

Report No. FAA-CT-80-184

CT 0010.10502375  
80-184 COPY 1 2

# TEST AND EVALUATION OF THE DISCRETE ADDRESS BEACON SYSTEM (DABS) / MOVING TARGET DETECTOR (MTD) / RADAR DATA ACQUISITION SUBSYSTEM (RDAS)

Edward Mancus

FEDERAL AVIATION ADMINISTRATION  
JUN 2 1981  
TECHNICAL CENTER LIBRARY  
ATLANTIC CITY, N.J. 08405



## PROJECT PLAN

MAY 1981

Document is available to the U.S. public through  
the National Technical Information Service,  
Springfield, Virginia 22161.

Prepared for  
**U. S. DEPARTMENT OF TRANSPORTATION**  
FEDERAL AVIATION ADMINISTRATION  
TECHNICAL CENTER  
Atlantic City Airport, New Jersey 08405



00008484

#### NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for the contents or use thereof.

The United States Government does not endorse products or manufacturers. Trade or manufacturer's names appear herein solely because they are considered essential to the object of this report.

## TABLE OF CONTENTS

	Page
1. OBJECTIVE	1
2. BACKGROUND	1
3. RELATED DOCUMENTS	2
4. DESCRIPTION OF EQUIPMENT	2
4.1 Discrete Address Beacon System	2
4.2 Moving Target Detector	4
4.3 Radar Data Acquisition Subsystem	4
4.4 Nike-Hercules Tracking Radar System	5
4.5 Aircraft Reply Interference Environment Simulator	5
4.6 DABS Random Fruit Generator	6
4.7 Video Reconstitutor/Video Delay Unit	7
5. DATA COLLECTION	5
5.1 Beacon-Only Processing	5
5.2 DABS/MTD and DABS/RDAS Interface Capacity Test	8
5.3 Clear Air Environment	9
5.4 Clutter Environments	11
5.5 Accuracy and Resolution	12
5.6 Weather Mapping	13
6. DATA REDUCTION AND ANALYSIS	13
7. COORDINATION AND AREAS OF RESPONSIBILITY	16
8. SCHEDULE	16
APPENDIX	

## LIST OF FIGURES

Figure		Page
1	DABS/ARIES Test Configuration	8
2	DABS/MTD Test Configuration	10
3	DABS/RDAS Test Configuration	10
4	Aircraft Flight Profiles	11
5	Weather Display Block Diagram	14
6	Program Schedule for DABS/MTD and DABS/RDAS as of 1/2/80	17

## LIST OF TABLES

Table		Page
1	Radar System Parameters and Performance Summary	1
2	Accuracy and Resolution Flight Plan	12

## 1. OBJECTIVE.

The primary objectives of testing the Moving Target Detector (MTD) and the Radar Data Acquisition Subsystem (RDAS) as an integral part of the Discrete Address Beacon System (DABS) are to characterize their combined performance in:

- a. Providing radar/beacon correlation of DABS and Air Traffic Control Radar Beacon System (ATCRBS) targets with radar targets provided as an input to DABS from either the RDAS or MTD.
- b. Providing improved radar surveillance on aircraft not equipped with a beacon transponder for display and tracking purposes.
- c. Providing weather information to an air traffic control (ATC) facility.

## 2. BACKGROUND.

Three engineering models (EM) of the DABS sensors were delivered to the Federal Aviation Administration (FAA) Technical Center for performance testing. Initial performance testing was emphasized for a single DABS sensor configuration. Subsequent testing has been expanded to include both partially and fully netted configurations. Two of the sensors (FAA Technical Center and Clementon) operate in a terminal environment, while the third sensor (Elwood) operates in an en route environment.

An MTD and RDAS have been delivered to the FAA Technical Center along with the interface to provide the DABS sensor with radar report data and weather data from either radar processor. A second MTD has been delivered to Clementon and interfaced with that DABS sensor. Modifications to the DABS sensor surveillance processing software to provide the capability of tracking radar-only aircraft and to disseminate radar track messages and weather messages to an ATC facility have also been accomplished.

The applicability of the MTD or RDAS and the DABS radar surveillance processing to service noncorrelating users is one object of these tests. The first experimental model of the MTD was a hard-wired digital processor referred to as the MTD-1. It was interfaced with the Automated Radar Terminal System (ARTS III) located at the Terminal Facility for Automated Surveillance Testing (TFAST) at the FAA Technical Center. Extensive testing was conducted jointly by Lincoln Laboratory and Technical Center personnel. Three reports were published on the results of the MTD tests conducted at the Technical Center. Two of the reports, "Description and Performance Evaluation of the Moving Target Detector," Report No. FAA-RD-76-190, and "Comparison of the Performance of the Moving Target Detector and the Radar Video Digitizer," Report No. FAA-RD-76-191, were prepared by Lincoln Laboratory. The third report, "Test and Evaluation of the Moving Target Detector Radar," Report No. FAA-RD-77-118, was prepared by the Technical Center.

Initial design of the DABS provided for a radar interface compatible with common digitizer inputs. The MTD that has been interfaced with the DABS consists of a design that employs substantially more software processing than that used in the MTD-1. This MTD, referred to as the MTD-2, is expected to provide improved radar data for radar beacon correlation and radar tracking functions residing in sensor software.

The sensor receiver and processor (SRAP) was developed for the FAA by the UNIVAC Corporation to replace the Beacon Data Acquisition Subsystem (BDAS), and to off-load the input/output processor (IOP) of the ARTS III by moving dwell processing from the IOP to the SRAP. A production model of the SRAP was integrated into the TFAST ARTS III at the Technical Center where tests were conducted.

Evaluation of the ability of the DABS sensor to process radar reports provided by the RDAS requires an additional interface. This interface between the DABS and RDAS involves transmission of uncorrelated radar reports from the DABS to the RDAS. These reports are used in the SRAP to adjust thresholding level. Thus, a feedback mechanism is established for the purpose of regulating the false target rate of the RDAS. The MTD and RDAS will also provide digital weather messages to the DABS sensor. The DABS will simply merge these weather messages into a common radar beacon surveillance data stream to ATC.

### 3. RELATED DOCUMENTS.

- a. "Discrete Address Beacon System (DABS) Sensor Engineering Requirement," FAA-ER-240-26, July 16, 1980.
- b. "Software CDR for DABS: MTD," DOT-FA76WA-3772, August 15, 1979.
- c. "Test and Evaluation of the Moving Target Detector (MTD) Radar," FAA-RD-77-118, October 1977.
- d. "DABS Single Sensor Performance Test Plan," FAA-NA-79-151, July 1979.
- e. "Description and Performance Evaluation of the Moving Target Detector," FAA-RD-76-190, March 1977.
- f. "Comparison of the Performance of the Moving Target Detector and the Radar Video Digitizer," FAA-RD-76-191, April 1977.
- g. "DABS: A System Description," FAA-RD-74-189 (ATC-42), November 1974.
- h. "FAA Technical Center Range Instrumentation Systems," FAA-NA-79-32, February 1980.
- i. "The Aircraft Reply and Interference Environment Simulator (ARIES)," FAA-RD-78-96, March 1979.

### 4. DESCRIPTION OF EQUIPMENT.

The following paragraphs are presented to give a brief description of the systems and equipment used to collect information on the DABS/MTD and the DABS/RDAS systems.

#### 4.1 DISCRETE ADDRESS BEACON SYSTEM.

The DABS is a cooperative surveillance and communication system for ATC. Each DABS aircraft is assigned a unique discrete address which provides a surveillance interrogation and reply protocol that inherently supports data link communications to or from a particular aircraft.

