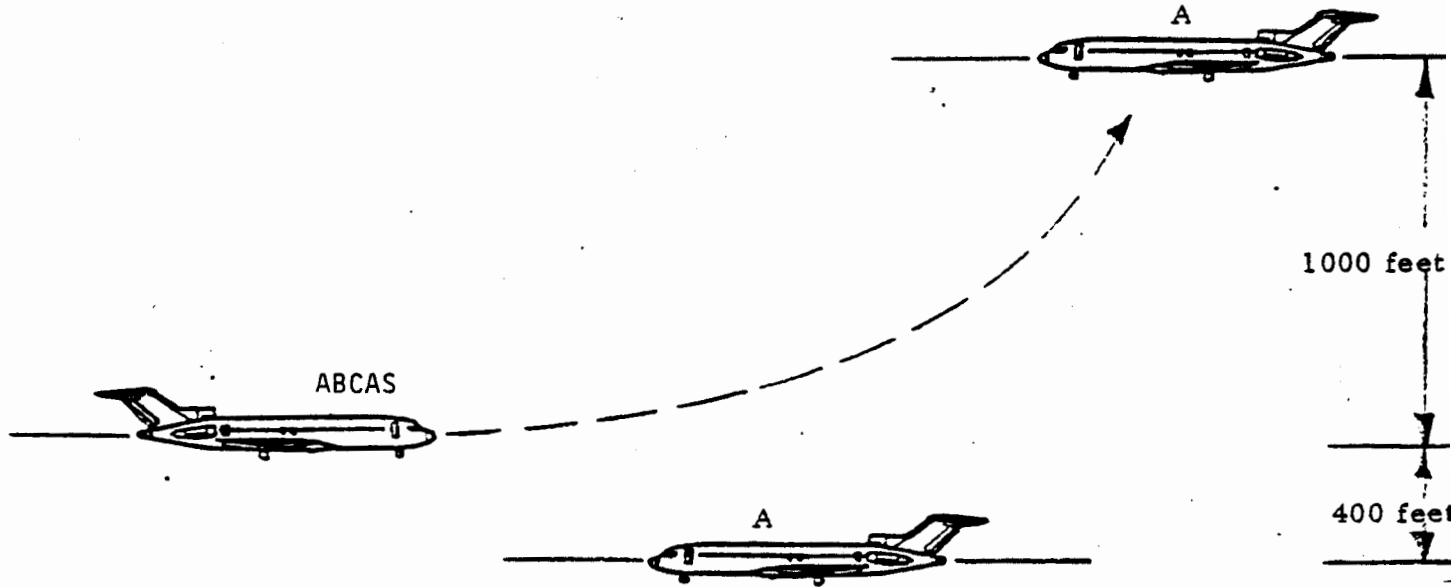
PROFILE 36

ALL AIRCRAFT SAME APEED



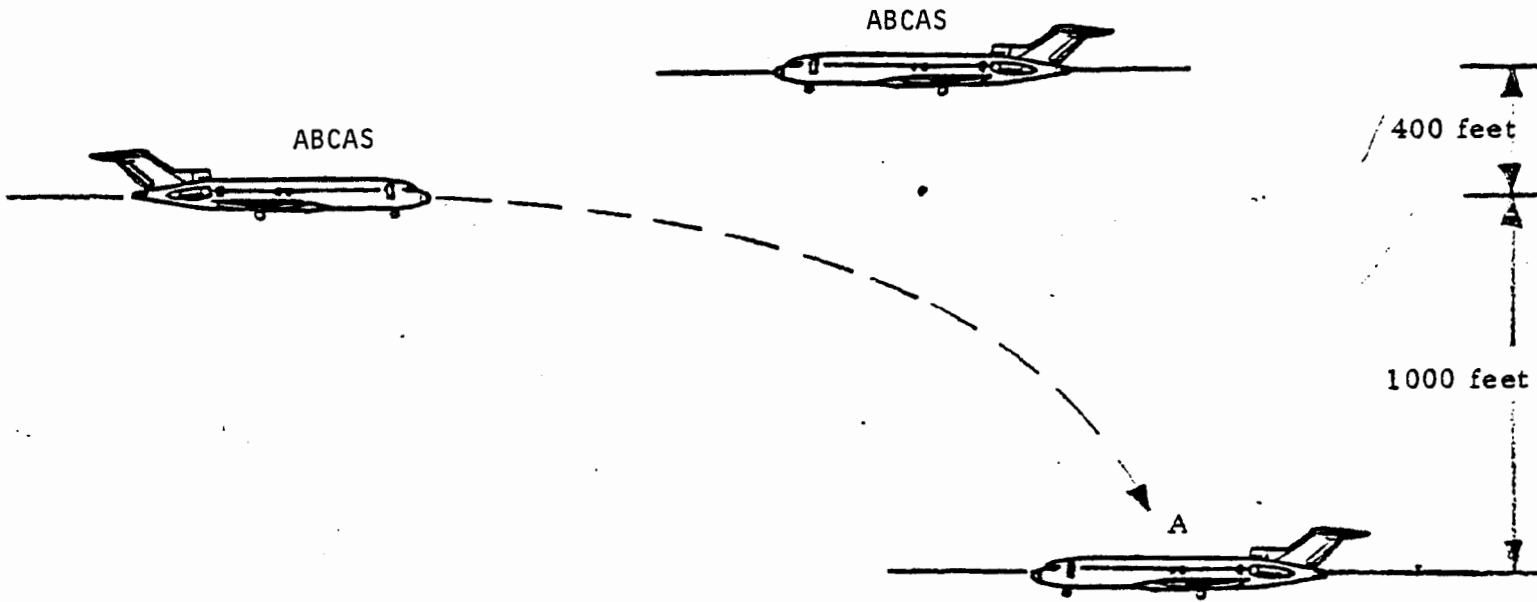
PROFILE 37

ALL AIRCRAFT SAME SPEED



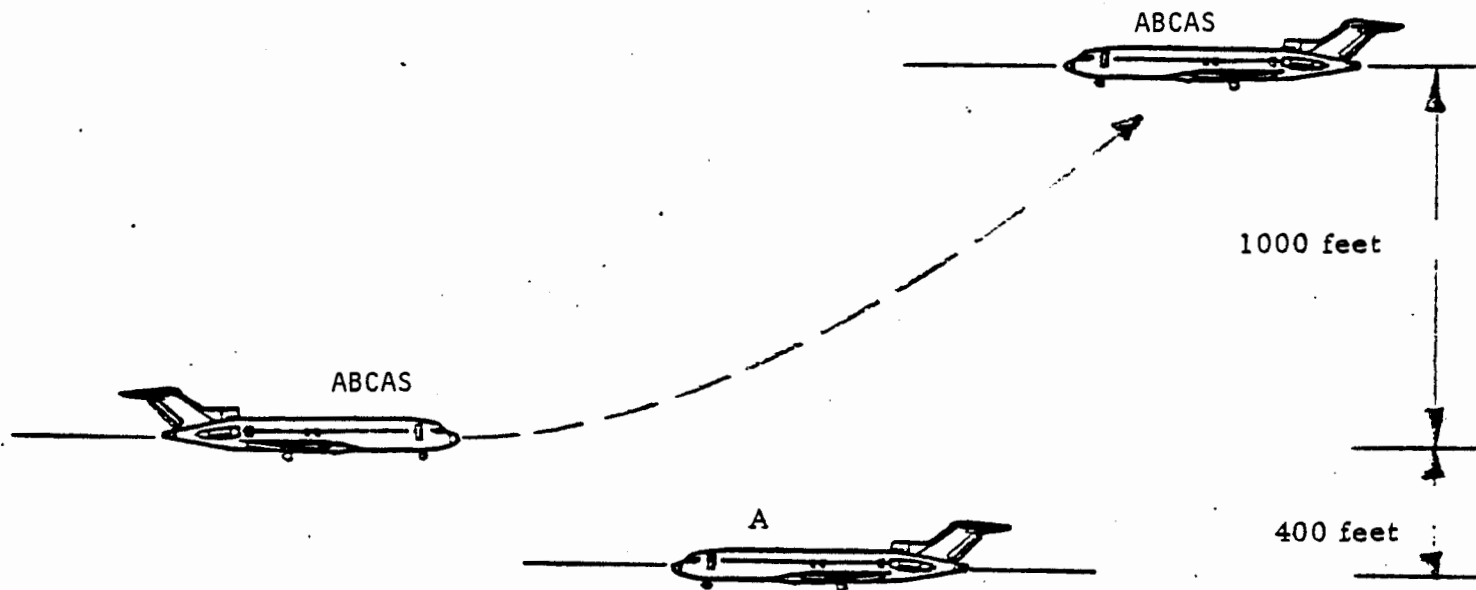
PROFILE 38

ALL AIRCRAFT SAME SPEED



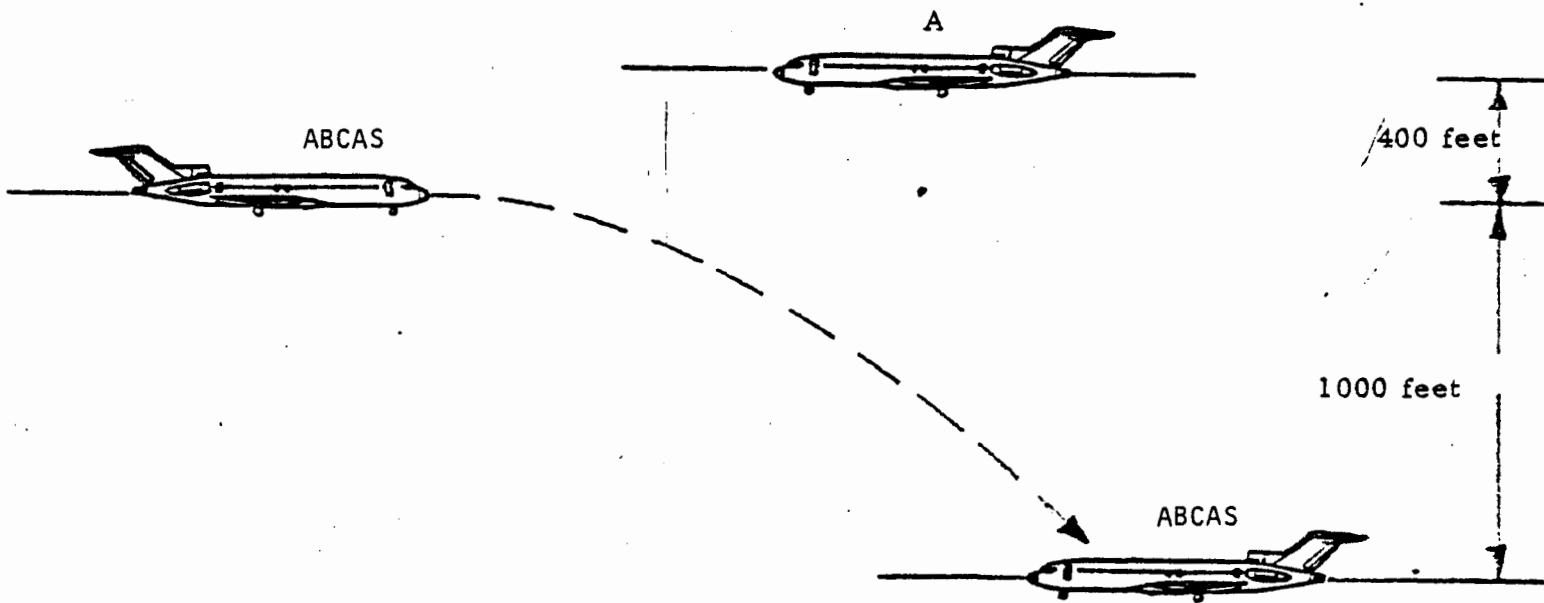
PROFILE 39

ALL AIRCRAFT SAME SPEED



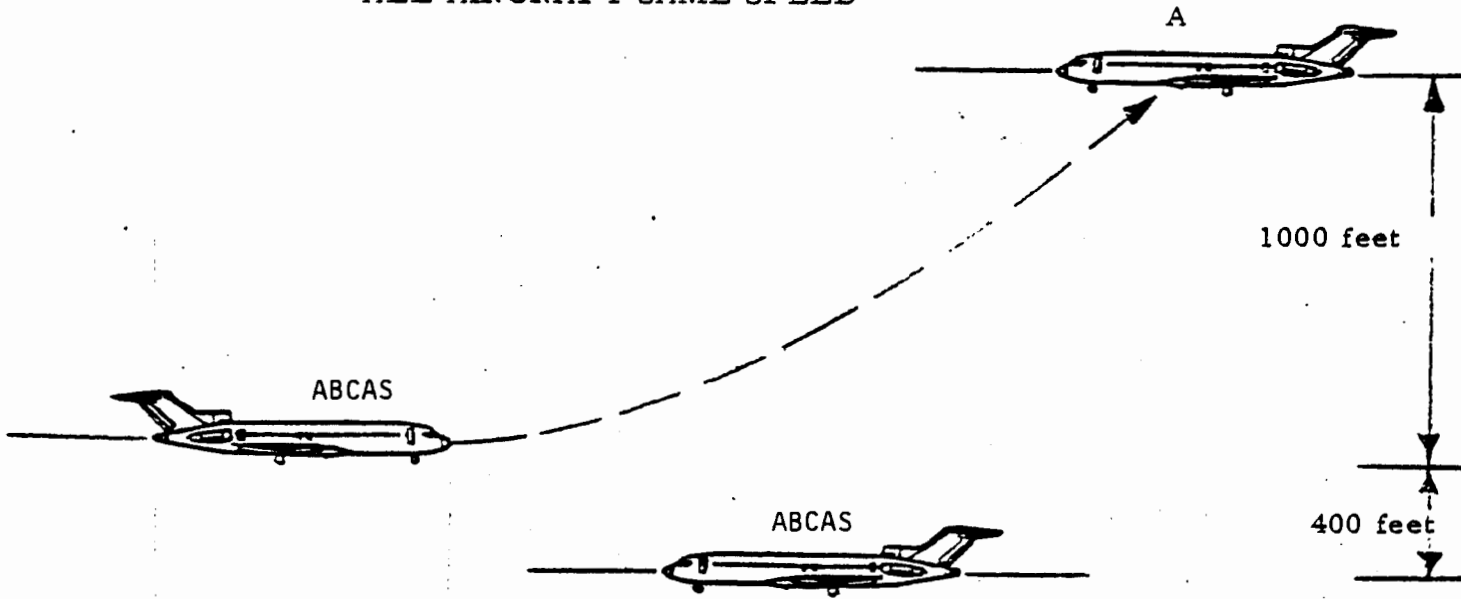
PROFILE 40

ALL AIRCRAFT SAME SPEED



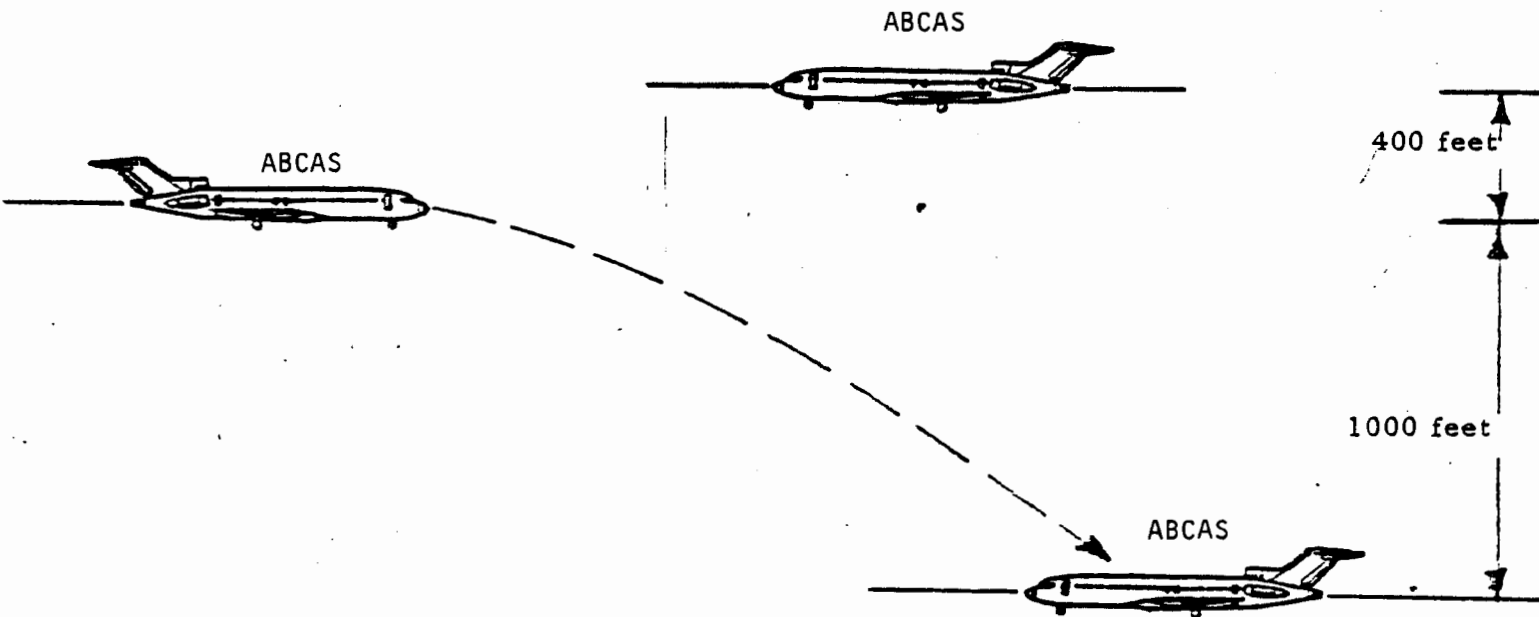
PROFILE 41

ALL AIRCRAFT SAME SPEED



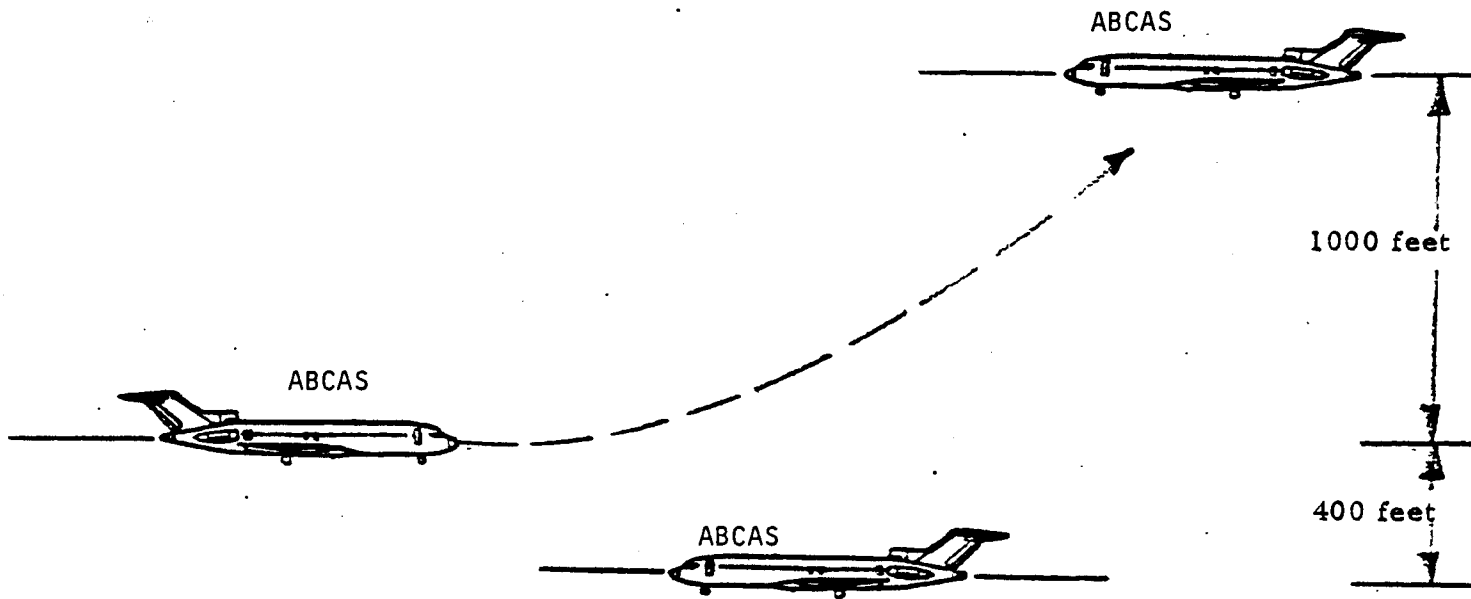
PROFILE 42

ALL AIRCRAFT SAME SPEED

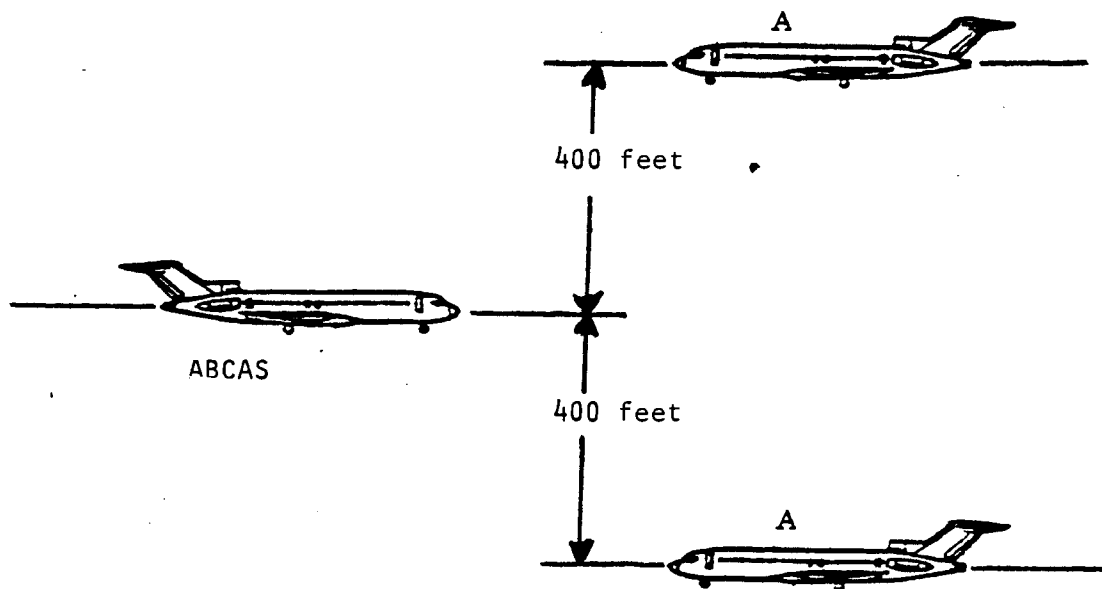


PROFILE 43

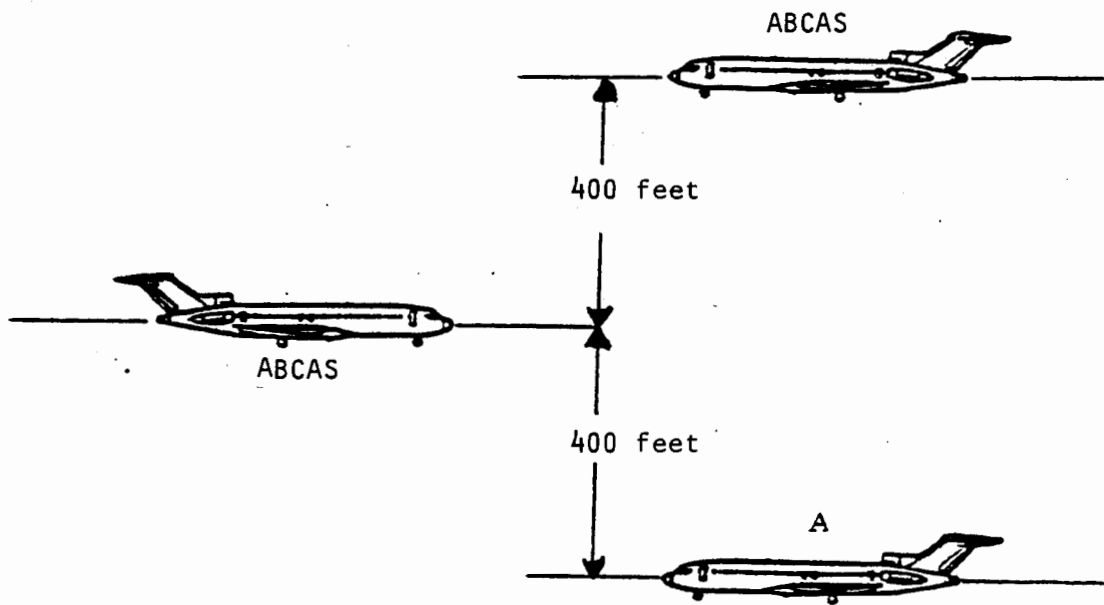
ALL AIRCRAFT SAME SPEED



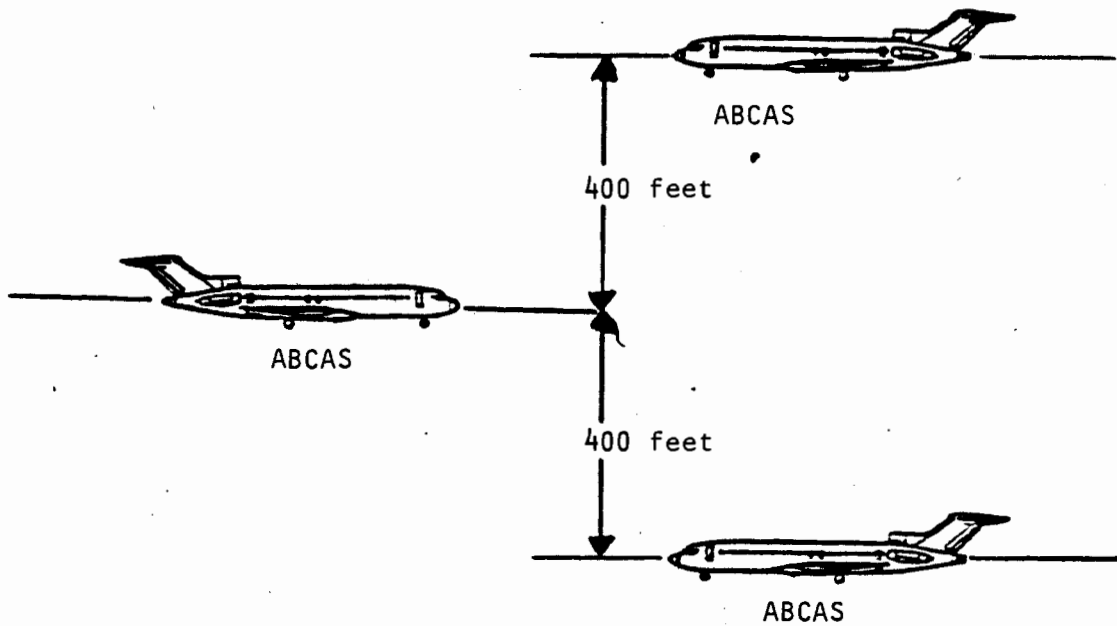
PROFILE 44



PROFILE 45



PROFILE 46



PROFILE 47

## APPENDIX B

### BEARING ANGLE ANALYSIS

It is expected that this equipment will have an overall standard deviation of error (azimuth angle) of between  $12^{\circ}$  and  $15^{\circ}$ . The data analysis will show the mean error, the standard deviation error, the number of points to average before updating the display, and the zones-of-silence. There will be point plots of azimuth and elevation versus azimuth error, elevation versus azimuth, azimuth and elevation versus average (time) azimuth error, azimuth and elevation versus average (number of points) azimuth error, and polar plots identical to the BCAS display. These plots are tabulated in table B1.

TABLE B1. DATA REDUCTION AND ANALYSIS PLOT DESCRIPTION

PITCH

NIKE EL vs AZ ER	NIKE AZ vs NIKE EL (Diag)
NIKE EL vs AZ ER (Ave. 5 pts.)	POLAR ( vs 3 MIN EA PLOT
NIKE EL vs AZ ER (Ave. 10pts.)	NIKE EL vs AZ (Time Ave) ER (BAR)
	NIKE EL vs AZ (Pt. Ave.) ER (BAR)

YAW

NIKE AZ vs AZ ER	NIKE EL vs NIKE AZ (Diag)
NIKE AZ vs AZ ER (Ave. 5 pts.)	POLAR ( vs ) 3 MIN EA PLOT
NIKE AZ vs AZ ER (Ave. 10 pts.)	NIKE AZ vs AZ (Time Ave.) ER (BAR)
