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16. Abstract

This report presents the twentieth Discrete Address Beacon System Quarterly Technical Summary covering the period 1 October through 31 December 1976. Included are the results to date of analytical studies, laboratory and flight experiments, and software developments supporting the concept feasibility and performance definition phase of the FAA DABS Program.

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CONTENTS

DEVELOPMENT OF A DISCRETE ADDRESS BEACON SYSTEM

I. INTRODUCTION AND PROGRAM OVERVIEW

A. Introduction

This is the twentieth Quarterly Technical Summary, covering work performed by Lincoln Laboratory between 1 October and 31 December 1976 to develop a Discrete Address Beacon System (DABS). This effort is supported by the Federal Aviation Administration through Interagency Agreement DOT-FA72-WAI-261 between the FAA and the United States Air Force.

DABS is an evolutionary upgrading of the present FAA ATC Radar Beacon System (ATCRBS) employing discretely addressable transponders and incorporating a ground-air-ground data link. DABS will provide the improved surveillance and communication capabilities required to meet the needs of an automated ATC system in the 1980's and 1990's.

Under Phase I, Lincoln Laboratory carried out a detailed system design of DABS based upon design studies, trade-off analyses, and experiments. This system design was described in a set of engineering requirements for engineering development models to be designed by the Sensor Development Contractor (SDC), and subsequently evaluated at NAFEC during Phase II of the DABS program. The completion of these requirements documents represented the nominal completion of Phase I.

During Phase II, Lincoln Laboratory is continuing to support the FAA as DABS System Engineering Contractor (SEC). Major areas of responsibility during this phase include: validation and refinement of the designs specified, assisting the FAA in monitoring the SDC, and using the DABS experimental facility to perform IPC flight tests.

B. Program Overview

Viewed broadly, DABS program efforts during the reported quarter have resulted in the following:

(1) Readily understood summaries of the large quantity of data obtained during experiments at ten TMF sites.

(2) Substantial progress in the fabrication, assembly, and test of ARIES hardware, and the first meaningful runs of ARIES computer microcode for interrogation processing.

(3) Completion of the present phase of IPC flight evaluation and final analysis of results.

(4) Provision of consulting (SEC) services to the FAA in support of the critical design review of portions of Texas Instruments DABS software modules.

C. DABS Activity Precis

Sections of this Quarterly Technical Summary contain DABS Phase II task reports as follows:

Section II – Design Validation and Refinement. In this section are given the results of additional DABS link reliability measurements, an indication of improvement in antenna gain to be expected when employing top and bottom antennas with a diversity transponder, and a discussion of the need for antenna diversity on large jet aircraft during takeoff.

The DABS round reliability data shown were obtained during Brea, California (LAX) site assessment experiments. Modifications had been made to the transponders used to reduce suppression of DABS replies due to ATCRBS sidelobe interrogations.

Statistical averages of diversity antenna gain during a number of DABSEF-based IPC flights show that nearly a 5-dB improvement in downlink gain would be provided by the use of both top and bottom antennas relative to bottom antenna only.

Large jet aircraft gain data, obtained for sustained, high-pitch takeoff conditions, indicate that, despite the severe fade caused by shielding of the bottom-mounted antenna, more than adequate signal is available on the ground. Indications are that, provided the sensor STC function is set properly, adequate signal will be available if the fade produced by aircraft antenna shielding does not exceed 40 dB.

Section III - Environmental Characterization. Monopulse accuracy and fade data are presented for four early TMF sites. Clearly discernable correspondence between large structures on the horizon and the peaking of the monopulse inaccuracy (vs azimuth) plots is pointed out. Similar, but less distinct, relationships between these objects and fadings are noted. Coverage efficiency is plotted against permissible monopulse error tolerance for six field sites. ATCRBS traffic density and ATCRBS fruit levels measured are also plotted.

Track quality statistics shown in the previous QTS for several TMF sites are augmented by like data for the Brea, California, and Salt Lake City Airport sites; percent of beacon-equipped aircraft with valid altimeter reporting is included.

Part B of this section demonstrates the degree to which uplink analysis software used to process AMF field data has been refined. Highly detailed transmission characteristics of more than a dozen Los Angeles area beacon interrogators obtained using this software are tabulated.

Section IV – IPC Test and Evaluation. A relative-motion analysis of rectilinear encounters has been developed, thus enabling a complete understanding of the numerous failure modes which have been observed during the flight tests. A complete description of the analysis and its consequence is the subject of a forthcoming report.

The flight testing of algorithm refinements has been terminated following this quarter. Subsequent improvements and modifications will be tested at NAFEC.

Section V – ARIES. Hardware and software development of the entire ARIES environment simulator will enter its integration and system test phase during the coming quarter. Photos of two major ARIES hardware drawers are shown, and a table identifies the location of lower level components within them.

The ARIES equipment must generate not only realistic aircraft replies but fruit whose arrival statistics simulate those expected at actual DABS sensor installations. Considerable attention has been paid to realistic fruit generation, and this section describes the means employed to generate fruit with exponentially distributed inter-arrival times.

Section VI – Experimental Facilities. Use of DABSEF, DABS Avionics, TMF, and AMF to support some 200 TMF experiments, 14 IPC flights, and a series of air-to-air multipath measurements is noted. Data reduction providing site characterization and uplink environmental data reported in Section III, and IPC test results reported in Section IV, depended heavily on the use of the DABSEF SEL 86 computer. In addition to routine maintenance necessary to keep supporting facilities "on-the-air," upgrading modifications were made to the TMF, the DABS transponders, and to the AMF equipment. Modifications to the AMF electronics to support BCAS measurements are scheduled to commence in the coming quarter.

II. DESIGN VALIDATION AND REFINEMENT

A. DABS Link Performance

Assessment of DABS link performance continues (refer to Sec. II-A of the 1 October 1976 DABS QTS) by means of TMF measurements made at Los Angeles International Airport (LAX) and at Brea, California (elevated site 25 nmi east of LAX).

The DABS Mod 4 transponders used in these tests had been modified prior to the Brea-based measurements, but not for the LAX measurements, to reduce the suppression of DABS replies caused by ATCRBS sidelobe interrogations (refer to Sec. VII-B of the 1 October 1976 DABS QTS). During these measurements, the transponders were not locked out to ATCRBS interrogations and the sensor interrogation mode was DABS-Only All-Call.

Tables II-1 and -2 (compare with Table II-1 in prior QTS) summarize the results obtained during the LAX and Brea flights. Averages are weighted according to flight duration as before. Note that the DABS link performance for the flights employing the modified transponders was superior to the performance measured prior to the modification.

B. Antenna Gain with Airborne Diversity

Downlink data taken during IPC missions in which top and bottom antennas were employed with a DABS diversity transponder have permitted comparison of "average" aircraft antenna gain with and without diversity.

The downlink data obtained during these flights, as recorded on SDP (format) tapes, were processed using the DABSLST program to determine aircraft antenna gain. Received power level of the discrete reports was corrected for pattern and path loss, and a transmitted power level of +54 dBm at the antenna terminals was assumed.

Note that the overall effect of diversity as shown in Table II-3 was an increase in mean gain (nearly 5 dB).

C. Need for Airborne Diversity During Takeoff

When certain aircraft, principally jet carriers, depart from a runway, they climb steeply and at a large angle of attack. This pitch maneuver frequently places the body of the aircraft between the bottom-mounted aircraft antenna and the terminal sensor. This geometrical relationship may persist for a minute or more.

Table II-4 shows the pitchup angle at which the bottom-mounted antenna first experiences a given fade, when viewed within ±20° right or left of the tail of the aircraft. (These data were obtained from model aircraft measurements.) Three of the aircraft experience a 30-dB fade at pitch angles under 20°, a common departure aspect. On the other hand, none of the aircraft reach 40 dB fade until nearly 40° pitch (if ever).

Takeoff downlink data have also been obtained using the Transportable Measurements Facility. Figure II-1 shows six examples of signal strength vs "miles from take off" for several air carrier type aircraft leaving Washington National (TMF-4054) and Philadelphia (TMF 6013) airports. The curves are normalized so that zero dB represents the average steady value of gain achieved several miles out. These cases are typical, and as can be seen, a fade greater than 20 dB is unlikely.

Since these fades occur close to the sensor, the fundamental link margin is more than adequate to cover the fades. (Measurements show that a 35-dB fade margin remains at 10 mni

TABLE II-1

SUMMARY OF LINK PERFORMANCE FOR LOS ANGELES DABSEF/TMF FLIGHTS 7020 – 7039

Flight	Replies per Interrogation	Correct Decode Given Reply Received	Correct Replies per Interrogation	Error Correction Contribution to Decoding	Correctable Messages not Decoded	Reports per Scan
7020 pt 1	0.876	0.998	0.874	0.015	0.002	0.959
7020 pt 2	0.828	0.998	0.826	0.032	0.0018	0.910
7020 pt 3	0.853	0.997	0.850	0.030	0	0.955
7022 pt 4	0.758	1.0	0.758	0.021	0	0.882
7022 pt 2	0.777	0.981	0.762	0.079	0.0072	0.912
7022 pt 3	0.832	0.998	0.830	0.030	0	0.940
7022 pt 4	0.850	0.989	0.840	0.046	0	0.951
7036 pt 1	0.821	0.991	0.814	0.020	0.002	0.918
7036 pt 2	0.794	0.994	0.789	0.033	0.002	0.888
7036 pt 3	0.814	0.994	0.809	0.014	0	0.918
7037	0.870	0.994	0.865	0.023	0	0.945
7038	0.775	0.986	0.764	0.038	0.003	0.875
7039	0.847	1.0	0.847	0.004	0	0.939
Weighted Average	0.812	0.994	0.807	0.029	0.0014	0.921

TABLE II-2

SUMMARY OF LINK PERFORMANCE FOR BREA, CALIFORNIA, DABS/TMF FLIGHT EXPERIMENTS NUMBERED 8053, 8057, 8059, AND 8100

Experiment	Replies per Interrogation	Correct Decode Given Reply Received	Correct Replies per Interrogation	Error Correction Contribution to Decoding	Correctable Messages not Decoded	Reports per Scan
8053 Circle Flight	0.932	0.996	0.924	0.0030	0.003	0.974
8057 LA to San Diego	0.885	0.991	0.877	0.026	0	0.966
8059 San Diego to LA	0.865	0.982	0.849	0.046	0.002	0.936
8100 Low-Altitude Loop West of Brea	0.850	0.970	0.82	0.06	0.004	0.95
Weighted Average	0.917	0.988	0.881	0.026	0.002	0.96