In order to provide for an evolutionary transition from an all ATRCBS environment to one consisting of the DABS, the DABS sensor operates in both an ATRCBS and DABS mode. The sensor uses the available processing time (channel time) first for ATRCBS functions and then for DABS functions. DABS employs a monopulse direction finding technique using a 5-foot vertical aperture beacon antenna having sum, difference, and integral omnidirectional patterns. The interrogation is transmitted and the reply received on the sum and difference patterns. The ratio of the amplitudes of the signals received on the difference and the sum patterns is used to determine the off-boresight angle of the target; i.e., the angular difference between the target position and the antenna point angle. Reliable and improved ATRCBS surveillance data are obtained with a nominal 4 hits per target, contrasted to today's ATRCBS of 16 to 30 hits per target. A DABS period is used to perform DABS surveillance and data link communications. DABS surveillance interrogations are scheduled in range order. In each antenna beam dwell, the DABS sensor first interrogates the DABS aircraft furthest from it and computes the expected reply arrival time. The DABS channel management then schedules the interrogation for the next furthest aircraft in a manner that allows the replies to arrive at the sensor in sequence that precludes overlap of replies. It continues interrogating succeeding aircraft at decreasing ranges until the first reply is expected, then schedules a "listening" period to receive the replies to its interrogations. This procedure is repeated for all DABS targets within the horizontal and vertical pattern of the antenna until a valid roll-call reply is received.

Only aircraft on the sensor's roll-call list can be discretely interrogated. To acquire targets not yet on the sensor's roll-call list, DABS transmits, when in the ATRCBS mode, an ATRCBS/DABS All-Call interrogation, which is similar to today's ATRCBS interrogation with an additional pulse, P4. An ATRCBS transponder is unaffected by the presence of the P4 pulse and responds with a normal ATRCBS reply. DABS transponders recognize the interrogation as a DABS All-Call interrogation and respond with an All-Call reply containing its discrete address.

After determining the position and velocity of a DABS equipped aircraft, the sensor places the target on its roll-call list. On a subsequent discrete interrogation, the DABS transponder can be locked-out from replying to All-Call interrogations, thereby, eliminating unwanted replies. In order to suppress ATRCBS transponders outside of the antenna main beam in the ATRCBS mode, DABS transmits a P2 suppression pulse on the omnidirectional antenna each time there is an All-Call interrogation. In the DABS mode, each discrete interrogation consists of a preamble of P1-P2 suppression pulse pairs to suppress ATRCBS transponders that are in the antenna main beam when the particular DABS target is being interrogated. This intentional suppression (nominally 35 microseconds) is to prevent unwanted ATRCBS replies that may interfere with the discrete reply.

The sensor also receives surveillance data from a colocated primary radar digitizer for correlation with beacon data. One specific radar digitizer that the sensor operates with is the common digitizer (CD). The sensor receives radar target reports plus map, strobe, status, search real time quality control (RTQC) target, and ATRCBS Identification Friend or Foe Mark XII System reports from the CD via a serial interface. A clock signal is provided by the sensor and controls the rate that data are transferred from the CD. To meet the requirement of target report delivery within the scan, the necessary data rate from the CD are 7,200 bits per second (bps). The radar surveillance data received from the CD are used for radar reinforcement of beacon reports or for radar substitution for coasting beacon

tracks. The remaining uncorrelated radar reports are forwarded to the ATC center by the sensor.

The sensor may operate with two other radar digitizers, the MTD and the RDAS. The sensor will receive radar target reports and weather messages from either radar digitizer via a parallel interface consisting of 16 data lines and associated control signals. Status lines are also used to monitor the interface status. The radar surveillance data are used for radar reinforcement and radar substitution. The remaining uncorrelated radar reports are used to initiate and update tracks on radar-only aircraft.

#### 4.2 MOVING TARGET DETECTOR.

The MTD is a digital signal processor employing linear, wide dynamic range, coherent doppler filtering, and adaptive thresholding techniques. Doppler filtering is generated by sequentially processing groups of eight samples in each range gate of 1/16 nautical miles through a two-pulse canceller and converting the remaining time samples into frequency (doppler) information using digital filter techniques. The MTD contains a bank of eight doppler filters. One of these filters includes zero radial velocity.

The nonzero radial velocity cells are level detected using the mean level of the signals in the same velocity filter averaged over 1/2 mile in range on either side of the cell of interest. In addition, the MTD contains a digital ground clutter map which establishes the thresholds for the zero radial velocity filter. The clutter level in the ground clutter map adapts to a value based on the average level in the previous eight scans. All eight filter outputs are sorted into approximately 3,000,000 range-azimuth-velocity cells for each scan allowing independent detection thresholding adjustment on each cell every scan.

The MTD uses a multiple pulse repetition rate varied for each group of eight pulses to eliminate blind speeds. This technique, when used with a coherent transmitter, also eliminates second-time-around ground clutter returns.

#### 4.3 RADAR DATA ACQUISITION SUBSYSTEM.

The RDAS receives normal and moving target indicator (MTI) analog video along with basic timing signals from the radar. The input video are converted by analog-to-digital converters to a series of 10-bit words representing the amplitude of the input, sampled every 625 nanoseconds. The quantized video is then rank ordered and converted into target hit data and clutter hit data. The clutter hit data generated from the normal video are used by the RDAS to determine which to use, normal or MTI video, for target processing for a specific area. The processing logic employs hit/miss filtering and adaptive hit-count thresholding techniques to detect potential targets. Each target report is assigned a quality which is defined as the number of hits counted on a target minus the applied hit count threshold.

The DABS receives the target reports and subjects them to a third level of discrimination based on their quality. Target reports that pass the quality threshold are processed by DABS radar tracking software. The remaining targets not used to update radar tracks or initiate new tracks are returned by the DABS sensor interface to the RDAS. These uncorrelated radar reports are then counted and compared to a false report threshold. If the count exceeds the threshold the rank order threshold is raised reducing target hit sensitivity.

#### 4.4 NIKE-HERCULES TRACKING RADAR SYSTEM.

The FAA Technical Center's Nike-Hercules radar tracking system consists of two separate and essentially distinct tracking radars. Each of the radars, one originally designed as a missile tracking radar (MTR) and the other designed as a target tracking radar (TTR), have been modified to include a digital, computer-based, range-detecting subanalysis system. The main radar system parameters and performance measures are summarized in table 1.

Both the MTR and TTR radars are checked and adjusted to applicable specifications before each mission. The electrical, mechanical, and optical axis of the pedestals have been adjusted to allow determination of angle bias by telescope sightings using both terrestrial and stellar objects.

TABLE 1. RADAR SYSTEM PARAMETERS AND PERFORMANCE SUMMARY

Radar Frequency	X-band (9.0 to 9.5 GHz)
Antenna Gain	44 dB
Beam Width	18 mrad
Peak Power	250 kW
Pulse Repetition Frequency (selectable)	1000, 320 Hz
Pulse Width (selectable)	0.5, 1.5 $\mu$ s
Angle Servo	Type 1
Angle Servo Bandwidth	2 Hz
Maximum Angle Rate: Azimuth	30°/second AZ
Elevation	15°/second EL
Range Servo	Type 2
Range Servo Bandwidth (selectable)	10, 5, 2.5, 1.2 Hz
Maximum Slew Rate	24,000 m/s
Angle Precision (S/N = 20 dB)	0.15 mrad (1 $\sigma$ )
Range Precision, TTR (S/N = 20 dB)	3 meters (1 $\sigma$ )
Maximum Range (at 320 Hz PRF)	469 km
Range for S/N = 20 dB on 1.0 m <sup>2</sup> target	61 km

#### 4.5 AIRCRAFT REPLY INTERFERENCE ENVIRONMENT SIMULATOR.

The ARIES was designed by Lincoln Laboratory to simulate DABS and ATCRBS target replies, ATCRBS asynchronous (fruit) replies, communications messages, and radar report data. The interrogation interface between the sensor and the ARIES is at the radiofrequency (RF) level and the replies generated by the ARIES are received by the DABS at the receiver intermediate frequency (IF) level. Radar reports from the ARIES to DABS are at the report level and transferred via a separate digital interface.