	NIKE AZ vs AZ (Pt. Ave.) ER (BAR)

ROLL

NIKE EL vs AZ ER	NIKE EL vs NIKE AZ (Diag)
NIKE EL vs AZ ER (Ave. 5 pts.)	POLAR ( vs ) 3 MIN EA PLOT
NIKE EL vs AZ ER (Ave.	AZ & EL vs AZ (Time Ave.) ER (BAR)
NIKE AZ vs AZ ER	AZ & EL vs AZ (Pt. Ave.) ER (BAR)
NIKE AZ vs AZ ER (Ave. 5 pts.)	
NIKE AZ vs AZ ER (Ave. 10 pts.)	

NOTES:

Cones of silence to be determined from plots.

Azimuth error for the bar graphs will be bars showing mean and standard deviation.

Azimuth errors are shown as red arrows for top antenna and black arrows for bottom antenna (arrows indicate climb or descend). For averages, a green arrow will indicate both top and bottom were used. An "X" (red or black) indicates aircraft climbing and descending during average. A circle indicates all combinations used in average.

## APPENDIX C

### MISSION REPORT

- I. Test Objective  
(As defined in flight test plan document)
- II. Resources Scheduled
  - a. Aircraft
  - b. Project equipment
  - c. Range facilities
  - e. Etc.
- III. Pre-mission Briefing
  - a. Attendees
  - b. Handouts
  - c. Project system and facility status
  - d. Critical areas requiring close coordination
  - e. Problems, questions, etc.
- IV. Pre-mission System Tests
  - a. Time scheduled
  - b. Personnel assigned
  - c. Procedures specified for pre-test (see pre-flight checklist)
  - d. Pre-test status, problems, critical areas
- V. Mission Conduct
  - a. Personnel Assignments
    1. Mission coordinator
    2. Flight coordinator
    3. Project engineers
    4. Project technicians
    5. Observers/analysts
    6. Flight crew
  - b. Test Procedures (see BCAS Crew Briefing Guide)
    1. Flight profile
    2. Number of runs
    3. ATC coordination
    4. Multiple aircraft coordination
    5. Etc.
  - c. Data Collected, and where stored
    1. Tape numbers
    2. Printouts
    3. Tag sheets
    4. Etc.

