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Impact of an Omnidirectional Traffic Alert and Collision Avoidance System on the Air Traffic Control Radar Beacon System and the Discrete Address Beacon System

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Annapolis, Maryland 21402

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Final Report

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16. Abstract A computer analysis was conducted to investigate the effect of an omnidirectional version of the Traffic Alert and Collision Avoidance System (TCAS) on the performance of: 1) the Air Traffic Control Radar Beacon System (ATCRBS), and 2) the planned Discrete Address Beacon System (DABS) in selected air traffic environments. The performance of ATCRBS and DABS was examined both with and without the TCAS in operation. Additional simulations were conducted to quantify the effect of TCAS when employing its interference-limiting function.			
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PREFACE

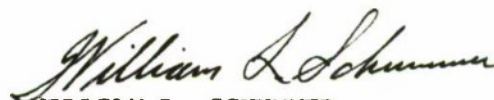
The Electromagnetic Compatibility Analysis Center (ECAC) is a Department of Defense facility, established to provide advice and assistance on electromagnetic compatibility matters to the Secretary of Defense, the Joint Chiefs of Staff, the military departments and other DoD components. The center, located at North Severn, Annapolis, Maryland 21402, is under policy control of the Assistant Secretary of Defense for Communication, Command, Control, and Intelligence and the Chairman, Joint Chiefs of Staff, or their designees, who jointly provide policy guidance, assign projects, and establish priorities. ECAC functions under the executive direction of the Secretary of the Air Force and the management and technical direction of the Center are provided by military and civil service personnel. The technical support function is provided through an Air Force sponsored contract with the IIT Research Institute (IITRI).

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To the extent possible, all abbreviations and symbols used in this report are taken from American Standards Y10.19 (1967) "Units Used in Electrical Science and Electrical Engineering" issued by the USA Standards Institute.



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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	What You Know	Multiply by	To Find	Symbol
LENGTH				
m	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
m ²	square inches	6.5	square centimeters	cm ²
ft ²	square feet	0.09	square meters	m ²
yd ²	square yards	0.8	square meters	m ²
mi ²	square miles	2.6	square kilometers	km ²
acres	acres	0.4	hectares	ha
MASS (weight)				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
VOLUME				
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft ³	cubic feet	0.03	cubic meters	m ³
yd ³	cubic yards	0.76	cubic meters	m ³
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

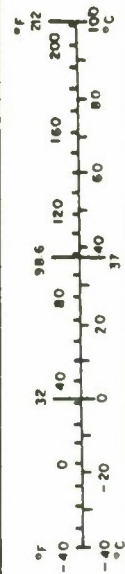


Approximate Conversions from Metric Measures

Symbol	What You Know	Multiply by	To Find	Symbol
LENGTH				
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
AREA				
cm ²	square centimeters	0.16	square inches	in ²
m ²	square meters	1.2	square yards	yd ²
km ²	square kilometers	0.4	square miles	mi ²
ha	hectares (10,000 m ²)	2.5	acres	ac
MASS (weight)				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	st
VOLUME				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m ³	cubic meters	35	cubic feet	ft ³
m ³	cubic meters	1.3	cubic yards	yd ³

TEMPERATURE (exact)

°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F
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* 1 in. = 2.54 exactly. For other metric conversions, see Metric Handbook, 1966, U.S. Dept. of Commerce, Bureau of Standards, Gaithersburg, MD. For other metric conversions, see Metric Handbook, 1966, U.S. Dept. of Commerce, Bureau of Standards, Gaithersburg, MD.

EXECUTIVE SUMMARY

An omnidirectional version of the Traffic Alert and Collision Avoidance System (TCAS), referred to in the past as the active Beacon Collision Avoidance System (BCAS), analyzed in this report provides the collision-avoidance function for TCAS-equipped aircraft against aircraft equipped with either Air Traffic Control Radar Beacon System (ATCRBS) or Discrete Address Beacon System (DABS) transponders. The Federal Aviation Administration (FAA) requested that the Electromagnetic Compatibility Analysis Center (ECAC) investigate the effect of TCAS on ATCRBS and DABS performance.

A computer simulation model of the proposed TCAS was developed to predict the impact of TCAS emissions on ground-based Air Traffic Control (ATC) systems. The model simulates TCAS-generated interrogations and merges them with interrogations generated by the ground ATC system in the ECAC-maintained DABS/ATCRBS/AIMS Performance Prediction Model (PPM).

Simulations were conducted to determine the impact of TCAS emissions on the performance of a) the Long Beach ATCRBS interrogator, and b) a hypothetical DABS sensor at Los Angeles (LAX-4), in hypothesized air traffic deployments for the Los Angeles Basin. Seven deployments were constructed as subsets of a hypothesized Los Angeles Basin deployment. Predictions were also made of the uplink suppression and interrogation rates.

Ground system performance was predicted both with and without TCAS operation, and with and without TCAS employing an interference-limiting procedure. ATCRBS performance is based on the ability of the processor to detect aircraft and to validate Mode A (identity) and Mode C (altitude) reply codes. DABS performance is based on the ability of the DABS sensor to elicit decodable surveillance and data-link replies from DABS-equipped aircraft with a minimum number of interrogations, and to detect ATCRBS aircraft and receive Modes A and C reply codes with high confidence.

For the ATCRBS interrogator at Long Beach, it was predicted that deploying TCAS, with or without interference-limiting, in any of the various air traffic deployments:

1. Will not reduce target detection probabilities.
2. Will reduce the Mode A validation probability by less than 2%.
3. Will reduce the Mode C validation probability by less than 2%.

Deploying TCAS, with interference-limiting, in any of the various air traffic deployments will reduce average transponder reply probability by less than 2%.

For the hypothetical DABS sensor at Los Angeles, it was predicted that deploying TCAS, with or without interference-limiting, in any of the various air traffic deployments:

1. Will not reduce the target detection probability.
2. Will not reduce the high-confidence Mode A validation probability.
3. Will reduce the high-confidence Mode C validation probability by less than 1%.
4. Will increase the roll-call interrogation rate by less than 6%.

Deploying TCAS, with interference-limiting, in any of the various air traffic deployments, will not reduce the high-confidence Mode C validation probability and will reduce the average transponder reply probability by less than 2%.

For the peak air traffic deployment simulation (743 aircraft within 60 nmi of Los Angeles) with approximately 25% of the aircraft equipped with TCAS, it was predicted that 133 of the 188 TCAS units were required to limit CAS transmissions; 2 of these units were required to terminate CAS activity.

TABLE OF CONTENTS

<u>Subsection</u>	<u>Page</u>
SECTION 1	
INTRODUCTION	
BACKGROUND.....	1
OBJECTIVE.....	3
APPROACH.....	3
SECTION 2	
MODEL INPUTS	
INTERROGATOR-OF-INTEREST OPERATION.....	5
DEAD TIMES.....	8
EQUIPMENT DEPLOYMENT.....	9
Aircraft Deployments.....	9
Ground Interrogator Deployments.....	12
TCAS/ATC COMPATIBILITY DESIGN.....	14
Ground-Based Radar Beacon Transponders (RBX).....	14
Interference Limiting.....	15
SECTION 3	
DISCUSSION OF RESULTS	
GENERAL.....	17
LONG BEACH ATRBS.....	17
Transponder Performance.....	18
Interrogator Performance.....	20

TABLE OF CONTENTS (Continued)

<u>Subsection</u>	<u>Page</u>
SECTION 3 (Continued)	
LOS ANGELES DABS.....	22
Transponder Performance.....	22
Sensor Performance.....	24

SECTION 4
CONCLUSIONS

ATCRBS PERFORMANCE AT LONG BEACH.....	27
DABS PERFORMANCE AT LOS ANGELES.....	27

LIST OF ILLUSTRATIONS

Figure

1	Transponder deployment.....	11
2	Ground interrogator deployment.....	13

LIST OF TABLES

Table

1	PARAMETER ASSIGNMENTS IN THE LONG BEACH SCENARIO.....	6
2	PARAMETER ASSIGNMENTS IN THE LAX SCENARIO.....	7

TABLE OF CONTENTS (Continued)

<u>Subsection</u>	<u>Page</u>
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LIST OF TABLES (Continued)

Table

3	TRANSPONDER DEAD TIMES.....	8
4	AIRCRAFT DEPLOYMENTS USED IN THE ANALYSIS.....	10
5	DABS SENSOR SURVEILLANCE AND DATA LINK ZONE ASSIGNMENTS.....	14
6	RBX CHARACTERISTICS.....	15
7	TCAS INTERROGATOR CHARACTERISTICS.....	16
8	SUMMARY OF EFFECTS OF TCAS ON ALL TRANSPONDERS RESPONDING TO LONG BEACH ATCRBS INTERROGATIONS.....	19
9	SUMMARY OF EFFECTS OF TCAS ON ATCRBS INTERROGATOR PERFORMANCE AT LONG BEACH.....	21
10	SUMMARY OF EFFECTS OF TCAS ON ATCRBS TRANSPONDERS RESPONDING TO LOS ANGELES ATCRBS-MODE-OF-DABS INTERROGATIONS.....	24
11	SUMMARY OF EFFECTS OF TCAS ON DABS SENSOR PERFORMANCE AT LOS ANGELES.....	26

LIST OF APPENDIXES

Appendix

A	AIRCRAFT DEPLOYMENTS.....	A-1
B	SIMULATION RESULTS.....	B-1
C	TCAS SUBMODEL RESULTS.....	C-1
D	MODEL DESCRIPTION.....	D-1

REFERENCES		R-1
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SECTION 1
INTRODUCTION

BACKGROUND

Several airborne Collision Avoidance Systems (CAS) that are compatible with the existing FAA Air Traffic Control Radar Beacon System (ATCRBS) and the future Discrete Address Beacon System (DABS) have been proposed. Both active and passive CAS systems are under development. Passive systems monitor replies elicited by ground-based interrogations. Active systems transmit interrogations from airborne interrogators to elicit replies from cooperating transponders.

The proposed omnidirectional active Beacon Collision Avoidance System (BCAS),^{1,2,3,4,5} henceforth referred to as the Traffic Alert and Collision Avoidance System (TCAS), analyzed in this study employs two signal formats, one that is compatible with the existing ATCRBS (Mode C) format and one that is compatible with the proposed DABS signal format (Mode S). TCAS is intended to provide the CAS function in a mixed environment of DABS and ATCRBS transponder-equipped aircraft; it is capable of interrogating both Mode C- and Mode S-equipped aircraft.

¹Preliminary Draft, Active BCAS Engineering Requirement, FAA, Washington, DC, 1 June 1976.

²Mann, Patricia, Simulation of Surveillance Processing Algorithms Proposed For The DABS Mode of BCAS, FAA-RD-77-138, FAA, Washington, DC, February 1978.

³"U.S. National Standard Active Beacon Collision Avoidance System (BCAS)," Federal Register, Vol 43, N0246, October 20, 1980.

⁴Beacon Collision Avoidance System (BCAS) Quarterly Technical Letter, BCAS QTL-4-11, Lincoln Laboratory, Lexington, MA, 24 July 1979.

⁵Beacon Collision Avoidance System (BCAS) Quarterly Technical Letter, BCAS QTL-4-12, Lincoln Laboratory, Lexington, MA, 22 October 1979.

During FY-77, the FAA requested that the Electromagnetic Compatibility Analysis Center (ECAC) investigate the impact of BCAS operation on ATCRBS performance in a hypothetical Washington, DC, area 1981 deployment (based on the 1975 deployment, increased by 3% per year).⁶ In that traffic deployment, it was predicted that deploying the BCAS would result in a slight reduction in transponder reply probability but not sufficient to result in an effect on the ATCRBS ground receiver/processor performance. A similar analysis was conducted by ECAC in FY-78 to investigate the impact of BCAS on ATCRBS and DABS performance in the Los Angeles Basin. This analysis was suspended to allow time for BCAS modifications to be incorporated into the ECAC model.⁷

Following these studies, the design for BCAS was modified to include interference-limiting features, and an Automatic Traffic Advisory and Resolution Service (ATARS) information data link. In addition, the Radar Beacon Transponder (RBX) units replaced the Desensitization Control Units (DCU) of the previous studies.

In view of these and other system changes, and to further investigate the impact of the TCAS on ATCRBS and DABS performance, ECAC was tasked to perform an analysis (similar to the FY-77 Washington, DC, and the FY-78 Los Angeles studies) in seven air traffic deployments for the Los Angeles Basin. These seven deployments as constructed are subsets of a hypothesized peak Los Angeles Basin deployments.⁸

⁶Theberge, Norman, The Impact of a Proposed Active BCAS on ATCRBS Performance in the Washington, DC, 1981 Environment, FAA-RD-77-140, FAA, Washington, DC, September 1977.

⁷Crawford, C. R., and Ehler, C. W., The DABS/ATCRBS/AIMS Performance Prediction Model, FAA-RD-79-088, Annapolis, MD, November 1979.

⁸Hildenberger, Mark, User's Manual for the Los Angeles Basin Standard Traffic Model Card Deck/Character Tape Version, FAA-RD-73-89, FAA, Washington, DC, May 1973.

OBJECTIVE

The objective of the analysis was to determine the impact of the TCAS on the performance of ATCRBS and DABS air traffic control systems in a hypothesized Los Angeles Basin air traffic deployment and in subsets of that deployment.

APPROACH

Using the time-event-store DABS/ATCRBS/AIMS Performance Prediction Model (Reference 7) supplemented with a statistical submodel of the TCAS, an analysis was conducted to determine the impact of TCAS operation on the performance of the ATCRBS and DABS ground systems.^a For each air traffic deployment of the Los Angeles Basin, the performance of ATCRBS and DABS was predicted both with and without TCAS operation (and with and without TCAS interference-limiting).

Two ground deployments were modeled, both of which were obtained from ATCRBS/IFF files at ECAC. The first, as specified by the FAA, consisted of all interrogators within a 500-nmi radius of Los Angeles. The second differed from the first in that four specified FAA ATCRBS interrogators were converted to DABS sensors.

Performance of all transponders within range of the interrogator-of-interest (I_0) was assessed in terms of the suppression rate, interrogation rate, and reply probability. The impact of TCAS on the ATCRBS ground system at Long Beach was evaluated in terms of variations in ATCRBS fruit rate, DABS fruit rate, and ARTS III^b target detection and code validation probabilities associated with TCAS activity. The impact of TCAS on the DABS ground system at Los Angeles was also evaluated in terms of variations in ATCRBS fruit rate,

^aThe model description relevant to this analysis is contained in APPENIDIX D.

^bARTS III - reply processor associated with ATCRBS FAA terminal sites, correlates replies to determine aircraft range, altitude, and identification.

DABS fruit rate, DABS roll-call transactions, and ATRBS target detection and code confidence probabilities associated with TCAS activity.

It should be emphasized that although system parameters such as interrogation rates, suppression rates, and reply probabilities are useful and meaningful transponder performance indicators, the parameters of primary significance are those defining the ability of the ground system to perform its fundamental air traffic control function of reliably detecting aircraft.

SECTION 2

MODEL INPUTS

INTERROGATOR-OF-INTEREST OPERATION

To determine the effect of TCAS on ATCRBS and DABS, the ground system performance with and without TCAS was simulated for both the Long Beach ATCRBS interrogator and the hypothetical Los Angeles (LAX-4) DABS sensor. The simulations with TCAS deployed were performed both with and without TCAS employing interference-limiting procedures. The characteristics and locations of the ATCRBS interrogator at Long Beach and the DABS sensor at Los Angeles, along with the transponder characteristics, as modeled, are given in TABLES 1 and 2, respectively.

The Long Beach ATCRBS interrogator was assumed to utilize an ARTS III processor; its performance was based on the ability of the processor to detect and to validate Mode A (identity) and Mode C (altitude) reply codes. Detection required receiving 5 clear replies from the 21 interrogations that each aircraft received during the mainbeam dwell period. Validation required receiving 2 consecutive clear replies to interrogations of the same mode. Fruit replies (false replies uncorrelated in time) that overlapped elicited replies were assumed to garble the desired replies to the extent that they could not be properly decoded regardless of the relative power levels.

The hypothesized LAX-4 DABS sensor has the processing capability to decode both ATCRBS and DABS replies. The performance of the ATCRBS mode of DABS is based on the ability of its processor to detect aircraft and to declare high- confidence Mode A and Mode C reply codes. Detection required two clear framing pulse pairs in response to interrogations of either mode. Declaration of high-confidence mode requires receipt of a single composite clear reply constructed from the set of replies to that particular mode. DABS surveillance and data-link performance is based on the ability to elicit decodable (Reference 8) roll-call replies from aircraft located within its surveillance and data-link volumes with a minimum number of interrogations. The surveillance and data-link interrogation rates are variables depending upon aircraft location and type. These rates are discussed on page 12.

TABLE 1
PARAMETER ASSIGNMENTS IN THE LONG BEACH SCENARIO

Long Beach ATCRBS Interrogator Characteristics

Latitude	33°49'09"N
Longitude	118°08'16"W
Power	0.08 kW (at antenna)
Scan Rate	13 rpm
Interrogation Rate	415/s
Mode Interlace	A, A, C
Receiver Sensitivity (MTL)	-86 dBm
Receiver Range	60 nmi
Interrogator Type	ATCBI-0003D
Cabling Loss	4 dB
STC (Sensitivity Time Control)	40 dB @ 1 nmi
Antenna Gain and Beamwidth	21 dBi for 4°
SLS Type	Improved sidelobe suppression (ISLS)

Transponder Characteristics

Power	0.5 kW (at transmitter)
Receiver Sensitivity (MTL) ^a	
ATCRBS Transponders	-74 dBm
DABS Transponders	-77 dBm
Cable Loss	3 dB
Antenna Gain (omnidirectional)	-2.5 dBi

^aAdded in proof. The current version of the National Standard (Reference 3) for Mode S (DABS) transponders established a -74 dBm nominal MTL.

TABLE 2
PARAMETER ASSIGNMENTS IN THE LAX SCENARIO

LAX DABS Sensor Characteristics

Latitude	33°57'12"N
Longitude	118°24'00"W
Power	0.1 kW (at antenna)
Scan Rate	13 rpm
PRF Interrogation Rate	128/s ^a
Mode Interlace	A, C
Receiver Sensitivity (MTL)	-88 dBm
Range of Receiver	200 nmi
Cabling Loss	4 dB
Antenna Gain and Beamwidth	21 dBi for 4°
SLS Type	Receiver SLS
STC (Sensitivity Time Control)	N/A

Transponder Characteristics

Power	0.5 kW (at transmitter)
Receiver Sensitivity (MTL) ^b	
ATCRBS Transponders	-74 dBm
DABS Transponders	-77 dBm
Cable Loss	3 dB
Antenna Gain (omnidirectional)	-2.5 dBi

^aThe reciprocal of the time interval between DABS all-call interrogations.

^bAdded in proof. The current version of the National Standard (Reference 3) for Mode S (DABS) transponders established a -74 dBm nominal MTL.