Along with simulated traffic, the ARIES generates a simulated ATCRBS fruit environment which is modeled as a random process with Poisson statistics. The operator can control the average fruit rate by setting parameters in a file on the system disk. The ARIES also provides for establishment of main-to-side-lobe fruit ratios and is capable of generating ATCRBS fruit replies at rates up to about 50,000 replies per second.

For both the simulated target and fruit replies, the ARIES provides the necessary signals to accurately simulate the monopulse off-boresight angle. Also, an omnidirectional signal is provided so that side-lobe replies can be simulated. These signals are supplied to the DABS sensor via an interface dedicated to the ARIES. The sensor combines the ARIES signals to similar signals from the sensor antenna. This allows for a controlled ARIES environment to be superimposed on the "real world" live environment.

A maximum of 400 targets may be simulated by the ARIES. Any mix of DABS and ATRBS targets is possible. There are also limitations on the number of targets bunched in azimuth. The ARIES is capable of generating the number of bunched targets specified for the DABS sensor, which are:

- a. Fifty aircraft in an 11.25° sector, for not more than eight consecutive sectors.
- b. Twelve aircraft in 1.0° azimuth wedge for up to four contiguous wedges.

The original design provides for simulated digitized radar data in the output format of the CD. A modification is being developed to include the capability of generating both MTD and RDAS formatted radar reports. The reported coordinates of a radar target are the same as those established by the test scenario for the beacon target. The ARIES operator can control the radar reply probability by setting parameters in a file on the system disk.

The ARIES equipment consists of interrogation receiving circuitry and a computer with associated peripheral equipment to control the system. This equipment was housed in two standard racks. A complete description of the ARIES as originally designed is contained in Lincoln Laboratory report FAA-RD-78-96.

#### 4.6 DABS RANDOM FRUIT GENERATOR.

The DABS random fruit generator outputs a digital serial data stream that simulates DABS received messages. This serial output is used to pulse modulate the DABS built-in performance monitoring RF test unit. The random simulated DABS received messages are coupled into the three lines: sum ( $\Sigma$ ), difference ( $\Delta$ ), and omni ( $\Omega$ ). The amplitude of the simulated DABS fruit message pulses are approximately -50 decibels above 1 milliwatt (dBm).

The DABS random fruit generator contains a 20-bit random number generator (RNG) which will repeat its pattern approximately every 4.2 seconds. This is approximately equal to the antenna scan rate. The output of the RNG is fed to a comparator whose other inputs come from fruit rate select switches. When the RNG input is greater than the fruit rate select switch a DABS reply is generated.

The fruit rate granularity is approximately 4 replies per second over a range of 4 replies per second to 4,000 replies per second under switch control. Replies can be generated with random range and azimuth distribution or in bursts. Reply messages can be 56 bits or 112 bits in length or a selectable percentage of either.

#### 4.7 VIDEO RECONSTITUTOR/VIDEO DELAY UNIT.

The video reconstitutor (VR) generates plan position indicator (PPI) primary and beacon video signals based on information contained in the digital messages disseminated by the DABS sensor. The digital message formats are specified in FAA-RD-80-14, section 4. The video reconstituted signals are used to drive a conventional ARTS display. The VR provides the potential of eliminating the broadband link between the transmitter and indicator site while retaining the PPI display as a backup to the ARTS digital system.

The video delay unit (VDU) provides for the delay of airport surveillance radar (ASR) video for proper registration with reconstituted DABS sensor beacon video. The delay technique employed converts the raw radar video to amplitude represented digitized data. Blocks of digitized data, including azimuth change pulse (ACP) and azimuth reference pulse (ARP) words, are stored in memory during each sweep for a preselected time. The size of memory and the pulse repetition frequency (PRF) rate determines the maximum delay. The output digitized data are then converted back to analog form for display on a PPI system. Thus, the VR will be used either with or without the video delay unit, based upon the availability of a radar digitizer (MTD or RDAS).

The VR/VDU unit is used as follows:

a. Beacon reconstitution mode (used in the absence of an MTD or RDAS). In this mode the VR accepts digital ATCRBS messages from the DABS sensor. ASR targets and weather information are received from the ASR and delayed by the VDU to provide for alignment with the reconstituted beacon video.

b. Full reconstitution mode (used with an MTD or RDAS). In this mode the VR accepts digital surveillance messages from a DABS sensor and generates broadband surveillance radar, beacon, and weather map videos in rho-theta coordinates specified by the digital messages.

#### 5. DATA COLLECTION.

The test and evaluation of the DABS/MTD system and the DABS/RDAS system will be divided into six major areas: (a) the first area will be concerned with beacon-only processing; (b) the second test involves DABS radar capacity; (c) the third test involving surveillance processing of radar/beacon targets and radar only targets in a clear environment will be accomplished; (d) the fourth test area will be concerned with radar surveillance and radar tracking performance for various clutter environments; (e) the fifth area of test will be designed to establish positional accuracy and resolution of radar reports; and (f) sixth, the performance of the radar processors in providing weather messages to DABS and, subsequently, to ATC facilities will be established.

##### 5.1 Beacon-Only Processing.

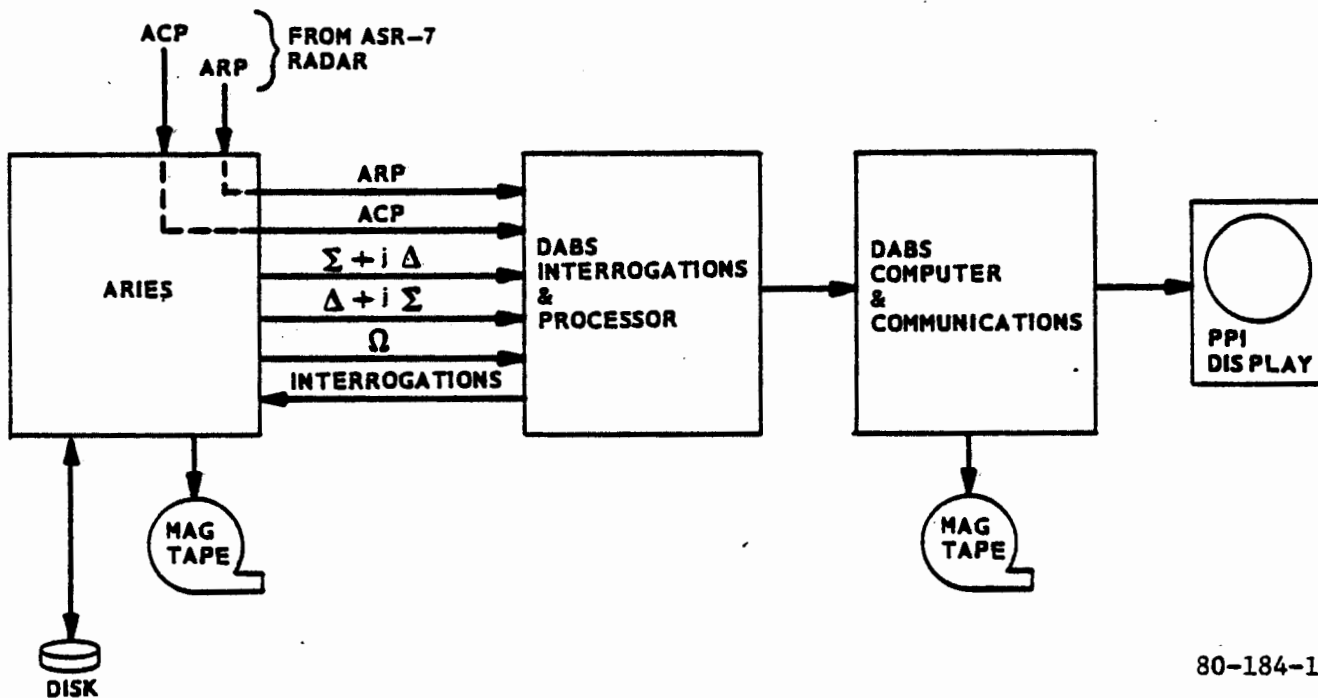
Prior to conducting tests involving the radar processors, several test runs will be conducted with only beacon inputs to insure proper DABS performance. These tests will determine if any degradation in sensor performance has resulted from the addition of radar surveillance processing software. A direct comparison of both DABS configurations (with and without MTD and RDAS surveillance processing) will be achieved using the ARIES to provide repeatable input to the DABS sensor. The Basic

ARIES 42-target scenario used during previous performance testing will be employed to support these tests. A complete description of the Basic 42-target scenario is contained in appendix A. The test configuration is depicted in figure 1.