VI. Post-Mission Debriefing

- a. Attendees
- b. Assessment of mission achievement level
- c. Problems and proposed solutions
- d. Changes recommended

VII. Mission Data Analysis Requirements

- a. Handoff procedures for data collected
- b. Specification of data reduction program
- c. Phase I - Analysis

Distribution:

- a. All participants
- b. Project Manager
- c. Program Manager
- d. ACT-100
- e. ACT-220
- f. ARD-242

## PRE-FLIGHT ABCAS CHECKS

Prior to each test flight, checks will be made to verify the operational readiness of the ABCAS. These checks are designed to be done on the ramp prior to the test flight and, to a great extent, relies on the presence of ATCRBS transponders within the range of the ABCAS. These "targets of opportunity" will produce ATCRBS tracks and, if landings and take-offs occur, CAS alarms. If a second aircraft, equipped with a DABS transponder, is involved in the flight test and is also on the ramp, then some of the DABS functions can be checked.

The first checks to be made are to verify the cabling to the aircraft systems and within the ABCAS. The following cables are to be checked:

1. "J" Box Cables
  - a. Ships encoded altimeter
  - b. Suppression buss
  - c. Air/ground line
  - d. Radar altimeter trip 7
  - e. Antenna control cables
  - f. DABS transponder cables
2. Top and Bottom RF Antenna Cables
3. IVSI Cable
4. AID Cable
5. Real Time Recording System
6. ABCAS Inter-unit Cabling

If the test box is installed, all switches should be checked to see that they are in the proper position.

The DABS ID plug should be checked for the proper ID code.

On the CAS Display, the performance level selector switch should be placed in the position required for the flight test.

On the Real Time Clock, the battery "On-Off" switch should be placed in the "On" position.

When the aircraft is on the ramp, and after ships project power is stabilized, power can be applied to the ABCAS using the "Power On" procedure. All power indicators should be checked.

A tape should be loaded on the Magnetic Tape recorder, time set in the Real Time Clock, and the program loaded into the Performance Monitor, per the system "Turn On" procedure.

With the system up and operating, the following checks should be made:

1. Check the CAS display for indications of failures of the self-test functions.

2. Check the tape drive for movement of the magnetic tape.

3. On the performance monitor, select the Beginning of Scan message and check for proper time, own altitude, and performance level. A hard copy of this message can be made for the log.

4. To check ATCRBS operation, on the performance monitor, select the following records.

- a. ATCRBS ICT
- b. ATCRBS Reply Buffer
- c. ATCRBS Track Record
- d. CAS Track Record
- e. Display Vector

5. To check DABS Operation, on the Performance Monitor, select the following records:

- a. DABS ICT
- b. DABS Reply Buffer
- c. Squitter Buffer
- d. DABS Track REcord
- e. CAS Track Record
- f. Display Vector

6. Both IVSI's, in the cockpit and on the ABCAS equipment rack, and the CAS display should be observed for commands and aural alarms.

7. Using the rack-mounted scope, the TPT signals and the log video signals should be observed. The TPT signals should be present when the ABCAS system is interrogating. The log video signals will verify that replies are being received.

8. The ATCRBS interrogation power will be measured using a calibrated detector directional coupler, attenuator and the rack scope. This check will verify the whisper/shout operation.

This checkout procedure may be varied as more experience is gained with the system.

## BCAS FLIGHT CREW BRIEFING GUIDE

FILE FLIGHT PLANS (IFR/VFR)

AIRCRAFT/FLIGHT CREWS

TEST PROJECT CREWS/PAX

BLOCK TIME/PLANNED FLIGHT TIME

TAXI/TAKE-OFF SEQUENCE. AIRCRAFT #1, #2, #3.

MISSION

PATTERNS & POSITIONING PROCEDURES

ALTITUDES/AIRSPEEDS

RUN SEQUENCE LIST

PROJECT CONTROL A/C--DISTANCE CALL OUT A/C

COMMUNICATIONS FREQUENCIES (TEST, A/A, ATC)

RESTRICTED AND WARNING AREAS

COCKPIT INDICATOR COMMANDS

VERTICAL MANEUVER LIMITS

HORIZONTAL MANEUVER LIMITS

TRANSPONDER SETTINGS

NIKE/EAIR REQUIREMENTS & GROUND CALIBRATION

LOST TRACKING ACQUISITION PROCEDURES

WEATHER

FUEL REQUIREMENTS

FLIGHT PLAN REMARKS (FORMATION, WAIVERS, ETC.)

ATC COORDINATION (APPROACH CONTROL, CENTER, MILITARY)

IN-FLIGHT CALIBRATION PROCEDURE

## APPENDIX D

### DATA REDUCTION SOFTWARE

This appendix describes the computer programs and processing flow which will be used to support the three phase flight data analysis plan presented in section 6.

During each flight test, data will be collected on two separate magnetic tapes (see figure D1). One tape will contain position data from ground tracking stations (up to two Nike-Hercules and one EAIR) as transmitted to the BCAS aircraft, as well as aircraft state data (pitch, roll, heading) as determined by on-board avionics. The other tape will contain Dalmo-Victor data recording messages extracted by the BCAS software in real time.

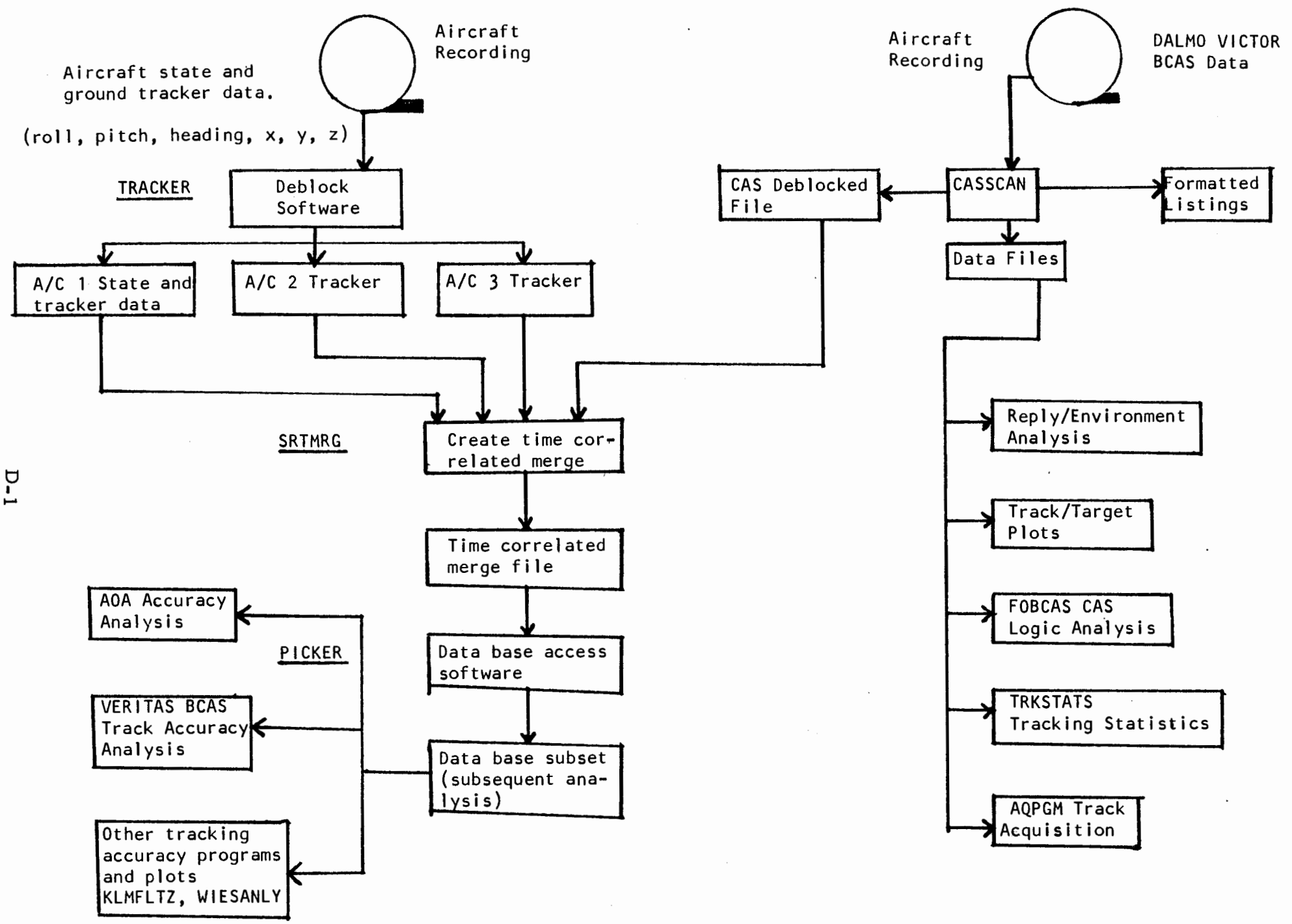
The later tape will be processed on the Technical Center's Honeywell Computer system by the program CASSCAN (see annex to appendix D) which provides three kinds of output. They are:

- a. Formatted listings of all BCAS messages in engineering units. This will provide quick availability of any desired BCAS data.
- b. Deblocked files which will be merged with the aircraft state and radar tracker data (SRTMRG) to provide a data base for subsequent accuracy analysis of BCAS tracking and the angle of arrival (AOA) subsystem. The result will be graphics, statistical analysis of errors, and correlation studies involving BCAS's overall performance and relative target position.
- c. Numerous data files for various plot/analysis programs which use only BCAS data as inputs and plot programs which operate on the Tektronix 4054 terminal. Thus, data files containing aircraft track/target will be processed to generate report quality plots of:

- Time vs Range
- Time vs Range Rate
- Time vs Altitude
- Time vs Altitude Rate
- Range vs Altitude
- Time vs Density
- Time vs AOA
- Time vs Fruit
- Range vs AOA

These plots also display advisories when they exist and are applicable. (See figures D2 through D8.)

Also provided by the data reduction software are per second summary files of system performance and aircraft environment which will be plotted to expose relationships among reply types (fruit, garble, Mode C), percent coasts, and AOA. (See figures D9 through D12).