TABLE II-3 EFFECTIVE ANTENNA GAIN DIVERSITY VS BOTTOM ANTENNA		
	Mean (dBi)	σ (dB)
Diversity Antennas		
DAB505 (5 flights)	6.9	2.8
DAB101 (5 flights)	5.2	2.7
DAB552 (3 flights)	6.7	2.6
	6.3 average	
Bottom Antenna Only		
DAB505 (7 flights)	3.1	4.1
DAB101 (4 flights)	−0.8	5.2
DAB552 (5 flights)	1.8	4.6
	1.4 average	

TABLE II-4 PITCHUP ANGLE AT WHICH FADE FIRST REACHES 30 dB AND 40 dB (within ±20° of tail)		
	30 dB	40 dB
Gates Lear Jet	17°	39°
Boeing 707	fade always < 30	fade always < 30
Boeing 727	18°	fade always < 40
Boeing 737	28°	fade always < 40
Boeing 747	12°	38°

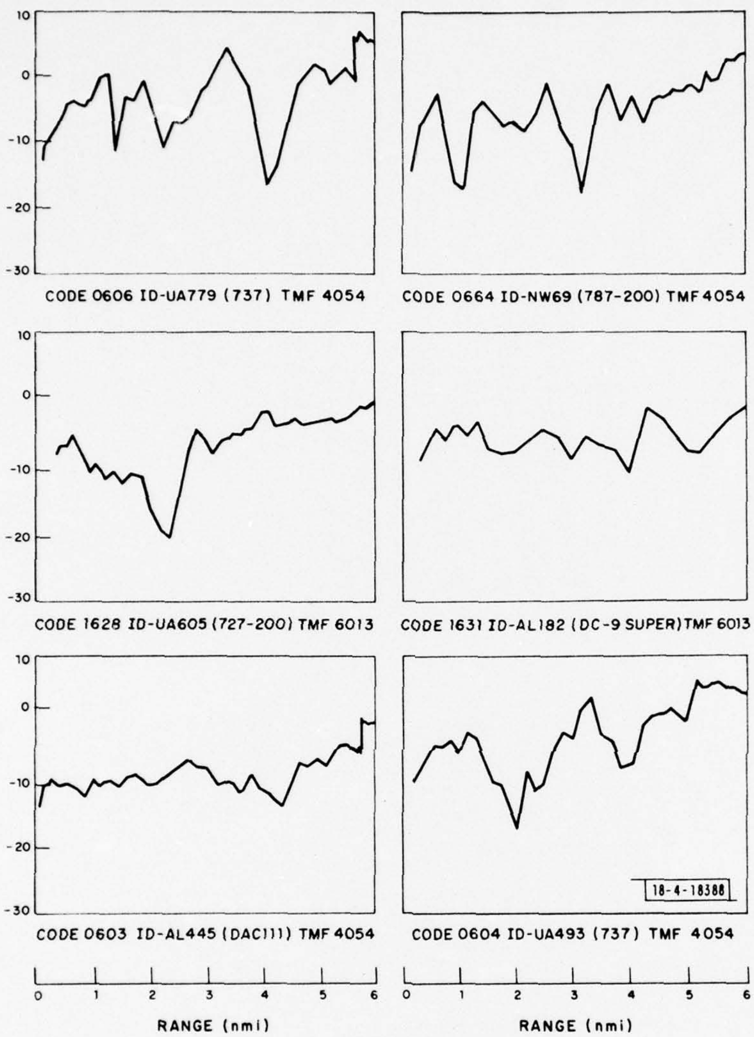

Fig. II-1. Signal fade during takeoff.

out.) However, Sensitivity Time Control (STC) for ATCRBS is normally set so that the link margin is severely reduced (Logan 25 dB, Newark 8 dB, JFK 18 dB, Philadelphia 27 dB, LAX 10 dB) at one mile and holds nearly constant out to about 30 nmi. In addition, many sites experience severe vertical lobing losses with the present ATCRBS antennas. It is then clear why difficulty is experienced receiving replies from the largest jet aircraft during takeoff.

The question to be addressed, however, is not whether fades are experienced with current procedures and equipment, but rather, are diversity antennas needed on these aircraft in a DABS sensor environment. Normally, ATCRBS STC is set to reduce reflections and false targets. DABS uses dynamic thresholds and software false target elimination routines. In addition, DABS ground antennas will have better vertical lobing properties.

The data given in Table II-4 and the foregoing lead to the conclusion that DABS performance during takeoff will be adequate for a given aircraft-antenna combination (one antenna, bottom mounted) as long as the measured fade during maximum angle-of-attack takeoff conditions does not exceed 40 dB.

III. ENVIRONMENTAL CHARACTERIZATION

A. DABS/TMF Performance vs Site

1. TMF Site Characterization

TMF site characterization by means of a program of circumferential flights continued this quarter with both measurement and data reduction activities. Flights were flown at the TMF/ Brea site and to a limited extent at the first TMF/Salt Lake site. The data processing software has at this point been put in its final form, and has been used to reprocess the TMF data tapes for the six sites through LAX.

Bar graphs showing monopulse accuracy and fading for four sites are given in Figs. III-1, -2, -3, and -4. Each bar represents a 3° azimuth wedge, showing in one plot the rms value of monopulse errors over that wedge, and in the other plot the average of the dB fades over that wedge (negative-going for weak signals). Similar data for the other two TMF sites (Philadelphia and Clementon) were given in the previous DABS QTS.

There are three major regions of obstructions evident in the Logan panoramic photograph, and the fading and monopulse disturbances that result from these are noteworthy. The three regions are: (1) several prominent smokestacks centered at about 250° azimuth (mag.) and with elevation up to about 2°; (2) the buildings of downtown Boston, centered at about 290° azimuth and extending up to about 2.5° elevation; and (3) the Logan Airport control tower at 340° azimuth, extending up to about 2.5° elevation. The resulting monopulse disturbances are clearly evident in Fig. III-1, showing up in several of the circumferential flights. The disturbances are seen to be worse at low elevation angles and generally decrease as elevation angle increases. At the highest elevation angle tested, 5°, the monopulse disturbances do not appear. Fading effects are also evident in the three obstructed regions, but these effects are generally less distinct. An interesting fade phenomenon is to be seen in the 1.5° elevation data for azimuths between 0° and 50°. Here a fade of about 6 dB occurs throughout, with no such fades observed in the data immediately below or above. Such effects are not unexpected, and may result from vertical lobing. Because of effects like this, the fade data do not describe as distinct a horizon as do the monopulse data, which property is generally observed at most of the TMF sites.

Coverage efficiency results for the six sites are plotted together in Fig. III-5. As defined in the previous DABS QTS, coverage efficiency is a measure of the percentage of all aircraft in the coverage volume under surveillance that can be seen with acceptable accuracy. Results show a wide range of site performance between the worst site (among those tested) at Los Angeles International Airport and the best site at Clementon. The appearance of the visible horizon on a panoramic photograph was found to be a generally valid indication of the distinction between a good site and a poor site.

TMF data have also been used to measure ATCRBS traffic densities and distributions, and ATCRBS fruit rates and distributions. Some results of these measurements are shown in Figs. III-6 and -7. The traffic distribution data in Fig. III-6 are plotted on log-log paper, formatted in this way so that either of two simple traffic models, uniform-in-range and uniform-in-area, appears as a straight line. Examples of these simple distributions are shown as dashed lines in Fig. III-6.

Fig. III-7 shows an RSLS-on vs RSLS-off comparison, which is a way of separating the mainbeam fruit from the total. From these curves, it is seen that sidelobe fruit is predominantly of low power (as expected) and that for a threshold of −80 dBm, sidelobe and mainbeam fruit occur in approximately equal proportions.

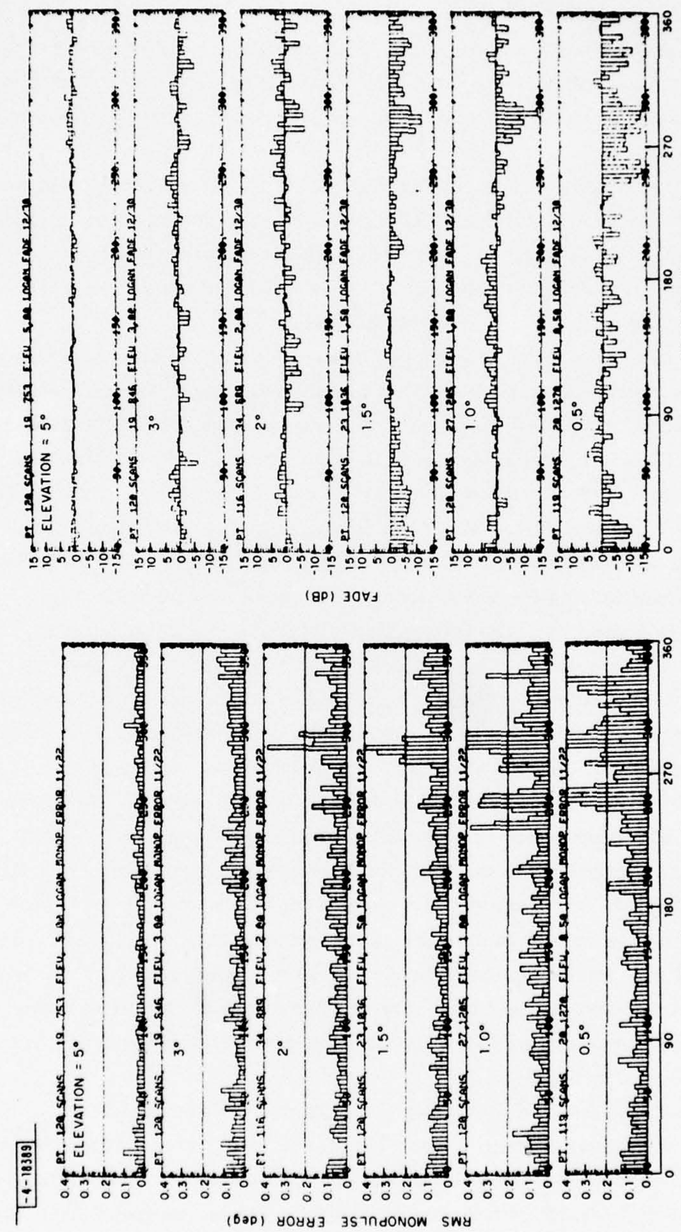

Fig. III-1. Monopulse and fading measurements for TMF/Logan Airport.