The DABS receiver will be configured to receive only the ARIES inputs. During these tests surveillance/ATC data will be recorded by the DABS data extraction subsystem on to magnetic tapes. Simultaneously, DABS interrogations and replies generated by the ARIES will be recorded on to magnetic tapes. These tapes will be used for subsequent analysis.

5.2. DABS/MTD and DABS/RDAS Interface Capacity Test.

The purpose of the radar interface capacity runs will be to determine if the radar processor (MTD or RDAS) to sensor interface meets the data rate requirements specified in document FAA-ER-240-26. The tests will be conducted with the sensor configured as a nonnetted terminal site. The approach will be to use ARIES to transfer radar reports to the DABS sensor over a 16-bit word parallel interface. ARIES tests scenario will be generated to simulate different loading conditions. A 400 radar-only target scenario will be generated to study system performance under peak radar load. The radar targets will be uniformly distributed between 180° to 270° in azimuth and randomly distributed in range (0 to 60 nautical miles). The scenario will start with 100 radar targets, adding in a staircase-type pattern 25 targets every 25 scans.



80-184-1

FIGURE 1. DABS/ARIES TEST CONFIGURATION

A 48-target scenario will be generated to study system performance under short term peak radar loading. The targets will be uniformly distributed within a 4° azimuth wedge and randomly distributed in range (0 to 60 nautical miles) and altitude (0 to 30,000 feet). Target mix for the 48-target scenario will be: (a) radar reinforced ATRBS with 70 percent ATRBS targets having discrete codes, (b) radar reinforced DABS targets, (c) radar-only targets, (d) radar-only targets and ATRBS targets with no radar-beacon correlation, and (e) radar-only targets with DABS targets with no radar-beacon correlation. These scenarios will initially start with a single target. After 25 scans two targets are added. The scenarios will then continue adding in a staircase-type pattern three targets every 25 scans.

The MTD radar report buffer and the MTD radar input buffer will be recorded, along with target report and track data, by the DABS data extraction subsystem on to magnetic tape and used for subsequent analysis.

### 5.3 Clear Air Environment.

This area of testing will focus on collecting DABS sensor track data plus the radar report and beacon report surveillance data. All beacon replies and reports and radar reports will be recorded. An indepth data analysis will be performed in areas of interest. The data collected during these tests will be reduced to evaluate the performance of the DABS radar surveillance processing for two independent areas:

- a. Display of digitized radar reports via video reconstitutor.
- b. Ability to perform radar report-to-track correlation and service non-correlating users of primary radar surveillance data.

The data will also be used to access beacon track enhancement when using digitized binary radar reports (MTD or RDAS) to support beacon processing.

The DABS/MTD test configuration and the DABS/RDAS test configuration are depicted in figures 2 and 3, respectively. The DABS receiver will be switched to the live environment and the radar tracking software package loaded in the DABS sensor. The MTD or the RDAS will be connected to the DABS radar interface board and used to provide radar reports to the sensor.

In order to provide DABS surveillance data, controlled test aircraft will be equipped with a DABS transponder. The data collected during these runs will be recorded by the DABS data extraction subsystem on to magnetic tapes for subsequent analysis.

The flight profiles of the controlled aircraft during these tests will be:

- a. Radials
- b. Orbitals
- c. Turns
- d. Aircraft overtakes
- e. Aircraft head-ons
- f. Crossing conflicts

The first three flight profiles will require only one controlled aircraft. The last three flight profiles will require two controlled aircraft. Examples of the flight profiles are depicted in figure 4.