D-1

Figure D1 - Data Reduction and Analysis Block Diagram

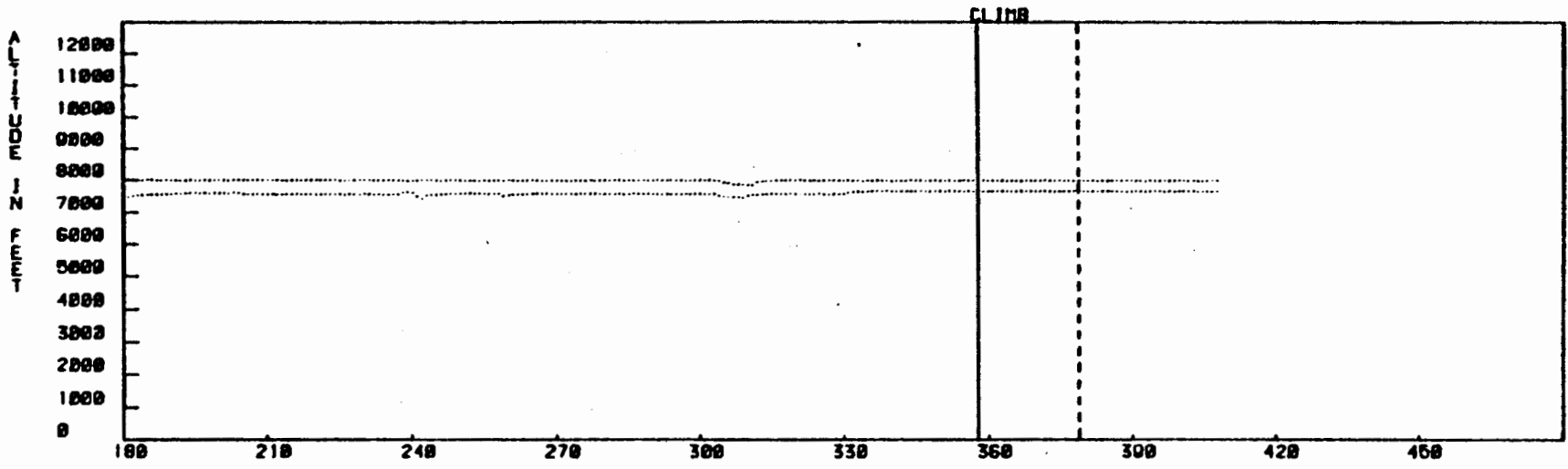


FIGURE TARGET OF OPPORTUNITY  
RUN #10

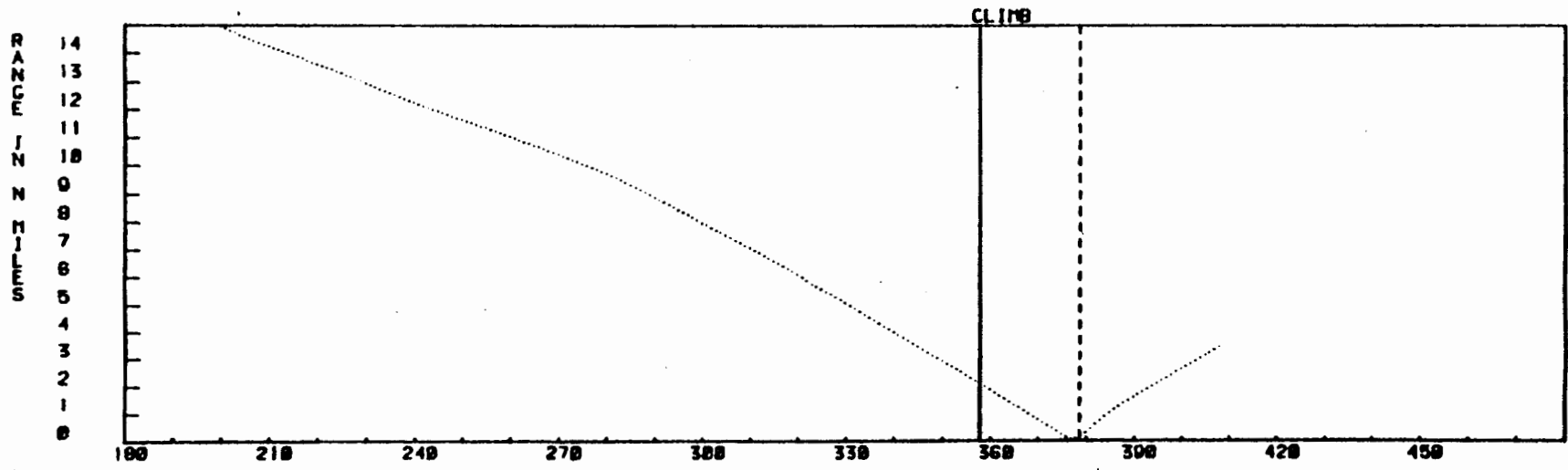


FIGURE TARGET OF OPPORTUNITY  
RUN #10

FIGURE D-2. THREAT CAS DATA PLOTS

BCAS ACCURACY ANALYSIS 9-26-80 OWN= N40 INT= N49 ENCOUNTER 1A  
PERFORMANCE LEVEL 4

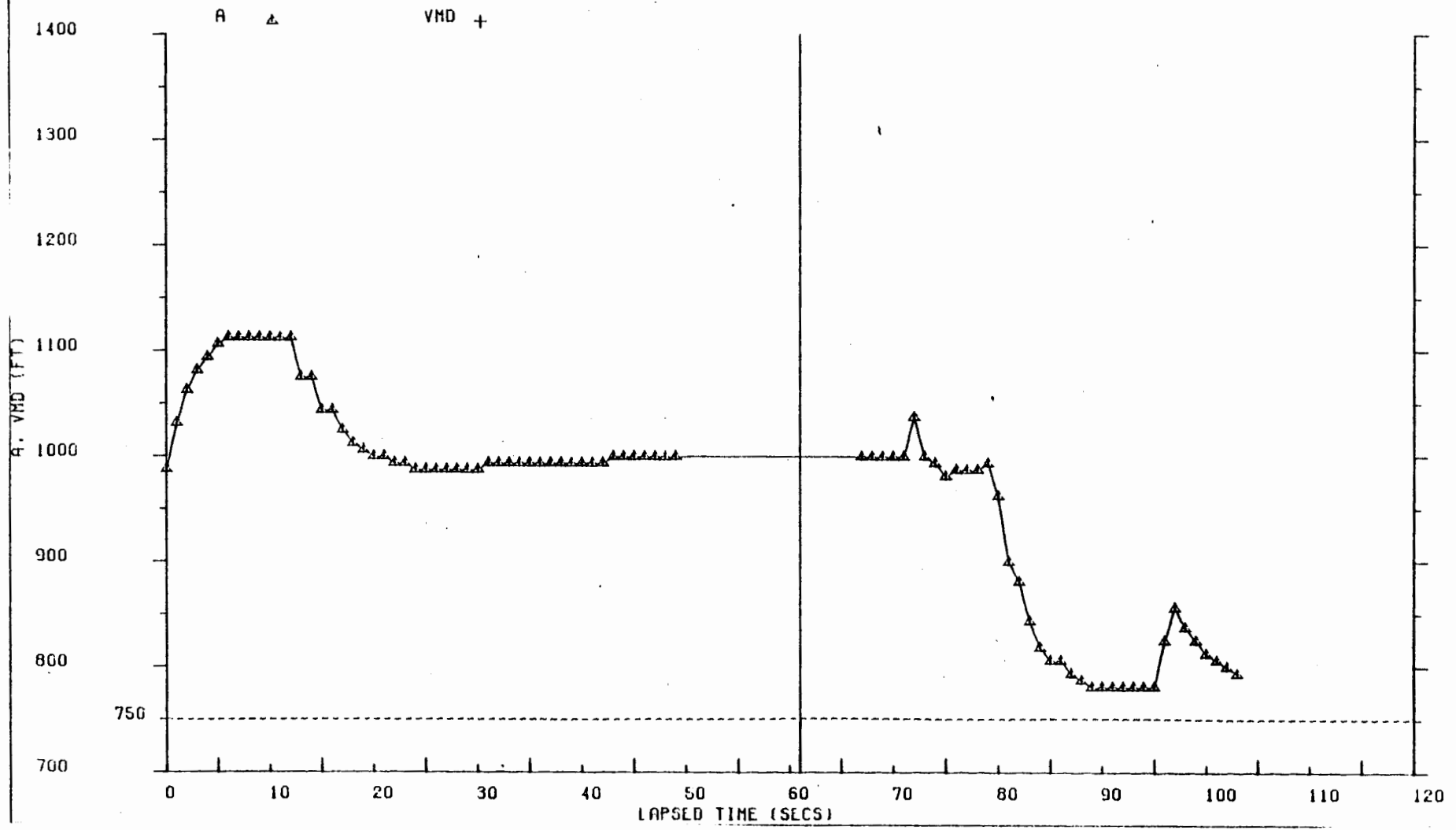


FIGURE D-3. LAPSED TIME VERSUS A. VMD

BCAS ACCURACY ANALYSIS 9-26-80 OWN= N40 INT= N49 ENCOUNTER 1A  
PERFORMANCE LEVEL 4

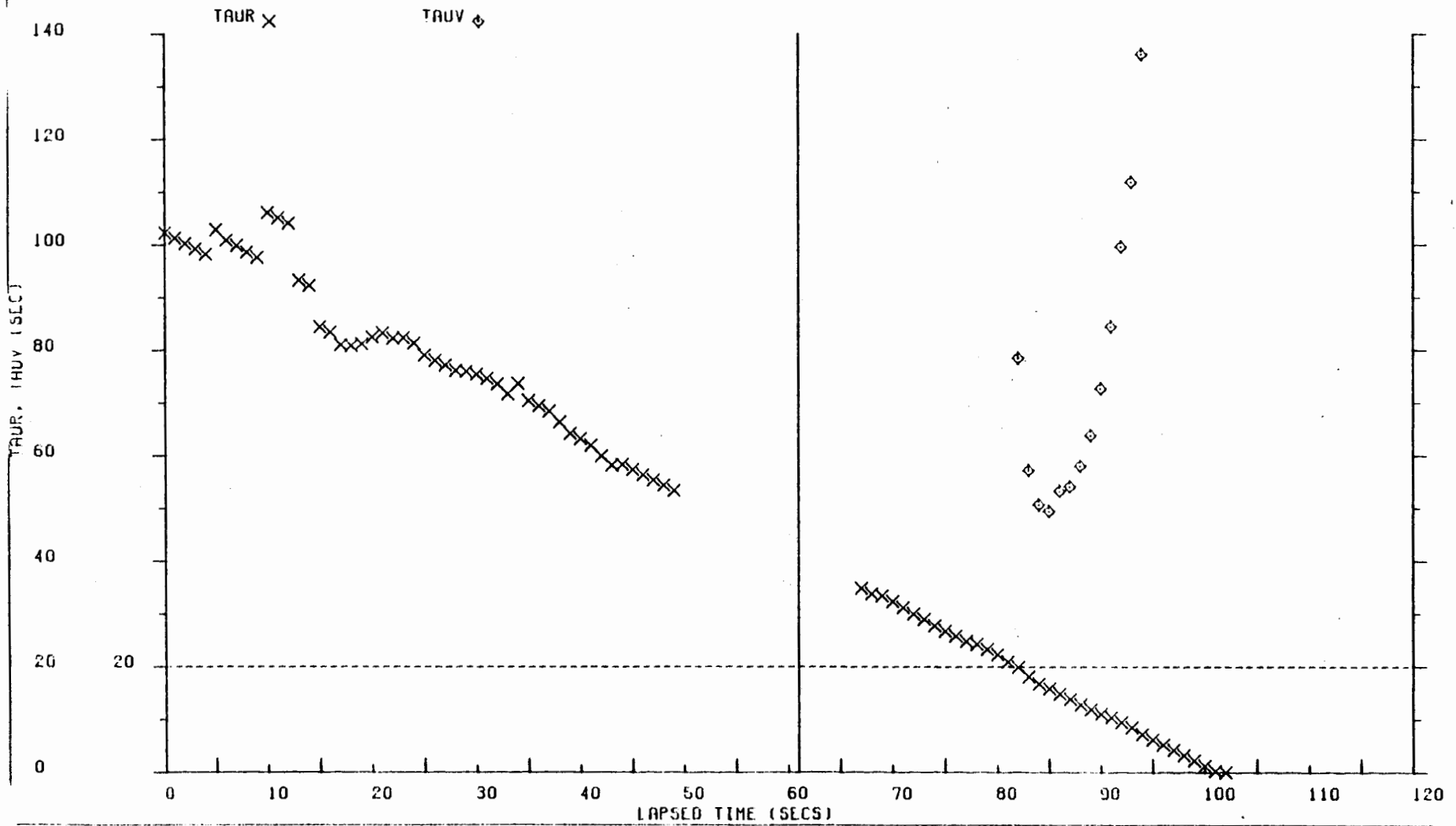


FIGURE D-4. LAPSED TIME VERSUS TAUR AND TAUV

BCAS ACCURACY ANALYSIS 9-26-80 OWN= N40 INT= N49 ENCOUNTER 1A  
PERFORMANCE LEVEL 4

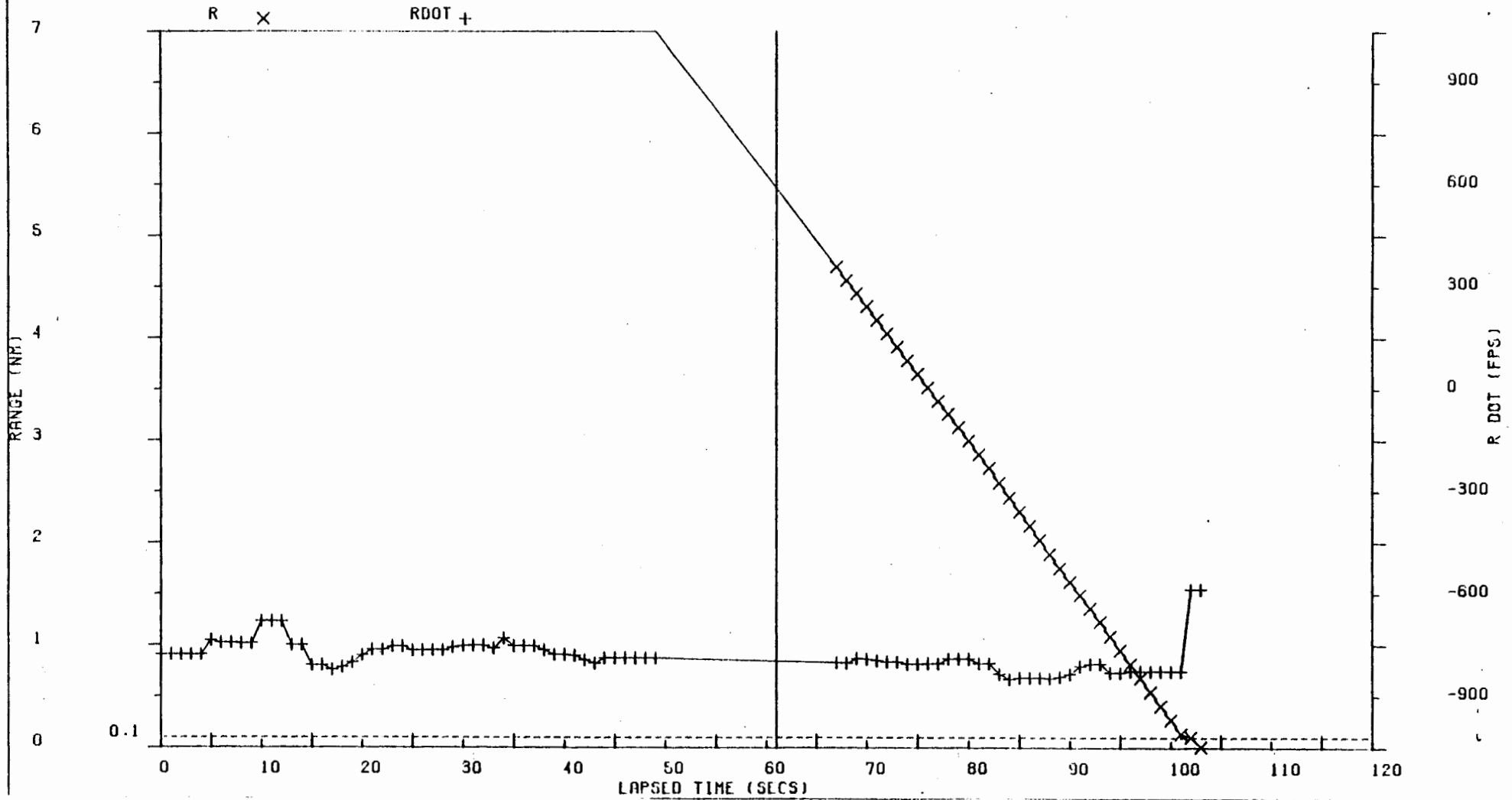


FIGURE D-5. LAPSED TIME VERSUS RANGE AND R DOT

BCAS ACCURACY ANALYSIS 9-26-80 OWN= N40 INT= N49 ENCOUNTER 1A  
 PERFORMANCE LEVEL 4

9-0