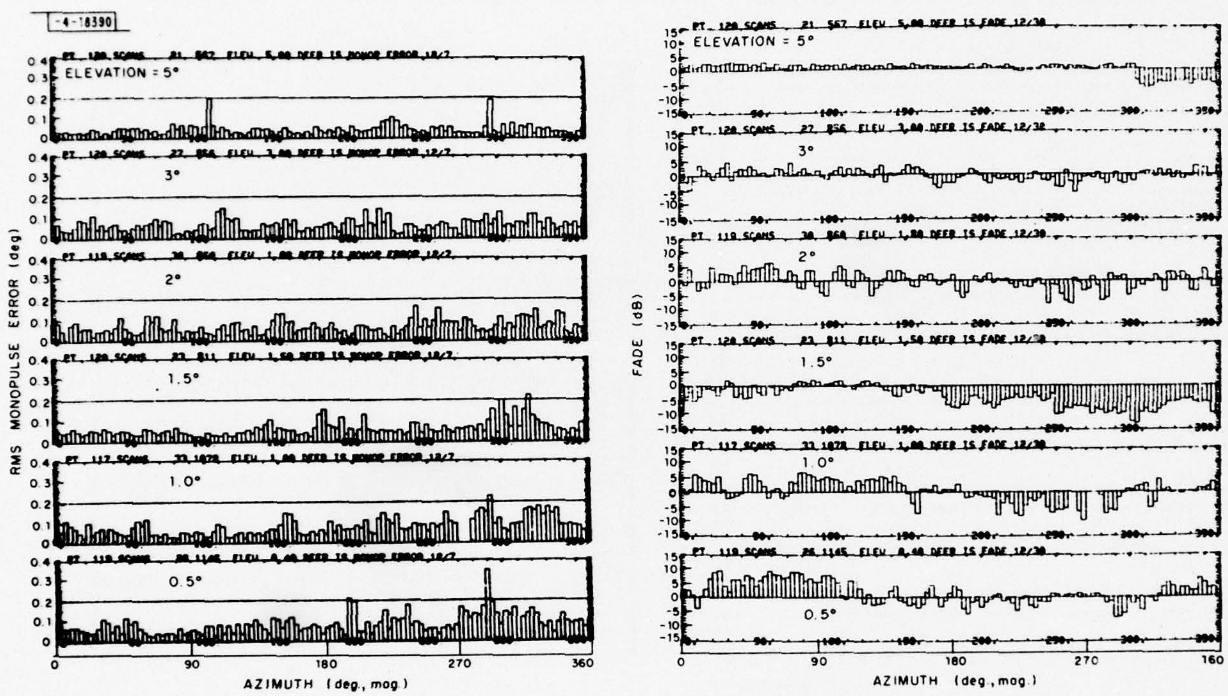

Fig. III-2. Monopulse and fading measurements for TMF/Deer Island.

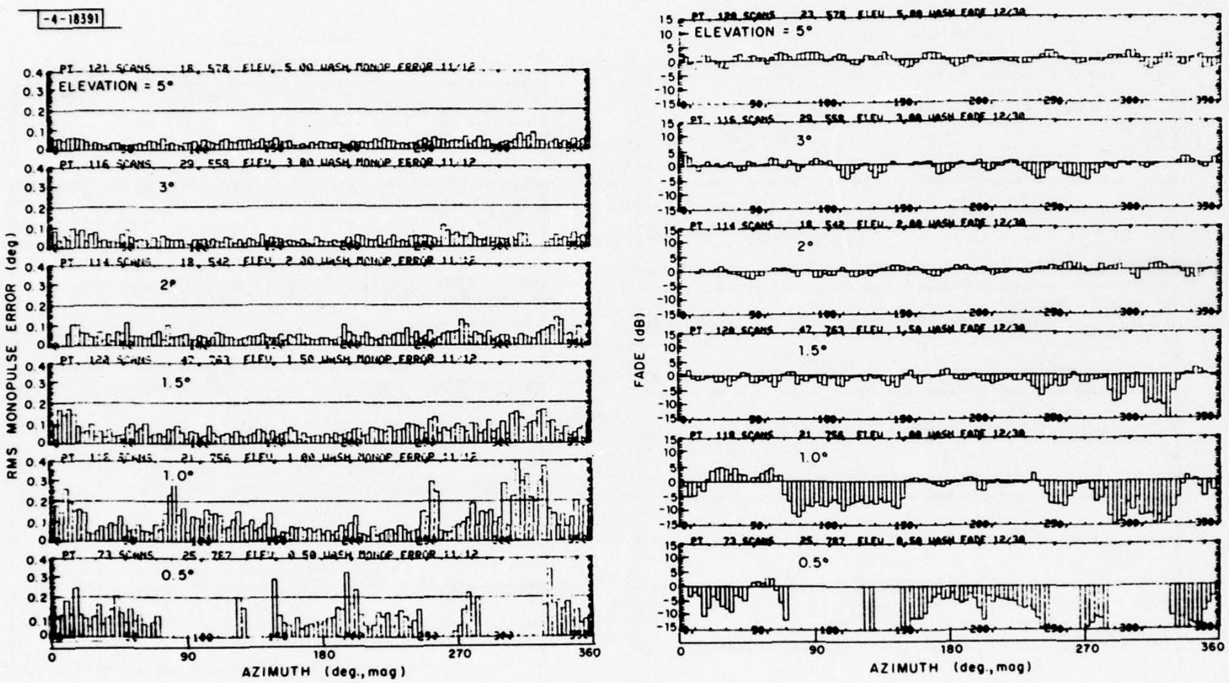

Fig. III-3. Monopulse and fading measurements for TMF/Washington National Airport.

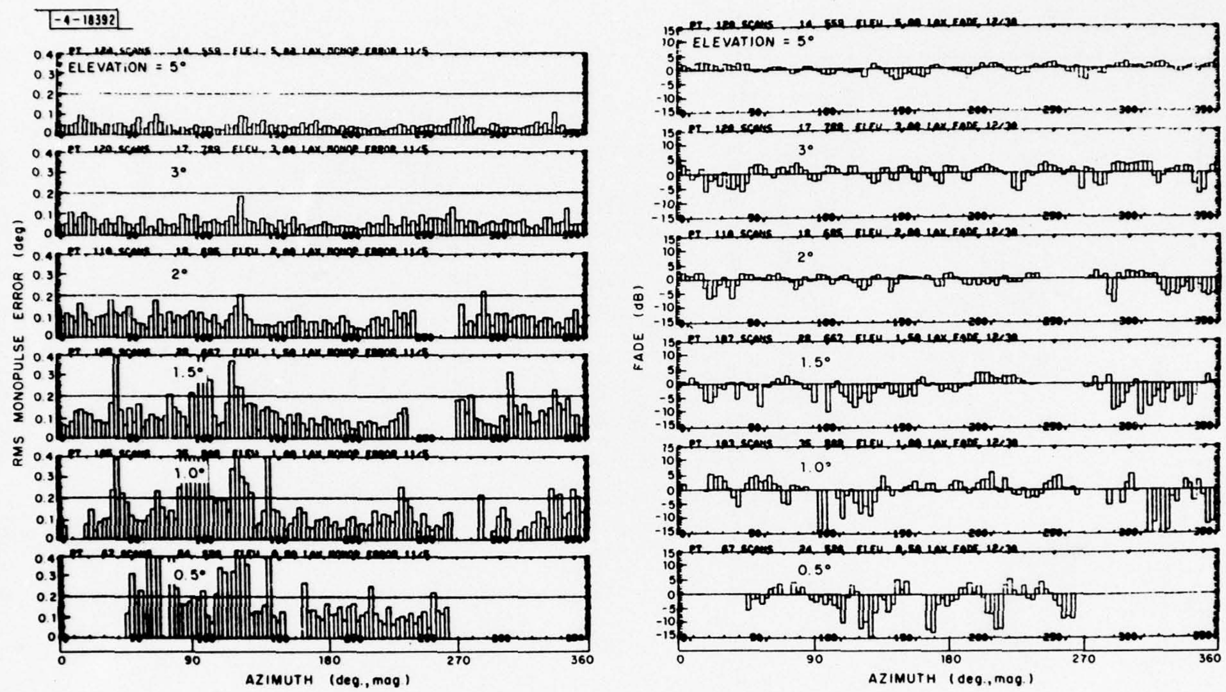

Fig. III-4. Monopulse and fading measurements for TMF/LA International Airport.

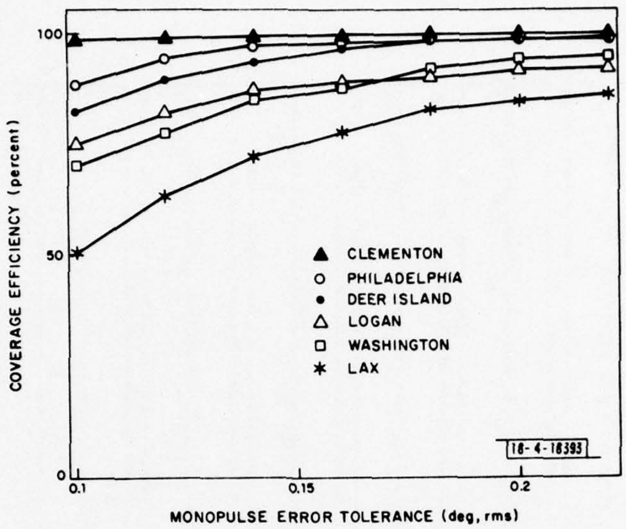

Fig. III-5. Coverage efficiency comparison among TMF sites.

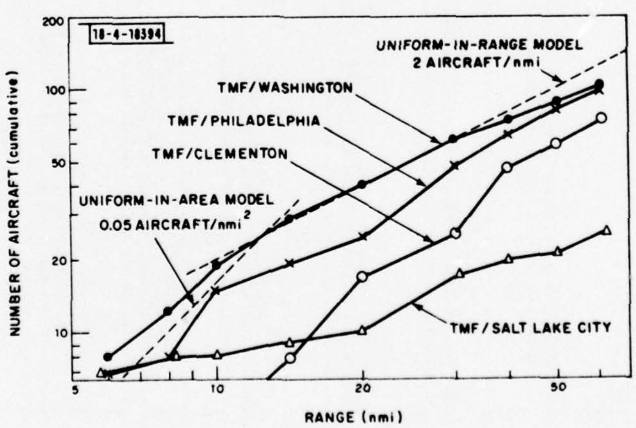

Fig. III-6. ATCRBS target distributions.

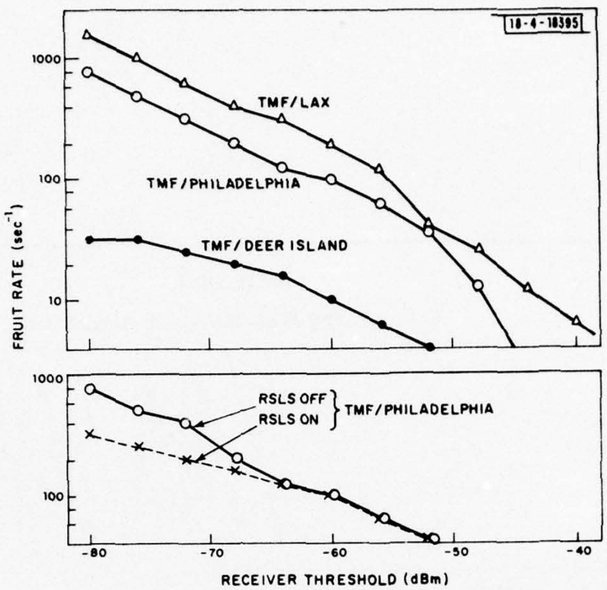

Fig. III-7. ATCRBS fruit measurements.