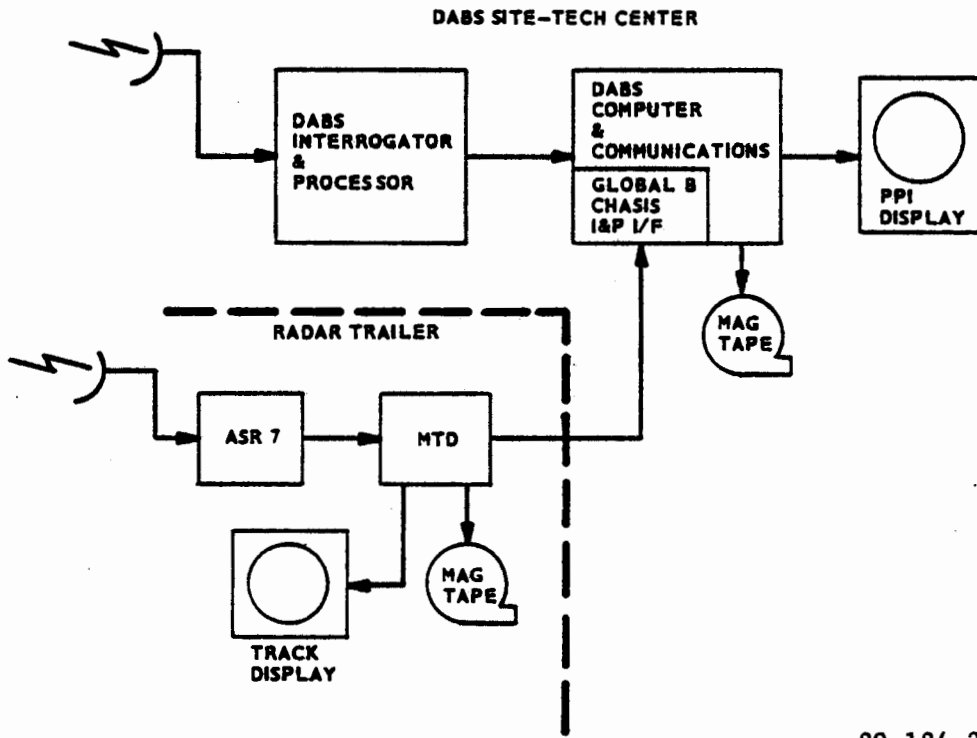


FIGURE 2. DABS/MTD TEST CONFIGURATION

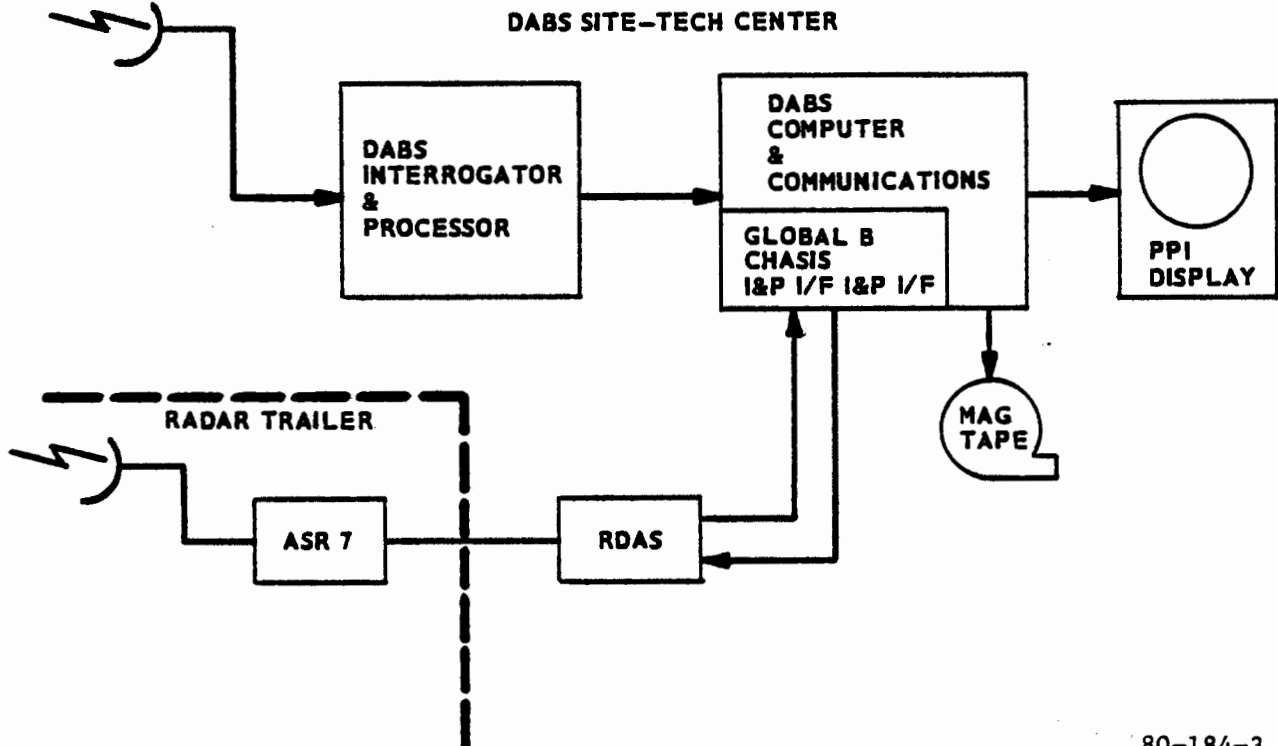


FIGURE 3. DABS/RDAS TEST CONFIGURATION

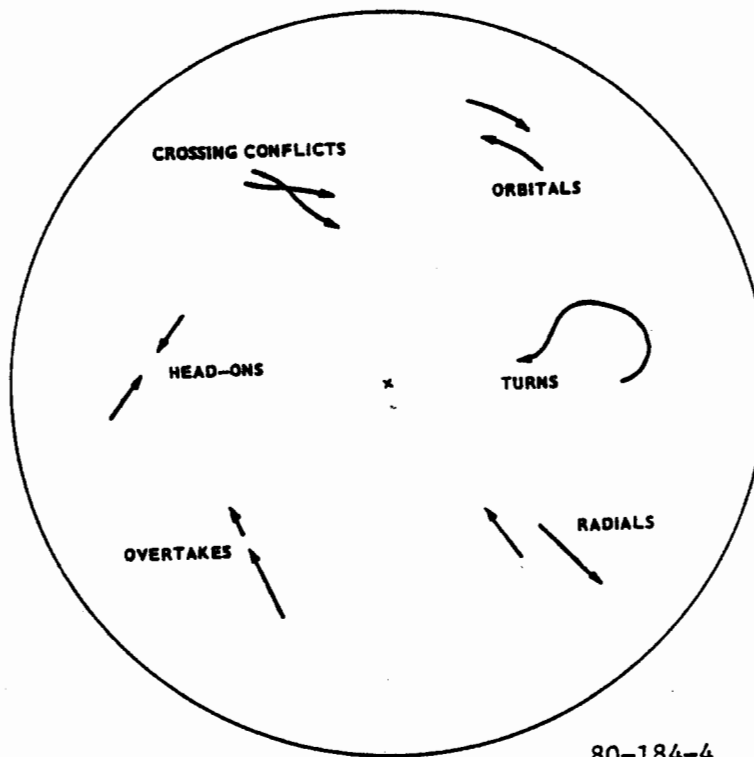


FIGURE 4. AIRCRAFT FLIGHT PROFILES

A software modification to the DABS radar processing and tracking software will be used during all controlled flights in order to provide beacon/radar tracking and radar-only tracking of an aircraft retrofitted with a DABS transponder, thereby, enabling data collection of both simultaneously.

#### 5.4 Clutter Environments.

The fourth area of testing will focus primarily on collecting radar and beacon surveillance data in different clutter environments. The DABS receiver will be placed in the live environment position. The software package containing radar processing and tracking will be loaded in the DABS sensor. The MTD or the RDAS will be connected to the DABS radar interface board to provide radar data to the sensor.

This sequence of tests will be divided into the following categories:

a. Ground Clutter Environment. Surveillance and ATC disseminated data will be collected in the ground clutter environment of the FAA Technical Center for areas that produce strong echoes from tall buildings. These tests will be conducted using targets of opportunity as well as controlled aircraft performing maneuvers (e.g., straight flights and turning flights).

b. Weather Clutter Environment. Surveillance and ATC disseminated data will be collected in weather clutter environments if weather clutter becomes available in the area. These tests will be conducted with targets of opportunity along with

controlled aircraft. The controlled aircraft will perform maneuvers similar to those performed over ground clutter.

### 5.5 Accuracy and Resolution.

The fifth area of test will focus primarily on radar accuracy and resolution. Once again, surveillance and ATC disseminated data will be recorded by the DABS data extraction subsystem on to magnetic tape. Simultaneously, the Nike-Hercules tracking system will record on to magnetic tape the positional data of the aircraft every 0.1 seconds. In addition, the Technical Center time-of-day (synchronized with WWVB) will be recorded by both data recording systems to synchronize the DABS and Nike-Hercules data for analysis.

Prior to collecting accuracy and resolution data, an alignment procedure will be conducted on each radar processor. This will be accomplished by positioning a radar MTI reflector on the Technical Center calibration performance monitoring equipment (CPME) tower in order to generate phase-shifted RF returns back to the radar. The phase-shifted returns simulate returns from a moving target, thus, preventing MTI receiver cancellation. This enables both radar processors to detect fixed target returns from the CPME tower. Both radar processors will then be calibrated to provide the same positional information on the tower as obtained by the DABS sensor.

Aircraft flights are subdivided into two areas: (1) Single aircraft flights for target accuracy, and (2) dual aircraft flights for target resolution. The radar accuracy and resolution flight plan is described in table 2. Each flight will be directed toward a specific objective. The accuracy test will be conducted to define the azimuth and range accuracy of radar-only targets as a function of range, azimuth, and elevation angle. The resolution test will be conducted to identify the range resolution, azimuth resolution, and the overall system resolution of radar-only targets. During the resolution test, aircraft will fly with visual flight rules (VFR) and be separated by at least 500 feet. Each run will require a minimum of 4 hours scheduled flight time. A minimum of three tests are proposed for accuracy and three tests for resolution, with additional tests conducted as required.