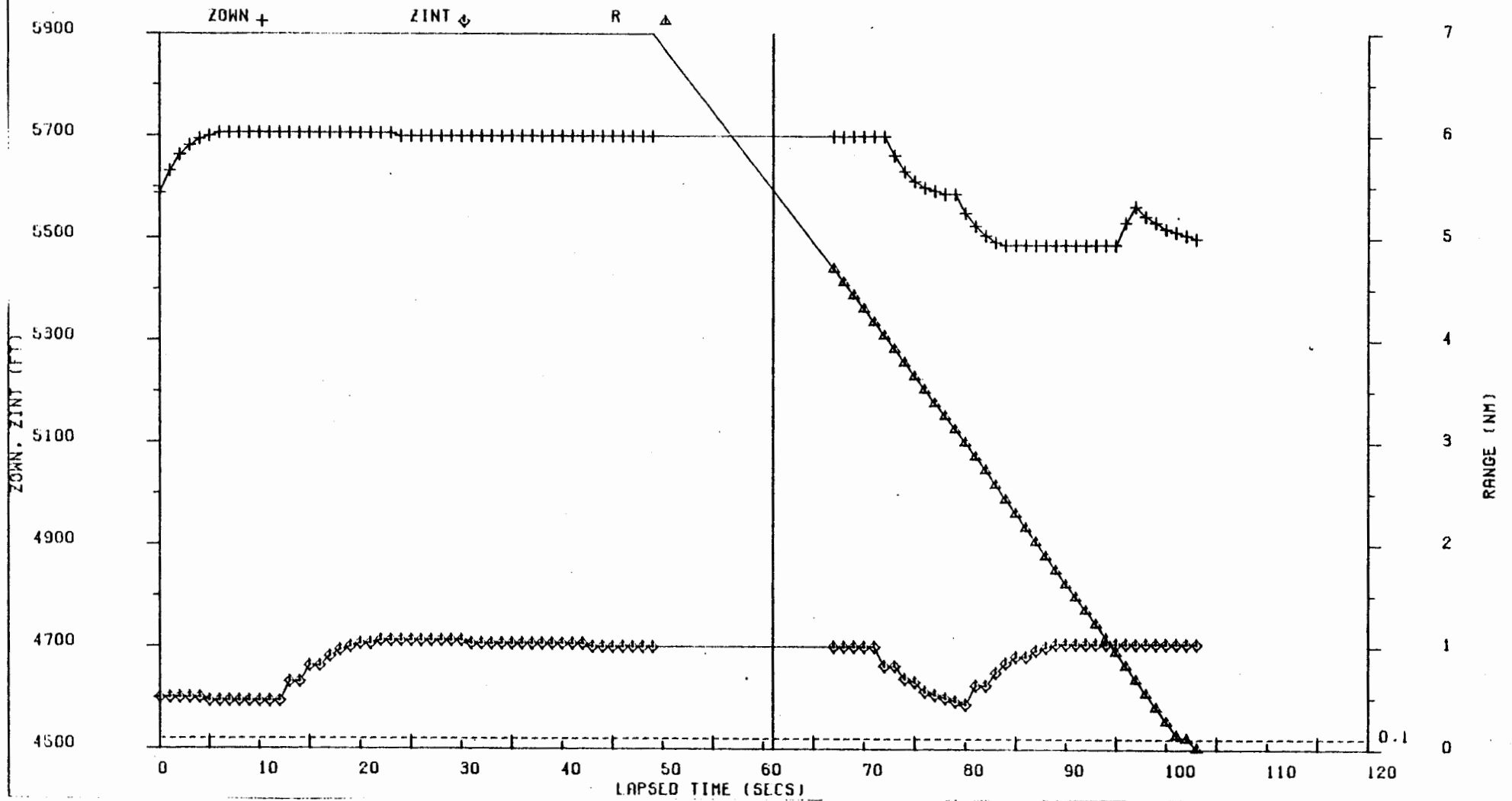


FIGURE D-6. LAPSED TIME VERSUS ZOWN, ZINT AND RANGE

BCAS ACCURACY ANALYSIS 9-26-80 OWN= N40 INT= N49 ENCOUNTER 1A  
 PERFORMANCE LEVEL 4

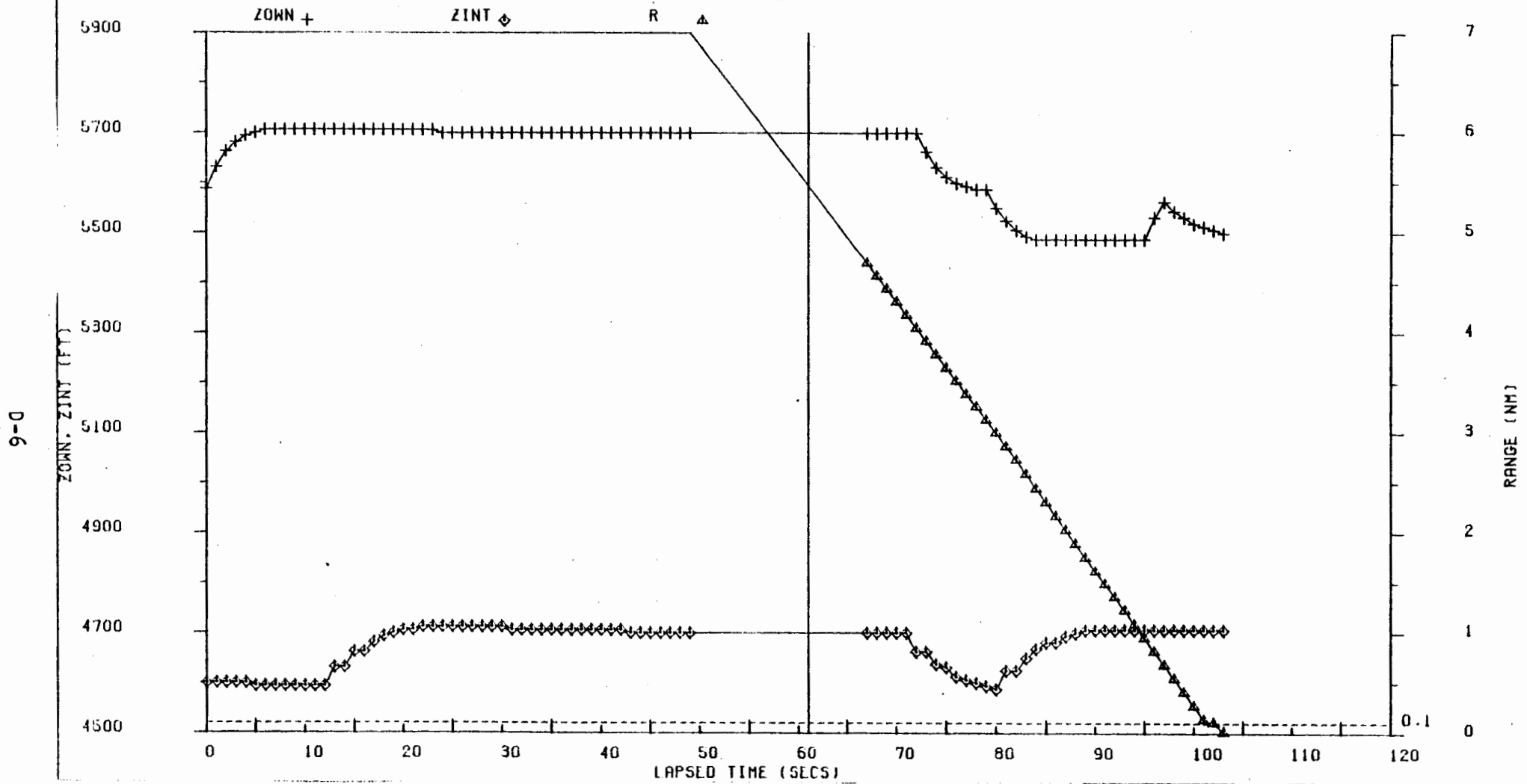


FIGURE D-6. LAPSED TIME VERSUS ZOWN, ZINT AND RANGE

BCAS ACCURACY ANALYSIS 9-26-80 OWN= N40 INT= N49 ENCOUNTER 1A  
PERFORMANCE LEVEL 4

BCAS

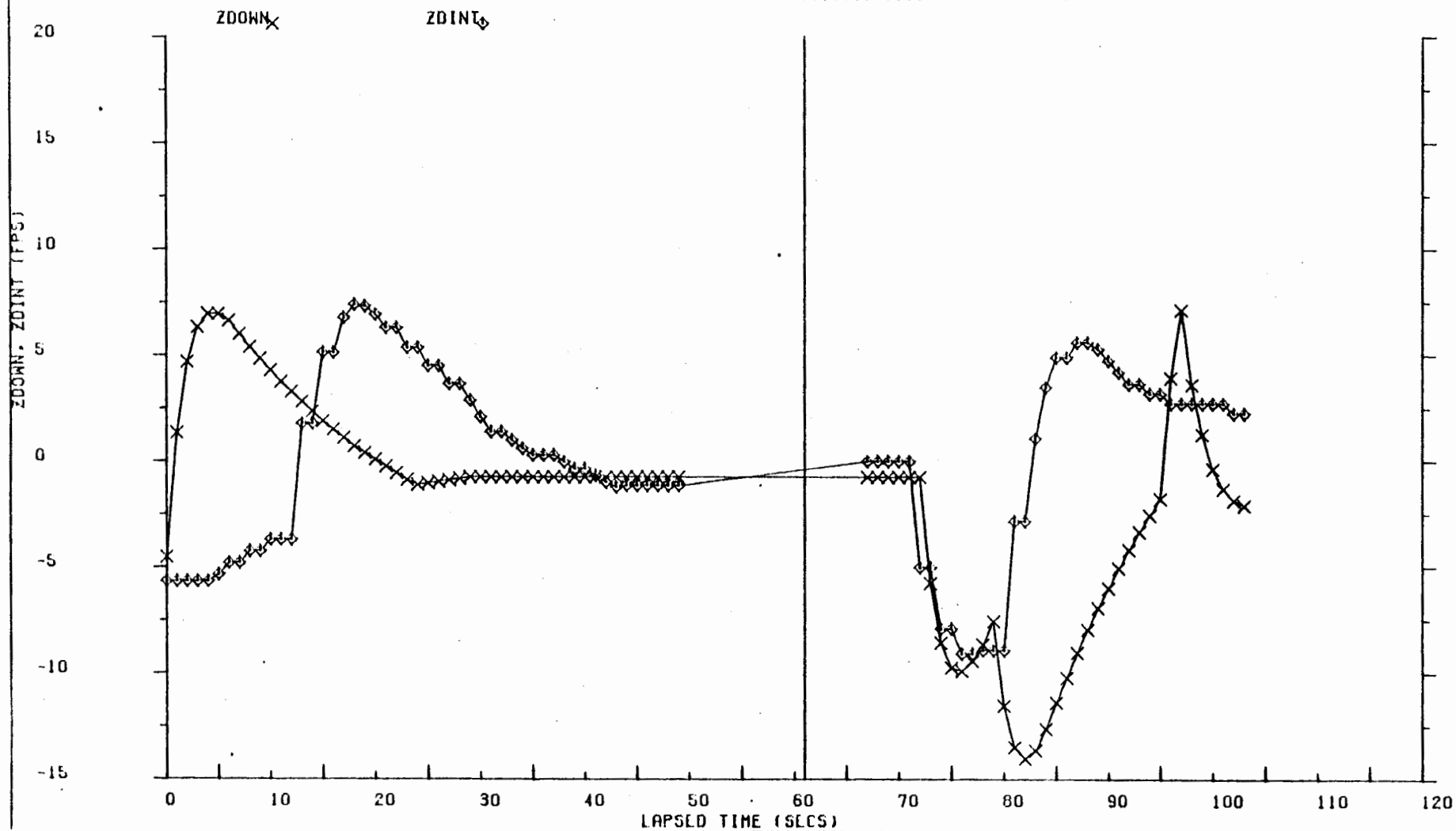


FIGURE D-7. LAPSED TIME VERSUS ZDOWN, ZDINT

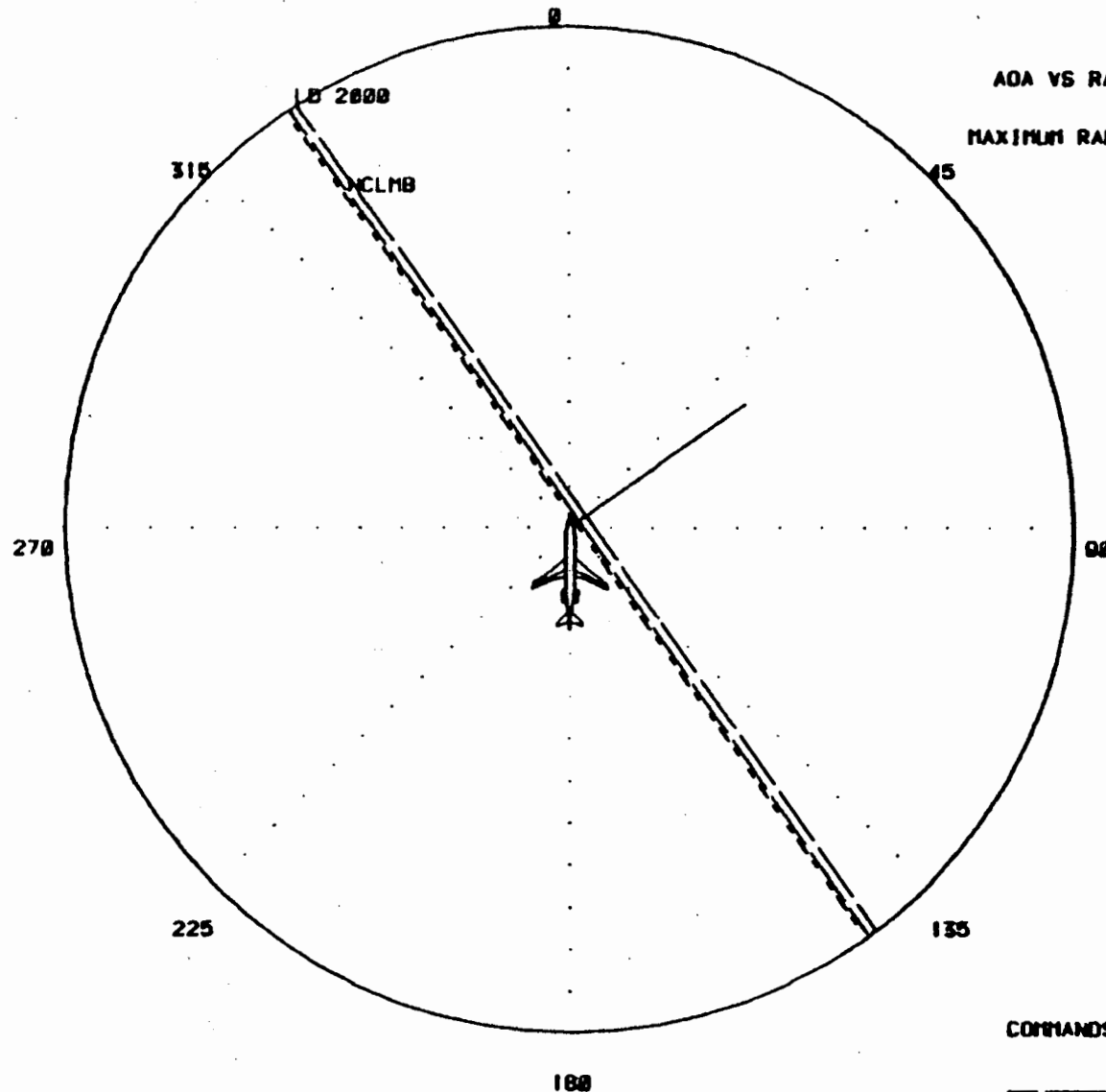
D-7

**FLIGHT PROFILE 15 FT**

DABS ID 14741  
 ATCRS ID 1234

**AOA VS RANGE**

MAXIMUM RANGE 12



TAU 35.76 SEC

AOA(START) 0.5

AOA(END) 122.5

x COAST

QVN AIRCRAFT HEADING 0  
 S

CLOSING SPEED 45.14 FT/SEC

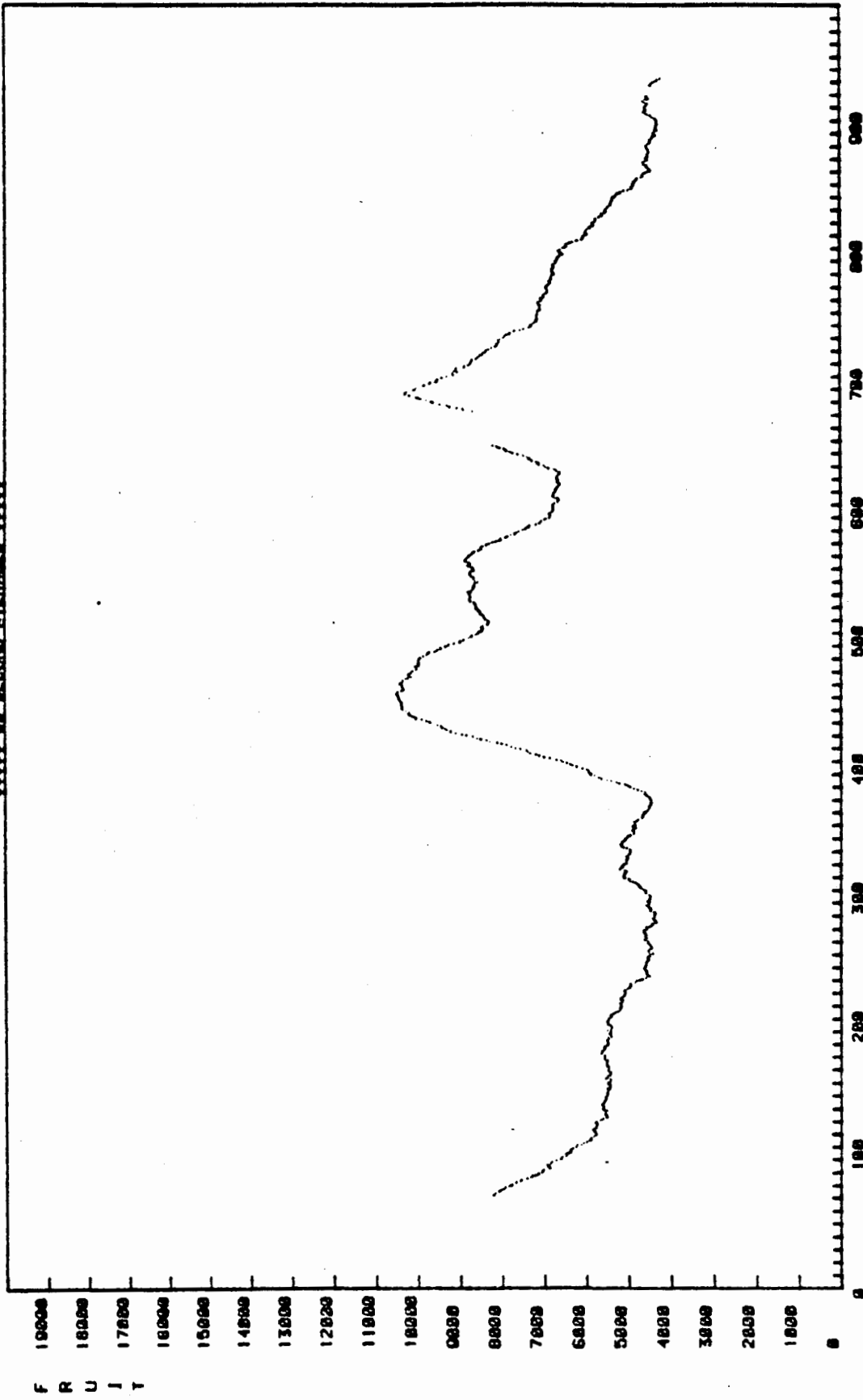
COMMANDS

END OF COMMAND

FIGURE D-8. AOA VERSUS RANGE

D-8

XXXX 60-SECOND AVERAGES IIIII



F  
R  
U  
I  
T

BCAS DATA (STATC003)