DEAD TIMES

Because TCAS transmits ATCRBS interrogations and suppressions and DABS interrogations, the total dead time of transponders within its range is increased, thereby reducing their reply efficiency. The dead times that were assumed for this analysis are shown in TABLE 3:^{9,10}

TABLE 3
TRANSPONDER DEAD TIMES

<u>Type Transmission</u>	<u>Transponder Type</u>	<u>Transponder Dead Time (μs)</u>
ATCRBS Interrogation	ATCRBS	60
ATCRBS-Only Interrogation ^a	ATCRBS	60
ATCRBS Suppression	ATCRBS	35
DABS Interrogation (All-Call and Roll-Call)	ATCRBS	35
ATCRBS Interrogation	DABS	60
ATCRBS-Only Interrogation ^b	DABS	35
ATCRBS Suppression ^b	DABS	35
DABS Interrogation (at transponder address)	DABS	192 (short reply) 248 (long reply)
DABS Interrogation ^b (not at transponder address)	DABS	35
DABS All-Call Interrogation	DABS	128
RBX Interrogation	DABS	128

^aATCRBS-only interrogations are transmitted by DABS sensors and TCAS interrogators.

^bThis desensitization effect was modeled as a suppression.

⁹Notice in the Federal Register, Vol. 43, No. 59, Monday, March 27, 1978, Part II, entitled, "Proposed U.S. National Aviation Standard for the Discrete Address Beacon System (DABS)."

¹⁰"U.S. National Standard for IFF Mark X (SIF)/Air Traffic Control Radar Beacon System Characteristics," Agency Order 1010.51, FAA, Washington, DC, March 1971.

EQUIPMENT DEPLOYMENTAircraft Deployments

Seven aircraft deployments were used in this analysis. All were constructed by selecting aircraft from a hypothesized peak Los Angeles Basin air traffic deployment (see Reference 8) supplied to ECAC by the FAA. This deployment consisted of 743 aircraft within 60 nmi of LAX (689 general aviation, 30 air carrier and 24 military aircraft).

Four of the air traffic deployments were constructed by decreasing the aircraft population while maintaining a nominal mix of 25% DABS (11% TCAS),^a and 75% ATCRBS transponder-equipped aircraft. The full-scale deployment (deployment A) included the maximum air traffic density (0.159 A/C per square nmi within 30 nmi of LAX) with the 30 air-carrier, the 53 high-performance general-aviation and 105 of the remaining general-aviation aircraft modeled as equipped with DABS transponders. The air-carrier and the high-performance general-aviation aircraft were also modeled to be equipped with TCAS interrogators. The remainder of the air traffic population was modeled as equipped with ATCRBS transponders. Three reduced deployments (deployments B, C, and D) were constructed by randomly deleting aircraft from the full-scale environment to produce aircraft densities of approximately 0.08, 0.04, and 0.02 A/C per square nmi.

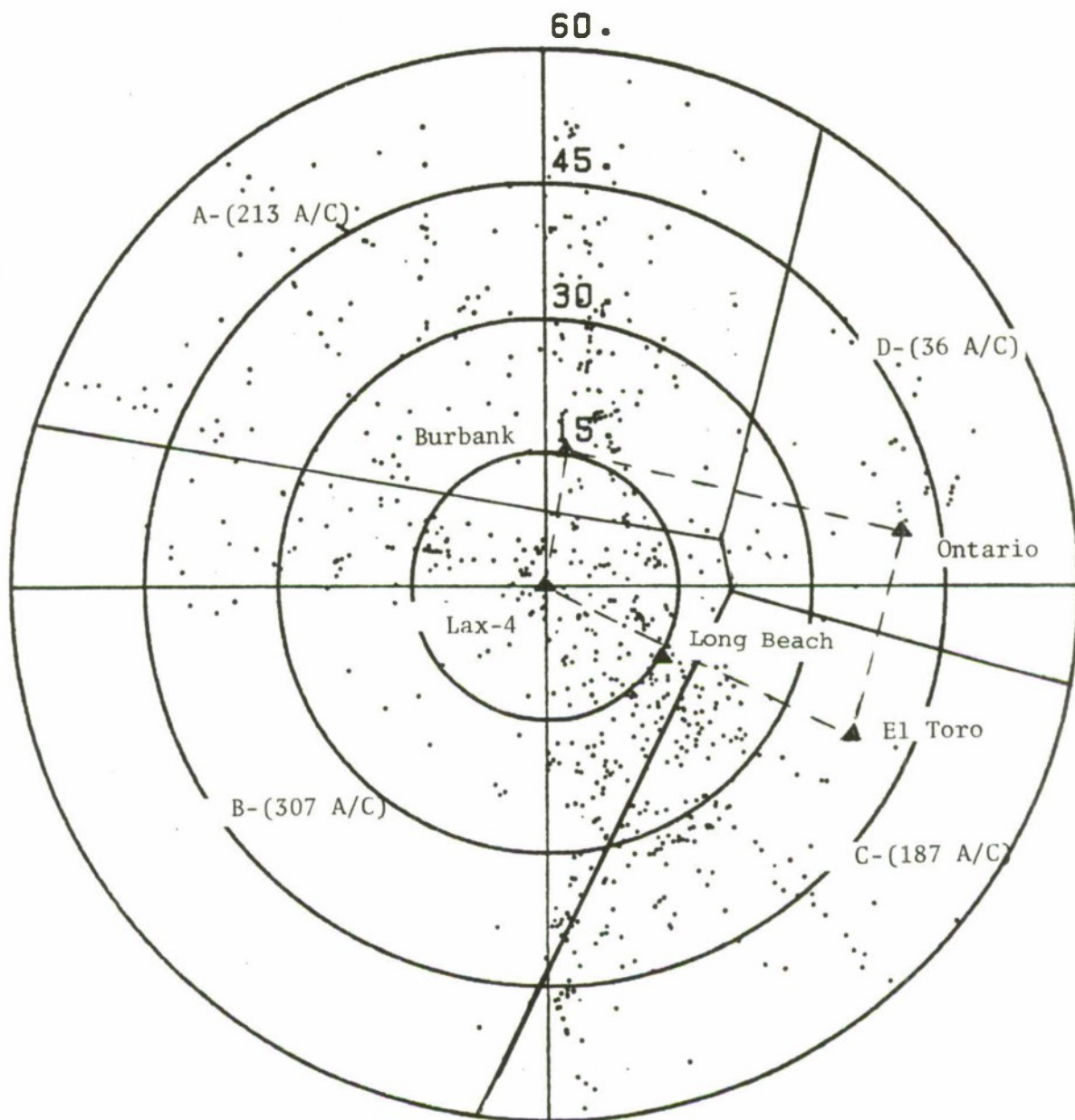
Three additional deployments (E, F, and G) were developed from deployments A and B by varying the percentage of transponders that are ATCRBS-, DABS-, and TCAS-equipped. Deployment E is similar to deployment A; however, all DABS transponders are TCAS-equipped; deployment F was constructed from deployment B in the same manner. Deployment G consisted of 0.08 aircraft per square nmi with 46% of the transponder population ATCRBS-equipped and 54% DABS-equipped (44% of DABS-equipped are TCAS equipped). These deployments are

^aThis notation will be used throughout the report. 25% DABS (11% TCAS) means that 25% of the aircraft are DABS-equipped and 11% of the aircraft are TCAS-equipped. All TCAS-equipped aircraft are also DABS-equipped.

summarized in TABLE 4. Range and altitude distributions are given in TABLES A-1 through A-8 of APPENDIX A. Figure 1 shows the full-scale deployment as seen by the Los Angeles interrogator and displays the DABS sensor surveillance zones, which are discussed later. Figures A-1 through A-7 show each of these aircraft deployments along with the corresponding DABS-equipped and TCAS-equipped aircraft locations.

TABLE 4
AIRCRAFT DEPLOYMENTS USED IN THE ANALYSIS
Deployment

	A	B	C	D	E	F	G
Total Number of Aircraft (within 60 nmi of LAX)	743	386	201	92	743	386	386
Approximate Density (within 30 nmi of LAX)	0.159	0.08	0.04	0.02	0.159	0.08	0.08
Number DABS-Equipped (TCAS-Equipped)	188 (83)	87 (40)	48 (23)	20 (12)	188 (188)	87 (87)	203 (87)
Number ATCRBS-Equipped	555	299	153	72	555	299	183
Maximum Aircraft Density Within 10 nmi of Any TCAS-Equipped Aircraft	0.398	0.201	0.099	0.038	0.436	0.220	0.220



A,B,C, and D are the primary surveillance zones of the DABS sensors at Burbank, Los Angeles, El Toro, and Ontario, respectively.

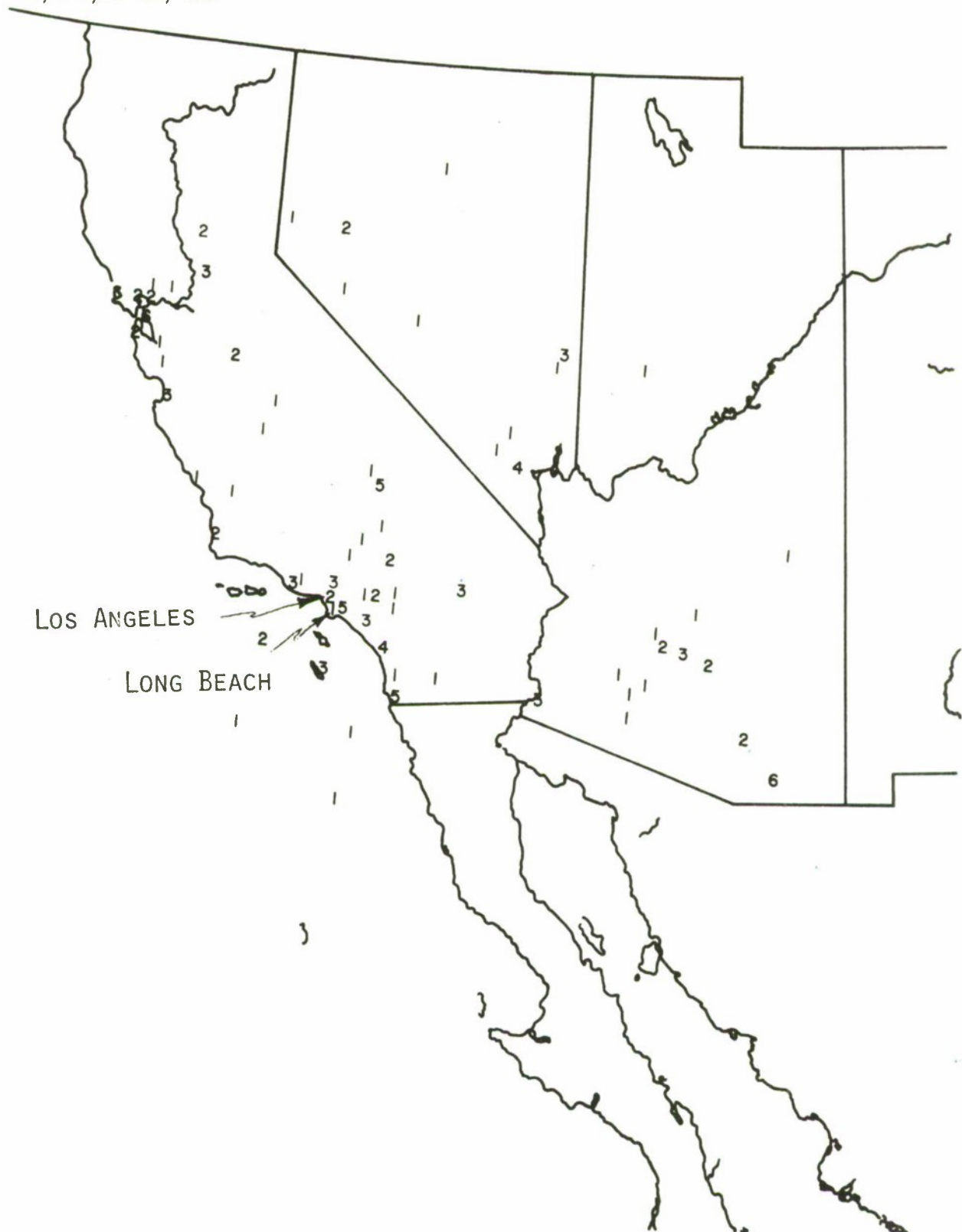
Figure 1. Transponder deployment (Origin is LAX-4, 33°57'12"N, 118°24'00"W).

Ground Interrogator Deployments

Two ground deployments, as specified by the FAA, were modeled by selecting interrogators from ECAC's ATCRBS/IFF files. The first deployment consisted of the 141 ATCRBS interrogators within 500 nmi of LAX. This deployment is illustrated in Figure 2, and was used to predict the impact of TCAS operations on the Long Beach ATCRBS ground sensor. The second deployment differed from the first in that four FAA terminal interrogators were converted to DABS sensors. This deployment was used to predict the impact of TCAS on DABS at LAX. The four converted interrogators were Los Angeles (LAX-4), Burbank, El Toro, and Ontario. Their surveillance and data-link coverage zones are given in TABLE 5 and illustrated in Figure 1. DABS channel activity is discussed below.

The DABS signal environment consisted of a combination of surveillance, and CDTI (Cockpit Display of Traffic Information) services.^{9,11} The service level provided to each aircraft from each DABS sensor was dependent upon aircraft type. Air-carrier and high-performance general-aviation aircraft (11% of the aircraft population) received from their primary sensor high-option CDTI or Extended Length Message (ELM) service that consisted of a series of Comm-C data segments addressed to a particular aircraft, containing information about other aircraft (targets) in the immediate vicinity (within the threat volume) of the addressed aircraft. The threat volume was arbitrarily chosen to extend for 3 nmi radially and within an altitude of ± 2500 ft. This entailed transmitting $((T/2)+2.5)$ ru Comm-C segments per scan, where T was the number of targets within the threat volume (ru denotes "rounding upward" to the next larger integer). All but two of the Comm-C

¹¹Keech, T., and Fleming, G., Impact of the Discrete Address Beacon System (DABS) on Air Traffic Control Radar Beacon System (ATCRBS) Performance in Selected Deployments, FAA/RD-80-93, Annapolis, MD, November 1979.



13

segments were contained within a precursor, and did not elicit replies.^a The remaining two Comm-C segments which serve to finalize the ELM transaction each elicited an ELM Comm-D reply.

Fourteen percent of the aircraft population (DABS-equipped) received mid-option CDTI or standard data link services that consisted of $((T/2) r_u + P)$ Comm-A interrogations per scan, where P is a random variable of Poisson distribution with a mean of 1.0. Each Comm-A transmission contained data for two targets. All but one of the Comm-A interrogations elicited surveillance (altitude or identity) replies. The remaining Comm-A interrogation elicited a mid-option CDTI finalizing Comm-B reply. If both T and P for a particular aircraft were computed to be zero, the A/C received one surveillance interrogation per scan from its primary sensor.

In addition, each DABS-equipped aircraft received one DABS surveillance interrogation per scan from its secondary sensor.

TABLE 5
DABS SENSOR SURVEILLANCE AND DATA LINK ZONE ASSIGNMENTS
(see Figure 1)

Site	Surveillance Primary	Responsibility Secondary	Data Link Responsibility
Burbank	A	B	A
Los Angeles	B	C	B
El Toro	C	D	C
Ontario	D	A	D

^aComm-C segments that do not elicit replies are transmitted at the beginning of the DABS interrogation schedule and thus are referred to as the precursor. (See Reference 7.)

TCAS/ATC COMPATIBILITY DESIGNGround-Based Radar Beacon Transponders (RBX)

In addition to the airborne transponder deployment described above, 20 FAA terminal sites were assumed to have RBX units located on the ground approximately 1 nmi from the ATC interrogator. The locations are given in APPENDIX A, Figure A-9. The characteristics of the RBX units as modeled are listed in TABLE 6. RBX-TCAS surveillance loading is discussed in Appendix D.

TABLE 6
RBX CHARACTERISTICS

Power	4.0 kW (at transmitter)
Receiver Sensitivity (MTL)	-87.0 dBm
Cabling Loss	3.0 dB
Peak Antenna Gain ^a	6.0 dBi

^aThe RBX antenna is omnidirectional in azimuth. (Added in proof. The TCAS concept does not use the RBX and considerations of deploying such a unit have been discontinued.)

Interference-Limiting

Each TCAS unit incorporates an interference-limiting function to ensure that TCAS-generated interrogations will not cause excessive interference to other systems, particularly the Air Traffic Control ground systems. Interference-limiting is achieved in this analysis by reducing a TCAS unit's output power and receiver threshold (MTL) in 6 dB steps, and by eliminating the high-power ATCRBS interrogation from the "Whisper-Shout" sequence^a to maintain the inequality:

$$\frac{(B+1)}{250} 10^{(MTL+74)} (DP_d + S \sum_{i=1}^n P_i) \leq 570 \quad \text{interrogations/second} \quad (1)$$

^aSee Reference 5 and APPENDIX D

where

- B = number of TCAS equipped aircraft detected by squitter
 D = DABS interrogation rate (per second)
 S = ATCRBS interrogation Whisper-Shout cycles per second = $1/(\text{second})$
 P_d = DABS power (watts at antenna)
 P_i = ATCRBS power (watts at antenna)
 n = number of Whisper-Shout levels
 MTL = receiver threshold (dBm at antenna). Note that this MTL adjustment is restricted to the 1090-MHz TCAS receiver channel. MTL at the 1030-MHz Mode S transponder is a constant (-77 dBm).

If the inequality cannot be satisfied after power is reduced by 12 dB, the TCAS will cease to transmit interrogations. The interference-limiting modeling procedures are discussed in APPENDIX D. APPENDIX C lists the interference-limiting state (permissible transmission power) of each TCAS interrogator for each of the aircraft deployments. In addition, APPENDIX C contains figures illustrating the locations of the TCAS units that were required to limit CAS activity for each of the simulations. TABLE 7 gives TCAS interrogator characteristics.

TABLE 7
TCAS INTERROGATOR CHARACTERISTICS

Power	P_t^a (at transmitter)
Receiver Sensitivity (MTL) (1090-MHz channel)	R_s^b
Cable Loss	3 dB
Peak Antenna Gain (omnidirectional in azimuth)	2.5 dBi

$a_{P_t} = (0.5/4^N)$ kW, where N is the number of 6 dB power reductions required to satisfy the interference-limiting inequality.

$b_{R_s} = (-77 + (N \times 6.0))$ dBm, where N is the number of 6 dB sensitivity reductions required to satisfy the interference-limiting inequality.

SECTION 3

DISCUSSION OF RESULTS

GENERAL

Performance of all transponders within range of the interrogator-of-interest (I_0) was assessed in terms of the suppression rate, interrogation rate, and reply probability. The performance of the ATCRBS ground system was evaluated in terms of ATCRBS fruit rate, DABS fruit rate, and ARTS III target detection and code validation probabilities. The performance of the DABS ground system was evaluated in terms of ATCRBS fruit rate, DABS fruit rate, DABS roll-call transactions, and ATCRBS target detection and code confidence.

It should be emphasized that although system parameters such as interrogation rates, suppression rates, and reply probabilities are useful and meaningful transponder performance indicators, the parameters of primary significance are those defining the ability of the ground system to perform its fundamental air traffic control function of reliably detecting aircraft.