TABLE 2. ACCURACY AND RESOLUTION FLIGHT PLAN

<u>Test</u>	<u>Aircraft</u>	<u>Pattern</u>	<u>Azimuth Heading</u>	<u>Slant Range</u>	<u>Altitude (ft)</u>	<u>Elevation Angle</u>
1	1	Radial	269	0-25	2,500	
2	1	Radial	269	0-50	5,000	
3	1	Radial	269	0-50	7,500	
4	1	Radial	269	0-50	10,000	
5	1	Orbital	190-330	10	1,000	1
6	1	Orbital	190-330	10	3,100	3
7	1	Orbital	190-330	10	6,300	6
8	1	Orbital	190-330	10	10,500	10
9	1	Orbital	190-330	10	15,600	15
10	1	Orbital	190-330	10	20,600	20
11	2	Radial	269	0-50	9,000	
12	2	Orbital	190-330	20	6,300	3
13	2	Tangential/ Intersecting		30	7,500	

## 5.6 Weather Mapping.

The final area of testing is the evaluation of the MTD and the RDAS to properly detect weather clutter and provide digital weather information for display at an ATC facility. The DABS sensor receives all weather messages from the MTD or RDAS and passes them along to users. A block diagram of the test setup is depicted in figure 5.

Initially, ASR-7 normal and MTI video containing weather clutter will be video recorded. A second video recorder will also be used to record MTD in-phase (I) and quadrature (Q) bipolar video. In addition, the azimuth and pretrigger signals from the ASR-7 radar, along with time from a time code generator, will be simultaneously recorded.

The recorded I and Q video will be fed back to the MTD to generate weather data. The MTD then forwards the weather messages to the DABS. The DABS sensor will disseminate the weather information via surveillance lines to a VR and the ARTS IIIA located at the Terminal Automation Test Facility (TATF). The VR will then generate reconstituted weather video from the received digital information for display on an ARTS IIIA display. The ARTS IIIA display will generate weather vectors for the all-digital configuration. Long exposure photographs will be taken of the reconstituted weather video.

The recorded normal and MTI video will be fed back to the RDAS, and the sequence of events will be the same as described in the previous paragraph. Again, long exposure photographs will be taken of the reconstituted video.

The photographs taken of the reconstituted weather video from both radar digitizers will be compared to photographs of the ASR-7 normal radar video and weather plots obtained from the National Weather Service. The recorded normal video, along with azimuth and radar pretrigger signals, will be transmitted via coaxial cables and line drivers to the video delay unit located at the TATF. The video delay unit will display the normal video on an ARTS IIIA display where similar photographs will be taken.

## 6. DATA REDUCTION AND ANALYSIS.

The information collected during the data collection phase will be analyzed in detail using computer programs to provide a comprehensive analysis of a single DABS sensor integrated with an MTD or RDAS. Due to the large number of functions that must be evaluated during such an analysis, each one will be addressed individually.

a. Radar/Beacon Correlation. Correlation of radar and ATCRBS and radar and DABS targets will be calculated as a ratio of the number of successful correlations obtained, with respect to the total number of possible correlations based on track history. This ratio will be expressed as a percentage.

b. Radar Substitution. Association of a radar report with a coasting ATCRBS or DABS track, for which no beacon was received during that scan, will be calculated as a ratio of the number of successful radar substitutions obtained, with respect to the total possible substitutions based on track history. This ratio will also be expressed as a percentage.

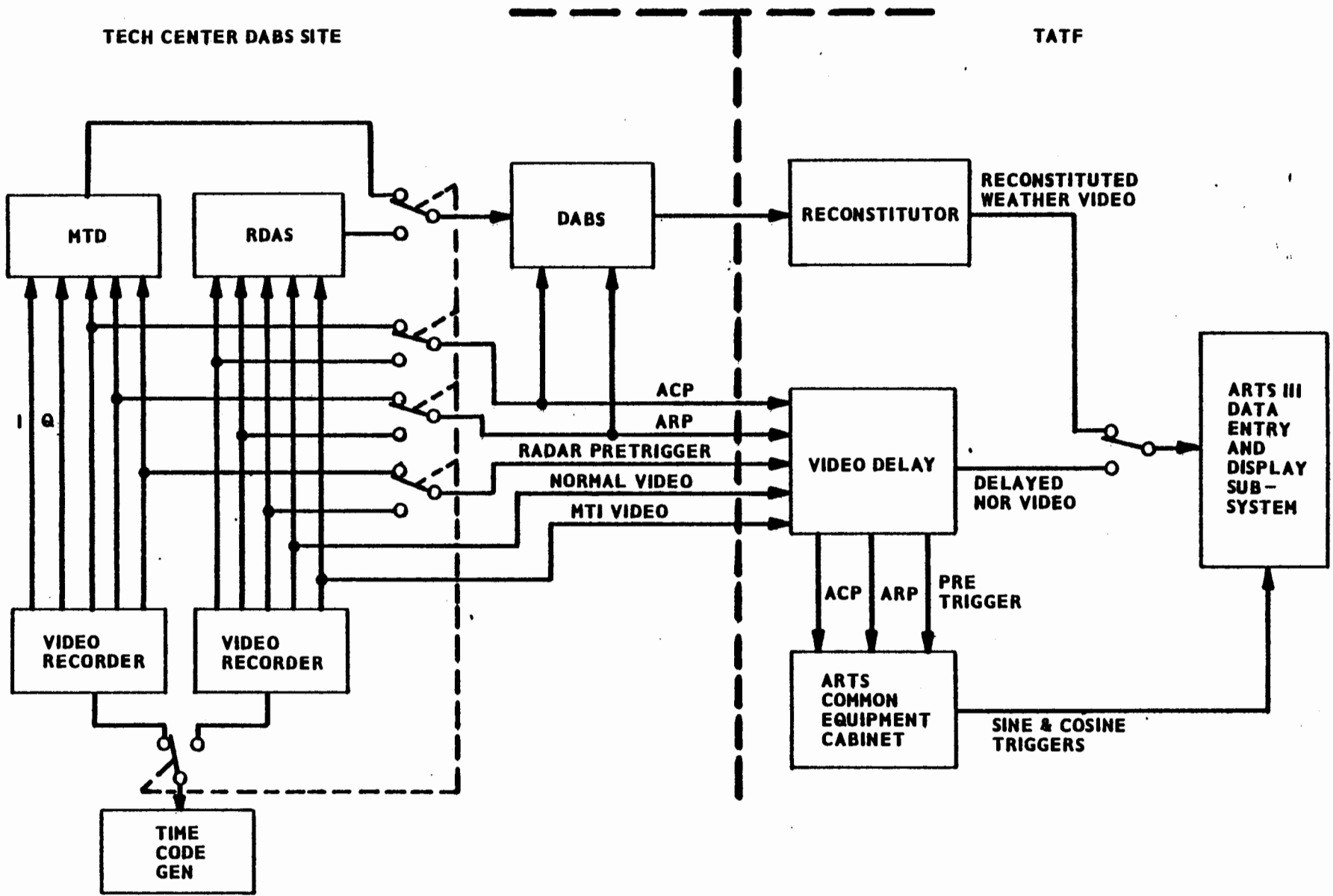


FIGURE 5. WEATHER DISPLAY BLOCK DIAGRAM

c. Radar Detection. Curves of percent detection versus type of aircraft maneuvers such as: turns, crossing, headings, etc. will be presented for radar-only targets. They will also be categorized for clear air, ground clutter, and weather clutter environments.

d. Tracking Performance. Tracking performance will be based on ARIES scenarios and controlled test aircraft equipped with a DABS beacon transponder. The specific areas that will be addressed are:

1. Track Coasts. The percentage of tracks for primary radar targets that go into coast will be presented as a function of flight patterns and environment. In either case, the distribution of the number of scans for which coasts occurred will be presented as well as the duration of coasts in terms of the number of scans.

2. Track Swaps. The frequency of track surveillance file number (SFN) swaps for radar tracks will be presented as a function of aircraft flight patterns in different radar clutter environments. Incidences of two SFN's for one aircraft and one SFN for two aircraft will also be determined.