7/2

60 SEC AVER/10 MI RAD

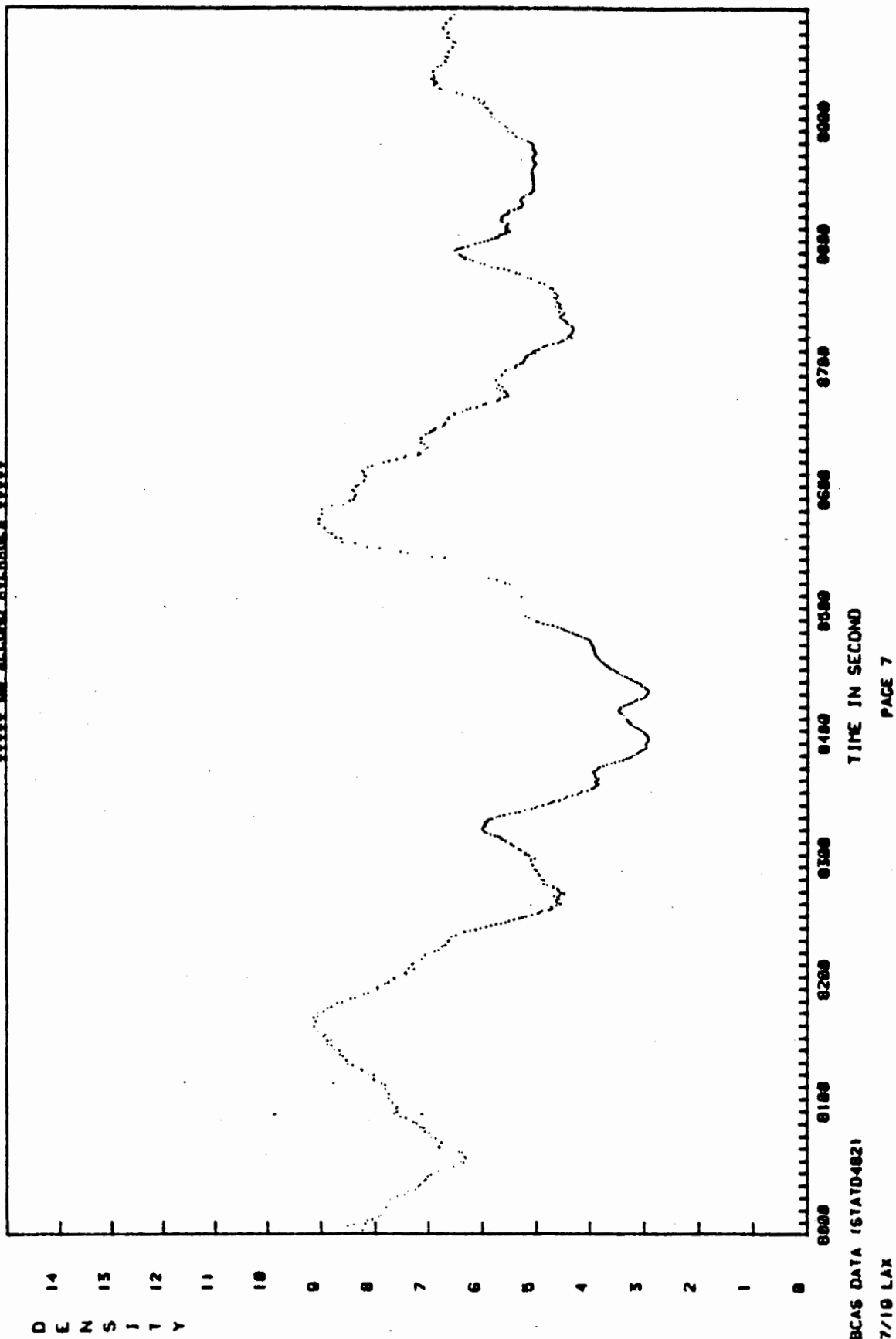
(PLD 10/8 KM)

TIME IN SECONDS

PAGE 1

FIGURE D-9. SIXTY SECOND AVERAGE FRUIT

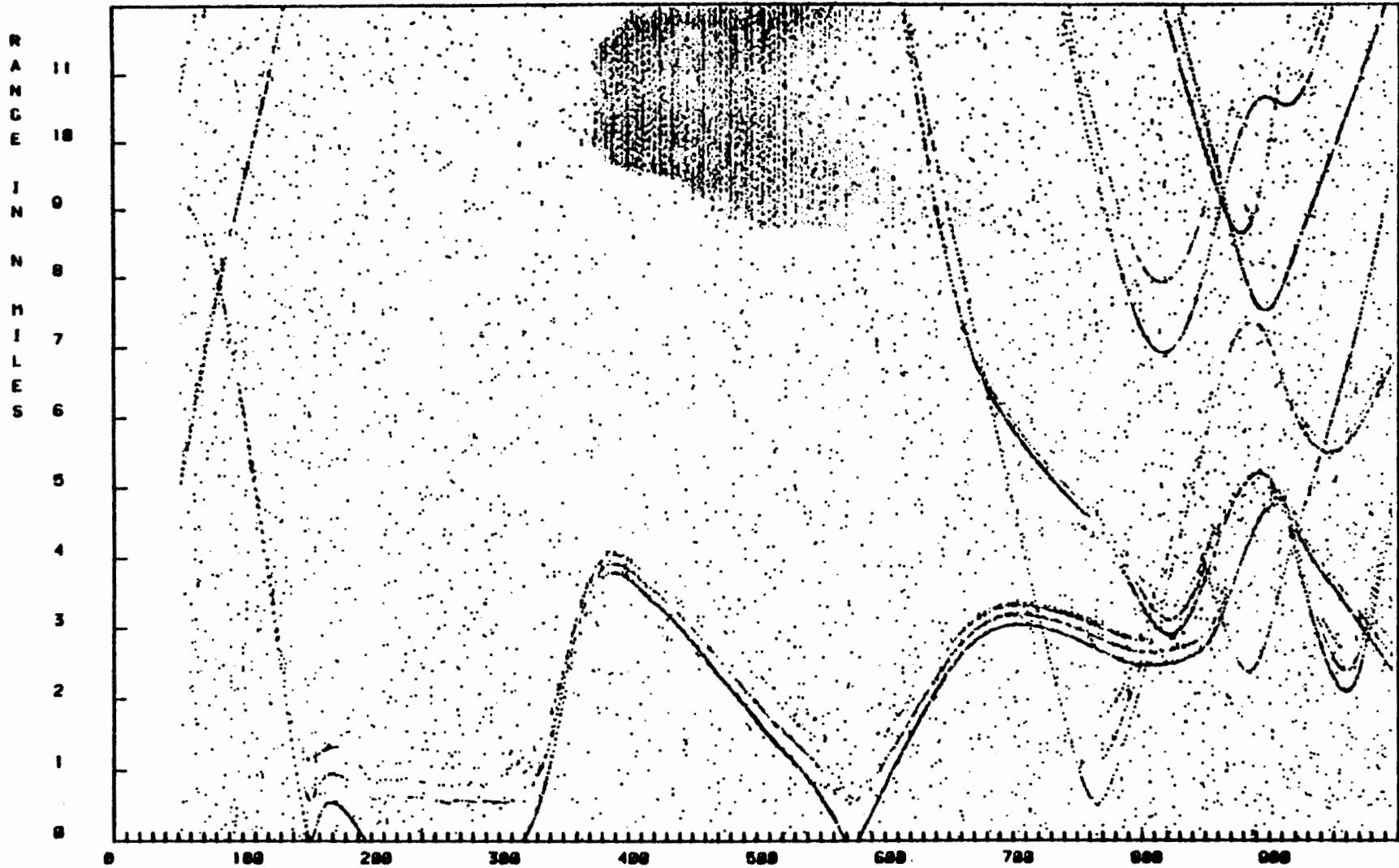
THIRTY 60-SECOND AVERAGES THIRTY



BCAS DATA (STATD482)  
7/10 LAX  
60 SEC AVER.  
(PLD 18/6 MH)

FIGURE D-10. SIXTY SECOND AVERAGE DENSITY

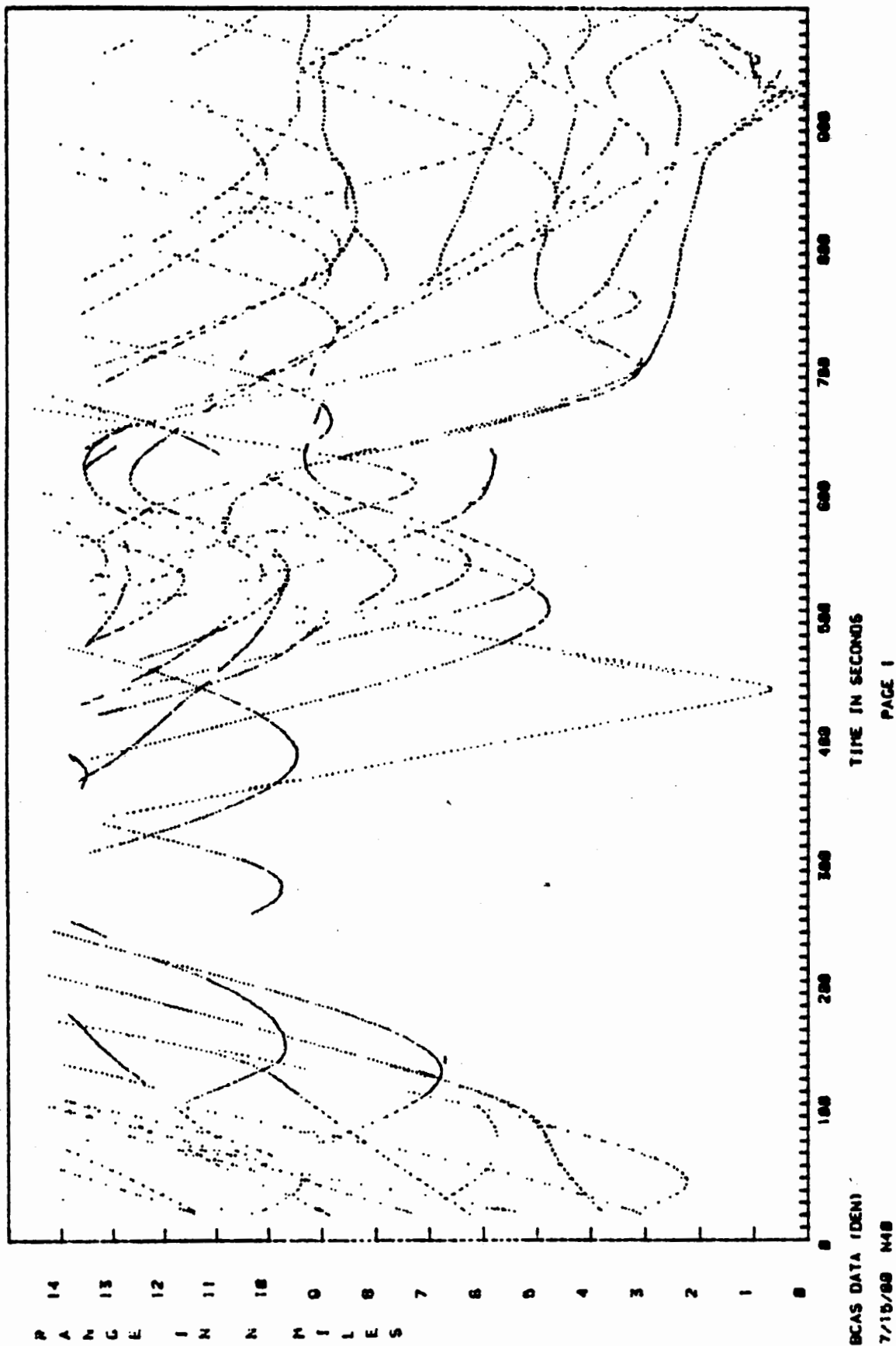
D-11



BCAS DATA  
3/28/88  
MSC 4  
(PLTD 7/16 TAPE1/1 KH)

TIME IN SECONDS  
PAGE 1

FIGURE D-11. REPLY DATA PLOT



BCAS DATA (DEN)  
 7/15/89 M4B  
 MSC 18/11  
 IPLD 8/11 TAPE1 (M4)

PAGE 1

FIGURE D-12. CAS TARGET PLOTS

## ANNEX TO APPENDIX D

### SUMMARY DESCRIPTION OF CAS DATA REDUCTION SOFTWARE

Program Name: CASSCAN

#### Scan Data Tape Mode (optional)

- For data in the neighborhood of an encounter
- For data pertaining to aircraft in conflict only
- Provide all options below in scanning mode.

#### BCAS Deblock/List/Plot Software

- Generate data files for subsequent plot/analysis software. These are of eight types and contain various messages:

1. File with one second of data/logical record for input to sort/merge software (SRTMRG).

2. Messages 1,2,3,4,10 and 11 - Statistical summary file of system status and aircraft environment.

- Studies of fruit, garble, coast, and density. (Tektronix 4054).

3. Messages 1 and 4 - Target reports (ATCRBS).

- Plots. (Tektronix 4054).

4. Messages 1,8 and 1,9 - Summary of pretrack files for DABS and ATCRBS targets, respectively.

- Plots. (Tektronix 4054).

5. Messages 1 and 14 - RBX/BEU link data.

- RBX performance monitoring software. (Tektronix 4054).

6. Messages 1, 10 and 11 - Track summary/advisory files.

- Plots. (Tektronix 4054).

- Tracker statistics (TRKSTATS). (MH 66/60).

- Acquisition range/drop (AOPGM). (MH 66/60).

7. Messages, 1, 10 and 11 - Encounter aircraft-only track data.

- Plots. (Tektronix 4054).