LONG BEACH ATCRBS

Performance measures of the Long Beach ATCRBS ground receiver, with and without TCAS, and with and without interference limiting, are shown in TABLES B-1 through B-14, of APPENDIX B.^a Results for the four levels of aircraft densities (0.159, 0.08, 0.04, and 0.02 A/C per square nmi) with a 25% DABS (11% TCAS) and 75% ATCRBS transponder distribution are given. Other variations of transponder distributions and aircraft densities were also analyzed. These were: a 25% DABS (25% TCAS) transponder distribution in aircraft densities of 0.159, and 0.08 A/C per square nmi, and a 54% DABS (25% TCAS) distribution in a 0.08 density. The location, interrogation rate, and transmission power of each TCAS unit for each simulation are listed in

^aThe results in APPENDIX B are given in terms of quadrant averages about the Long Beach interrogator.

APPENDIX C. The results discussed below are based on a 1-scan (4.6-second) simulation of the victim antenna for each aircraft deployment.

Transponder Performance

The average probability of reply was computed by dividing the total number of transponder replies to Long Beach interrogations during a complete 360° scan of the mainbeam by the total number of Long Beach interrogations in the same scan. Each aircraft received approximately 21 ATCRBS interrogations.

TABLE 8 gives the performance of transponders within 60 nmi of the Long Beach interrogator, both with and without TCAS (and with and without interference-limiting). It can be seen that TCAS activity without interference-limiting reduced the average transponder probability of reply by more than 2% for the full-scale deployment (0.159 aircraft per square nmi) for both the distribution of 25% DABS (11% TCAS) and the 25% DABS (25% TCAS) distribution. This reduction is caused by both the increased ATCRBS interrogation rate and the increase in effective sidelobe suppression rate associated with TCAS activity.^a With TCAS employing interference-limiting, the degradation in average probability of reply was 1% for both the 25% DABS (11% TCAS) and the 25% DABS (25% TCAS) distributions.

For the three reduced air traffic densities, the reduction in average reply probability was greater than 2% only in the aircraft density of 0.08 A/C per square nmi with 54% DABS (25% TCAS). Again, interference-limiting reduced this effect to 1%.

Also included in TABLE 8 are the standard deviations of the ATCRBS interrogation rate, the effective suppression rate, and the probability of reply for each simulation. The magnitudes of these quantities indicate a wide variation about their mean values.

^aThe effective sidelobe suppression rate is the sum of the actual sidelobe suppression rate and the misaddressed roll-call interrogation rate.

TABLE 8
SUMMARY OF EFFECTS OF TCAS ON ALL TRANSPONDERS
RESPONDING TO LONG BEACH ATCRBS INTERROGATIONS

DEPLOYMENT A E B F G C D

A/C DENSITY TOTAL # of A/C % DABS (% TCAS) % ATCRBS	TCAS OFF		TCAS ON Interference Limiting		TCAS OFF		TCAS ON Interference Limiting		TCAS OFF		TCAS ON Interference Limiting		TCAS OFF		TCAS ON Interference Limiting		TCAS OFF		TCAS ON Interference Limiting	
	On		On		On		On		On		On		On		On		On		On	
	Off	On	Off	On	Off	On	Off	On	Off	On	Off	On	Off	On	Off	On	Off	On	Off	On
Average ATCRBS Interrogation Rate (Standard Deviation)	234 (252)	268 (252)	302 (254)	287 (254)	234 (252)	260 (238)	230 (239)	260 (238)	230 (239)	281 (243)	303 (246)	253 (275)	342 (279)	244 (225)	244 (247)	240 (245)	260 (223)	260 (223)	240 (245)	260 (223)
Average Effective Suppression Rate (Standard Deviation)	565 (490)	726 (508)	1599 (786)	745 (496)	565 (490)	723 (521)	564 (482)	723 (521)	564 (482)	707 (507)	982 (583)	661 (496)	2006 (785)	528 (472)	543 (477)	543 (477)	548 (472)	548 (472)	543 (477)	548 (472)
Average Probability of Reply (Standard Deviation)	.969 (.038)	.960 (.043)	.931 (.059)	.959 (.043)	.969 (.038)	.962 (.042)	.969 (.037)	.962 (.042)	.969 (.037)	.961 (.042)	.953 (.045)	.963 (.043)	.918 (.063)	.963 (.044)	.969 (.038)	.970 (.038)	.962 (.044)	.962 (.044)	.970 (.038)	.962 (.044)

It can be seen that, even without TCAS activity, increasing the percentage of aircraft that are DABS-equipped resulted in an increased average interrogation rate and an increased average effective suppression rate (compare 0.08 density 25% DABS (11% TCAS) and 25% DABS (25% TCAS) simulations with 0.08 density 54% DABS (25% TCAS) simulations). This is explained by noting that the sensitivity (MTL) of a DABS-equipped aircraft is -77 dBm while an ATCRBS-equipped aircraft's sensitivity is -74 dBm.

Interrogator Performance

The effects of TCAS on the ATCRBS interrogator performance are summarized in TABLE 9 and discussed below.

Fruit Rates. The two types of fruit arriving at the Long Beach interrogator receiver are defined as follows:

- ATCRBS fruit. ATCRBS replies elicited by ATCRBS and TCAS interrogators other than the Long Beach interrogator.
- Roll-Call fruit. DABS replies elicited by TCAS roll-call interrogations.

ATCRBS transponder replies to the active ATCRBS mode of TCAS result in increased levels of ATCRBS fruit at the ground receiver. For TCAS operating without interference-limiting, these levels varied from a 3.7% increase in ATCRBS fruit for the 0.02 aircraft density, to 57% for the 0.159 aircraft density with 25% DABS (25% TCAS).^a With interference-limiting, the 57% increase was reduced to a 16% increase.

DABS transponder replies associated with TCAS operation result in DABS roll-call fruit at the ground receiver. The ATCRBS interrogator receivers are assumed to be blanked out to ATCRBS replies for the duration of a DABS reply (64 μ s). The full-scale deployment simulation with 25% DABS (25% TCAS)

^aThe increased fruit rates are due to the increased ATCRBS interrogation rates associated with TCAS activity.

TABLE 9
SUMMARY OF EFFECTS OF TCAS ON ATCRBS INTERROGATOR
PERFORMANCE AT LONG BEACH

DEPLOYMENT	A			E			B			F			G			C			D		
A/C Density	.159			.159			.08			.08			.08			.04			.02		
TOTAL # of A/C	716			716			376			376			376			196			90		
% DABS (% TCAS)	25 (11)			25 (25)			25 (11)			25 (25)			54 (25)			25 (11)			25 (11)		
% ATCRBS	75			75			75			75			46			75			75		
	TCAS			TCAS ON			TCAS			TCAS			TCAS			TCAS			TCAS ON		
	Interference Limiting			Interference Limiting			Interference Limiting			Interference Limiting			Interference Limiting			Interference Limiting			Interference Limiting		
	On Off			On Off			On Off			On Off			On Off			On Off			On Off		
ATCRBS Fruit	7462			8664			4093			3677			4581			1842			478		
Per Second	8284			9304			7462			7462			4093			4093			461		
DABS Roll Call Fruit	-			-			-			-			-			-			-		
Per Second	37			85			18			13			22			3			1		
Reduction in Target	-			0			0			0			0			0			0		
Detection Probability(%)	-			0			0			0			0			0			0		
Reduction in Mode A	-			0.2			0.4			0.3			0.3			0.3			0		
Validation Probability(%)	-			0.5			1.5			0.3			0.3			0.3			0		
Reduction in Mode C	-			-			-			-			-			-			-		
Validation Probability(%)	-			0			0.2			0.3			1.9			0.3			0		

resulted in 176 roll-call fruit/s or (1.1% receiver blanking) without limiting, and 48 roll-call fruit/s (0.3% receiver blanking) with limiting. Other variations of DABS roll-call fruit, including those for the reduced deployments, are given in TABLE 9.

Target Detection and Code Validation. Deploying TCAS (with or without interference-limiting) did not degrade the ability of the ARTS III processor to detect aircraft. For the full-scale deployment of 0.159 aircraft per square nmi and the distribution of 25% DABS (25% TCAS), a 1.5% reduction of Mode A and a 1.9% reduction in Mode C validation is predicted without interference-limiting. Interference-limiting will reduce the effect to 0.5% and 0.3% for Mode A and Mode C, respectively. For the reduced air traffic environments (0.08, 0.04, and 0.02 aircraft per square nmi), TCAS operation resulted in less than a 1% reduction to mode-validation probabilities.

LOS ANGELES DABS

DABS performance at LAX-4, with and without TCAS, and with and without TCAS employing its interference-limiting is given (in terms of quadrant averages about LAX-4) in TABLES B-15 through B-28 in APPENDIX B. The location, interrogation rate, and transmission power of each TCAS unit for each simulation are listed in APPENDIX C. These results (discussed below) are based on a 1-scan (4.6-second) simulation of the victim antenna for each aircraft deployment.

Transponder Performance

The average transponder probability of reply was computed by dividing the total number of DABS and ATCRBS replies during a complete 360° scan of the mainbeam by the total number of LAX-4 interrogations. Each ATCRBS-equipped aircraft received approximately six ATCRBS-Only interrogations per scan. DABS-equipped transponders received a variable number of discrete interrogations from the LAX-4 DABS sensor (see Section 2).

TABLE 10 gives the performance of ATCRBS-equipped transponders within 60 nmi of the Los Angeles sensor, both with and without TCAS (and with and without TCAS employing interference-limiting). It can be seen that with TCAS (without interference-limiting), the reduction in average transponder probability of reply exceeded 2% for the full-scale air traffic environment for both the distribution of 25% DABS (11% TCAS) and the 25% DABS (25% TCAS) distribution. Again, this is caused by the increased ATCRBS interrogation rate and the increased effective suppression rate (sidelobe suppressions rate plus misaddressed roll-call interrogation rate) associated with TCAS transmissions. With TCAS employing its interference-limiting function, the degradation in average reply probability was reduced to less than 1% for both distributions.

For the reduced air traffic deployments, the reduction in average reply probability due to TCAS operation (without interference-limiting) was greater than 2% only for the 54% DABS (25% TCAS) distribution in the 0.08 A/C per square nmi deployment. With TCAS employing interference limiting, the degradation in average reply probability was reduced to about 1%.

Sensor Performance

The effects of TCAS on the DABS sensor performance are summarized in TABLE 11 and discussed below.

Fruit Rates. With TCAS deployed, the increase in ATCRBS fruit varied from less than 4% in the least-dense aircraft environment (0.02 aircraft per square nmi) to about 55% in the full-scale deployment for the 25% DABS (25% TCAS) distribution. With interference-limiting, the 55% increase was reduced to a 23% increase. The roll-call fruit rate ranged from 43/s with the full-scale air traffic deployment for the distribution of 25% DABS (25% TCAS) to zero with the least-dense (0.02 aircraft per square nmi) air traffic configuration.

TABLE 10
SUMMARY OF EFFECTS OF TCAS ON ATCRBS TRANSPONDERS
RESPONDING TO LOS ANGELES ATCRBS-MODE-OF-DABS INTERROGATIONS

DEPLOYMENT	A		B		E		F		G		C		D	
	TCAS		TCAS		TCAS		TCAS		TCAS		TCAS		TCAS	
	Interference Limiting	Off	Interference Limiting	Off	Interference Limiting	Off	Interference Limiting	Off	Interference Limiting	Off	Interference Limiting	Off	Interference Limiting	Off
A/C DENSITY	.159		.08		.159		.08		.08		.04		.02	
TOTAL # of A/C	743		386		743		386		386		201		92	
% DABS (% TCAS)	25 (11)		25 (11)		25 (25)		25 (25)		25 (25)		25 (11)		25 (11)	
% ATCRBS	75		75		75		75		46		75		75	
Average ATCRBS	236		219		292		251		287		220		229	
Interrogation Per Second	(240)		(214)		(250)		(220)		(232)		(210)		(208)	
(Standard Deviation)														
Average Effective	398		375		578		533		742		366		341	
Suppression Per Second	(349)		(332)		(407)		(407)		(450)		(326)		(315)	
(Standard Deviation)														
Average Probability	.965		.975		.960		.966		.954		.972		.964	
of Reply	(.070)		(.066)		(.076)		(.078)		(.103)		(.062)		(.065)	
(Standard Deviation)														

ATCRBS Mode of DABS Target Detection and Code Confidence. All ATCRBS transponder-equipped aircraft were detected and processed with high Mode A code confidence for all simulations with and without TCAS. For the full-scale deployment, without interference-limiting, less than a 1% reduction in Mode C validation is predicted. With interference-limiting, this effect is eliminated. For the reduced air traffic environments (0.08, 0.04, and 0.02 aircraft per square nmi), TCAS operation did not affect code confidence.

DABS Surveillance and Data-Link Performance. All DABS transponder-equipped aircraft were detected for all simulations, with and without TCAS. The DABS sensor at Los Angeles made 323 roll-call type interrogations to DABS-equipped aircraft in its coverage zones during a single scan, without TCAS operating in the 0.08 air traffic density with the 54% DABS (25% TCAS) distribution. With TCAS in the environment, operating with and without interference-limiting, the DABS sensor transmitted 2 and 17 additional interrogations, respectively, during those simulations. The DABS roll-call interrogation rates for each simulation are listed in TABLE 11.

TABLE 11
SUMMARY OF EFFECTS OF TCAS ON DABS
SENSOR PERFORMANCE AT LOS ANGELES

DEPLOYMENT	A			E			B			F			G			C			D		
	.159			.159			.08			.08			.08			.04			.02		
	TCAS OFF	TCAS ON Interference Limiting	TCAS ON Off	TCAS OFF	TCAS ON Interference Limiting	TCAS ON Off	TCAS OFF	TCAS ON Interference Limiting	TCAS ON Off	TCAS OFF	TCAS ON Interference Limiting	TCAS ON Off	TCAS OFF	TCAS ON Interference Limiting	TCAS ON Off	TCAS OFF	TCAS ON Interference Limiting	TCAS ON Off	TCAS OFF	TCAS ON Interference Limiting	TCAS ON Off
ATCRBS Fruit	1875	2024	2381	1875	2311	2909	916	1042	1042	916	1123	1204	973	1127	1237	479	513	513	226	234	234
Per Second																					
DABS All-Call	5	5	5	5	5	5	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1
Fruit Per Second																					
DABS Roll-Call	3	11	22	3	15	43	2	4	4	2	6	8	3	11	22	2	2	2	0	0	0
Fruit Per Second																					
Reduction in Target Detection Probability	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reduction in High-Confidence Mode A Decision (%)	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0
Reduction in High-Confidence Mode C Decision (%)	-	0	0	-	0	0.9	-	0	0	-	0	0	-	0	0	-	0	0	-	0	0
Roll-Call Interrogations Per Scan from DABS Sensor	505	506	519	505	509	525	205	206	206	205	208	212	323	325	340	80	81	81	21	21	21

SECTION 4
CONCLUSIONS

ATCRBS PERFORMANCE AT LONG BEACH

Deploying TCAS, with or without interference-limiting, in any of the various air traffic deployments:

1. Will not reduce target detection probabilities.
2. Will reduce the Mode A validation probability by less than 2%.
3. Will reduce the Mode C validation probability by less than 2%.

Deploying TCAS, with interference-limiting, in any of the various air traffic deployments will reduce average transponder reply probability by less than 2%.

DABS PERFORMANCE AT LOS ANGELES

Deploying TCAS, with or without interference-limiting, in any of the various air traffic deployments:

1. Will not reduce the target detection probability.
2. Will not reduce the high-confidence Mode A validation probability.
3. Will not reduce the high-confidence Mode C validation probability by less than 1%.
4. Will increase the roll-call interrogation rate by less than 6%.

Deploying TCAS, with interference-limiting, in any of the various air traffic deployments, will not reduce the high confidence Mode C validation probability and will reduce the average transponder reply probability by less than 2%.

For the peak air traffic deployment simulation (743 aircraft within 60 nmi of Los Angeles) with approximately 25% of the aircraft equipped with TCAS, it was shown that 133 of the 188 TCAS units were required to limit CAS transmissions; 2 of these units were required to terminate CAS activity.

APPENDIX A

AIRCRAFT DEPLOYMENTS

TABLES A-1 through A-8 give the aircraft range and altitude distributions about the Long Beach ATCRBS interrogator and about the Los Angeles DABS sensor for the four aircraft populations used in this study. Figures A-1 through A-8 show the aircraft distribution as viewed from LAX-4 for each of the air traffic environments. Figure A-9 shows the deployment of the ground-based RBX units.

TABLE A-1

AIRCRAFT DISTRIBUTION ABOUT LOS ANGELES

(Density = 0.159 A/C per sq. nmi; See Figure A-1)

Altitude		Range	
Altitude (1000-foot Increments)	Number of Aircraft in Increment	Range Increment (nmi)	Number of Aircraft in Increment
0-1	72	0-5	35
1-2	138	5-10	45
2-3	128	10-15	93
3-4	110	15-20	89
4-5	89	20-25	104
5-6	51	25-30	86
6-7	41	30-35	81
7-8	31	35-40	57
8-9	39	40-45	66
9-10	15	45-50	47
10-11	8	50-55	24
11-12	1	55-60	14
12-13	1	60-65	2
13-14	1		
14-15	0		
15-16	0		
16-17	2		
17-18	1		
18-19	1		
19-20	1		
20-21	1		
21-22	2		
22-23	0		
23-24	4		
24-25	4		
25-26	0		
26-27	1		
27-28	0		
28-29	1		
29-30	0		

TABLE A-2

AIRCRAFT DISTRIBUTION ABOUT LOS ANGELES
(Density = 0.08 A/C per sq. nmi; See Figure A-3)

Altitude		Range	
Altitude (1000-foot Increments)	Number of Aircraft in Increment	Range Increment (nmi)	Number of Aircraft in Increment
0-1	34	0-5	20
1-2	77	5-10	22
2-3	75	10-15	47
3-4	58	15-20	48
4-5	48	20-25	49
5-6	17	25-30	48
6-7	21	30-35	42
7-8	17	35-40	29
8-9	19	40-45	38
9-10	5	45-50	23
10-11	5	50-55	15
11-12	1	55-60	4
12-13	1	60-65	1
13-14	0		
14-15	0		
15-16	0		
16-17	1		
17-18	0		
18-19	1		
19-20	0		
20-21	1		
21-22	1		
22-23	0		
23-24	1		
24-25	2		
25-26	0		
26-27	0		
27-28	0		
28-29	1		
29-30	0		

TABLE A-3

AIRCRAFT DISTRIBUTION ABOUT LOS ANGELES
 (Density = 0.04 A/C per sq. nmi; See Figure A-6)

Altitude		Range	
Altitude (1000-foot Increments)	Number of Aircraft in Increment	Range Increment (nmi)	Number of Aircraft in Increment
0-1	19	0-5	10
1-2	42	5-10	14
2-3	40	10-15	20
3-4	33	15-20	19
4-5	20	20-25	22
5-6	6	25-30	30
6-7	11	30-35	22
7-8	5	35-40	18
8-9	11	40-45	22
9-10	4	45-50	14
10-11	4	50-55	6
11-12	0	55-60	3
12-13	0	60-65	1
13-14	0		
14-15	0		
15-16	0		
16-17	0		
17-18	0		
18-19	1		
19-20	0		
20-21	0		
21-22	1		
22-23	0		
23-24	0		
24-25	2		
25-26	0		
26-27	0		
27-28	0		
28-29	1		
29-30	0		

TABLE A-4

AIRCRAFT DISTRIBUTION ABOUT LOS ANGELES
 (Density = 0.02 A/C per sq. nmi; See Figure A-7)