2. Track Quality Statistics and False Target Locations

In the previous DABS QTS, track quality statistics were presented for samples of data collected at the first six TMF locations along with plots of the location of reflectors causing false targets. During this quarter, similar data were collected for two more sites – Brea, California (near Ontario) and the first of two sites at Salt Lake City International Airport. Table III-1 presents the performance summary synopsis for Brea and Salt Lake City. Figure III-8 shows reflector locations for Salt Lake City.

The various sites visited by TMF represent a variety of terrain, environment (number of interrogators, types of reflecting surfaces and diffracting obstacles), and traffic. One characteristic of the traffic which is significant to the operation of automated air traffic control systems is the percent of beacon-equipped aircraft with valid altimeter reporting, and a value representative of this characteristic is presented in the summary table. An additional traffic characteristic, the average number of target reports per scan in a typical 6-min. period, has been added to the summary table.

B. Ground-to-Air Link Characterization

Recent uplink data reduction and analysis, using the now fully developed AMF Uplink Analysis Program, has resulted in a comprehensive tabularization of the characteristics of more than a dozen beacon interrogators in the Los Angeles area. These results, shown in Tables III-2, -3, and -4 are based on data from a circular flight (radius of 22 nmi) at 7200 feet around Los Angeles on 1 October 1976. Figure III-9 depicts 17 AMF aircraft positions along this circle at which data were recorded.

Table III-2 characterizes those interrogators which are regular enough to produce a PRI "track." The alphabetic code (A, B, etc.) assigned to each interrogator applies throughout this

TABLE III-1

TMF ATCRBS PERFORMANCE SUMMARY

	Brea, California TMF 8121 11/18/76 14:30 PST Thursday	Brea, California TMF 8115 11/17/76 14:00 PST Wednesday	Salt Lake Site 1 TMF 9005 12/3/76 10:13 MST Friday
Range Window (nmi)	80	80	80
Tracks Started			
Number	298	266	60
Average length (scans)	99	124	58
Target Reports			
Average number per scan for typical 6-min period	115	114	24
Percent Target Reports			
With valid altimeter code	49	49	56
Percent Target Reports			
With brackets only or on ground	42	44	35
Percent Target Reports			
With no Mode C response	9	7	9
Qualifying Tracks			
Number	276	299	28
Blip/Scan	0.98	0.98	0.98
Average miss length (scans)	1.4	1.5	1.4

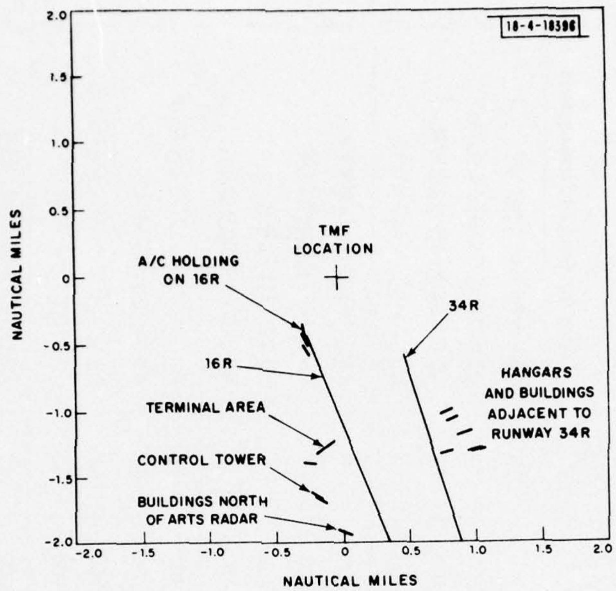

Fig. III-8. False target reflectors within ±2 nmi: Salt Lake Site 1.

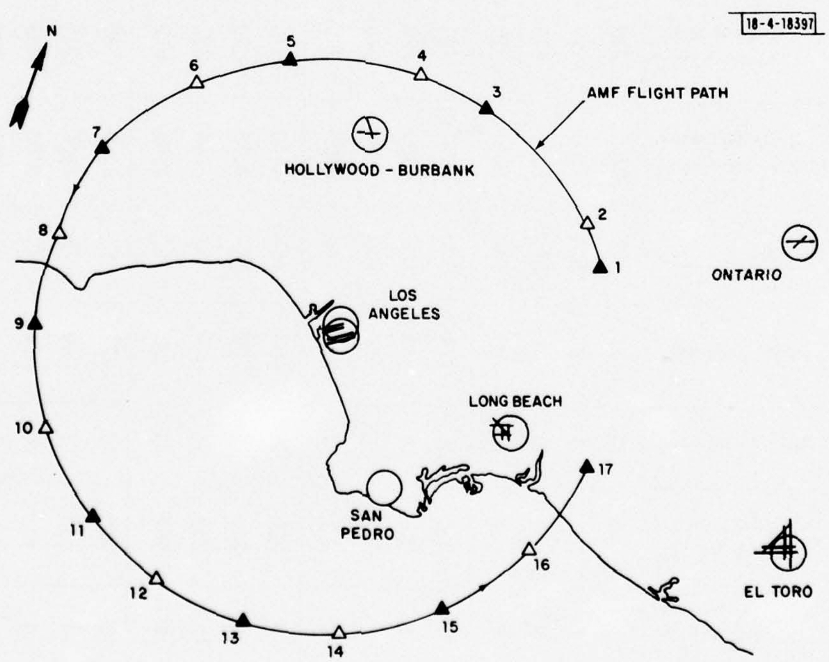

Fig. III-9. Points at which AMF measurements were made.

TABLE III-2

INTERROGATORS REGULAR ENOUGH TO PRODUCE A PRI "TRACK"

AC Position	Bearing from LAX (deg)	Seconds of Data	Threshold (dBm)	AC Heading (deg)	Pulses per second seen by AMF	Suppressions per second	Interrogations per second	Stray Pulses per second	Interrogators Tracked	Codes for Tracked Interrogators
1	60	30	−74	338	3400	750	450	900	13	A B C D E F H I J K M T W *
2	51	15	−80	327	4500	990	360	1600	14	A B C D (E) F G (H) I J K M S W *
3	19	30	−74	284	2000	520	120	700	15	A B C D E F H I J K M R V W X
4	6	15	−80	270	4200	910	210	1700	13	A B D F H I (J) K M S U (V) X
5	338	30	−74	235	2000	440	100	900	16	A B C D E F G H I J L M R T V X
6	318	15	−80	228	4800	790	330	2400	14	A B C D E G H I L M S T U X
7	298	30	−74	196	1500	240	140	700	11	A B C D F H I J L M X
8	277	15	−80	176	4500	780	330	2100	13	A B C (D) E F I J L M Q U X
9	258	30	−74	167	1800	310	130	900	16	A B C D E F G H I J (K) L N R S X
10	239	15	−80	145	4600	830	280	2200	11	A B C E (G) H I L M N X
11	218	30	−74	130	1800	280	140	900	17	A B C D E F G H I J K L M N O P X
12	199	15	−80	114	4700	870	290	2100	10	(E) (F) H I J L M O P X
13	180	30	−74	92	1500	80	110	1000	15	A B C D E F H I J K M N R S X
14	160	15	−80	75	4800	1010	300	1900	17	A B C D E F (G) H I (J) K M P Q T U X
15	140	30	−74	52	2100	450	80	1000	16	A B C D E F H I J K M N (P) Q R X
16	119	15	−80	39	3900	770	230	1700	8	(B) D E H (J) M Q X
17	98	30	−74	4	2300	670	80	800	16	A B C D E F G H I J K M Q R T X

Underlined letters mean more than 100 interrogations; parenthesized, less than 20; starred, more than 1000 (all these numbers must be halved for the shorter data samples at the even locations).

TABLE III-3

COMPLETE CHARACTERIZATION OF CHIEF LA AREA INTERROGATORS

Interrogator Code	A	B	C	D	E	F	G	H	I	J	K	M	L	X
Interrogator Name	San Pedro	LAX	LAX ASR-7	Ontario	El Toro	Burbank	Miramar	S. Nic. Island	S. Clem. Island	Long Beach	Norton AFB			
Best Position to Describe	17	13	11	17	17	5	9	11	11	17	1	11	11	11
Estimated Angle of Arrival (deg)	243	10	53	20	110	101	111	202	140	290	87	129	134	134
PRI – Pulse Repetition Interval (μsec)	2700.4	2468.0	2641.0	2221.0	2563.7	2665.0	2856.9	2782.6	2899.4	2966.6	3650.8	3240.8	3301.0	3299.5
PRF – Pulse Repetition Frequency (per sec)	370.31	405.20	378.64	450.24	390.06	375.24	350.03	359.38	344.90	337.08	273.91	308.56	302.94	303.07
Interrogation Modes	2ACA	AAC	AAC	AAC	AAC	AAC	AAC	1AC	2*2ACA	AAC	AC	4*2C	2A	2A
Average Dwell Time (msec)	167	59	54	50	54	75	42	187	162	57	103	869	228	272
Average Scan Period (sec)	11.86	4.67	4.67	4.68	4.69	6.00	4.68	9.66	12.02	4.67	3.86	10.96	9.91	9.89
Average Beamwidth (deg)	5.08	4.54	4.12	3.87	4.13	4.51	3.26	6.98	4.86	4.42	9.62	28.53	8.28	9.89
No. of Main Beams Seen	3	7	7	6	6	5	6	3	3	6	4	4	3	3
Average Main Beam Interrogations	43	19	16	20	17	23	12	57	41	16	24	196	56	59
Percent of Total Interrogations	52	99	90	98	97	76	87	82	98	100	69	89	98	87
Percent Sidelobe Interrogations	48	1	10	2	3	24	13	18	2	0	31	11	2	13
Total Interrogations in 30 sec	250	138	125	122	109	157	84	211	126	101	140	880	172	204
Max. P3-Power Measured (dBm)	–35	–46	–54	–55	–51	–44	–64	–49	–50	–44	–48	–50	–50	–46
Max-Ave P3-Power (dB)	19	10	8	7	7	10	4	11	9	6	8	13	8	13
Max-Min P3-Power (dB)	40	23	16	15	19	33	9	34	20	17	22	20	19	25
Length of Track (sec)	23.81	28.02	28.08	23.43	23.50	24.07	28.09	29.13	24.11	23.39	15.49	32.99	20.02	19.84
Max. Site Clock Delay (μsec)	0.6	34.7		0.2	1.0	0.1	1.4	0.4	6.3	0.1	4.0	28.9	4.2	0.5
Max. Site Clock Advance (μsec)	1.0	0.3		3.4	0.5	37.8	1.8	1.8	0.8	0.1	0.1	3.0	155.5	0.2