8. Input file for program FOBCAS (messages 1 and 10 summary).

(MH 66/60).

o Generate CALCOMP plots of track reports for:

1. Time vs Range
2. Time vs Range Rate
3. Time vs Relative Altitude
4. Time vs Relative Altitude Rate

#### CASSCAN Outputs

##### Listings:

- o All messages in engineering units.
- o Summary of system performance.
- o Overall data content summary.

Program Name: TRACKER

Purpose: Deblock airborne generated tape containing aircraft state parameters and tracker data into three separate files containing one aircraft data in each.

Program Name: SRTMRG

Purpose: Create time correlated data base. The input is up to three BCAS data files output from CASSCAN and up to three tracker files output from TRACKER.

Program Name: PICKER

Purpose: Access the time correlated merge files created by SRTMRG and extract a data subject for a given time segment.

Program Name: AQPGM

Purpose: Determines acquisition and drop ranges for each surveillance track.

Program Name: TRKSTATS

Purpose: Gives statistics of coast in 15 range zones (0-15 miles) and relative elevation zones ( $10^{\circ}$  boundary) above and below the aircraft.

Program Name: VERTITAS

Purpose: Compares BCAS with ground trackers for accuracy analysis. Also creates plot file for Tektronix and various utilities to sort data, generate plots, etc.

Program Name: FOBCAS

Purpose: Analyzes BCAS detection and resolution logic. Real position data is input into a fast time BCAS simulation. Commands generated by the BCAS prototype and the simulator are compared and discrepancies analyzed.

Program Name: KLMFLT2

Purpose: Compares BCAS and ground tracker data. Position and velocity estimates for ground track data are derived by curve fitting and Kalman filtering techniques.

Program Name: WEISANLY

Purpose: Correlation and prediction plots of BCAS vs Tracker (Range, range rate, altitude, and altitude rate).

Program Name: CASPLT

Purpose: A series of five plots per encounter which aids in analyzing CAS logic performance. These plots are described in detail in section 6, Flight Test Analysis, Phase II.

APPENDIX E  
PILOT AND OBSERVER QUESTIONNAIRES

24

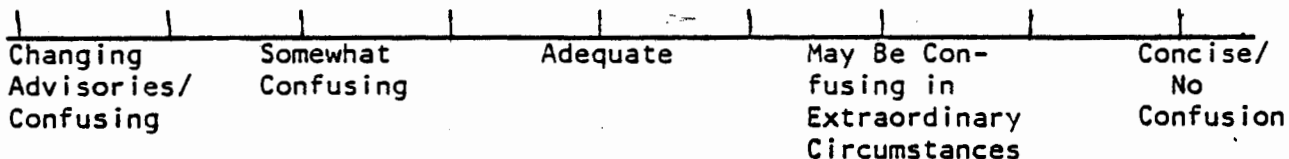
OBSERVER QUESTIONNAIRE INSTRUCTIONS:

1. Each run (or encounter) should have a discrete run number to allow correlation with each preplanned scenario for that date.
2. Each run should bear the date and approximate run time to allow future correlation with video tapes of the display and data reduction tapes.
3. questions which deal with qualitative effects allow the observer to rate on a continuously variable scale. This will allow the observer to rate the item at any intermediary point. These ratings will later be converted to points from which means, deviations, and distributions will be calculated.

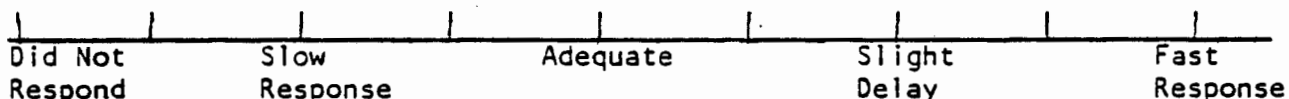
Word ratings were, in general, chosen to represent the two possible extremes which might be encountered. The midpoint was chosen to represent middle ground between the extremes and not the most expected result.



b. How clear was the advisory displayed in your opinion?



c. Did the pilot delay in responding?



d. Was the advisory displayed correct in sense and magnitude (as determined preflight according to the planned scenario and BCAS logic)?

Yes \_\_\_\_\_ No \_\_\_\_\_

4. AID Display:

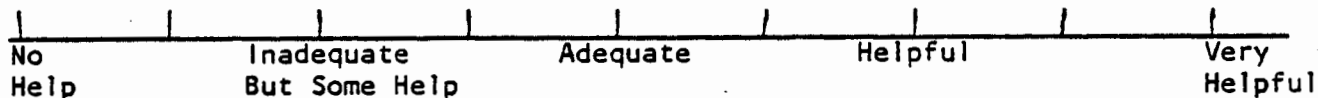
a. Did the pilot, in your opinion, use the AOA information in the AID display to locate the intruder?

Yes \_\_\_\_\_ No \_\_\_\_\_

b. Was visual contact made with the intruder/intruders?

Yes \_\_\_\_\_ No \_\_\_\_\_

c. How effective, in this instance, was the AID in sighting those intruders?



d. Was there doubt as to whether the sighted aircraft was the actual intruder?

Yes \_\_\_\_\_ No \_\_\_\_\_

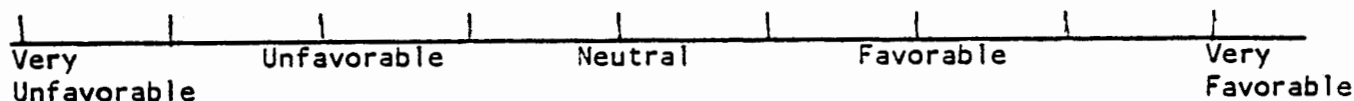
5. General:

a. Performance level:

(1) Automatic - Correctly Selected \_\_\_\_\_ Incorrectly Selected \_\_\_\_\_

(2) Manual - Level Selected      1      2      3      4      5

b. Pilot reaction:



c. Other comments:

PILOT

RUN NO. \_\_\_\_\_

TIME \_\_\_\_\_

DATE \_\_\_\_\_

1. Pilot workload:

a. What kind of workload impact would you say the BCAS System created?

Substantial Reduction in Workload	Some Reduction in Workload	No Change	Some Additional Workload	Substantial Increase in Workload			

b. Would you say that the advisories complemented or interfered with other pilot workload?

Complemental	Somewhat Complemental	Neutral/ Transparent	Some Interference	Substantial Interference			

c. Were there any circumstances in which you would have preferred to have the BCAS powered off?

Yes \_\_\_\_\_ No \_\_\_\_\_

If yes, briefly explain circumstances:

d. Did you experience any nuisance (false) alarms?

Yes \_\_\_\_\_ No \_\_\_\_\_

e. If yes, how did the false alarms impact your workload?

Neutral No Effect	Brief Distraction	Little Impact	Some Impact Confusion	Substantial Impact/Much Wasted Time and Motion			

f. Other comments:

2. Audible Alarm:

a. Was the BCAS audible alarm clearly discernible from all other cockpit audible alarms?

Yes \_\_\_\_\_ No \_\_\_\_\_

b. How would you rate the ability to hear the audible alarm?

Too Soft/ Difficult to Hear	Soft	Adequate	Loud	Too Loud Distracting		

c. How would you rate the duration of the tone?

Too Short Not Enough Time to Recognize	Somewhat Short	Generally Appropriate	Somewhat Longer Than Necessary	Too Long Distracting		

d. Would you prefer a tone of constant fixed duration, or some other system which cancels the tone upon pilot recognition?

Fixed Tone \_\_\_\_\_ Cancelling System \_\_\_\_\_

e. If you prefer a tone cancelling system, how would you like it implemented?

Yoke mounted switch \_\_\_\_\_

Computer determined from track information \_\_\_\_\_

Combination - computer/switch \_\_\_\_\_

f. In comparison to the older single tone system, how would you rate the new sequential tone system?

Much Worse	Somewhat Worse	No Difference	Improvement	Substantial Improvement		

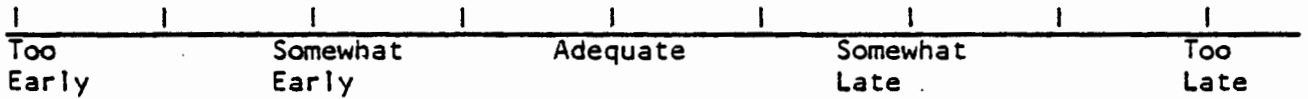
g. Do you feel that the audible alarm should be optional (may be disabled by pilot activated switch) or mandatory?

Optional \_\_\_\_\_ Mandatory \_\_\_\_\_

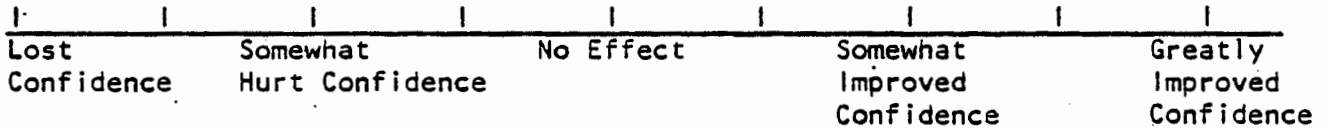
h. How useful was the audible alarm in alerting you to an advisory in comparison to either the IVSI or AID displays?

Much Less Useful	Somewhat Less Useful	No Difference	Somewhat More Useful	Much More Useful	

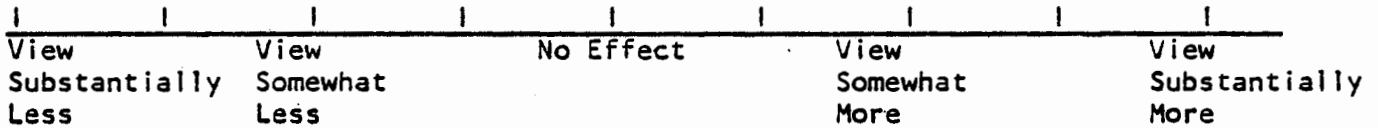
i. How would you rate the timeliness of the alarm?



j. How, in general, did the audible alarm affect your confidence in the operation of BCAS?



k. How did the audible alarm affect the need to periodically view the IVSI or AID display?



l. Other comments:

3. IVSI Display:

a. How would you rate the IVSIs location in the cockpit?

Poor	Undesirable	Adequate	Good	Ideal		

b. Did the sun wash out some indications?

Never	Seldom	Sometimes	Often	Always	

c. Did the intensity of the indications and/or location of the display impair your night vision?

Never	Seldom	Sometimes	Often	Always	

d. Did the selection of colors for the eyebrows or arrows ever confuse you as to the desired intent?

Yes \_\_\_\_\_ No \_\_\_\_\_

If yes, explain:

e. Were there every instances in which you had difficulty in interpreting the display - i.e., you did not know for sure what you were supposed to do.

Yes \_\_\_\_\_ No \_\_\_\_\_

If yes, explain:

f. Did you ever misinterpret the display and perform the wrong maneuver? (A wrong maneuver is any maneuver different from the displayed advisory including doing nothing if a positive command was given)

Yes \_\_\_\_\_ No \_\_\_\_\_

If yes, explain:

g. When visual contact was NOT made with the intruder, how confident were you in following the displayed advisory?

No Confidence	Doubted Advisory	Adequate	Good Confidence	Complete Confidence
------------------	---------------------	----------	--------------------	------------------------

h. Other comments:

4. AID Display:

a. How would you rate the <sup>AID</sup> IVSI location in the cockpit:

Poor	Undesirable	Adequate	Good	Ideal		

b. Did the sun and/or glare make the display difficult to read?

Never	Seldom	Sometimes	Often	Always	

c. Were there circumstances in which displayed alphanumeric and/or targets overlap and make it difficult to read and interpret?

Never	Seldom	Sometimes	Often	Always	

d. How would you rate the quantity of information presented?

Far Too Little	Not Enough	About Right	More Than Needed	Far Too Much/ Confusing	

e. How would you rate the quality of information presented?

Poor	Fair	Good	Very Good	Excellent	

f. Were the locations and/or data for the displayed targets every suspect?

Never	Seldom	Sometimes	Often	Always	

g. How would you rate the display format (data blocks, target representation, etc.)?

Poor	Fair	Good	Very Good	Excellent	

h. In terms of interpreting resolution advisories, how would you rate the relative value of the AID and IVSI displays?

IVSI Display Much More Valuable	IVSI Somewhat Better Than AID	Utilized AID & IVSI Equally	AID Somewhat Better Than IVSI	AID Display Much More Valuable	

i. Did the AID enhance your confidence in advisories presented in the IVSI?

Much Less Confidence	Less Confidence	No Change		More Confidence	Much Greater Confidence	

j. When resolution advisories were not being presented, how often would you estimate you sought or referred to the traffic advisories on the AID?

Never	Seldom	Sometimes		Often	Very Often

k. Did you find the AID distracting?

Never	Seldom	Sometimes	Often	Always

l. How would you rate the Angle of Arrival information presented?

No Help	Barely Adequate Help	Good Help		Very Good Help
				Excellent Help

m. Which sequence would best describe your normal series of actions? (Check one)

- \_\_\_ (1) Interpret IVSI, verify via AID, locate intruder, perform maneuver.
- \_\_\_ (2) Interpret IVSI, locate intruder, perform maneuver, verify via AID.
- \_\_\_ (3) Interpret IVSI, perform maneuver, locate intruder.
- \_\_\_ (4) Predict advisory via AID, interpret IVSI, perform maneuver, locate intruder.
- \_\_\_ (5) Predict advisory via AID, locate intruder, perform maneuver.
- \_\_\_ (6) Interpret IVSI, perform maneuver, check AID, locate intruder.

n. How good was the AID in helping you visualize traffic separation as well as location?

Poor	Fair	Good	Very Good	Excellent

o. In the event that the information appearing in the AID seemed to conflict with the resolution advisory displayed on the IVSI, what would you most likely do? (Check one)

Follow the IVSI, ignore the AID.

Follow the AID, ignore the IVSI.

Wait for more positive commands on the IVSI.

Attempt to visually sight the intruder using AID bearing information, maneuver accordingly.

Ask ATC for assistance.

Do nothing.

p. Additional comments:

5. System.

a. Was there any difference in your confidence in performing positive and negative maneuvers?

Much greater confidence in negative conditions	More confidence in negative conditions	No Difference	More confidence in positive conditions	Much greater confidence in positive conditions			

b. Did you every doubt whether the equipment had silently failed without your knowledge?

Yes \_\_\_\_\_ No \_\_\_\_\_

If yes, explain:

c. What is the best feature of this present system?

d. What is the least desirable feature of this present system?

e. Is this system an improvement over previous designs?

Yes \_\_\_\_\_ No \_\_\_\_\_

f. Other comments:

## APPENDIX F

### FLIGHT DATA COLLECTION SYSTEM

For the purposes of supporting pilot system interface and ground system versus BCAS range and bearing accuracy studies, the Technical Center has designed and built a flight data collection system. A block diagram showing this system appears in figure F1.

Data to evaluate performance of the Dalmo-Victor (D-V) BCAS equipment are collected on two digital 9-track recorders. Output from the BCAS equipment is recorded on the recorder provided by D-V. Timing is supplied by the time-of-day clock. Aircraft state parameters, event mark, and tracking range data are recorded on the second tape drive.

Aircraft state variables to be recorded are roll, pitch, and heading, and are obtained from the ship's Inertial Navigation Unit. These signals are converted from a synchro format into digital form by a 14 bit S/D module. Provision for a spare synchro recording channel is made in the present design. A block diagram showing the data collection system is given in figure F1.