Altitude Altitude (1000-foot Increments)	Number of Aircraft in Increment	Range Range Increment (nmi)	Number of Aircraft in Increment
0-1	10	0-5	2
1-2	13	5-10	7
2-3	22	10-15	12
3-4	15	15-20	7
4-5	10	20-25	6
5-6	2	25-30	19
6-7	7	30-35	15
7-8	2	35-40	6
8-9	5	40-45	8
9-10	1	45-50	7
10-11	3	50-55	0
11-12	0	55-60	2
12-13	0	60-65	1
13-14	0		
14-15	0		
15-16	0		
16-17	0		
17-18	0		
18-19	1		
19-20	0		
20-21	0		
21-22	1		
22-23	0		
23-24	0		
24-25	2		
25-26	0		
26-27	0		
27-28	0		
28-29	1		
29-30	0		

TABLE A-5

AIRCRAFT DISTRIBUTION ABOUT LONG BEACH
(Density = 0.159 A/C per sq. nmi; See Figure A-1)

Altitude		Range	
Altitude (1000-foot Increments)	Number of Aircraft in Increment	Range Increment (nmi)	Number of Aircraft in Increment
0-1	72	0-5	32
1-2	138	5-10	87
2-3	128	10-15	83
3-4	110	15-20	109
4-5	89	20-25	62
5-6	51	25-30	69
6-7	41	30-35	67
7-8	31	35-40	72
8-9	39	40-45	46
9-10	15	45-50	32
10-11	8	50-55	28
11-12	1	55-60	29
12-13	1	60-65	14
13-14	1	65-70	9
14-15	0	70-75	4
15-16	0		
16-17	2		
17-18	1		
18-19	1		
19-20	1		
20-21	1		
21-22	2		
22-23	0		
23-24	4		
24-25	4		
25-26	0		
26-27	1		
27-28	0		
28-29	1		
29-30	0		

TABLE A-6

AIRCRAFT DISTRIBUTION ABOUT LONG BEACH
(Density = 0.08 A/C per sq. nmi; See Figure A-3)

Altitude		Range	
Altitude (1000-foot Increments)	Number of Aircraft in Increment	Range Increment (nmi)	Number of Aircraft in Increment
0-1	34	0-5	13
1-2	77	5-10	42
2-3	75	10-15	45
3-4	58	15-20	61
4-5	48	20-25	27
5-6	17	25-30	43
6-7	21	30-35	33
7-8	17	35-40	39
8-9	19	40-45	23
9-10	5	45-50	17
10-11	5	50-55	15
11-12	1	55-60	18
12-13	1	60-65	4
13-14	0	65-70	5
14-15	0	70-75	1
15-16	0		
16-17	1		
17-18	0		
18-19	1		
19-20	0		
20-21	1		
21-22	1		
22-23	0		
23-24	1		
24-25	2		
25-26	0		
26-27	0		
27-28	0		
28-29	1		
29-30	0		

TABLE A-7

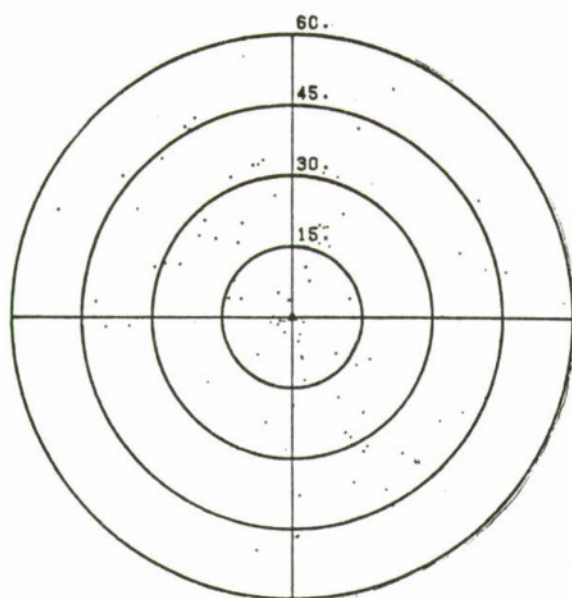
AIRCRAFT DISTRIBUTION ABOUT LONG BEACH
(Density = 0.04 A/C per sq. nmi; See Figure A-6)

Altitude		Range	
Altitude (1000-foot Increments)	Number of Aircraft in Increment	Range Increment (nmi)	Number of Aircraft in Increment
0-1	19	0-5	6
1-2	42	5-10	24
2-3	40	10-15	21
3-4	33	15-20	33
4-5	20	20-25	16
5-6	6	25-30	19
6-7	11	30-35	15
7-8	5	35-40	22
8-9	11	40-45	11
9-10	4	45-50	11
10-11	4	50-55	8
11-12	0	55-60	12
12-13	0	60-65	2
13-14	0	65-70	2
14-15	0	70-75	1
15-16	0		
16-17	0		
17-18	0		
18-19	1		
19-20	0		
20-21	1		
21-22	1		
22-23	0		
23-24	0		
24-25	2		
25-26	0		
26-27	0		
27-28	0		
28-29	1		
29-30	0		

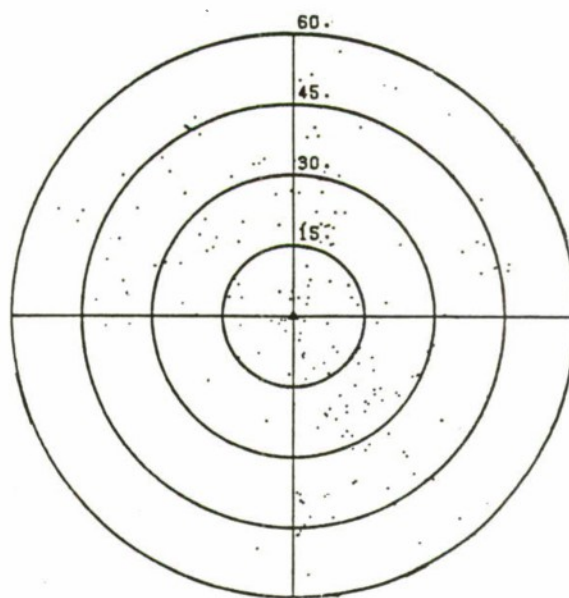
TABLE A-8

AIRCRAFT DISTRIBUTION ABOUT LONG BEACH
(Density = 0.02 A/C per sq. nmi; See Figure A-7)

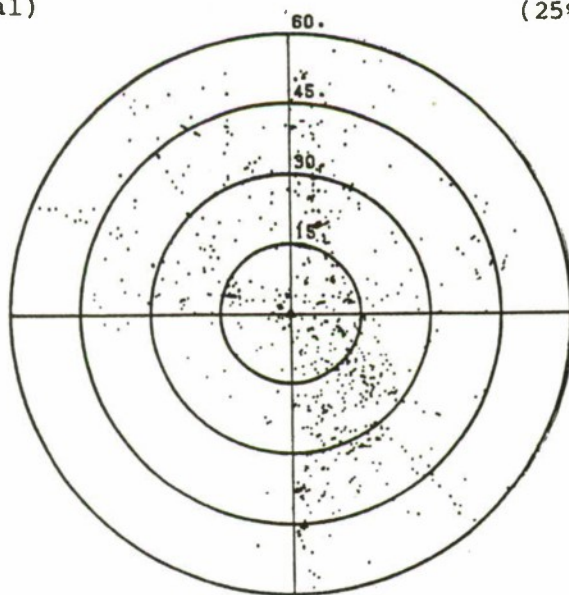
Altitude		Range	
Altitude (1000-foot Increments)	Number of Aircraft in Increment	Range Increment (nmi)	Number of Aircraft in Increment
0-1	10	0-5	0
1-2	13	5-10	10
2-3	22	10-15	11
3-4	15	15-20	14
4-5	10	20-25	11
5-6	2	25-30	10
6-7	7	30-35	4
7-8	2	35-40	10
8-9	5	40-45	4
9-10	1	45-50	6
10-11	3	50-55	4
11-12	0	55-60	6
12-13	0	60-65	1
13-14	0	65-70	1
14-15	0		
15-16	0		
16-17	0		
17-18	0		
18-19	1		
19-20	0		
20-21	0		
21-22	1		
22-23	0		
23-24	0		
24-25	2		
25-26	0		
26-27	0		
27-28	0		
28-29	0		
29-30	0		



TCAS A/C
(11% of Total)

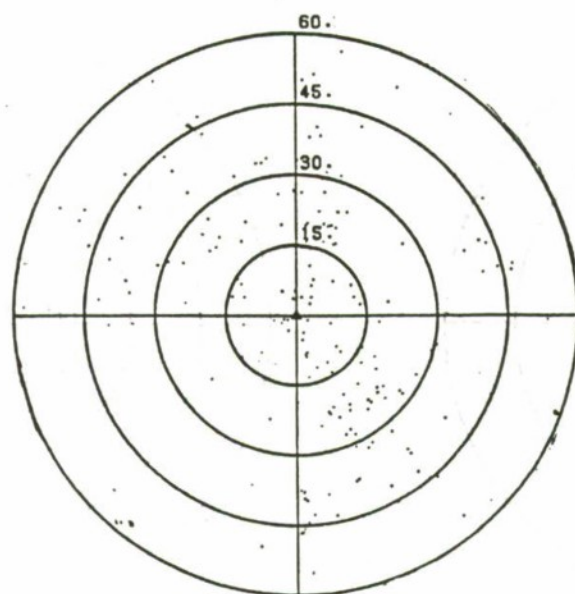


DABS A/C
(25% of Total)

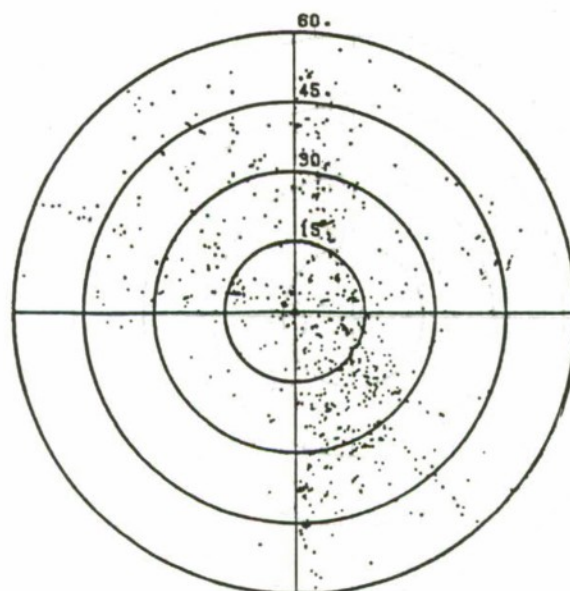


ALL A/C
(Total = 743 A/C)

Figure A-1. Distribution of aircraft about Los Angeles-Table 4 Deployment A
(0.159 A/C per sq nmi to 30 nmi).

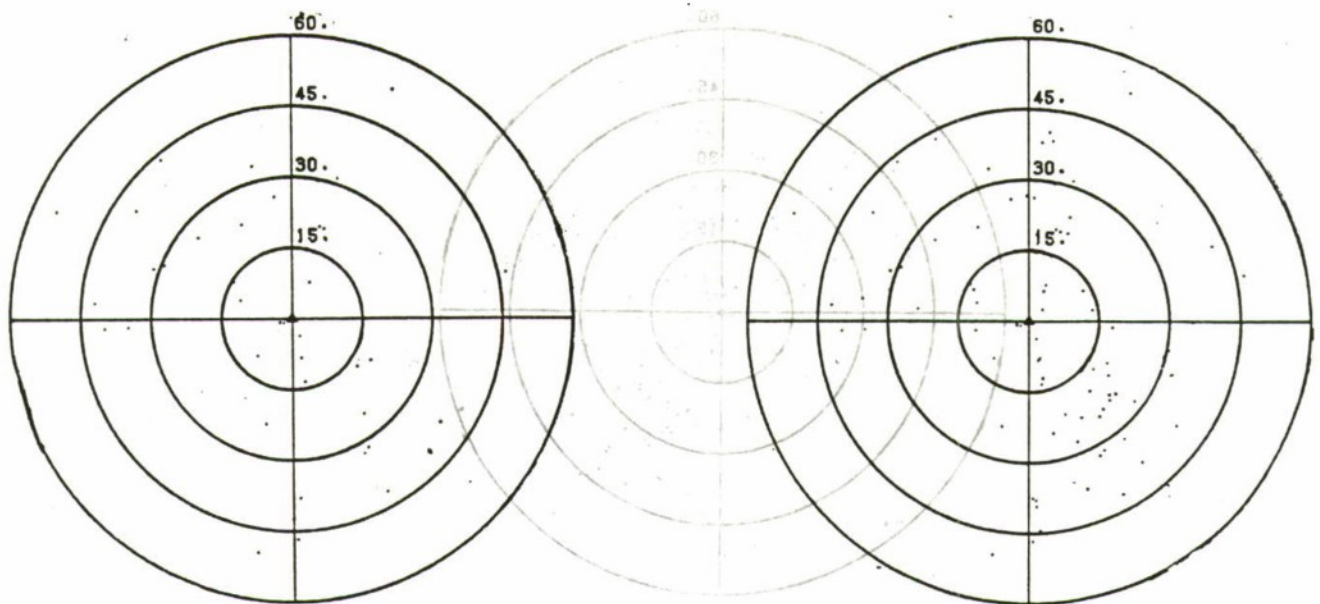


DABS/TCAS A/C
(25% of Total)



ALL A/C
(Total = 743 A/C)

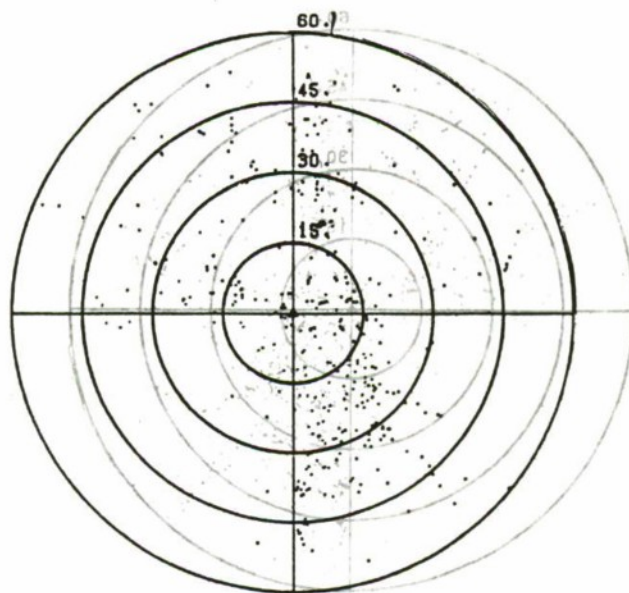
Figure A-2. Distribution of aircraft about Los Angeles-Table 4 Deployment E
(0.159 A/C per sq nmi to 30 nmi).



TCAS A/C
(11% of Total)

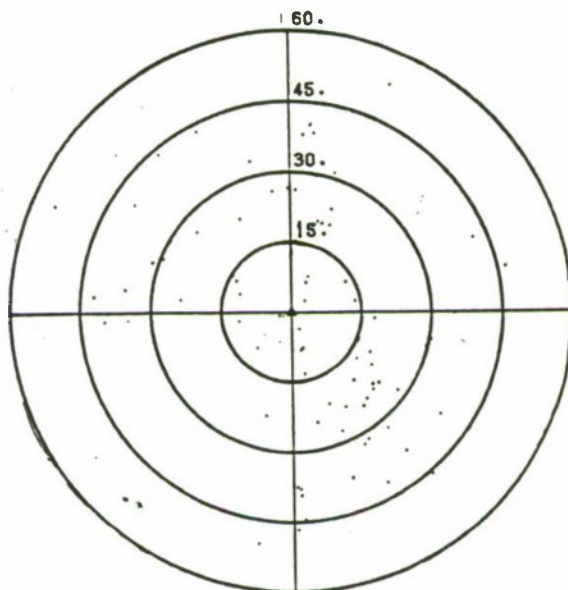
DABS A/C
(25% of Total)

ALL A/C
(Total = 386 A/C)

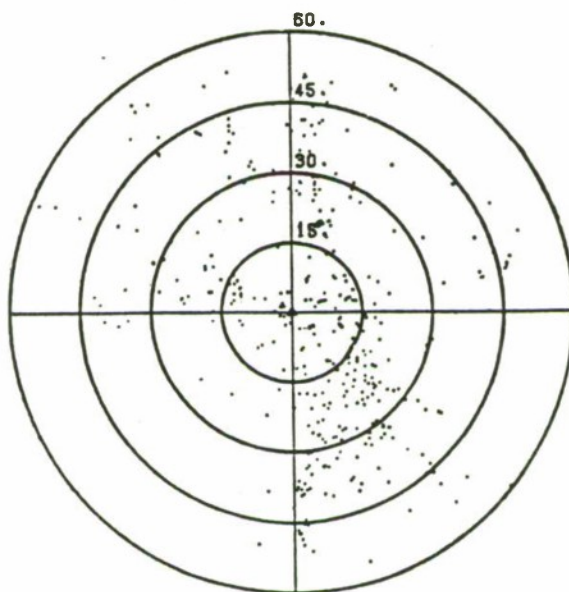


ALL A/C
(Total = 386 A/C)

Figure A-3. Distribution of aircraft about Los Angeles-Table 4. Deployment B
(0.08 A/C per sq nmi to 30 nmi).

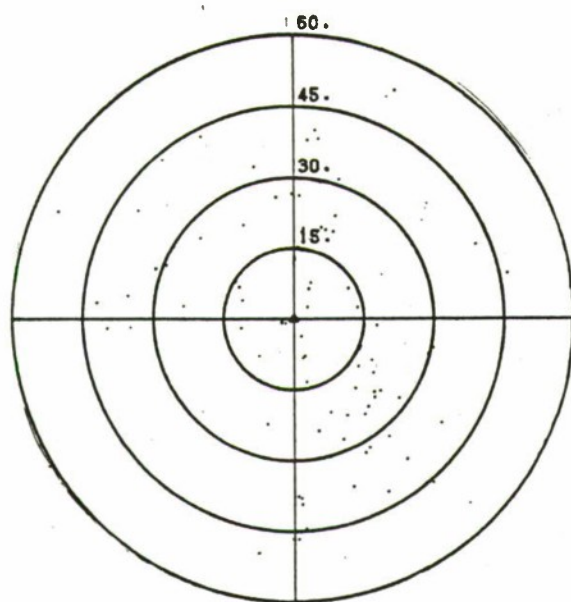


DABS/TCAS A/C
(25% of Total)

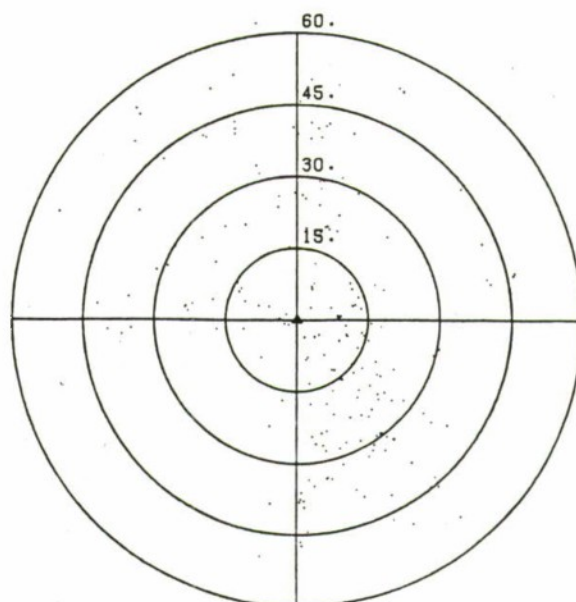


ALL AIRCRAFT
(Total = 386 A/C)

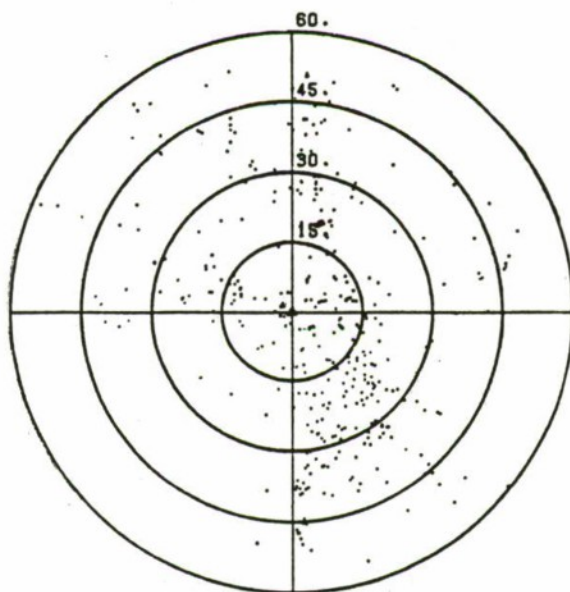
Figure A-4. Distribution of aircraft about Los Angeles-Table 4 Deployment F
(0.08 A/C per sq nmi to 30 nmi).