TABLE III-4

SITE CLOCK ERRORS FOR LA AREA INTERROGATORS

Aircraft Position	San Pedro 370.31	LAX 405.20	Ontario 450.24	El Toro 390.06	Burbank 375.24	Miramar 350.03	San Nicolas 359.38	San Clemente 344.90	Long Beach 337.08	Norton 273.92	L 302.96	X 303.07	M 308.56	Mt. Laguna 330.23
1		1 / 5	0 / 5	0 / 9	0 / 6				1 / 14	4 / 15				
3	2 / 12	6 / 29	5 / 23	19 / 23	38 / 24		1 / 10	1 / 12	1 / 28			2 / 21	35 / 22	
5	0 / 12	3 / 28	4 / 23	3 / 14	38 / 24	2 / 14	1 / 10	0 / 12	1 / 28		125 / 20	1 / 20	14 / 11	
7	2 / 24	2 / 23	14 / 23		34 / 27			1 / 12	1 / 28		49 / 20	1 / 20	142 / 22	
9	1 / 12	13 / 19	4 / 23	6 / 23	24 / 24	3 / 28	1 / 19	1 / 24	2 / 24		242 / 20	1 / 20		
11	1 / 25	3 / 32	9 / 33	16 / 28	6 / 24	6 / 28	2 / 29	7 / 24	1 / 24	5 / 27	160 / 20	1 / 20	32 / 33	
13	1 / 12	36 / 28	4 / 28	6 / 28	9 / 24			0 / 12	1 / 23	3 / 12		1 / 20		
15		8 / 23	5 / 23	5 / 24	25 / 24		1 / 20		1 / 23	4 / 23		1 / 20		
17	2 / 24	1 / 23	4 / 23	2 / 24	2 / 24	4 / 23	1 / 10	0 / 12	0 / 23			5 / 20		2 / 24

Top numbers: Sum of maximum advance and delay in interrogations from the expected times for perfect PRI (μsec).

Bottom numbers: Time (sec) during which clock deviation occurred.

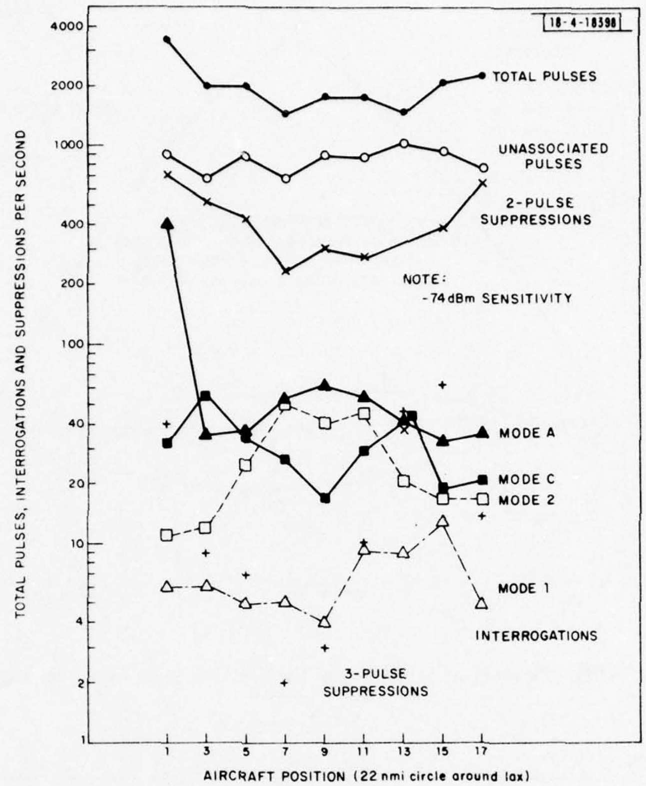

Fig. III-10. Pulse, interrogation, and suppression rates.

section. Columns 6 through 9 of this table (having to do with pulses, interrogations, and suppressions) have been plotted in Fig. III-10 for all data recorded at −74 dBm. The unusually large number of Mode A interrogations at position 1 is due to a single interrogator (W* in the table) on the PRF of 437.9 either searchlighting the AMF or producing omnidirectional interrogations without SLS.

Table III-3 provides further data on the LAX area interrogators; following any row from left to right discloses the spread of any characteristic at a glance. The analysis program determines the edge of a mainbeam in either direction by finding nine missing interrogations in a row. Data for the last two rows of the table (maximum site clock delay and advance) are produced by an algorithm which finds for each track interrogations near the first and last mainbeam centers, modifies the PRI slightly so that they correspond to these points (working toward the center of the track from each end), and determines how far ahead or behind their expected times the corrected PRI interrogations actually occur. The "length of track" is the time in seconds during which these clock deviations were observed. The same algorithm can also be used to differentiate sidelobe interrogations from reflections, which would show a systematic extra delay.

Site clock errors, with respect to correct PRI, are shown in Table III-4 for the interrogators already characterized otherwise (odd-numbered aircraft positions only). The sum of the maximum advance and maximum delay is given so that a single number may be given at each location. Blank squares imply not enough data, and the error is rounded to the nearest microsecond. It may be seen that the average error for LAX, Ontario, El Toro, Burbank, and

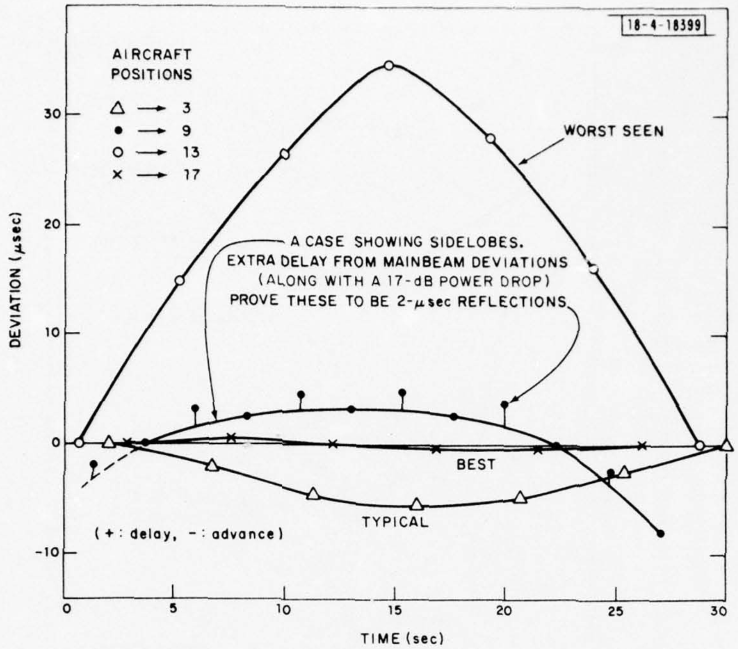

Fig. III-11. Deviation from expected PRI at four aircraft locations.

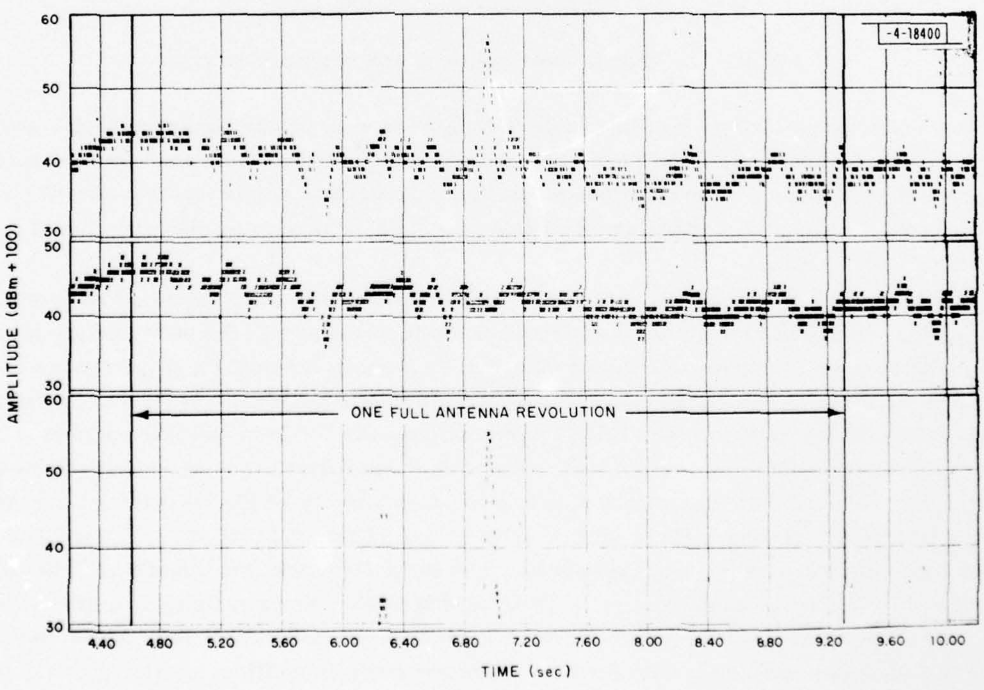

Fig. III-12. P1-P2-P3 pulses from Long Beach interrogator.

Norton (all terminal interrogators with short scan period) is about 6 or 7 μsec. The steadiest interrogators are San Pedro, San Nicolas Island, San Clemente Island, Interrogator X (all of long scan period), and the new radar at Long Beach (terminal) on its changed PRF of 337.12.

The best, worst, and typical site clock errors are plotted for LAX, the most important interrogator of the area in Fig. III-11. A fourth curve is shown because it illustrates how the PRI delay algorithm can be used to pick out reflections halfway between the mainbeams by their extra 2 μsec delay from the mainbeam clock error. These extra interrogations are 17 dB weaker in power, which fact by itself does not distinguish between sidelobe punchthrough and reflection. The timing characteristics plotted in Fig. III-11 make it clear that these extra interrogations are in fact reflections.

The AMF analysis program has the capability of extracting from the total pulse data the small fraction of pulses arriving from a single interrogator of interest, and plotting the corresponding P1-P2-P3 pulse power against time. This provides an in-flight antenna pattern measurement for both the directional and omnidirectional antennas of the selected site. At position 17 of the 22-nmi 7200-ft circle around LAX (within 8 nmi of Long Beach), such an in-flight antenna pattern measurement of the Long Beach interrogator was made. This is a new ASR-8/ATCBI-5 equipment which has one of the few revolving omnidirectional antennas in use. The antenna patterns are shown in Fig. III-12 where P1-P2-P3 pulses are plotted for the same 6-sec span of time in top-middle-bottom sequence. This is about 1.33 sec more than the scan period of Long Beach (4.67 sec, shown by the heavy lines, equidistant from the mainbeam).