3. Track Life. This will be delineated for each type of aircraft flight pattern and radar clutter environment. This parameter is defined for each SFN as the number of scans lapsing from the first occurrence of the SFN to and including the last scan in which there was a correlated target report.

e. False Radar Tracks. Radar reports not correlated or associated with a beacon or radar track, or correlated with other radar reports resulting in radar track initiations, will be calculated as an average of the total number of uncorrelated reports obtained over the number of scans in determining the number of uncorrelated reports. This average will be expressed as a number of false radar tracks per scan and correlated with the false target rates of the RDAS and MTD.

f. MTD/RDAS Report Age. The time in storage (or age) of MTD or RDAS reports will be calculated by taking the current azimuth, which is the azimuth at the time the report is moved from the radar input buffer to the radar report buffer, minus the report's corrected azimuth. The difference is converted into a value of time based on a specified scan rate. These results will then be expressed as a delay probability of a radar report as a function of data capacity and clutter environment.

g. Radar Accuracy. Radar accuracy is defined as the capability of DABS to report the actual spatial position of an aircraft using radar reports from the MTD or the RDAS. The accuracy will be determined by comparing DABS surveillance data obtained from the MTD or the RDAS with reference data obtained simultaneously from the Nike-Hercules instrumentation tracking system. The difference (or error) will be tabulated in both rho/theta and X-Y coordinates and statistically analyzed for specific increments in range and azimuth relative to the Technical Center sensor's coordinates.

h. Radar Detection and Resolution. Radar resolution is defined as the ability to accurately detect and track two aircraft that are in close proximity. This will be determined by comparing target and track data derived from the DABS sensor to aircraft separation as measured by the Nike-Hercules. Using DABS surveillance data obtained from the MTD or the RDAS, analysis will include the

calculation of aircraft separation values. These results will then be compared with aircraft separation values obtained from the Nike-Hercules tracking system. The percent detection of a real aircraft over regions of quantified clutter will be determined for both the MTD and the RDAS.

i. Percent Radar Detection Versus Percent False Target Rate. The percent radar detection and percent false target rate, as defined previously, will be plotted to permit a direct analysis of the tradeoffs between radar detection and false target rate as a function of the RDAS uncorrelated radar report threshold.

j. The performance of the MTD and the RDAS to detect and provide weather information to an ATC facility for weather contour mapping will be based on empirical evaluation. Photographs will be taken of weather maps generated by the VR from weather map information received from either the MTD or the RDAS. These photographs will be compared to photographs taken of an analog display using normal video from which the weather information was collected.

## 7. COORDINATION AND AREAS OF RESPONSIBILITY.

### Organization Responsibility

### Product

ARD-230	Provide an MTD radar in an operating configuration ready for testing at the Technical Center and Clementon.
Lincoln Laboratory	Provide the capability at the Technical Center of selecting inputs to either the MTD or the RDAS.
Texas Instruments, Inc.	Provide the addition of collecting radar reports and tracks, and extend existing analysis capability to include radar-only tracks.
ACT-100H	Install and maintain the MTD at the Technical Center and Clementon.
ACT-750	Provide a live environment analysis program to include extensive radar data processing of DABS data extraction subsystem recordings.
UNIVAC Corp.	Provide, install, and maintain an SRAP/RDAS in an operating configuration ready for testing at the Technical Center.
ACT-100A	Conduct the test and evaluation of the DABS/MTD and DABS/RDAS configurations.  Coordinate all facilities and aircraft.

## 8. SCHEDULE.

The milestone schedule is shown in figure 6.

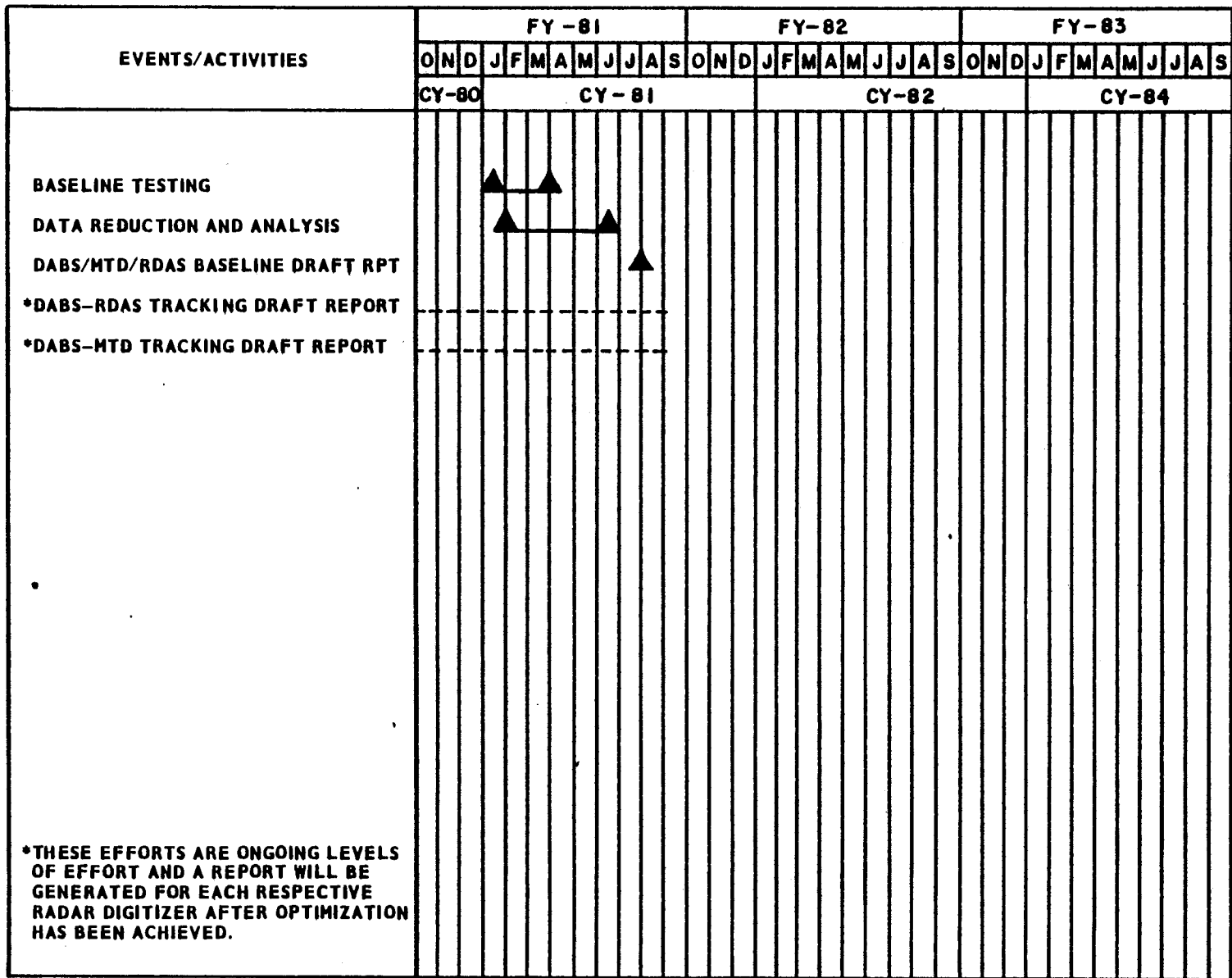


FIGURE 6. PROGRAM SCHEDULE FOR DABS/MTD AND DABS/RDAS AS OF 1/2/80

## APPENDIX A

### 1. BASIC 42-TARGET SCENARIO.

#### 1.1 SCENARIO DESCRIPTION.

The Basic 42-target configuration was designed to thoroughly exercise the surveillance functions of the Discrete Address Beacon System (DABS). Four of the targets were used only for synchronization of the data reduction and analysis programs. The purposes for the remaining targets are as defined in table A-1.