TCAS A/C
(25% of Total)

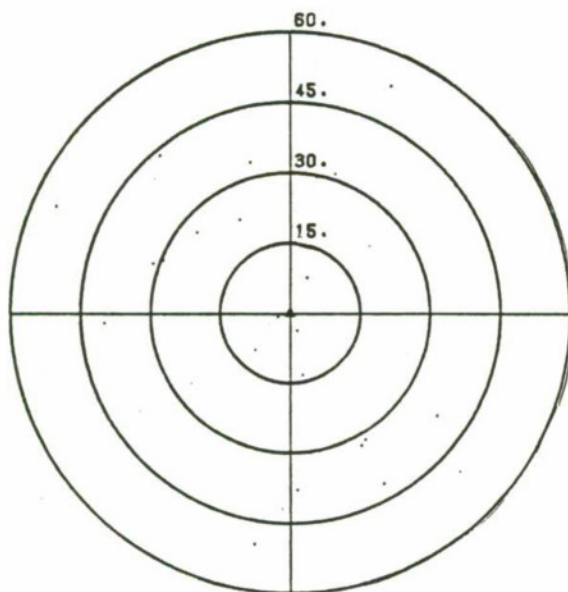


DABS A/C
(54% of Total)

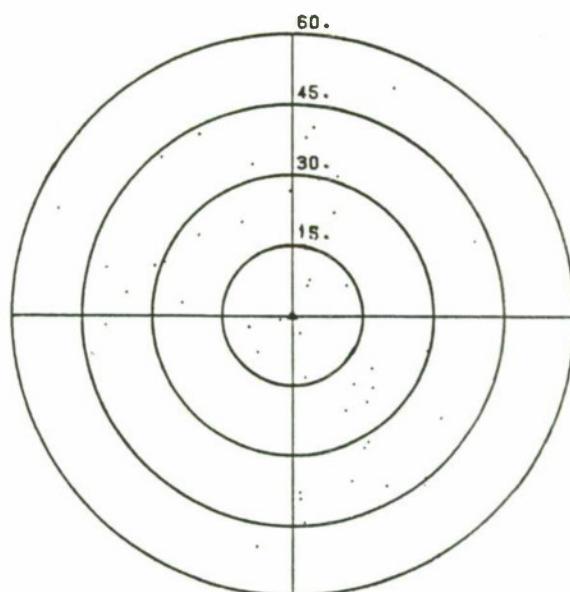


ALL A/C
(Total = 386 A/C)

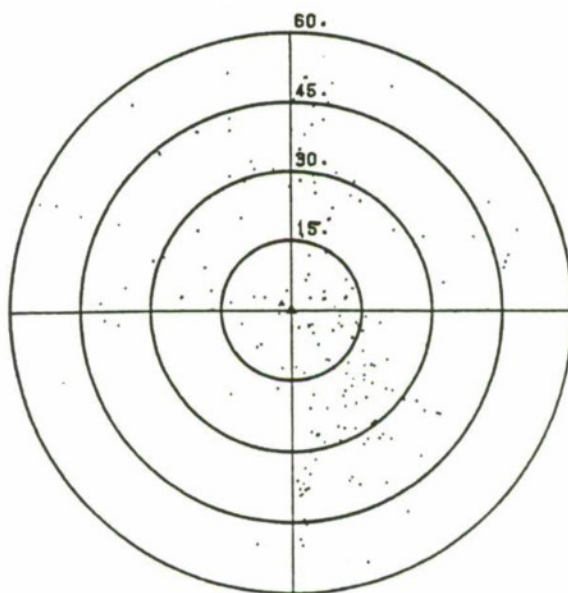
Figure A-5. Distribution of aircraft about Los Angeles-Table 4 Deployment G
(0.08 A/C per sq nmi to 30 nmi).



TCAS A/C
(11% of Total)

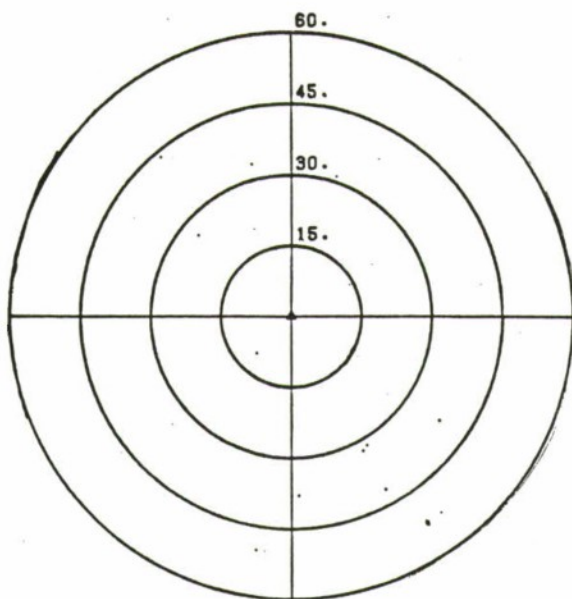


DABS A/C
(25% of Total)

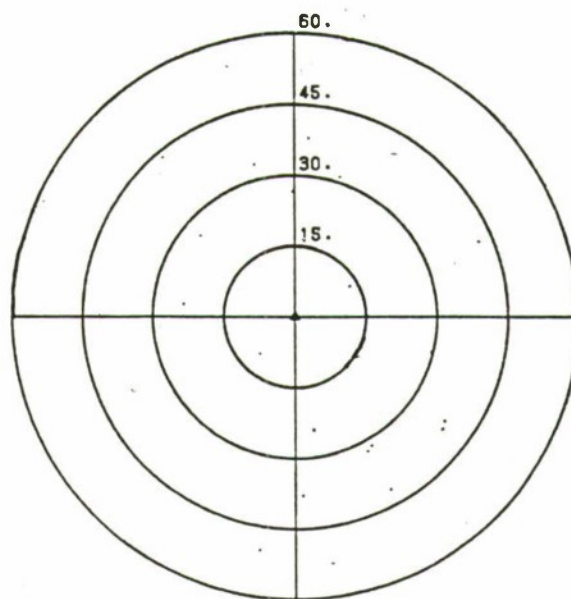


ALL A/C
(Total = 201 A/C)

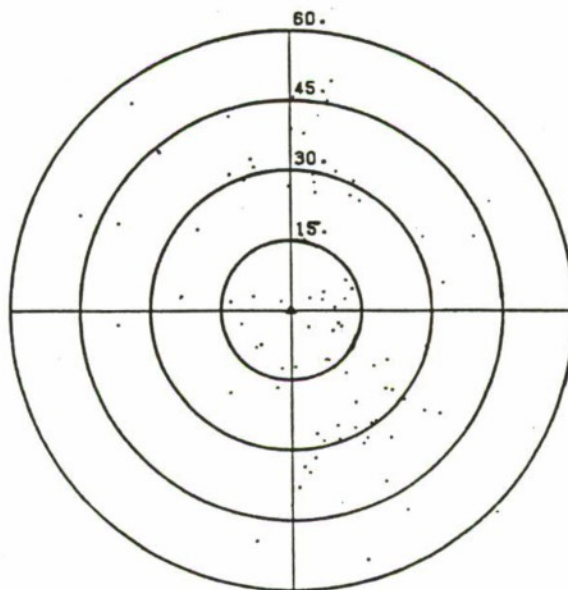
Figure A-6. Distribution of aircraft about Los Angeles-Table 4 Deployment C
(0.04 A/C per sq nmi to 30 nmi).



TCAS A/C
(11% of Total)

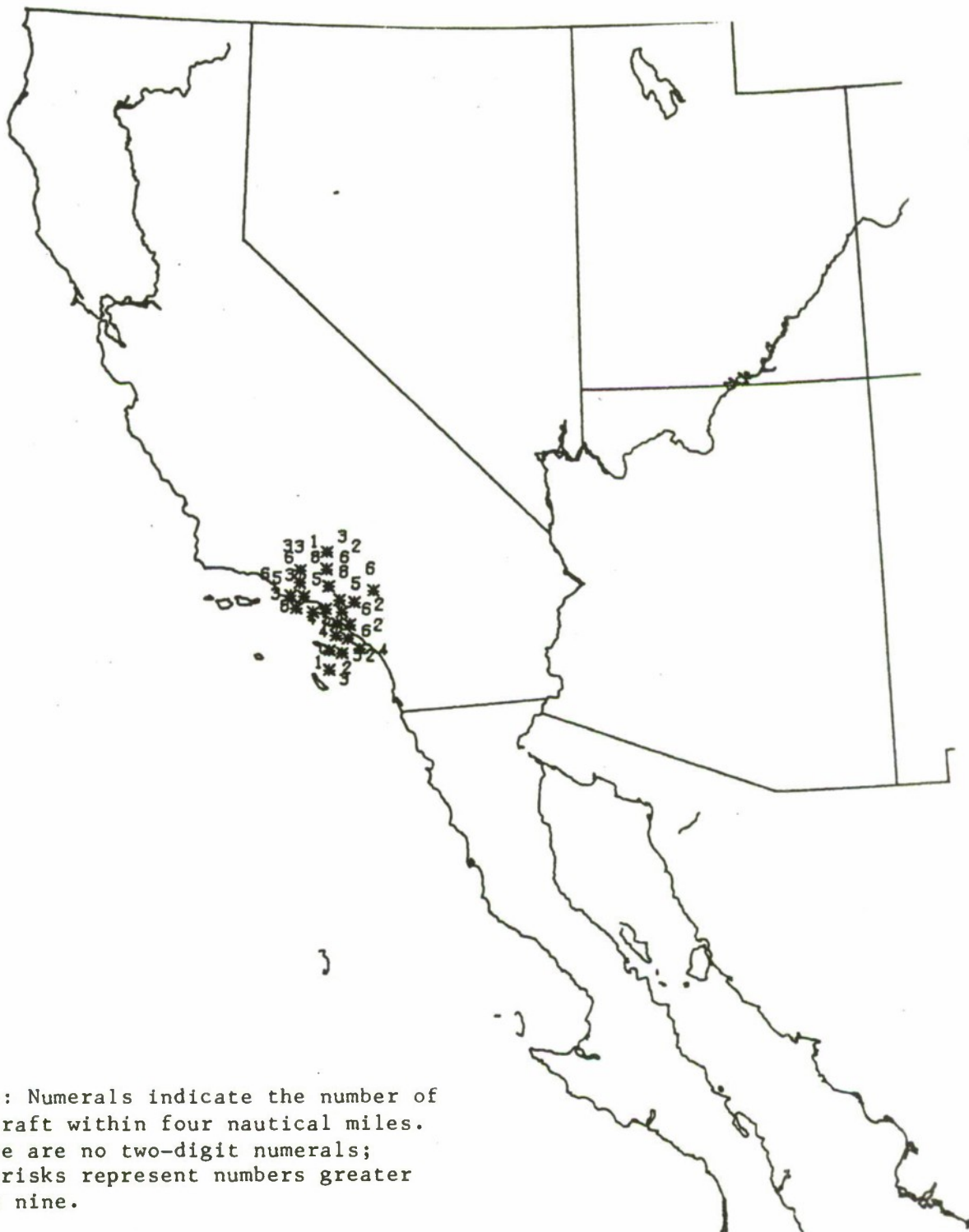


DABS A/C
(25% of Total)



ALL A/C
(Total = 92 A/C)

Figure A-7. Distribution of aircraft about Los Angeles-Table 4 Deployment D
(0.02 A/C per sq nmi to 30 nmi).



Note: Numerals indicate the number of aircraft within four nautical miles. There are no two-digit numerals; asterisks represent numbers greater than nine.

Figure A-8. Los Angeles Basin air traffic deployment. Note that this figure gives the deployment on the same scale as the Figure 2 interrogator deployment on page 13 (743 A/C within 60 nmi of LAX-4).

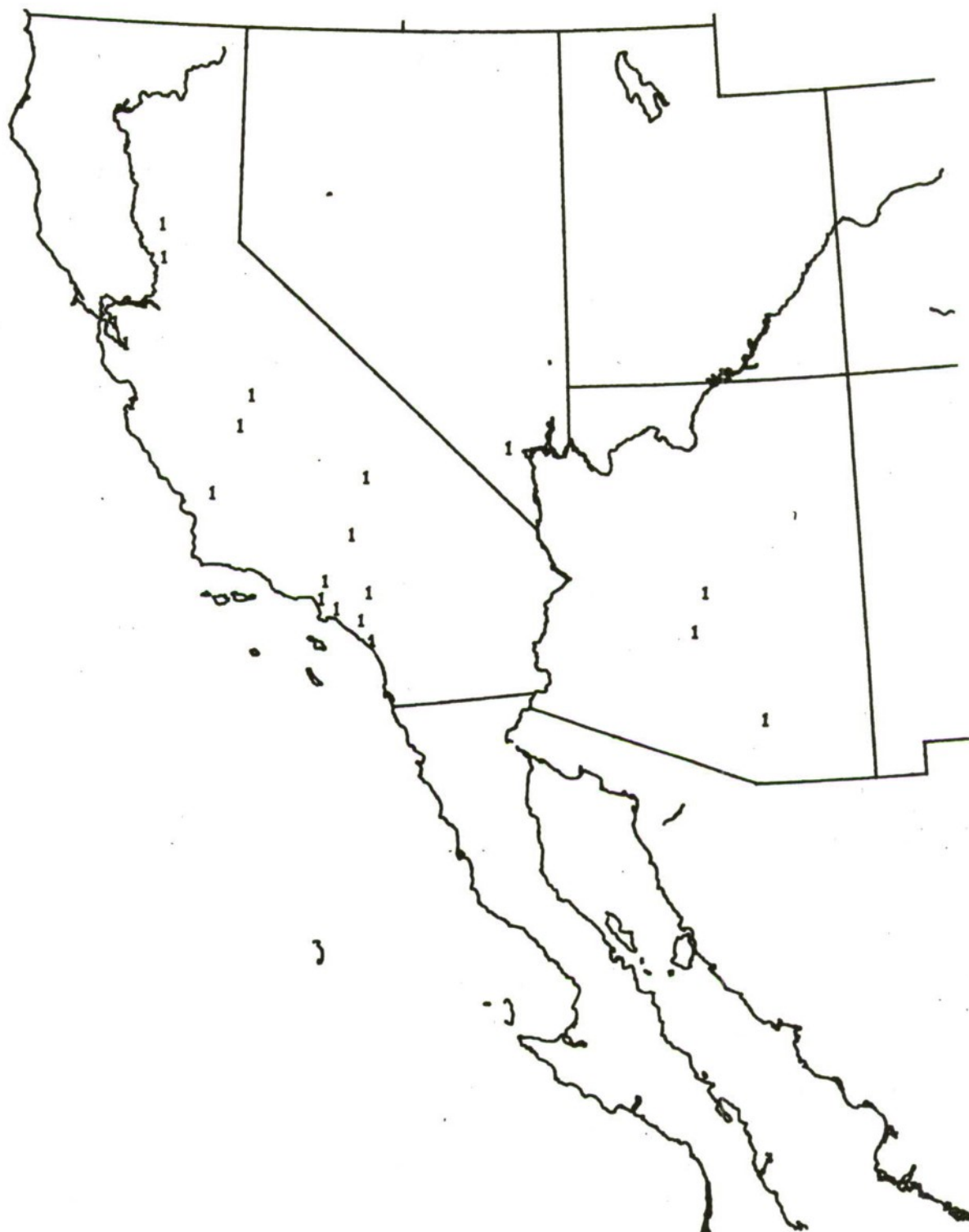
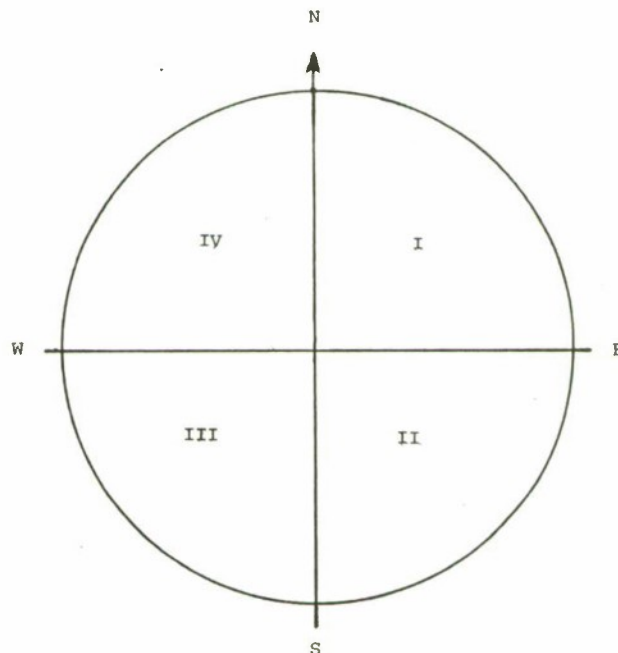


Figure A-9. RBX Deployment. One RBX at each FAA terminal site.

APPENDIX B SIMULATION RESULTS

The following tables (B-1 through B-28) contain the quadrant averages (and standard deviations) of the uplink and downlink signal rates and the probability of reply for the simulations. These quantities correspond to signals transmitted (uplink) and elicited (downlink) by interrogators other than the victim interrogator.

The following convention was used for the computation of quadrant averages:



The full-scan averages are the weighted quadrant averages based on the fraction of the transponder population in each quadrant. The fraction of aircraft in each quadrant for each aircraft distribution is given below.