The figure shows that the P1 pattern follows the P2 pattern, about 3 dB below the P2 power, everywhere except near 6.96 sec where P1 forms a mainbeam, which is also present in the P3 plot. This implies that the P1 pulse is being transmitted on both the directional antenna (hence its mainbeam) and on the omni (hence it does not go to zero as does the P3 pulse being transmitted on the directional antenna only), which is the normal operation of improved sidelobe suppression (IISLS).

The consistently higher power in the P2 pulse relative to P1 shows that there are no punchthroughs at Long Beach, a fact established independently by the PRI Tracker. The sharp "nulls" in the P2 pattern (repeated more or less from scan to scan) show an omni structure which is revolving with the directional antenna. The lack of "exact" repetition of the pattern in the 1.33-sec overlap region is not surprising. Small but definite in-flight antenna pattern changes from scan to scan have already been reported in the last issue of the QTS.

IV. IPC TEST AND EVALUATION

A. Relative Motion Analysis

During this quarter, a particularly fruitful approach to the analysis of rectilinear encounters has been developed. The analysis permits accurate insight into the nature of encounters, the effectiveness of proposed maneuvers, and prediction of failure modes. When applied to flight-test data, the analysis provides complete explanation of resolution failures in terms of encounter geometries and error sensitivities.

A report describing the development and application of the relative motion analysis will be forthcoming in the next quarter.

It is expected that the new analysis method can be fruitfully employed in the design of improvements to the IPC concept and resolution strategies.

B. Flight-Test Status

It has been decided that no future modifications to the IPC algorithms will be flight tested at DABSEF. Thus, all remaining improvements will be incorporated into the engineering development sensors at NAFEC, and tested there in the 1978-79 time period.

At this time, many of the features of FAA-EM-74-4, as it applies to single sensors, have been validated, and the results subjected to analysis. The analysis and conclusions will be incorporated in the final report, which will be prepared during the next quarter.

At the completion of the tests, the following statistics were relevant: Table IV-1 lists the missions run, Table IV-2 lists the encounter classifications, and Table IV-3 lists missions logged with each algorithm version.

TABLE IV-1

IPC FLIGHT-TEST STATUS
March 1975 – January 1977

Missions	126	Pilots	101
Validation	59	Test	9
Demonstration	23	Demonstration	27
Subject Pilot	44	Subject	65
Encounters	1562		
Planned	1383		
Unplanned	179		

TABLE IV-2

IPC FLIGHT TEST ENCOUNTERS RECORDED
March 1975 – January 1977

Encounters Planned	1383	Encounters Unplanned	179
DABS/DABS	1098	DABS/ATCRBS	179
VFR-VFR	562	VFR-VFR	14
VFR-IFR	491	VFR-IFR	3
IFR-IFR	45	IFR-IFR	–
ATCRBS/DABS	285		
VFR-VFR	106		
VFR-IFR	149		
IFR-IFR	30		

TABLE IV-3

IPC ALGORITHM VERSIONS FLIGHT TESTED
March 1975 – January 1977

Algorithm Version	Validation	Demonstration	Subject Pilot	IPC Missions Total
LTAC-1	30	9	14	53
LTAC-2	1	1	3	5
LTAC-3	7	4	8	19
LTAC-4	9	8	18	35
LTAC-5	12	1	1	14
	59	23	44	126

Effective Date	IPC Algorithm Versions
3/75	LTAC-1: FAA-EM-74-2, Rev. 1
11/75	LTAC-2: (LTAC-1 Plus) M-S1, M-S2, M-S3, M-S5
12/75	LTAC-3: (LTAC-2 Plus) M-S6, M-S7.1
2/76	LTAC-4: (LTAC-3 Plus) M-S12, M-S15, M-S16, L-S1, L-S2
9/76	LTAC-5: FAA-EM-74-4, Change 2 (Single Site)

V. AIRCRAFT REPLY AND INTERFERENCE ENVIRONMENT SIMULATOR (ARIES)

A. Equipment and Software Status

1. Hardware Status

Components of the ARIES hardware drawers are identified in Table V-1. The RF Receiver, IF Units, and IF Combiner Network, comprising the RF Assembly, have been designed, fabricated, and installed in the Analog Drawer (see Fig. V-1). Initial bench testing, tuning, and debugging are currently in process. All digital hardware with the exception of the computer interfaces and the ARIES Tester are fabricated and installed in the Digital Logic Drawer (see Fig. V-2). The hardware interfaces to be installed in the computer mainframe are designed and are currently being assembled. Interface cabling and computer back-plane wiring are also complete and checked out.

TABLE V-1

ARIES COMPONENTS

Drawer	Unit(s)
Analog	Receiver (Analog) IF Reply Generators (6) IF Combiner Network
Digital	Receiver (Digital) Target Generator, CAT(3) Target Generator, FAT(3) Target Controller, CAT Target Controller, FAT Random Process Generator Sense Formatter Universal Interval Timer ACP/ARP Decoder/Simulator
ARIES Tester	–
Computer Interface*	CAT Controller Interface FAT Controller Interface Digital Receiver Interface Random Number Generator Interface Sense Formatter Interface Universal Timer Interface ARIES Tester Interface Production Common Digitizer (PCD) Interface

* mounted in computer chassis

Designs for the ARIES Tester are complete and initial fabrication has begun. It is expected that all hardware (including the computer system) will be checked out and rack mounted by the end of the next reporting period.

-4-18401

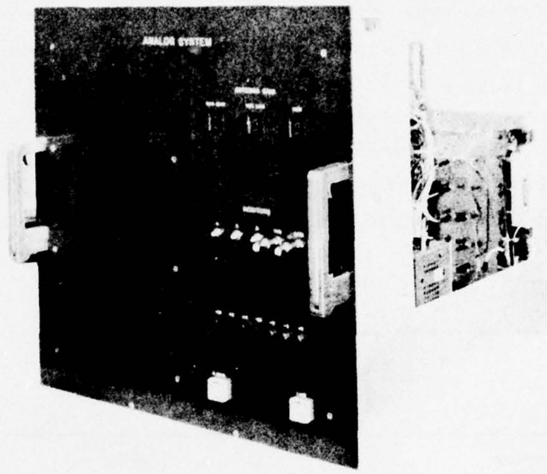

Fig. V-1. ARIES analog drawer.

-4-18402

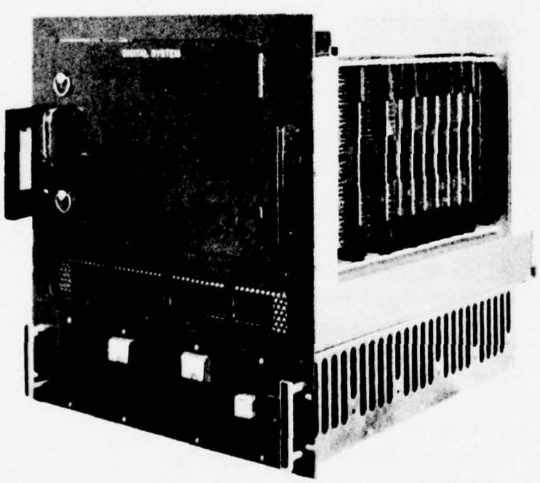

Fig. V-2. ARIES digital drawer.

2. Software Status

The Eclipse (Data General) computer being used in ARIES provides for user-written microcode. This can be used to implement instructions which carry out certain operations at a much faster rate. This feature is being used in ARIES to implement portions of the interrogation processing algorithms. Initial testing has demonstrated that the microprogram will run in about 1/3 the time of an equivalent assembly language program. A similar microprogram for ATCRBS and All-Call reply processing will be generated shortly, and both of these microprograms will be combined to complete the ARIES interrogation processing task. Thus, sufficient software will be available to begin initial ARIES system tests.

It is anticipated that by the end of the next reporting period the rest of the ARIES software tasks which now exist in skeleton form will be completed.

B. Generation of Exponentially Distributed Inter-Arrival Times

The simulated fruit to be generated by ARIES will be characterized by arrival statistics corresponding to those of a Poisson process. Thus inter-arrival time will be a random variable with exponential probability density, and the probability that the interval between two successive events will be between t and $t + dt$ is

$$P(t) = \lambda e^{-\lambda t}\, dt \quad ,$$

where λ is the fruit rate. In ARIES, it is desired that the fruit rate be variable over the range from 1,000 to 64,000 fruit/second.

The timing constraints involved in generating these fruit rates dictate that a hardware device be used to generate the inter-arrival times. The input to this device is related to $1/\lambda$, a dilation factor. The output is a series of 16-bit exponentially distributed inter-arrival times, with the least significant bit corresponding to the least significant bit of the ARIES range clock (62.5 nsec).

The approach taken has been to approximate the exponential distribution by a step function which can be generated by combining the output of several random number generators with uniform distributions. Such a step function approximation, drawn to scale, is shown in Fig. V-3, but with only a small number of steps for clarity. In the actual implementation, 1024 steps are used.

The step times t_n in Fig. V-3 are chosen so that the areas of the horizontal strips are $1/N$, where N is the number of strips. They thus represent areas of equal probability. Each strip then represents a uniform distribution with total probability $1/N$ and height $1/N \cdot t_n$. The overall step function is the sum of these distributions.

To generate an exponentially distributed random number, a uniformly likely number n, between 1 and N, is first generated. This is used to obtain t_n from a table (implemented as a read-only memory). This essentially corresponds to picking one of the horizontal strips with probability $1/N$, which matches the probability that each strip represents.

Next, another uniform random number generator is used to obtain a number between 0 and t_n. The probability of picking a given number is $1/t_n$ (the t_n are integers), and the overall probability is $1/N \cdot t_n$, representing a small area of probability such as the filled-in rectangle in Fig. V-3. The total probability of picking any t corresponds to the sum of all such rectangles in the column for t.