TABLE A-1 SCENARIO DESCRIPTION

<u>Scenario Target Identifier(s)</u>	<u>Description Of Scenario Target Maneuvers</u>
A-B-C-D	<ol style="list-style-type: none"><li>1. These targets comprise a set of four aircraft whose altitude separation is 600 feet, and which engage in multiple conflicts.<ol style="list-style-type: none"><li>a. Conflict 1 involves three aircraft. One aircraft flies south along north mark (NM), while the other two fly across the third with angles of intersection of 55° and 60°. The mode 3/A codes are unique discrete Air Traffic Control Radar Beacon System (ATCRBS) in the all-ATCRBS scenario. The southbound aircraft and one of the other aircraft have DABS identification (ID's) in the mixed scenario.<p>Objectives:</p><ol style="list-style-type: none"><li>(1) Test DABS ability to track an NM radial trajectory (area of azimuth discontinuity).</li><li>(2) Test tracker's ability to resolve and identify aircraft during an NM conflict.</li></ol></li><li>b. The southbound aircraft flies into and out of the zenith cone.</li><li>c. Conflict 2 involves two aircraft whose trajectories intersect that of the southbound aircraft and each other; turn and regroup around south mark to engage in another conflict. They are joined by the fourth aircraft. The objective is to assess the sensor's ability to resolve a four-target conflict.</li></ol></li></ol>
E-N-B	<ol style="list-style-type: none"><li>2. They are ATCRBS discrete and nondiscrete and DABS targets traversing the zenith cone. There is one target turning in the cone of silence (COS). The</li></ol>

TABLE A-1. (Continued)

Scenario Target Identifier(s)	Description Of Scenario Target Maneuvers
701x, 702x, 703x	<p>objective is to observe the sensor tracking response to COS targets. In the 200 nautical mile (nmi) scenario there is also a unique discrete ATCRBS target descending while in the COS.</p> <p>3. An ATCRBS target flies the region 1-2 tracking zone boundary. The region forms the transition from a first-order to second-order <math>\rho, \theta</math> tracker. The objective in generating this flightpath is to assess the sensor tracking response in this region. This target is an element of a set of three aircraft coming in conflict over NM. All targets are identically nondiscrete, but fly at different flight levels with minimum separation of 600 feet.</p>
801x, 802x	<p>4. A set of targets flies multiple intersecting paths in tracking region 1 (outermost). These targets are both DABS targets in the mixed scenario and discrete unique mode A codes in ATCRBS scenario. The altitude separation is 700 feet. The intersecting angle is approximately <math>30^\circ</math>. In the DABS scenario, the objective is to assess the sensor's ability to transact ground-to-air-to-ground communications in conflict situations.</p>
601x, 602x	<p>5. Two aircraft trajectories intersect at approximately <math>10^\circ</math>. The trajectories are identical in both the ATCRBS and mixed scenarios. One of the aircraft changes its code from nondiscrete to discrete and complementary to the other aircraft code just prior to the conflict. After the conflict, both aircraft change codes to radio failure 7600 and emergency 7700, respectively. The altitude separation is 600 feet during the full trajectory.</p> <p>Objectives:</p> <ul style="list-style-type: none"> <li>a. To evaluate shallow-angle crossing path tracking.</li> <li>b. To evaluate the sensor's ability to decouple complementary mode A codes during a conflict.</li> <li>c. To determine system response to emergency codes.</li> </ul>
U-W	<p>6. This is a pair of intersecting trajectories which cross at <math>64^\circ</math>. Both aircraft have nondiscrete, identical mode A codes in the mixed and ATCRBS scenarios. The altitude separation is 600 feet.</p>

TABLE A-1. (Continued)

<u>Scenario Target Identifier(s)</u>	<u>Description Of Scenario Target Maneuvers</u>
803x	7. A target flies a closed circular path into and out of zenith cone. The purpose for this trajectory is to assess the ground-to-air-to-ground data link in the zenith cone proximity.
501x, 502x, 503x	8. A set of three aircraft flew in the same vertical plane separated from each other by 0.7 nmi and 1,000 feet. All have ATCRBS discrete codes in the ATCRBS scenario and the aircraft flying the middle flight level is a DABS target in the mixed scenario. The objective is to evaluate the sensor's ability to track through a potential continuous garble situation.
401x, 402x	9. A set of two aircraft fly parabolic paths whose point of closest approach (at the vertex of each trajectory) is approximately 750 feet. Both targets are nondiscrete but unique with respect to each other. The flight levels are identical. The purpose for this conflict is an attempt to cause a track swap response in the sensor.
301x, 302x	10. A pair of aircraft fly in overtake patterns. The altitude separation is 600 feet, and mode 3/A codes are unique, discrete, and complementary. Both the ATCRBS and mixed scenario have identical aircraft specifications. The relative velocity is 50 knots. In the mixed scenario, one aircraft is DABS and the other ATCRBS.
101x	11. An aircraft flies west to east while decelerating from 650 knots to 250 knots and then accelerating back to 650 knots. The target is an ATCRBS with a discrete mode A code. The purpose for this flight path is to determine the sensor's ability to track an accelerating aircraft.
201x, 202x	12. A pair of aircraft widely separated execute a 180° turn in the vicinity of NM. One aircraft turn is executed in tracking region 1 (far out) and the other is in the near tracking region (region 3). NM proximity was chosen to complicate the prediction process. The far-out aircraft is a unique discrete ATCRBS mode 3/A code while the close-in aircraft is nondiscrete. The close-in aircraft simulates landings. Both aircraft specifications are identical in ATCRBS and mixed baseline scenarios.

TABLE A-1. (Continued)

<u>Scenario Target Identifier(s)</u>	<u>Description Of Scenario Target Maneuvers</u>
O-P-Q	13. Target O is a flyover, target Q is a real target, and target P is a false target which is a reflection of Q from the hangar at the Technical Center. The purpose is to assess the sensor's ability to label false and/or real targets when reflector geometry is included in the appropriate site-adapted data bases. The target (and reflection) identification is ATCRBS, unique, and discrete in both the baseline ATCRBS and mixed scenarios.
F-G-H	14. A set of three aircraft are involved, two of which are flying parallel to each other at the same flight level while the third intersects the path of the other two twice; first at a 50° angle of intersection and then at a 15° angle of intersection. The altitude of the intruding aircraft is 600 feet above the other aircraft. All targets are identified by the same nondiscrete mode 3/A code. In addition to testing conflict resolution capability, these tracks are designed to create linked track sets to determine if they are handled properly.
K	15. An aircraft executes a closed-path trajectory in the region 1 tracking area. Its trajectory does not intersect that of any other aircraft. This aircraft is a unique discrete ATCRBS target in the baseline ATCRBS scenario, and a DABS target in the mixed scenario. Its purpose is to assess sensor ability to follow turns in nonconflict situations.
I-J	16. A pair of aircraft are involved whose ground trajectories approach head-on. The altitude separation is 600 feet. These targets are unique discrete in the ATCRBS baseline scenario. In the mixed scenario, one target maintains its ATCRBS identification, while the other becomes a DABS target. The purpose for the targets is to attempt to invoke conflict alert, since altitude garbling during the path approach is likely in the ATCRBS baseline case.
Y	17. One aircraft flies a trajectory which traverses the coverage region while keeping within the region 1 tracking area.

TABLE A-1. (Continued)

<u>Scenario Target Identifier(s)</u>	<u>Description Of Scenario Target Maneuvers</u>
Z	18. A target which generates a long track history executes a turn at 65°, flies out of coverage, turns while outside of coverage, and reenters the coverage region.
Fix 1 Fix 2 Fix 3 Fix 4	19. Four targets flying outbound radials of 15°, 105°, 195°, and 285° at 200 knots with codes of 7654, 6754, 7645, 7465, respectively, become stationary after 32 scans. These targets are used to synchronize the Aircraft Reply and Interference Environmental Simulator (ARIES) and DABS data extraction tapes.