DENSITY		0.159	0.08	0.04	0.02
Interrogator	Quadrant	Percent of A/C			
LONG BEACH	I	9.2	9.2	5.6	6.6
	II	18.4	18.9	20.2	20.2
	III	23.6	22.7	24.1	24.1
	IV	48.8	49.2	49.1	49.1
LOS ANGELES	I	25.1	26.3	26.7	29.1
	II	48.3	45.4	48.5	42.6
	III	3.7	4.7	5.3	8.3
	IV	22.9	23.6	19.5	20.0

The legend given below is to be used in conjunction with TABLES B-1 through B-7.

QUAD - Quadrant results (I-IV) and full scan average

ALL-CALL RATE - DABS all-call interrogations per DABS-equipped aircraft per second

ALL-CALL RATE (STD. DEV.) - DABS all-call interrogations per DABS-equipped aircraft per second standard deviation

ROLL-CALL RATE - DABS roll-call interrogations per DABS-equipped aircraft per second

ROLL-CALL RATE (STD. DEV.) - DABS roll-call interrogations per DABS-equipped aircraft per second standard deviation

ATCRBS RATE - ATCRBS interrogations per aircraft per second

ATCRBS RATE (STD. DEV.) - ATCRBS interrogations per aircraft per second standard deviation

EFF. SUPP. RATE - Effective suppressions per aircraft per second

EFF. SUPP. RATE (STD. DEV.) - Effective suppressions per aircraft per second standard deviation

PROB. OF REPLY - Probability of reply

PROB. OF REPLY (STD. DEV.) - Probability of reply standard deviation

TABLE B-1

RESULTS AND STATISTICS FOR UPLINK QUANTITIES COMPUTED AT EACH TRANSPONDER AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.159, TOTAL A/C 716, & ATCRBS 75, & DABS 25 (% TCAS 11), LONG BEACH

QUAD	ALL-CALL RATE	ALL-CALL RATE STD.DEV.	ROLL-CALL RATE	ROLL-CALL RATE STD.DEV.	ATCRBS RATE	ATCRBS RATE STD.DEV.	EFF.SUPP. RATE	EFF.SUPP. RATE STD.DEV.	PROB. OF REPLY	PROB. OF REPLY STD.DEV.
TCAS OFF										
I	.000	.000	.000	.000	370.795	312.045	442.000	387.175	.968	.038
II	.000	.000	.000	.000	372.584	348.526	409.500	285.414	.967	.038
III	.000	.000	.000	.000	261.808	229.780	515.884	379.081	.963	.038
IV	.000	.000	.000	.000	144.731	154.812	666.701	580.549	.973	.037
AVG*	.000	.000	.000	.000	234.272	251.806	565.145	489.695	.969	.038
TCAS ON WITH INTERFERENCE LIMITING										
I	.000	.000	.295	2.400	391.182	309.191	521.773	386.996	.964	.043
II	.000	.000	.744	3.751	405.183	346.617	557.908	294.542	.958	.043
III	.000	.000	.692	3.619	294.231	233.863	684.577	399.046	.954	.043
IV	.000	.000	1.271	5.249	182.571	156.462	943.913	595.454	.963	.043
AVG*	.000	.000	.952	4.453	268.397	251.898	726.019	507.535	.960	.043
TCAS ON WITHOUT INTERFERENCE LIMITING										
I	.000	.000	2.068	10.335	423.682	305.971	1196.000	731.770	.944	.048
II	.000	.000	1.786	6.143	430.191	351.656	1371.847	567.267	.933	.059
III	.000	.000	2.423	8.562	324.115	239.591	1564.961	716.201	.927	.058
IV	.000	.000	3.480	11.748	220.853	160.248	1773.227	846.553	.930	.061
AVG*	.000	.000	2.805	10.162	301.922	253.544	1599.405	785.677	.931	.059

*AVG - Full Scan Average

TABLE B-2

RESULTS AND STATISTICS FOR UPLINK QUANTITIES COMPUTED AT EACH TRANSPONDER AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.159 , TOTAL A/C 716, % ATCRBS 75, % DABS 25 (% TCAS 25), LONG BEACH

QUAD	ALL-CALL RATE	ALL-CALL RATE STD.DEV.	ROLL-CALL RATE	ROLL-CALL RATE STD.DEV.	ATCRBS RATE	ATCRBS RATE STD.DEV.	EFF.SUPP. RATE	EFF.SUPP. RATE STD.DEV.	PROB. OF REPLY	PROB. OF REPLY STD.DEV.
I	.000	.000	.000	.000	370.795	312.945	442.000	387.175	.968	.038
II	.000	.000	.000	.000	372.584	344.526	409.500	285.414	.957	.038
III	.000	.000	.000	.000	261.808	229.780	515.884	379.081	.963	.038
IV	.000	.000	.000	.000	144.731	154.812	666.701	580.549	.973	.037
AVG	.000	.000	.000	.000	234.272	251.806	565.145	489.695	.969	.038
TCAS OFF										
I	.000	.000	1.477	5.199	409.204	311.409	555.753	382.404	.961	.044
II	.000	.000	1.796	5.647	426.916	348.518	601.523	303.417	.959	.040
III	.000	.000	1.503	5.629	312.461	232.505	696.344	375.814	.954	.042
IV	.000	.000	1.823	6.729	201.021	159.538	855.403	585.953	.962	.043
AVG	.000	.000	1.716	6.165	287.406	253.551	745.383	496.275	.959	.043
TCAS ON WITH INTERFERENCE LIMITING										
I	.000	.000	3.545	12.757	507.886	317.399	2368.659	1460.765	.897	.077
II	.000	.000	7.443	21.695	537.366	363.536	3018.033	1039.941	.872	.078
III	.000	.000	7.154	19.803	428.884	256.054	3131.653	1232.214	.874	.083
IV	.000	.000	5.745	15.323	301.504	171.867	2997.915	1465.532	.893	.083
AVG	.000	.000	6.101	17.379	397.948	268.449	2975.701	1347.422	.887	.082
TCAS ON WITHOUT INTERFERENCE LIMITING										

*ABG - Full Scan Average

TABLE B-3

RESULTS AND STATISTICS FOR UPLINK QUANTITIES COMPUTED AT EACH TRANSPONDER AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.08, TOTAL A/C 376, % ATCRBS 75, % DABS 25 (% TCAS 11), LONG BEACH

QUAD	ALL-CALL RATE	ALL-CALL RATE STD.DEV.	ROLL-CALL RATE	ROLL-CALL RATE STD.DEV.	ATCRBS RATE	ATCRBS RATE STD.DEV.	EFF.SUPP. RATE	EFF.SUPP. RATE STD.DEV.	PROB. OF REPLY	PROB. OF REPLY STD.DEV.
I	.000	.000	.000	.000	336.514	312.549	483.600	372.241	.970	.036
II	.000	.000	.000	.000	369.107	296.873	447.943	302.475	.966	.039
III	.000	.000	.000	.000	248.512	242.970	484.552	373.303	.963	.041
IV	.000	.000	.000	.000	156.519	161.173	662.274	370.009	.973	.035
AVG*	.000	.000	.000	.000	229.303	238.736	564.462	481.899	.969	.037
TCAS OFF										
I	.000	.000	3.236	3.236	352.671	311.870	590.571	449.997	.969	.036
II	.000	.000	5.181	5.181	398.636	297.935	591.407	360.736	.956	.047
III	.000	.000	4.131	4.131	277.762	243.590	630.122	441.358	.956	.047
IV	.000	.000	2.821	2.821	184.814	160.299	842.026	585.629	.966	.038
AVG*	.000	.000	3.333	3.333	250.242	237.833	722.848	523.734	.962	.042
TCAS ON WITH AND WITHOUT INTERFERENCE LIMITING										

*AVG - Full Scan Average

TABLE B-4

RESULTS AND STATISTICS FOR UPLINK QUANTITIES COMPUTED AT EACH TRANSPONDER AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.08, TOTAL A/C 376, % ATCRBS 75, % DABS 25 (% TCAS 25), LONG BEACH

QUAD	ALL-CALL RATE	ALL-CALL RATE STD.DEV.	ROLL-CALL RATE	ROLL-CALL RATE STD.DEV.	ATCRBS RATE	ATCRBS RATE STD.DEV.	EFF.SUPP. RATE	EFF.SUPP. RATE STD.DEV.	PROB. OF REPLY	PROB. OF REPLY STD.DEV.
I	.000	.000	.000	.000	336.514	312.549	483.509	372.241	.970	.036
II	.000	.000	.000	.000	369.107	295.873	447.943	302.475	.966	.039
III	.000	.000	.000	.000	248.512	242.370	484.552	373.303	.963	.041
IV	.000	.000	.000	.000	156.519	151.173	662.274	570.029	.973	.035
AVG *	.000	.000	.000	.000	229.903	238.796	564.462	481.899	.969	.037

TCAS OFF										
I	.000	.000	.000	.000	370.500	312.108	567.720	428.910	.969	.036
II	.000	.000	2.786	9.961	432.900	301.730	644.893	366.052	.954	.049
III	.000	.000	1.587	6.141	301.343	245.706	638.738	428.723	.956	.048
IV	.000	.000	.830	3.847	203.816	164.690	792.135	580.692	.965	.038
AVG *	.000	.000	1.193	5.290	283.520	243.203	707.185	506.827	.961	.042

TCAS ON WITH INTERFERENCE LIMITING										
I	.000	.000	.557	3.296	396.686	312.964	808.971	581.730	.960	.041
II	.000	.000	1.950	6.763	457.136	308.029	917.057	456.125	.945	.051
III	.000	.000	.907	4.131	324.471	251.185	906.070	533.722	.948	.048
IV	.000	.000	1.660	6.478	224.872	163.763	1077.789	632.958	.957	.041
AVG *	.000	.000	1.402	5.790	303.079	245.969	981.845	583.341	.953	.045

TCAS ON WITHOUT INTERFERENCE LIMITING										
---------------------------------------	--	--	--	--	--	--	--	--	--	--

*AVG - Full Scan Average

TABLE B-5

RESULTS AND STATISTICS FOR UPLINK QUANTITIES COMPUTED AT EACH TRANSPONDER AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.08, TOTAL A/C 376, % ATRBS 46, % DABS 54 (% TCAS 25), LONG BEACH

QUAD	ALL-CALL RATE	ALL-CALL RATE STD.DEV.	ROLL-CALL RATE	ROLL-CALL RATE STD.DEV.	ATCRBS RATE	ATCRBS RATE STD.DEV.	EFF.SUPP. RATE	EFF.SUPP. RATE STD.DEV.	PROB. OF REPLY	PROB. OF REPLY STD.DEV.
I	.000	.000	.000	.000	374.766	295.098	622.172	417.241	.963	.037
II	.000	.000	.000	.000	475.091	366.454	538.909	331.043	.953	.044
III	.000	.000	.000	.000	264.483	241.324	588.362	370.884	.956	.043
IV	.000	.000	.000	.000	137.885	163.918	748.731	591.032	.970	.042
AVG*	.000	.000	.000	.000	252.666	274.762	660.888	495.688	.963	.043
TCAS OFF										
I	.000	.000	1.828	5.775	401.578	293.478	735.516	442.390	.960	.036
II	.000	.000	2.364	8.033	524.432	369.118	783.841	337.812	.941	.052
III	.000	.000	2.017	7.305	316.931	242.047	804.879	395.068	.947	.048
IV	.000	.000	2.192	6.872	179.423	168.238	916.038	588.129	.961	.045
AVG*	.000	.000	2.055	7.000	297.278	277.662	850.110	498.205	.953	.047
TCAS ON WITH INTERFERENCE LIMITING										
I	.000	.000	1.828	5.775	437.531	291.384	1709.906	925.239	.930	.049
II	.000	.000	6.500	14.446	571.409	363.156	2064.341	562.893	.904	.059
III	.000	.000	3.810	7.777	355.931	247.342	1998.638	746.231	.910	.072
IV	.000	.000	4.962	12.228	226.269	173.675	2033.422	945.578	.927	.061
AVG*	.000	.000	4.722	11.438	341.611	278.585	2006.442	785.438	.918	.063
TCAS ON WITHOUT INTERFERENCE LIMITING										

*AVG - Full Scan Average

TABLE B-6

RESULTS AND STATISTICS FOR UPLINK QUANTITIES COMPUTED AT EACH TRANSPONDER AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.04, TOTAL A/C 196, % ATCRBS 75, % DABS 25 (% TCAS 11), LONG BEACH

QUAD	ALL-CALL RATE	ALL-CALL RATE STD.DEV.	ROLL-CALL RATE	ROLL-CALL RATE STD.DEV.	ATCRBS RATE	ATCRBS RATE STD.DEV.	EFF.SUPP. RATE	EFF.SUPP. RATE STD.DEV.	PROB. OF REPLY	PROB. OF REPLY STD.DEV.
I	.000	.000	.000	.000	416.000	295.389	198.250	320.754	.984	.024
II	.000	.000	.000	.000	449.583	272.793	422.500	232.658	.956	.047
III	.000	.000	.000	.000	179.739	194.464	523.109	408.640	.947	.054
IV	.000	.000	.000	.000	180.587	149.157	622.728	552.802	.972	.038
AVG *	.000	.000	.000	.000	244.833	225.067	528.017	472.147	.963	.044
TCAS OFF										
I	.000	.000	.000	.000	417.300	282.823	428.025	375.920	.972	.039
II	.000	.000	.000	.000	352.566	286.381	454.145	269.147	.963	.040
III	.000	.000	.000	.000	228.913	237.208	454.435	354.459	.960	.047
IV	.000	.000	.000	.000	158.463	171.212	651.915	578.669	.974	.034
AVG *	.000	.000	.000	.000	244.148	247.301	543.015	477.048	.959	.038
TCAS ON WITH AND WITHOUT INTERFERENCE LIMITING										

*AVG - Full Scan Average

TABLE B-7

RESULTS AND STATISTICS FOR UPLINK QUANTITIES COMPUTED AT EACH TRANSPONDER AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.02, TOTAL A/C 90, % ATRBS 75, % DABS 25 (% TCAS 11), LONG BEACH

QUAD	ALL-CALL RATE	ALL-CALL RATE STD.DEV.	ROLL-CALL RATE	ROLL-CALL RATE STD.DEV.	ATCRBS RATE	ATCRBS RATE STD.DEV.	EFF.SUPP. RATE	EFF.SUPP. RATE STD.DEV.	PROB. OF REPLY	PROB. OF REPLY STD.DEV.
TCAS OFF										
I	.000	.000	.000	.000	413.475	231.911	428.025	375.852	.972	.039
II	.000	.000	.000	.000	380.763	284.890	452.605	269.330	.964	.040
III	.000	.000	.000	.000	225.322	239.060	454.435	364.809	.951	.048
IV	.000	.000	.000	.000	158.463	171.212	651.915	578.543	.974	.034
AVG*	.000	.000	.000	.000	240.357	243.385	542.617	477.445	.970	.038
TCAS ON										
I	.000	.000	.000	.000	422.501	231.752	221.000	321.876	.984	.024
II	.000	.000	.000	.000	456.083	269.631	436.583	238.239	.955	.047
III	.000	.000	.000	.000	197.543	195.027	542.609	439.011	.947	.054
IV	.000	.000	.000	.000	197.957	180.877	645.196	559.380	.969	.039
AVG*	.000	.000	.000	.000	260.203	222.580	549.157	472.051	.962	.044

TCAS ON WITH AND WITHOUT INTERFERENCE LIMITING

*AVG - Full Scan Average

TABLE B-8

RESULTS AND STATISTICS FOR DOWNLINK QUANTITIES COMPUTED AT THE LONG BEACH INTERROGATOR AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.159, TOTAL A/C 716, % ATRBS 75, % DABS 25 (% TCAS 11)

QUADRANT	DABS ROLL-CALL FRUIT RATE (/s)		ATCRBS FRUIT RATE (/s)		NUMBER DETECTED		NUMBER MODE A VALIDATED		NUMBER MODE C VALIDATED	
	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off
I	-	13 24	5986 6424 7033	68 68 68	62 62 61	58 58 58	58 58 58	58 58 58	58 58 58	
II	-	64 138	9956 11244 13049	117 117 117	104 104 103	92 92 92	92 92 92	92 92 92	92 92 92	
III	-	34 101	8769 9418 10059	167 167 167	135 136 136	123 122 122	123 122 122	123 122 122	122 122 122	
IV	-	37 77	5136 6050 7078	322 322 322	237 235 235	206 207 205	206 207 205	206 207 205	205 205 205	

TABLE B-9

RESULTS AND STATISTICS FOR DOWNLINK QUANTITIES COMPUTED AT THE LONG BEACH INTERROGATOR AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.159, TOTAL A/C 716, % ATCRBS 75, % DABS 25 (% TCAS 25)

QUADRANT	DABS ROLL-CALL FRUIT RATE (/s)		ATCRBS FRUIT RATE (/s)		NUMBER DETECTED		NUMBER MODE A VALIDATED		NUMBER MODE C VALIDATED	
	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off
I	-	11 77	5986 8273	6556 8273	68 66	66 66	61 61	61 61	58 57	56
II	-	87 294	9956 17464	12000 17464	117 117	117 117	105 101	105 101	92 93	91
III	-	64 186	8769 11906	9773 11906	167 167	167 167	135 135	135 135	123 122	120
IV	-	32 148	5136 9211	6326 9211	322 322	322 322	234 231	237 231	206 205	199

TABLE B-10

RESULTS AND STATISTICS FOR DOWNLINK QUANTITIES COMPUTED AT THE LONG BEACH INTERROGATOR AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.08, TOTAL A/C 376, % ATRBS 75, % DABS 25 (% TCAS 11)

QUADRANT	DABS ROLL-CALL FRUIT RATE (/s)		ATCRBS FRUIT RATE (/s)		NUMBER DETECTED		NUMBER MODE A VALIDATED		NUMBER MODE C VALIDATED	
	TCAS OFF	TCAS ON Interference Limiting	TCAS OFF	TCAS ON Interference Limiting	TCAS OFF	TCAS ON Interference Limiting	TCAS OFF	TCAS ON Interference Limiting	TCAS OFF	TCAS ON Interference Limiting
I	-	8	8	3135	3426	3426	36	36	35	35
II	-	34	34	4889	5512	5512	67	67	64	64
III	-	11	11	4129	4465	4465	83	83	78	78
IV	-	19	19	2549	2968	2968	174	174	148	148
							149	149	127	126
							71	71	62	62
							33	33	33	33

TABLE B-11

RESULTS AND STATISTICS FOR DOWNLINK QUANTITIES COMPUTED AT THE LONG BEACH INTERROGATOR AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.08, TOTAL A/C 376, & ATRCBS 75, & DABS 25 (% TCAS 25)

QUADRANT	DABS ROLL-CALL FRUIT RATE (/s)		ATRCBS FRUIT RATE (/s)		NUMBER DETECTED		NUMBER MODE A VALIDATED		NUMBER MODE C VALIDATED	
	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off
I	-	8 18	3135 3644	3927	36 36	36 36	35 35	35 35	33 33	33 33
II	-	24 59	4889 6137	6580	67 67	67 67	64 64	64 64	62 62	62 62
III	-	13 52	4129 4733	5093	83 83	83 83	78 78	78 78	71 71	71 71
IV	-	8 23	2549 3267	3501	174 174	174 174	149 148	148 148	127 126	126 126

TABLE B-12

RESULTS AND STATISTICS FOR DOWNLINK QUANTITIES COMPUTED AT THE LONG BEACH INTERROGATOR AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.08, TOTAL A/C 376, % ATCRBS 46, % DABS 54 (% TCAS 25)

QUADRANT	DABS POLL-CALL FRUIT RATE (/s)		ATCRBS FRUIT RATE (/s)		NUMBER DETECTED		NUMBER MODE A VALIDATED		NUMBER MODE C VALIDATED	
	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off
I	-	11 27	3278 3525	3564	33 33	33 33	33 33	33 33	32 32	31 31
II	-	32 135	5541 6325	7105	59 59	59 59	57 57	57 57	53 53	53 53
III	-	27 66	4839 5226	5456	88 88	88 88	81 81	81 81	78 78	78 78
IV	-	19 64	2901 3249	3593	163 163	163 163	136 136	136 136	126 126	126 126

TABLE B-13

RESULTS AND STATISTICS FOR DOWNLINK QUANTITIES COMPUTED AT THE LONG BEACH INTERROGATOR AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.04, TOTAL A/C 196, & ATCRBS 75, & DABS 25 (& TCAS 11)

QUADRANT	OABS ROLL-CALL FRUIT RATE (/s)		ATCRBS FRUIT RATE (/s)		NUMBER DETECTED		NUMBER MODE A VALIOATED		NUMBER MODE C VALIOATED	
	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off
I	-	0 0	1484	1532 1532	21 21	21 21	21 21	21 21	21 21	21 21
II	-	3 3	2374	2549 2549	34 34	34 34	34 34	34 34	34 34	34 34
III	-	0 0	2040	2109 2109	45 45	45 45	44 44	44 44	42 42	42 42
IV	-	8 8	1097	1179 1179	90 90	90 90	83 83	83 83	77 77	77 77

TABLE B-14

RESULTS AND STATISTICS FOR DOWNLINK QUANTITIES COMPUTED AT THE LONG BEACH INTERROGATOR AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.02, TOTAL A/C 90, % ATRBS 75, % DABS 25 (% TCAS 11)

QUADRANT	DABS ROLL-CALL FRUIT RATE (/s)		ATCRBS FRUIT RATE (/s)		NUMBER DETECTED		NUMBER MODE A VALIDATED		NUMBER MODE C VALIDATED	
	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off
I	-	0 0	358 366	366 366	7 7	7 7	7 7	7 7	7 7	7 7
II	-	0 0	779 816	816 816	17 17	17 17	17 17	17 17	17 17	17 17
III	-	0 0	337 345	345 345	21 21	21 21	21 21	21 21	21 21	21 21
IV	-	3 3	374 387	387 387	43 43	43 43	43 43	43 43	38 38	38 38

The legend given below is to be used in conjunction with TABLES B-15 through B-21.