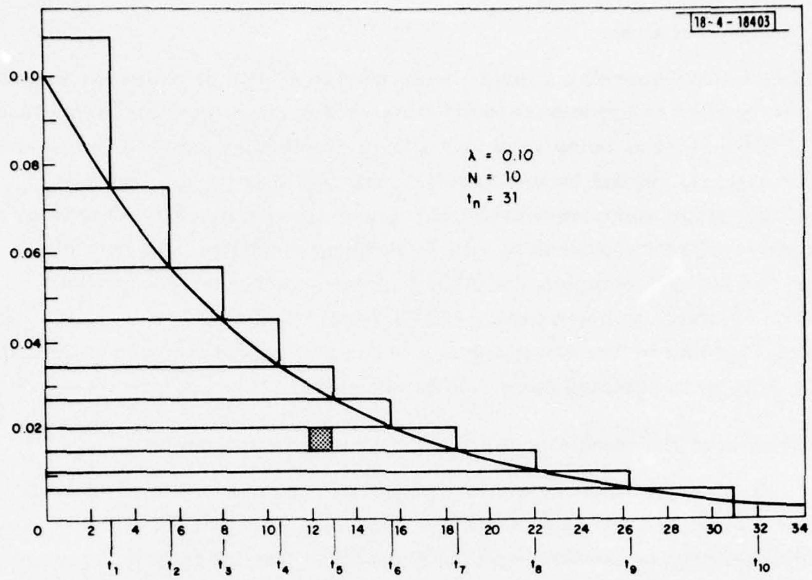

Fig. V-3. Approximation of $\lambda e^{-\lambda t}$ by a step function.

To calculate the t_n, an expression for the area of each strip is set equal to $1/N$, and the resulting equality solved for t_{n-1} in terms of t_n.

$$t_n\left(\lambda e^{-\lambda t_{n-1}} - \lambda e^{-t\lambda_n}\right) = 1/N$$

$$\boxed{t_{n-1} = -\frac{1}{\lambda} \ln\left[\frac{1}{N\lambda t_n} + e^{-\lambda t_n}\right]}$$

The value t_N is set equal to the maximum value that can be stored in the lookup table, and then the above recursion is used to generate the other entries. To preserve numerical accuracy, all calculations must be performed in floating point or double precision and the resulting t_n then converted to integers of the desired size.

VI. EXPERIMENTAL FACILITIES

A. DABSEF

Data from approximately 200 TMF experiments collected at 3 TMF sites (LAX, Brea, and Salt Lake City) have been processed at DABSEF during the period 1 October through 31 December 1976. Fourteen of the experiments at LAX were flown for IPC purposes. The IPC data collected were to have been processed onto an SDP-formatted tape which would then be inputted to the IPC playback program using the LTAC5 algorithm. However, the processor limit of 125 tracks made it necessary to change the initial DABSEF processing to create an SDP tape with less than 125 tracks. This was accomplished by inputting azimuth limits to process only areas of interest. The output tape of the playback processing was then forwarded to the IBM 370 computer for conflict analysis.

In addition to the 14 IPC flights, DABSEF supported 2 demonstration flights using the LTAC4 algorithm and 12 validation flights using the LTAC5 algorithm, simulation tests of the BCAS system on the SEL 8600 computer, and Mod 4 transponder checks.

B. Avionics

Evaluation of transponder in-flight performance has continued as a byproduct of the IPC test program. Unexpected performance has been correlated with bench performance. When necessary, bench-test procedures and/or specifications have been modified to reflect actual operating conditions of more realistic requirements.

It has been found, for example, that the transponder dead time goes beyond its specified limit at low signal levels. This has been observed only in actual flight operation. Specifications now require dead time performance "at all signal levels."

Transponder retrofit to confine suppression to ATCRBS only has been carried out on two units. On the average, Mod 4 transponder availability has exceeded 75 percent.

C. Transportable Measurements Facility (TMF)

The TMF completed its measurement activity at Los Angeles International Airport, was relocated to an abandoned NIKE site in Brea, California, for a series of measurements, and is currently located at Salt Lake City International Airport. Table VI-1 notes the dates and recording activity at each of these sites.

The Brea location was selected in order that a potential site for a future DABS sensor might be evaluated. The site is located 25 miles east of Los Angeles Airport at an elevation of 1428 feet above MSL (see Fig. VI-1), and appears to provide good coverage for most of the airports in the Los Angeles Basin.

The TMF was moved to Salt Lake City at the end of November 1976 in response to a request by the FAA to evaluate a new site for the Salt Lake ARTS radar. The present ARTS radar location generates troublesome extended false target tracks in the vicinity of the northern approach to the airport. The Rocky Mountains regional office chose two candidate locations at which they desire to collect siting measurements (see Fig. VI-2). One (Site No. 1) is located near the northern end of the Salt Lake International Airport property, between the approaches to runways 16L and 16R. The second site (Site No. 2), at which it may be possible to service Salt Lake, Hill AFB, and Ogden Municipal jointly, is located near Layton, Utah, approximately 17 nmi north of Salt Lake Airport.

TABLE VI-1

TMF RECORDING ACTIVITIES

Experiment	Brea, California 2-22 November 1976	Salt Lake, Utah 1 December 1976 – 5 January 1977
TMF-centered circular flights for site characterization.	X	
Radial flights of DABS-equipped aircraft to evaluate the DABS processor	X	
Low-altitude coverage involving approaches to 19 airports in the LA Basin and two airports in Salt Lake.	X	X
Low-altitude coverage of FAA specified fixes, waypoints, and Victor airways.		X
Vertical lobing experiments.		X
Target-of-opportunity recordings. simultaneously with ARTS for performance comparison.	X	X

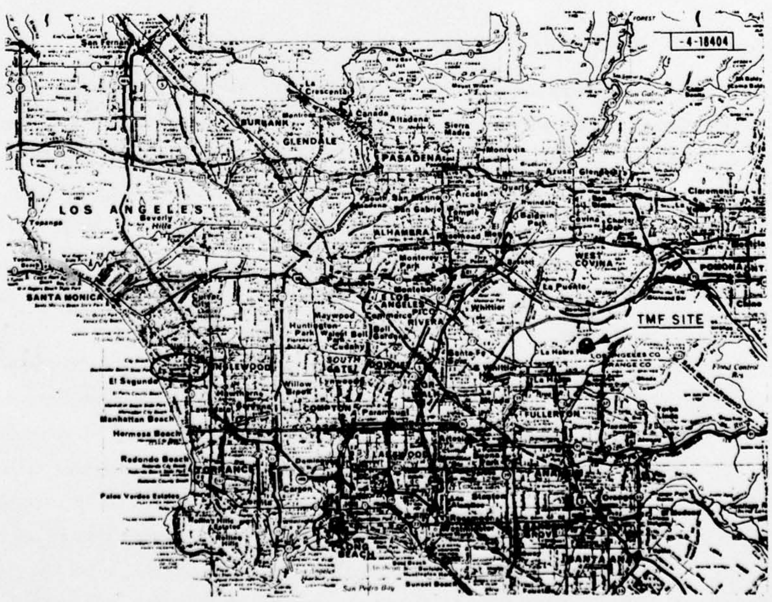

Fig. VI-1. Brea TMF site vs LA International Airport TMF site.

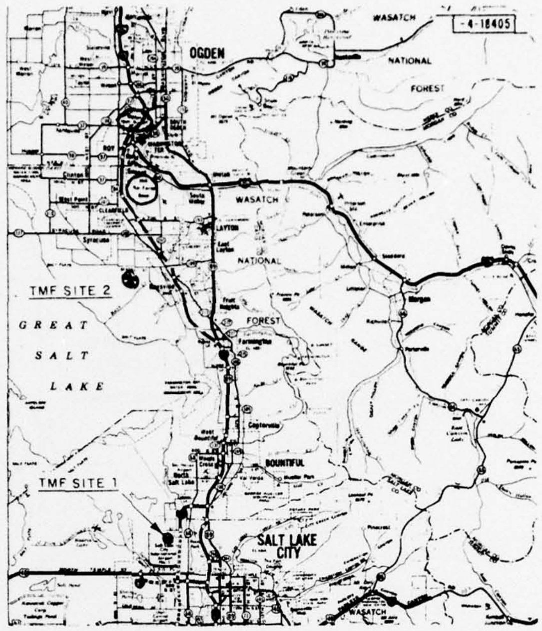

Fig. VI-2. TMF sites near Salt Lake City, Utah.

A modification was installed into the TMF hardware while it was located at Brea in order to reduce a burden on the DABS recording and processing functions. In the DABS recording mode of operation, TMF previously used neither ISLS or real-time RSLS, and therefore recorded a considerable amount of unnecessary sidelobe data. The modification involved the use of the RSLS bit as an inhibiter to prevent detection of DABS preambles arriving via the TMF antenna sidelobes.

D. AMF

The AMF was used in a series of air-to-air multipath measurements in October. In fact, the bulk of the data in the air-to-air program was recorded in this time period, with samples over ocean, city, suburbs, mountains, and lakes. Several additional air-to-air missions are planned in February.

The angle-of-arrival function of the AMF was calibrated in more detail this quarter. This was done by analyzing data received from ATCRBS interrogators in the Los Angeles area for a large number of AMF aircraft locations and orientations. It was found that in addition to a random scatter or noise, there is a detectable nonlinearlity in the angle transfer function, as plotted in Fig. VI-3. The error characteristic may be described approximately as a double-frequency sinusoid plus a constant bias.

Detailed design work has begun on the AMF modifications that are planned. When modified, the AMF will provide the following new functions: (1) a new VPQ (video pulse quantizer) which agrees with equipment that would be used in BCAS, (2) a hardware DABS preamble detector and data block demodulator for DABS replies, (3) a mode in which DABS replies and air-to-air multipath data can both be recorded, and (4) a 1030-MHz interrogation transmitter which includes the following modes – ATCRBS Modes A, C, and D, DABS/ATCRBS All-Call Modes A and C, and DABS discrete interrogations. These modifications are scheduled for completion in April.

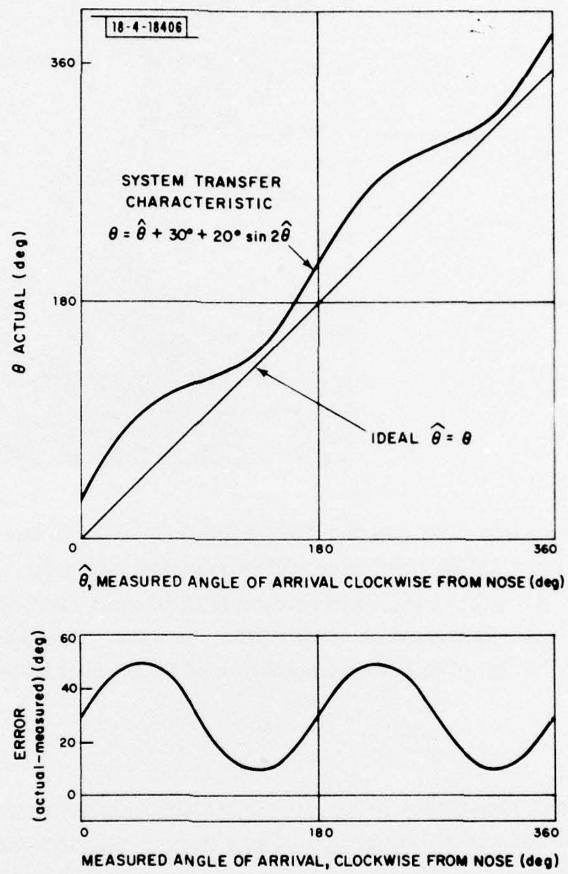

Fig. VI-3. Calibration of the AMF angle-of-arrival subsystem.