Four event markers are available to allow the pilot or operator to indicate the occurrence of some phenomenon or to input a reaction. These are discrete inputs and are driven by single-pole, single-throw switches (normally open) or open-collector TTL gates. The event is declared when the switch is closed or the TTL gate pulls the input line down. In addition to being recorded on the digital tape, these inputs gate four audio signals which are then mixed and brought out to a BNC connector. This output signal can be fed to an audio recorder or to the audio channel of a video tape recorder for use in human factors analysis. The event marks and their associated audio frequencies are listed in table F1.

Tracking data is input through the telemetry port. A  $\pm 1$  volt, 2400 baud, asynchronous signal is expected at this input. Data to be transmitted from the ground include x, y, z coordinates for two aircraft, distance between them, and angle to the other ship with respect to magnetic north. Format for the telemetry is shown in table F2 and geometry for the telemetered data in figure F2.

All inputs are sampled at a 5-hertz rate and recorded at the rate of one physical record per second. Each physical record is time tagged with data from the same time-of-day clock which tags the D-V data. Table F3 shows the format of a physical record. Note that each record contains data from every 200 millisecond sample. Termination of flight data is noted by five end-of-file marks on the tape which is written from the front panel of the recorder.

TABLE F1. EVENT MARKER INPUTS

<u>Input #</u>	<u>Frequency</u>	<u>Purpose</u>
1	2857.14 Hz	Pilot response
2	2222.22 Hz	Pilot response
3	1818.18 Hz	Observer response
4	1333.33 Hz	Spare

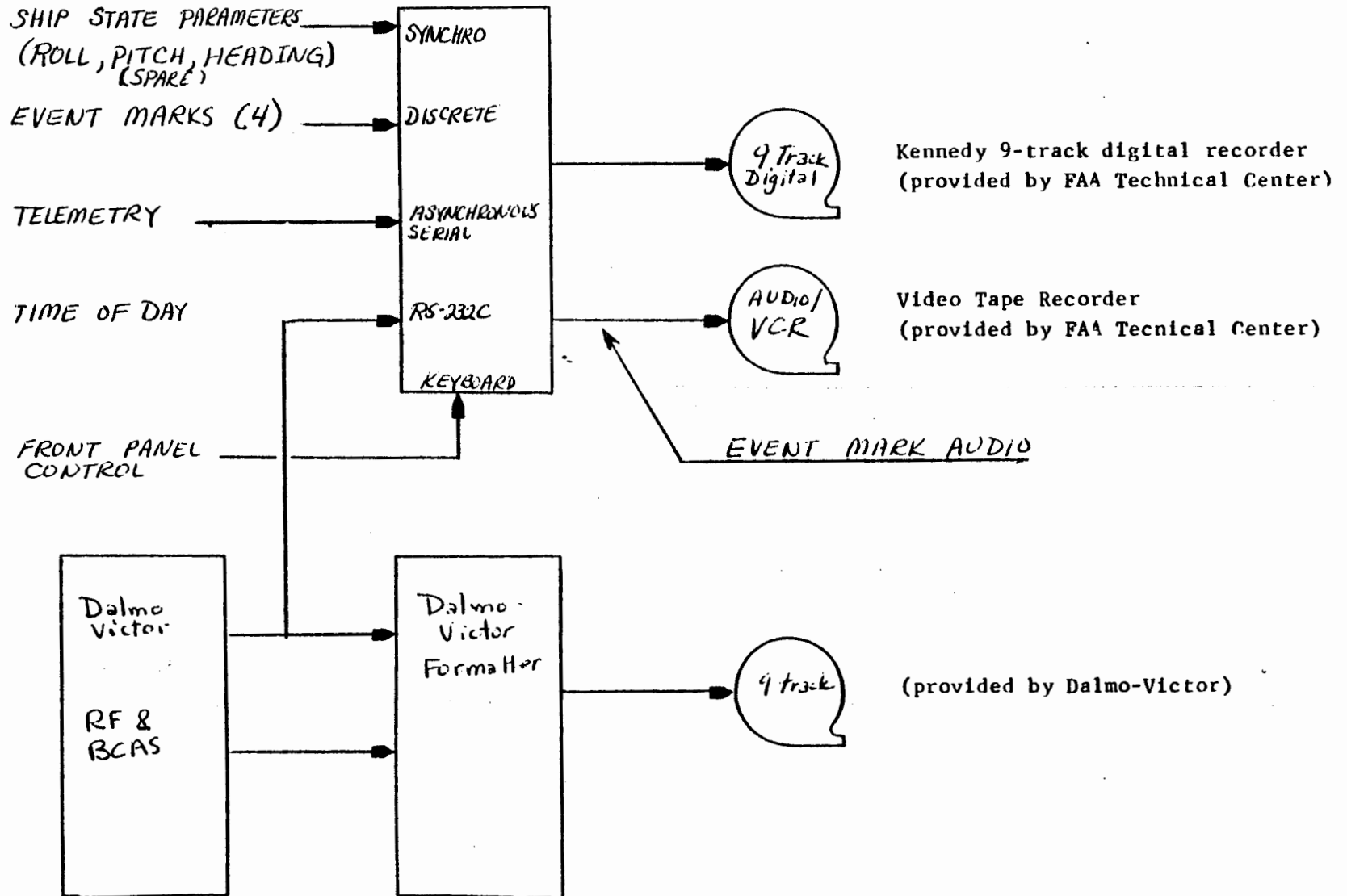


FIGURE F1. BCAS DATA COLLECTION SYSTEM FOR DALMO VICTOR FLIGHT TESTS

TABLE F2. TELEMETRY FORMAT

<u>Identification</u>	<u>Character (Hexadecimal)</u>
1. Start of Header (SOH)	01
2. Byte Count	N Number of <u>data</u> bytes
3. Start of Text (STX)	02
4. Label (Sample Time)	80
5. Data MSB	
6. Data	
7. Data LSB	
8. Label (Aircraft #1 X-Coordinate)	11
9. Data MSB	
10. Data	
11. Data LSB	
12. Label (Aircraft #1 Y-Coordinate)	12
13-15 Data	
16. Label (Aircraft #1 Z-Coordinate)	13
17-19 Data	
20. Label (Aircraft #2 X-Coordinate)	21
21-23 Data	
24. Label (Aircraft #2 Y-Coordinate)	22
25-27 Data	
28. Label (Aircraft #2 Z-Coordinate)	23
29-31 Data	
32. Label (Aircraft #3 X-Coordinate)	31
33-35 Data	
36. Label (Aircraft #3 Y-Coordinate)	32
37-39 Data	
40. Label (Aircraft #3 Z-Coordinate)	33

TABLE F2. TELEMETRY FORMAT (CONTINUED)

<u>Identification</u>	<u>Character (Hexadecimal)</u>
41-43 Data	
44. Label (Distance $T_1 T_2$ )	15
45-47 Data	
48. Label (Distance $T_1 T_3$ )	35
49-51 Data	
52 Label (Distance $T_2 T_3$ )	25
53-55 Data	
56. Label (Angle between Aircraft $_{12}$ )	16
57-59 Data	
60. Label (Angle between Aircraft $_{13}$ )	36
61-63 Data	
64. Label (Angle between Aircraft $_{23}$ )	26
65-67 Data	
68. Label (Tracker calculated heading $_1$ )	14
69-71 Data	
72. Label (Tracker calculated heading $_2$ )	24
73-75 Data	
76. Label (Tracker calculated heading $_3$ )	34
77-79 Data	
80 Checksum	
81 End of Text (ETX)	03
82 NULL (Fill to next SPH)	00

Each data field consists of an 8 bit label which identifies the variable and a 24 bit binary word. Each variable has an implied binary point associated with it.

Established data formats:

<u>Label</u>	<u>Variable</u>	<u>Units</u>	<u>LSB</u>
80	Time	Seconds	1/32 Second

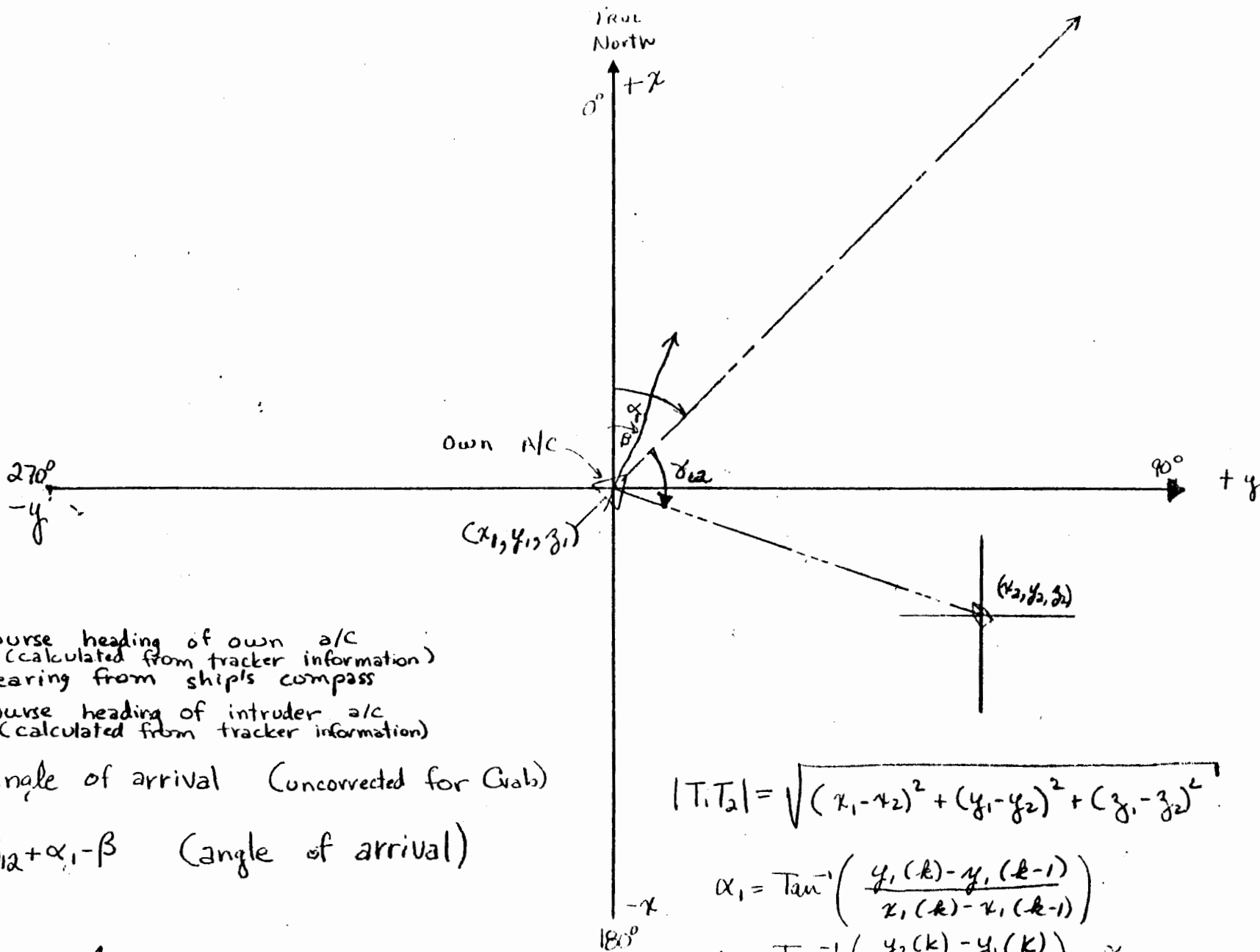
TABLE F2. TELEMETRY FORMAT (CONTINUED)

<u>Label</u>	<u>Variable</u>	<u>Units</u>	<u>LSB</u>
11	X(translated & rotated)	Meters	1/16 meter
12	Y(translated & rotated)	Meters	1/16 Meter
13	Z(translated & rotated)	Meters	1/16 Meter
21	X(translated & rotated)	Meters	1/16 Meter
22	Y(translated & rotated)	Meters	1/16 Meter
23	Z(translated & rotated)	Meters	1/16 Meter
31	X(translated & rotated)	Meters	1/16 Meter
32	Y(translated & rotated)	Meters	1/16 Meter
33	Z(translated & rotated)	Meters	1/16 Meter
15	Distance $ T_1 T_2 $	Meters	1/16 Meter
25	Distance $ T_2 T_3 $	Meters	1/16 Meter
35	Distance $ T_1 T_3 $	Meters	1/16 Meter
16	Angle between aircraft	Radians	$\pi/2^{23}$ Radians
26	Angle between aircraft	Radians	$\pi/2^{23}$ Radians
36	Angle between aircraft	Radians	$\pi/2^{23}$ Radians
14	Tracker calculated heading	Radians	$\pi/2^{23}$ Radians
24	Tracker calculated heading	Radians	$\pi/2^{23}$ Radians
34	Tracker calculated heading	Radians	$\pi/2^{23}$ Radians

Format - 10 Bit Asynchronous serial, consisting of 1 start bit, 8 data bits and 1 stop bit.

Baud rate available - 2400 Baud

Data Rate - 5 samples per second



$\alpha_1$  = course heading of own a/c  
(calculated from tracker information)

$\beta$  = bearing from ship's compass

$\alpha_2$  = course heading of intruder a/c  
(calculated from tracker information)

$\delta_u$  = angle of arrival (uncorrected for Crab)

$\delta_c = \delta_{12} + \alpha_1 - \beta$  (angle of arrival)

$H_{rd} = z_2 - z_1$

$$|T_1 T_2| = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2}$$

$$\alpha_1 = \tan^{-1} \left( \frac{y_1(k) - y_1(k-1)}{x_1(k) - x_1(k-1)} \right)$$

$$\delta_u = \tan^{-1} \left( \frac{y_2(k) - y_1(k)}{x_2(k) - x_1(k)} \right) - \alpha_1$$

FIGURE F2. TELEMETERED DATA GEOMETRY

TABLE F3. PHYSICAL RECORD DEFINITION

<u>Byte</u>	<u>Data</u>	
1-2	Index (hexadecimal FFFF)	
3	Years x 10 (ASCII)	
4	Years x 1 (ASCII)	
5	Days x 100 (ASCII)	
6	Days x 10 (ASCII)	
7	Days (ASCII)	
8	Hours x 10 (ASCII)	
9	Hours x 1 (ASCII)	
10	Minutes x 10 (ASCII)	
11	Minutes x 1 (ASCII)	
12	Seconds x 10 (ASCII)	
13	Seconds x 1 (ASCII)	
14-24	Unused	
25	Status byte	} Data field 1 time = t + 0.0 seconds
26	Event Marker byte	
27-28	Roll	
29-30	Pitch	
31-32	Heading	
33-34	Spare Synchro Channel	
35-110	Telemetry	
111-224	Unused	
225-424	data field 2	time = t + 0.2 seconds
425-624	data field 3	time = t + 0.4 seconds
625-824	data field 4	time = t + 0.6 seconds
825-1024	data field 5	time = t + 0.8 seconds

TABLE F3. PHYSICAL RECORD DEFINITION (CONTINUED)

Status byte: Bit 7 (MSB)	Time entered & triggered from time-of-day clock
Bit 6	Time entered manually and remotely triggered
Bit 5	Time entered & triggered manually
Bit 4 - Bit 0 (LSB)	Unused
Event marker: Bit 7 (MSB) - Bit 4 byte	Unused
Bit 3	Event marker #4
Bit 2	Event marker #3
Bit 1	Event marker #2
Bit 0 (LSB)	Event marker #1