QUAD - Quadrant results (I-IV) and full scan average

ALL-CALL RATE - DABS all-call interrogations per DABS-equipped aircraft per second

ALL-CALL RATE (STD. DEV.) - DABS all-call interrogations per DABS-equipped aircraft per second standard deviation

ROLL-CALL RATE - DABS roll-call interrogations per DABS-equipped aircraft per second

ROLL-CALL RATE (STD. DEV.) - DABS roll-call interrogations per DABS-equipped aircraft per second standard deviation

ATCRBS RATE - ATCRBS interrogations per aircraft per second

ATCRBS RATE (STD. DEV.) - ATCRBS interrogations per aircraft per second standard deviation

EFF. SUPP. RATE - Effective suppressions per aircraft per second

EFF.SUPP. RATE (STD. DEV.) - Effective suppressions per aircraft per second standard deviation

PROB. OF REPLY - Probability of reply

PROB. OF REPLY (STD. DEV.) - Probability of reply standard deviation

TABLE B-15

RESULTS AND STATISTICS FOR UPLINK QUANTITIES COMPUTED AT EACH TRANSPONDER AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.159, TOTAL A/C 743, & ATRBS 75, & DABS 25 (& TCAS 11), LOS ANGELES

QUAD	ALL-CALL RATE	ALL-CALL RATE STD.DEV.	ROLL-CALL RATE	ROLL-CALL RATE STD.DEV.	ATCRBS RATE	ATCRBS RATE STD.DEV.	EFF.SUPP. RATE	EFF.SUPP. RATE STD.DEV.	PROB. OF REPLY	PROB. OF REPLY STD.DEV.
I	3.750	15.940	13.500	41.494	217.964	220.322	389.505	401.174	.961	.069
II	3.790	15.184	.000	.000	232.253	244.107	453.008	265.296	.965	.068
III	.000	.000	.000	.000	225.041	223.500	532.297	357.260	.955	.065
IV	.000	.000	.000	.000	257.423	251.551	262.154	390.162	.971	.074
AVG*	2.593	12.887	2.904	22.175	236.388	239.662	398.188	348.892	.965	.070

TCAS OFF										
I	3.750	15.940	13.875	39.820	251.718	225.292	537.784	461.174	.955	.079
II	3.790	15.184	4.555	9.951	267.082	248.525	625.127	328.361	.959	.077
III	.000	.000	11.707	12.333	266.676	225.544	751.013	502.595	.959	.069
IV	.000	.000	3.734	7.756	294.231	261.281	403.500	458.900	.968	.079
AVG*	2.593	12.887	7.572	22.755	272.291	245.510	559.489	417.667	.959	.074

TCAS ON WITH INTERFERENCE LIMITING										
I	3.750	15.940	10.875	42.388	287.056	229.787	1335.502	952.494	.932	.103
II	3.790	15.184	10.890	19.110	301.686	250.581	1563.047	732.596	.928	.111
III	.000	.000	11.700	17.750	316.216	237.100	1913.108	855.077	.924	.091
IV	.000	.000	9.543	15.144	328.731	269.027	1167.576	918.951	.943	.097
AVG*	2.593	12.887	13.330	27.140	300.168	249.536	1431.633	865.061	.931	.105

TCAS ON WITHOUT INTERFERENCE LIMITING										
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*AVG - Full Scan Average

TABLE B-16

RESULTS AND STATISTICS FOR UPLINK QUANTITIES COMPUTED AT EACH TRANSPONDER AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.159, TOTAL A/C 743, % ATCRBS 75, % DABS 25 (% TCAS 25), LOS ANGELES

QUAD	ALL-CALL RATE	ALL-CALL RATE STD.DEV.	ROLL-CALL RATE	ROLL-CALL RATE STD.DEV.	ATCRBS RATE	ATCRBS RATE STD.DEV.	EFF. SUPP. RATE	EFF. SUPP. RATE STD.DEV.	PROB. OF REPLY	PROB. OF REPLY STD.DEV.
I	3.750	15.940	10.503	41.494	217.964	220.322	389.505	401.174	.951	.069
II	3.790	15.194	.000	.000	232.253	244.137	453.008	265.296	.965	.068
III	.000	.000	.000	.000	225.041	223.500	532.297	357.260	.955	.065
IV	.000	.000	.000	.000	257.423	251.551	262.154	390.162	.971	.074
AVG *	2.593	12.887	2.904	22.175	236.388	239.662	398.188	348.892	.965	.070
TCAS OFF										
I	3.750	15.940	16.500	44.598	270.822	228.715	568.667	459.365	.961	.076
II	3.790	15.184	5.825	11.863	288.724	253.459	643.218	316.168	.958	.075
III	.000	.000	7.800	9.888	276.689	229.342	715.703	459.123	.952	.073
IV	.000	.000	5.394	10.526	312.346	266.195	419.192	447.420	.966	.077
AVG *	2.593	12.887	8.920	25.615	292.263	250.100	577.703	406.576	.960	.076
TCAS ON WITH INTERFERENCE LIMITING										
I	3.750	15.940	35.625	55.521	368.421	239.104	2566.080	1633.873	.890	.131
II	3.790	15.184	36.974	32.350	409.443	266.456	3258.470	1243.579	.866	.134
III	.000	.000	22.100	21.947	406.865	251.583	3485.756	1595.001	.868	.108
IV	.000	.000	12.032	17.980	395.307	290.666	2020.499	1532.646	.920	.124
AVG *	2.593	12.887	29.872	38.496	399.867	264.793	2807.837	1528.316	.883	.132
TCAS ON WITHOUT INTERFERENCE LIMITING										

*AVG - Full Scan Average

TABLE B-17

RESULTS AND STATISTICS FOR UPLINK QUANTITIES COMPUTED AT EACH TRANSPONDER AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.08, TOTAL A/C 386, & ATCRBS 75, & DABS 25 (% TCAS 11), LOS ANGELES

QUAD	ALL-CALL RATE	ALL-CALL RATE STD.DEV.	ROLL-CALL RATE	ROLL-CALL RATE STD.DEV.	ATCRBS RATE	ATCRBS RATE STD.DEV.	EFF.SUPP. RATE	EFF.SUPP. RATE STD.DEV.	PROB. OF REPLY	PROB. OF REPLY STD.DEV.
I	6.500	19.641	13.812	38.350	187.875	210.059	348.375	384.106	.981	.056
II	.527	3.206	.000	.000	236.353	211.536	428.327	242.088	.970	.066
III	.000	.000	.000	.000	168.187	151.681	521.625	360.217	.970	.063
IV	.000	.000	.000	.000	223.807	231.294	259.705	374.583	.978	.075
AVG*	2.017	10.736	3.810	20.762	218.794	214.065	375.147	332.159	.975	.066
TCAS OFF										
I	6.500	19.641	17.062	38.707	216.937	213.693	497.250	468.276	.971	.065
II	.527	3.206	2.108	6.139	269.077	217.072	586.008	308.803	.958	.086
III	.000	.000	2.167	6.500	195.812	155.307	732.875	447.420	.970	.063
IV	.000	.000	3.079	7.305	258.818	241.532	413.267	451.952	.976	.077
AVG*	2.017	10.736	6.500	21.785	251.125	223.360	532.663	407.051	.966	.078
TCAS ON WITH AND WITHOUT INTERFERENCE LIMITING										

*AVG - Full Scan Average

TABLE B-18

RESULTS AND STATISTICS FOR UPLINK QUANTITIES COMPUTED AT EACH TRANSPONDER AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.08, TOTAL A/C 386, % ATRBS 75, % DABS 25 (% TCAS 25), LOS ANGELES

QUAD	ALL-CALL RATE	ALL-CALL RATE STD.DEV.	ROLL-CALL RATE	ROLL-CALL RATE STD.DEV.	ATCRBS RATE	ATCRBS RATE STD.DEV.	EFF. SUPP. RATE	EFF. SUPP. RATE STD.DEV.	PROB. OF REPLY	PROB. OF REPLY STD.DEV.
I	6.500	19.641	13.812	38.350	187.875	210.058	348.375	384.106	.981	.056
II	.527	3.206	.000	.000	236.353	211.536	428.327	242.088	.970	.066
III	.000	.000	.000	.000	168.187	151.681	521.625	360.217	.970	.063
IV	.000	.000	.000	.000	223.807	231.294	259.705	374.583	.978	.075
AVG*	2.017	10.736	3.810	20.782	218.794	214.065	375.147	332.159	.975	.066
TCAS OFF										
I	6.500	19.641	17.875	41.829	231.187	216.332	467.812	434.207	.975	.062
II	.527	3.206	5.270	9.910	295.638	222.816	605.284	295.275	.960	.079
III	.000	.000	4.333	3.599	207.187	156.404	667.062	416.048	.970	.063
IV	.000	.000	6.158	11.357	267.017	242.658	360.528	411.992	.976	.077
AVG*	2.017	10.736	3.810	23.939	269.312	224.410	518.012	385.092	.968	.074
TCAS ON WITH INTERFERENCE LIMITING										
I	6.500	19.641	23.562	42.637	259.000	216.721	747.937	586.078	.960	.076
II	.527	3.206	5.797	11.131	318.612	224.670	902.715	400.613	.949	.085
III	.000	.000	.000	.000	234.812	157.422	1005.062	589.152	.959	.070
IV	.000	.000	3.079	7.305	285.631	248.354	575.693	552.290	.974	.078
AVG*	2.017	10.736	9.638	25.035	292.853	226.661	794.245	519.632	.957	.081
TCAS ON WITHOUT INTERFERENCE LIMITING										

*AVG - Full Scan Average

TABLE B-19

RESULTS AND STATISTICS FOR UPLINK QUANTITIES COMPUTED AT EACH TRANSPONDER AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.08, TOTAL A/C 386, % ATRBS 46, % DABS 54 (% TCAS 25), LOS ANGELES

QUAD	ALL-CALL RATE	ALL-CALL RATE STD.DEV.	ROLL-CALL RATE	ROLL-CALL RATE STD.DEV.	ATCRBS RATE	ATCRBS RATE STD.DEV.	EFF.SUPP. RATE	EFF.SUPP. RATE STD.DEV.	PROB. OF REPLY	PROB. OF REPLY STD.DEV.
I	1.393	7.370	12.536	36.579	226.837	227.121	346.821	352.118	.961	.085
II	.700	.000	1.026	6.327	246.584	270.452	441.017	264.219	.961	.076
III	5.571	14.741	.000	.000	238.588	238.579	548.294	403.235	.985	.048
IV	.000	.000	.000	.000	258.375	273.534	235.625	387.232	.987	.052
AVG *	.768	5.515	3.939	20.084	247.581	258.693	376.524	336.703	.967	.074
TCAS OFF										
I	.000	.000	3.000	7.175	297.839	280.374	395.803	427.292	.982	.058
II	.788	5.515	5.909	20.176	290.227	262.487	561.642	372.842	.959	.083
III	1.393	7.370	12.536	34.888	267.826	231.838	493.867	385.414	.954	.095
IV	.000	.000	4.105	10.296	289.439	273.296	657.898	284.987	.953	.082
AVG *	5.571	14.741	.000	.000	284.765	232.345	742.147	450.294	.954	.103
TCAS ON WITH INTERFERENCE LIMITING										
I	1.393	7.370	17.411	36.516	304.439	234.797	1510.852	821.152	.919	.129
II	.000	.000	7.697	13.248	330.366	279.056	1865.537	626.696	.904	.121
III	5.571	14.741	5.571	9.515	339.529	252.942	2031.441	808.119	.909	.107
IV	.000	.000	4.500	10.031	338.696	285.690	1488.035	891.852	.929	.096
AVG *	.788	5.515	9.652	22.351	331.605	268.030	1698.665	776.341	.912	.117
TCAS ON WITHOUT INTERFERENCE LIMITING										

*AVG - Full Scan Average

TABLE B-20

RESULTS AND STATISTICS FOR UPLINK QUANTITIES COMPUTED AT EACH TRANSPONDER AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.04, TOTAL A/C 203, % ATRCBS 75, % DABS 25 (% TCAS 11), LOS ANGELES

QUAD	ALL-CALL RATE	ALL-CALL RATE STD.DEV.	ROLL-CALL RATE	ROLL-CALL RATE STD.DEV.	ATCRBS RATE	ATCRBS RATE STD.DEV.	EFF.SUPP. RATE	EFF.SUPP. RATE STD.DEV.	PROB. OF REPLY	PROB. OF REPLY STD.DEV.
I	.000	.000	15.321	38.379	206.143	219.419	301.902	372.073	.985	.045
II	4.105	17.894	.000	.000	229.021	196.627	447.878	240.505	.963	.070
III	.000	.000	.000	.000	192.000	166.579	448.500	362.284	.949	.076
IV	.000	.000	.000	.000	221.159	236.329	228.768	360.197	.984	.047
AVG*	1.625	11.258	4.469	21.376	220.224	210.300	366.037	326.523	.972	.062

TCAS OFF										
I	.000	.000	18.107	37.831	218.679	223.628	326.973	388.244	.985	.045
II	4.105	17.894	.000	.000	248.521	199.517	474.431	251.988	.959	.072
III	.000	.000	.000	.000	205.500	169.739	492.000	385.210	.949	.076
IV	.000	.000	1.625	5.629	235.902	234.195	265.866	374.119	.984	.047
AVG*	1.625	11.258	5.687	21.646	236.619	212.690	395.433	339.753	.970	.063

TCAS ON WITH AND WITHOUT INTERFERENCE LIMITING

*AVG - Full Scan Average

TABLE B-21

RESULTS AND STATISTICS FOR UPLINK QUANTITIES COMPUTED AT EACH TRANSPONDER AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.02, TOTAL A/C 92, % ATRCBS 75, % DABS 25 (% TCAS 11), LOS ANGELES

QUAD	ALL-CALL RATE	ALL-CALL RATE STD.DEV.	ROLL-CALL RATE	ROLL-CALL RATE STD.DEV.	ATRCBS RATE	ATRCBS RATE STD.DEV.	EFF.SUPP. RATE	EFF.SUPP. RATE STD.DEV.	PROB. OF REPLY	PROB. OF REPLY STD.DEV.
I	6.500	15.922	3.250	7.961	286.839	155.760	282.054	368.747	.958	.069
II	9.750	27.577	.000	.000	243.500	217.367	445.500	215.410	.961	.068
III	.000	.000	.000	.000	166.833	153.578	424.667	359.929	.956	.074
IV	.000	.000	.000	.000	261.083	269.631	149.500	292.615	.988	.042
AVG*	5.850	19.085	.975	4.360	229.337	208.291	341.250	315.430	.964	.065
TCAS OFF										
I	6.500	15.922	3.250	7.961	212.411	157.200	282.750	368.311	.958	.069
II	9.750	27.577	.000	.000	258.500	227.307	446.500	215.207	.961	.068
III	.000	.000	.000	.000	173.333	157.650	424.667	360.236	.956	.074
IV	.000	.000	.000	.000	265.417	269.382	149.500	292.639	.988	.042
AVG*	5.850	19.085	.975	4.360	238.663	213.365	341.886	315.354	.964	.065
TCAS ON WITH AND WITHOUT INTERFERENCE LIMITING										

*AVG - Full Scan Average

TABLE B-22

RESULTS AND STATISTICS FOR DOWNLINK QUANTITIES COMPUTED AT THE LOS ANGELES DABS SENSOR AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.159, TOTAL A/C 743, % ATCRBS 75, % DABS 25 (% TCAS 11)

QUADRANT	DABS ROLL-CALL FRUIT RATE (/s)		ATCRBS FRUIT RATE (/s)	
	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off
I	11	16 30	1820	2092 2386
II	0	12 31	3429	3419 4309
III	0	8 8	346	404 468
IV	0	8 19	1906	2179 2359

TABLE B-23

RESULTS AND STATISTICS FOR DOWNLINK QUANTITIES COMPUTED AT THE LOS ANGELES DABS SENSOR AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.159, TOTAL A/C 743, % ATCRBS 75, % DABS 25 (% TCAS 25)

QUADRANT	DABS ROLL-CALL FRUIT RATE (/s)		ATCRBS FRUIT RATE (/s)	
	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off
I	11	23 57	1820	2267 2938
II	0	18 78	3429	4252 5472
III	0	5 13	346	415 561
IV	0	11 23	1906	2310 2665

TABLE B-24

RESULTS AND STATISTICS FOR DOWNLINK QUANTITIES COMPUTED AT THE LOS ANGELES DABS SENSOR AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.08, TOTAL A/C 386, % ATCRBS 75, % DABS 25 (% TCAS 11)

QUADRANT	DABS ROLL-CALL FRUIT RATE (/s)		ATCRBS FRUIT RATE (/s)	
	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off
I	7	12 12	810	982 982
II	0	3 3	1821	1989 1989
III	0	2 2	250	198 198
IV	0	2 2	784	1001 1001