ABBREVIATIONS AND ACRONYMS

ABIL	Airborne Beacon Interrogator Locator
AC	Air Carrier
A/C	Aircraft
ACS	All-Call to Subset
ACS	Acquisition and Control System (part of SEL-86 computer)
A/D	Analog to Digital
ADC	Air Defense Center
ADIZ	Air Defense Identification Zone
AGL	Above Ground Level
AIMS	Compatible DOD-ATC Beacon System
ALEC	Altitude Echo
AMF	Airborne Measurements Facility
AMPS	ATCRBS Monopulse Processing Subsystem
APG	Azimuth Pulse Generator
ARB	Ambiguity Resolution Bit
ARIES	Aircraft Reply and Interference Environment Simulator
ARINC	Aeronautical Radio, Inc.
ARSR	Air Route Surveillance Radar
ARTCC	Air Route Traffic Control Center
ARTS	Automated Radar Terminal System
ASCII	American Standard Code for Information Interchange
ASR	Airport Surveillance Radar
ATA	Air Transport Association
ATAS	Aircraft Tone and Audio System
ATC	Air Traffic Control
ATCAC	Air Traffic Control Advisory Committee
ATCBI-X	ATCRBS Beacon Interrogator (Model X)
ATCRBS	Air Traffic Control Radar Beacon System
Au	Angle Unit
BCAS	Beacon Collision Avoidance System
BDAS	Beacon Data Acquisition System
BRP	Beacon Reply Processor
C	Climbing
CA	Controller Acknowledgment
CAS	Collision Avoidance System
CAT	Controlled ARIES Targets
CD	Common Digitizer
CDM	Cockpit Display Monitor
CF	Close Fit (algorithm)
CIDIN	Communications ICAO Data Interchange Network
COMM-n	DABS Message Type Designation (n = A, B, C, or D); See FAA-RD-74-62
CONUS	Conterminous United States

CP	Collision Point
CPME	Calibration Performance Monitoring Equipment
CPU	Central Processing Unit
CPV	Correlation Preference Value (NAS)
CRT	Cathode Ray Tube
CRW	Close Range Window
csc^2	Cosecant Squared
CTU	Crosslink Transponder Unit
CW	Continuous Wave
D	Descending
DABS	Discrete Address Beacon System
DABSEF	DABS Experimental Facility
DABSIM	DABS Simulation (software program)
DABSLST	DABS Performance Measurement Program (software)
DAS	Digital Acquisition System (ARTS)
dBI	Decibels With Respect to "Isotropic
dBm	Decibels With Respect to 1.0 Milliwatt
DCAS	DABS-Based CAS
DCFSK	Direct-Coupled Frequency-Shift Keying
DF	Direction Finding
DG	Design Gain
DIM	DABS Interrogation Modulator
DME	Distance Measuring Equipment
DMID	Downlink Message Identification (No.)
DOD	Department of Defense
DOT	Department of Transportation
DOT	Range Times Range Rate (vector "dot" product)
DPSK	Differential Phase-Shift Keying
DRP	DABS Reply Processor
DSF	Digital Simulation Facility (at NAFEC)
DTSD	DABS Traffic Situation Display
DV&R	Design Validation & Refinement
DYNO	A High-Efficiency Interrogation Scheduling Algorithm
ECAC	Electromagnetic Compatibility Analysis Center
EER	Envelope of Error
ELM	Extended Length Message
EN	Envelope of Nulls
E-SCAN	Electronically Scanned Antenna
ER	Engineering Requirement
ERP	Effective Radiated Power
ESC	Experimental Sensor Configuration

FA	Fade Allowance
FAA	Federal Aviation Administration
FAT	Fruit ARIES Targets
FPWI	Flashing PWI (indication)
FR	Full Ring (algorithm)
FSK	Frequency-Shift Keying
GA	General Aviation
GCAS	Ground-Based Collision Avoidance System
GTC	Gain Time Control
HSC	High-Speed Channel (SEL-86 computer)
IAC	Instantaneous Airborne Count
IAR	Interrogation Arrival Rate
ICAO	International Civil Aviation Organization
ICR	Integrated Cancellation Ratio
ID	Identification
IFF	Identification Friend or Foe
IFR	Instrument Flight Rules
IISLS	Improved Interrogation Sidelobe Suppression
ILS	Instrument Landing System
I/O	Input/Output
IPC	Intermittent Positive Control
IRO	Increasing Range Order
LAX	Los Angeles International Airport
LEA	Link Elevation Angle
LED	Light Emitting Diode
LOS	Line of Sight
LR	Link Reliability
LSB	Least Significant Bit
LSI	Large Scale Integrated (-tion)
LTC	Link Test Configuration
Mb/S	Megabits/Second
MCU	Modulator Control Unit
MIL	Military
MILS	Microwave Instrument Landing System
MLS	Microwave Landing System
MNAS	Maximum Number of Sensors
MS	Maximum Number of Sectors
MSI	Medium Scale Integrated (-tion)
MSL	Mean Sea Level
MTDS	Military Tactical Data Systems
MTL	Minimum Triggering Level
MUDSL	Minimum Usable DABS Signal Level

NAFEC	National Aviation Facility Experimental Center
NAS	National Aviation System
NDA	No Data Available
NIKE	United States Army Anti-Aircraft System
NOZ	Normal Operating Zone
NRTCP	New-Real-Time Control Program
NRZ	Non Return to Zero
NRZI	Differentially Encoded NRZ (flux reversal equals "1")
NTDS	Naval Tactical Data System
OAT	Outside Air Temperature
ORW	Open Range Window
OSEM	Office of Systems Engineering Management
PA	Pilot Acknowledgment
PAM	Pulse Amplitude Modulation
PAR	Pulse Arrival Rate
PCA	Positive Control Area
PCD	Production Common Digitizer
PEM	Position Entry Module
PIAC	Peak Instantaneous Airborne Count
PLE	Pseudo Leading Edge
PLL	Phase Lock Loop
PLRACTA	Position Location, Reporting and Control of Tactical Aircraft
PPM	Pulse Position Modulation
PRF	Pulse Repetition Frequency
PRI	Pulse Repetition Interval
PROM	Programmable Read Only Memory
PRP	Pulse Repetition Period
PSK	Phase-Shift Keying
PWI	Pilot Warning Indicator
QSLS	Quadrature (or Quantized) Sidelobe Suppression
QTS	Quarterly Technical Summary
RAM	Random Access Memory
RAS	Readout; Aircraft State
RBTF	Radar Beacon Test Facility (at NAFEC)
RCC	Regional Control Center
RDJ	Reply Delay Jitter
RIANG	Rhode Island Air National Guard
RIU	Range Interval Unit
RMSE	Root Mean Square Error
ROM	Read-Only Memory
RPG	Random Process Generator

RSLS	Receive Sidelobe Suppression
RT	Round Trip
RTCP	Real-Time Control Program
Ru	Range Unit
S&C	Surveillance and Communication
SAR	Suppression Arrival Rate
SAW	Surface Acoustic Wave
SCP	Surveillance and Communication Processor
SDC	System Development Contractor
SDP	Sensor Demonstration Program
SEC	System Engineering Contractor
SEL	System Engineering Laboratory, Inc.
SIF	Military IFF
SIR	Signal-to-Interference Ratio
SLS	Sidelobe Suppression
SM	Short Message
SMR	Signal-to-Multipath (Signal) Ratio
SNR	Signal-to-Noise Ratio
SPI	Special Pulse Identification
SPM	System Program Manager
SPWI	Steady PWI (indication)
SQV	Sampled Quantized Video
SRDS	System Research and Development Service
SS	Sum of Squares
SSF	System Support Facility (at NAFEC)
STC	Sensitivity Time Control
SWD	Sliding Window Detector
TACAN	Military Aircraft Navigation System (Providing Range and Bearing from Station)
TAD	Technical Acknowledgment, Downlink
TATF	Terminal Automation Test Facility (at NAFEC)
TAU	Technical Acknowledgment, Uplink
TCA	Terminal Control Area
TCR	Transmit Control Register
TDP	Technical Development Plan
TMF	Transportable Measurements Facility
TOA	Time of Arrival
TOD	Time of Day
TSC	Transportation Systems Center, DOT, Cambridge, Mass.
TTL	Transistor-to-Transistor Logic
TWG	Transmit Waveform Generator
UMID	Uplink Message Identification

VFR	Visual Flight Rules
VOR	Very High Frequency Omnirange (Provides Bearing Data)
VORTAC	Combined VOR and TACAN Facility
VPQ	Video Pulse Quantizer
V/STOL	Vertical/Short Takeoff and Landing
ZFLAG/ FLAGSTAT	ATCRBS Performance Measurement and Diagnostic Program (software)
ZRT	Zero-Range Trigger

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FAA-RD-72-44	QTS 1	1 April 1972	Development of a Discrete Address Beacon System
FAA-RD-72-76	QTS 2	1 July 1972	Development of a Discrete Address Beacon System
FAA-RD-72-117	QTS 3	1 October 1972	Development of a Discrete Address Beacon System
FAA-RD-73-12	QTS 4	1 January 1973	Development of a Discrete Address Beacon System
FAA-RD-73-48	QTS 5	1 April 1973	Development of a Discrete Address Beacon System
FAA-RD-73-101	QTS 6	1 July 1973	Development of a Discrete Address Beacon System
FAA-RD-73-165	QTS 7	1 October 1973	Development of a Discrete Address Beacon System
FAA-RD-74-8	QTS 8	1 January 1974	Development of a Discrete Address Beacon System
FAA-RD-74-85	QTS 9	1 April 1974	Development of a Discrete Address Beacon System
FAA-RD-74-136	QTS 10	1 July 1974	Development of a Discrete Address Beacon System
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FAA-RD-75-4	QTS 12	1 January 1975	Development of a Discrete Address Beacon System
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FAA-RD-72-30	ATC-9	12 April 1972	Final Report, Transponder Test Program	G. V. Colby E. A. Crocker
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FAA-RD-74-210	ATC-46	June 1975	Plan for Flight Testing Intermittent Positive Control	J. W. Andrews J. F. Golden J. C. Koegler A. L. McFarland M. E. Perie K. D. Senne
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FAA-RD-75-61	ATC-48	12 September 1975	DABS Downlink Coding	J. T. Barrows
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