TABLE B-25

RESULTS AND STATISTICS FOR DOWNLINK QUANTITIES COMPUTED AT THE LOS ANGELES DABS SENSOR AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.08, TOTAL A/C 386, % ATCRBS 75, % DABS 25 (% TCAS 25)

QUADRANT	DABS ROLL-CALL FRUIT RATE (/s)		ATCRBS FRUIT RATE (/s)	
	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off
I	7	10 20	810	1051 1166
II	1	8 10	1821	2195 2325
III	0	2 0	250	208 232
IV	0	3 3	784	1036 1089

TABLE B-26

RESULTS AND STATISTICS FOR DOWNLINK QUANTITIES COMPUTED AT THE LOS ANGELES DABS SENSOR AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.08, TOTAL A/C 386, % ATCRBS 46, % DABS 54 (% TCAS 25)

QUADRANT	DABS ROLL-CALL FRUIT RATE (/s)		ATCRBS FRUIT RATE (/s)	
	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off
I	11	16 29	949	1096 1207
II	0	16 32	1796	2091 2281
III	0	3 5	166	197 230
IV	0	8 23	980	1123 1230

TABLE B-27

RESULTS AND STATISTICS FOR DOWNLINK QUANTITIES COMPUTED AT THE LOS ANGELES DABS SENSOR AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.04, TOTAL A/C 201, % ATCRBS 75, % DABS 25 (% TCAS 11)

QUADRANT	DABS ROLL-CALL FRUIT RATE (/s)		ATCRBS FRUIT RATE (/s)	
	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off
I	6	8 8	505	535 535
II	0	0 0	926	999 999
III	0	0 0	97	109 109
IV	0	1 1	390	410 410

TABLE B-28

RESULTS AND STATISTICS FOR DOWNLINK QUANTITIES COMPUTED AT THE LOS ANGELES DABS SENSOR AND AVERAGED OVER THE QUADRANT FOR A/C DENSITY 0.02, TOTAL A/C 92, % ATCRBS 75, % DABS 25 (% TCAS 11)

QUADRANT	DABS ROLL-CALL FRUIT RATE (/s)		ATCRBS FRUIT RATE (/s)	
	TCAS OFF	TCAS ON Interference Limiting On Off	TCAS OFF	TCAS ON Interference Limiting On Off
I	1	1 1	246	252 252
II	0	0 0	397	423 423
III	0	0 0	56	56 56
IV	0	0 0	204	205 205

Figures B-1 through B-8 graphically present the reply performance of transponders corresponding to the 0.159 and the 0.08 aircraft density simulations with both the 25% DABS (11% TCAS) distribution and the 25% DABS (25% TCAS) distribution. Included is the position of the aircraft with the lowest probability of reply for each simulation.^a Note that the Long Beach ATCRBS interrogator transmits an average of 21.28 interrogations to each aircraft during the mainbeam dwell; some aircraft received 21 interrogations and some received 22. Similarly, the Los Angeles DABS sensor transmits an average of 6.56 ATCRBS-Only interrogations to each aircraft during the mainbeam dwell; some aircraft received 6 interrogations and some received 7.

Figures B-9 through B-12 give the cumulative distributions of the ATCRBS interrogation rate and the effective suppression rate for transponders in the 0.159 aircraft density environment for the 25% DABS (11% TCAS) distribution.

^aAircraft positions are given in radians; multiply by 57.296 to find the position in degrees.

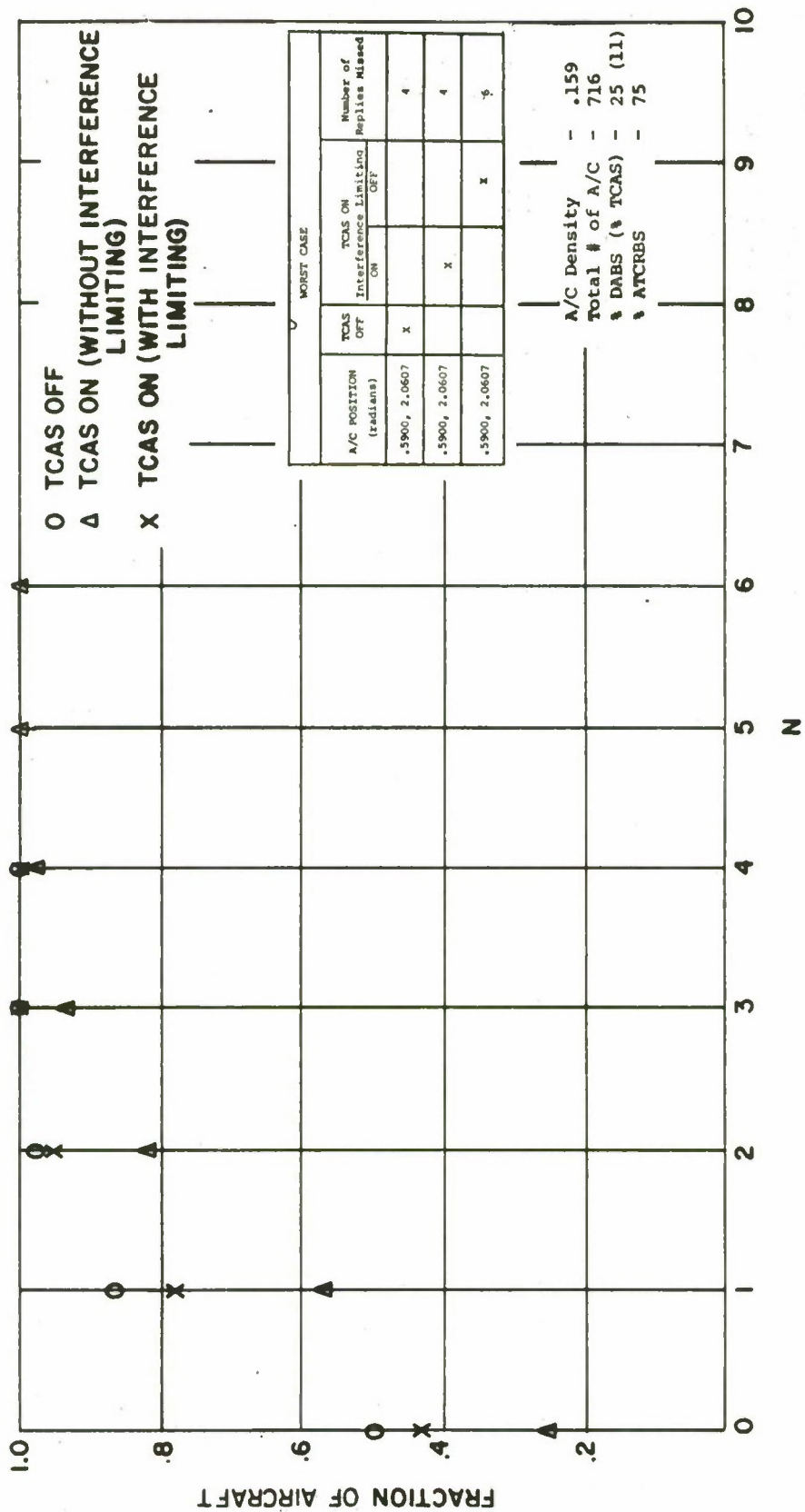


Figure B-1. Cumulative distribution for the number of missed interrogations (N) out of a possible 21 or 22 per mainbeam dwell for the Long Beach ATCRBS interrogator.

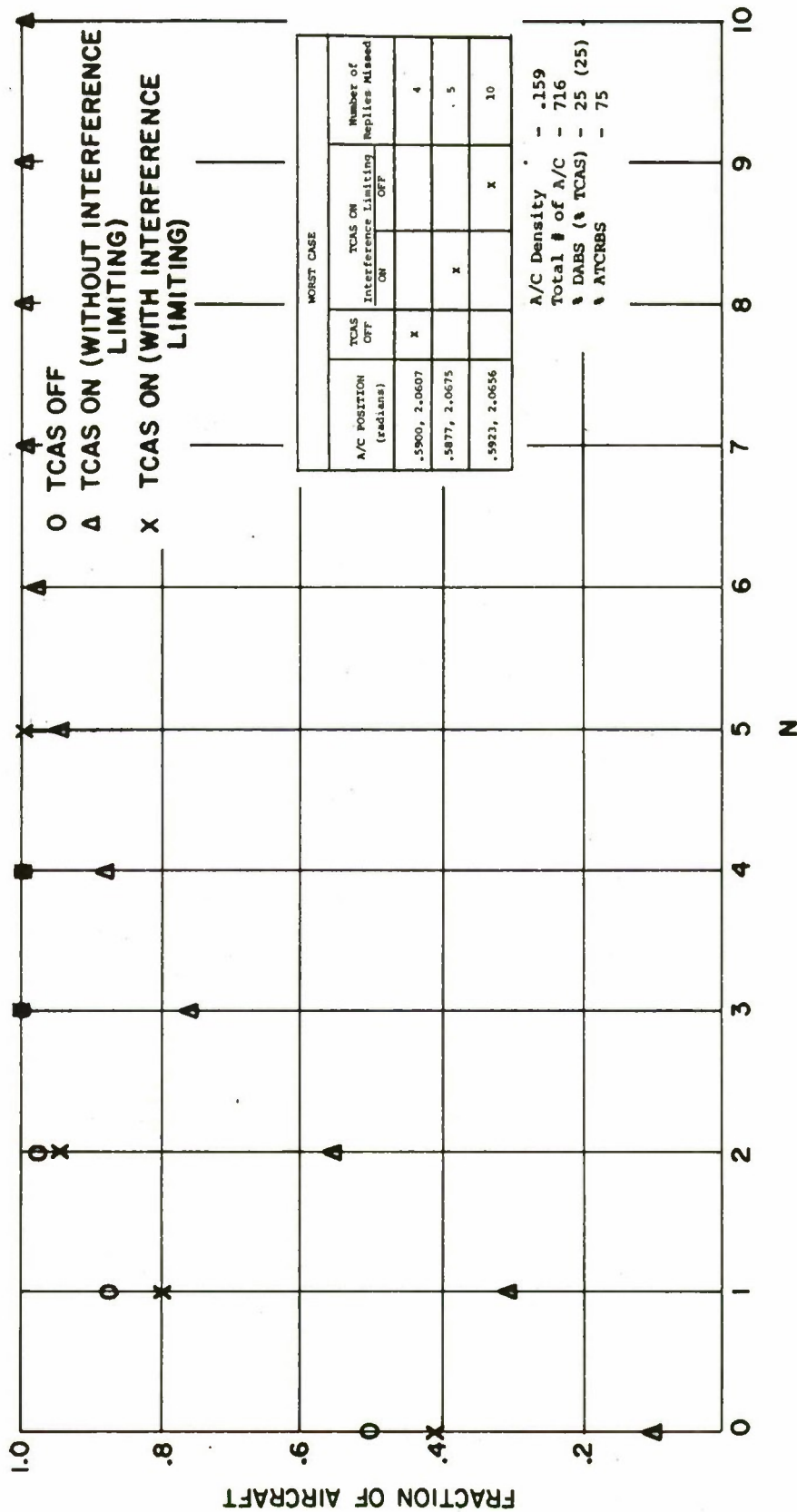


Figure B-2. Cumulative distribution for the number of missed interrogations (N) out of a possible 21 or 22 per mainbeam dwell for the Long Beach ATCRBS interrogator.

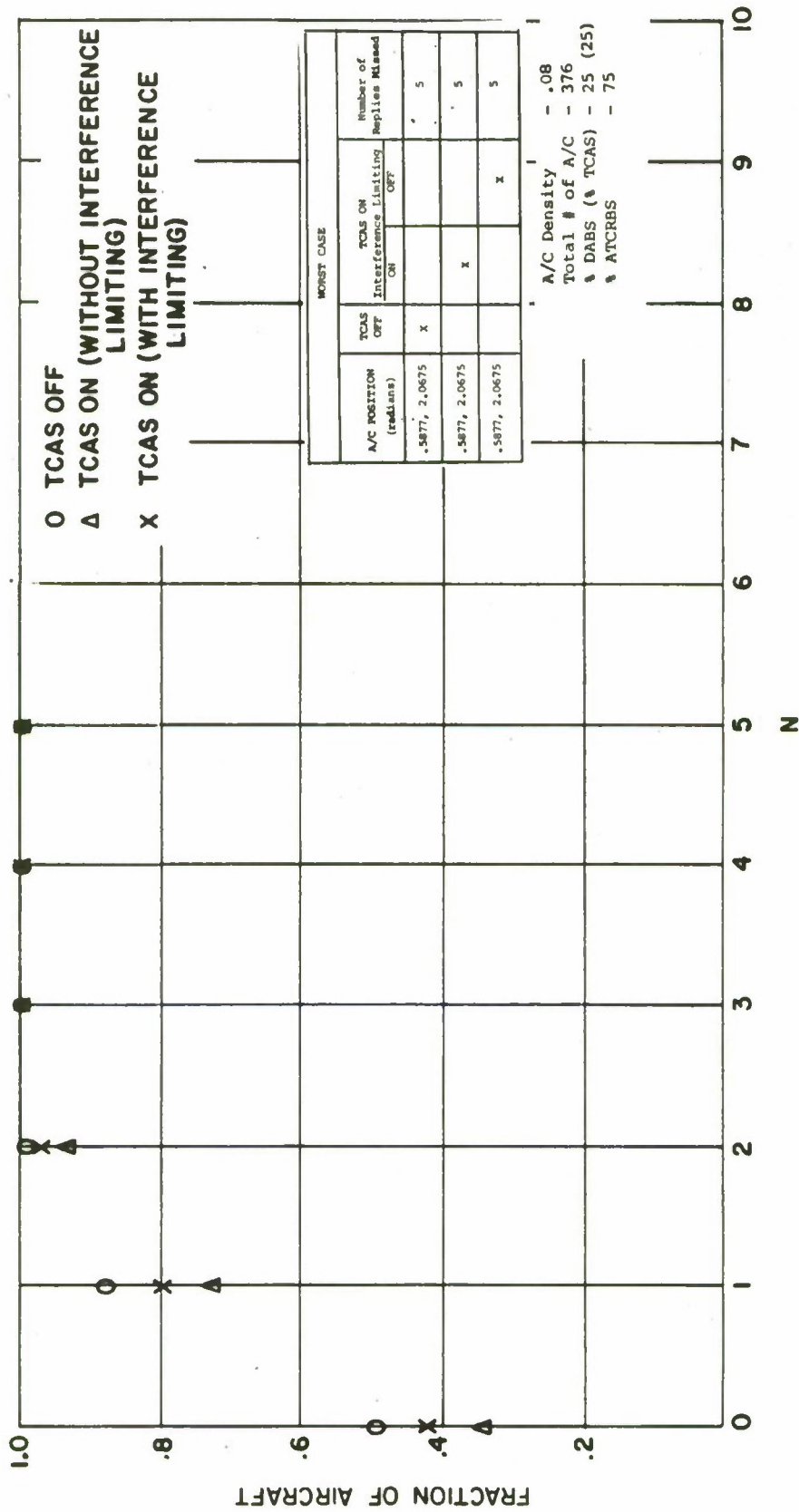


Figure B-3. Cumulative distribution for the number of missed interrogations (N) out of a possible 21 or 22 per mainbeam dwell for the Long Beach ATCRBS interrogator.

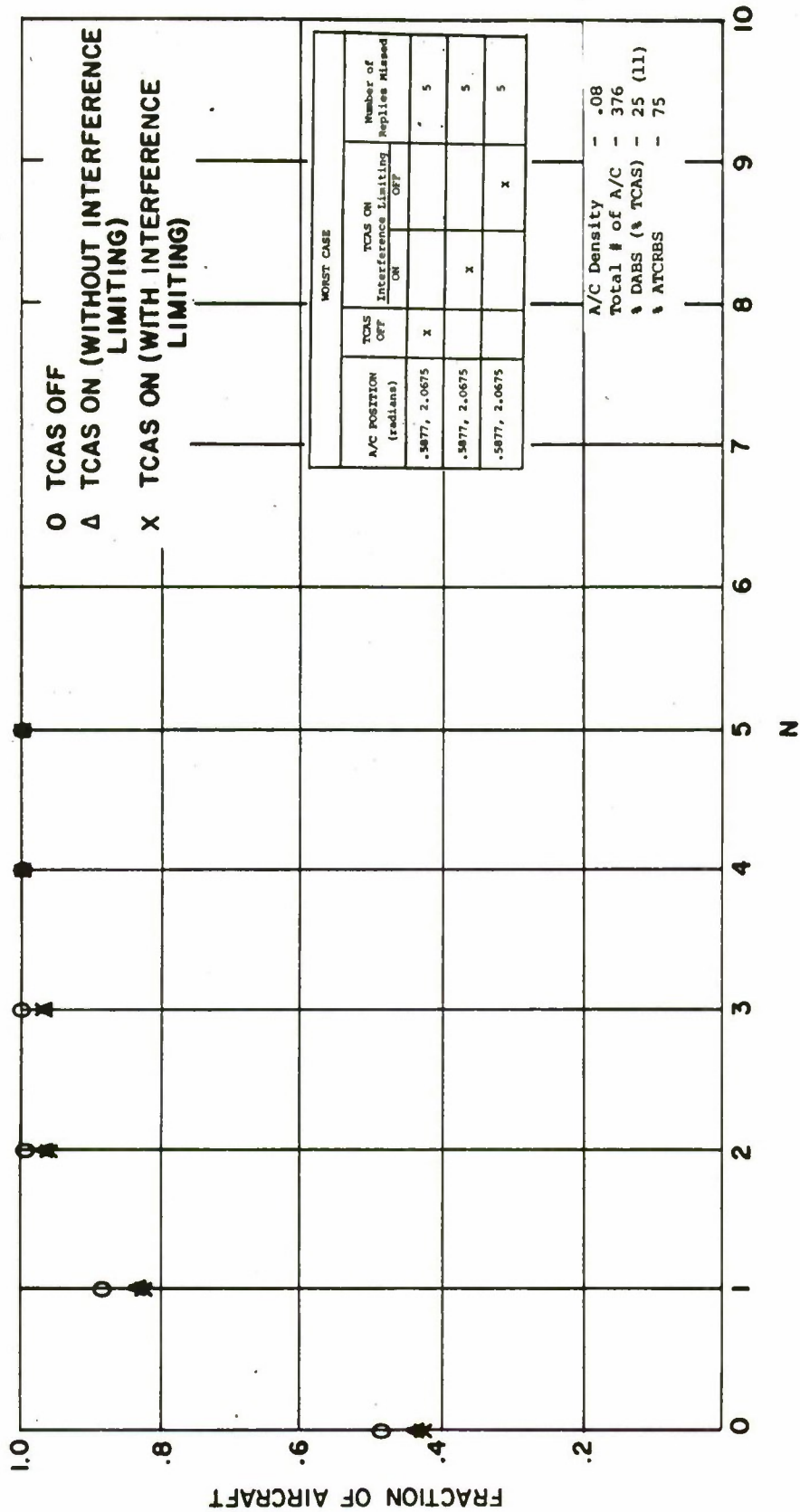


Figure B-4. Cumulative distribution for the number of missed interrogations (N) out of a possible 21 or 22 per mainbeam dwell for the Long Beach ATCRBS interrogator.

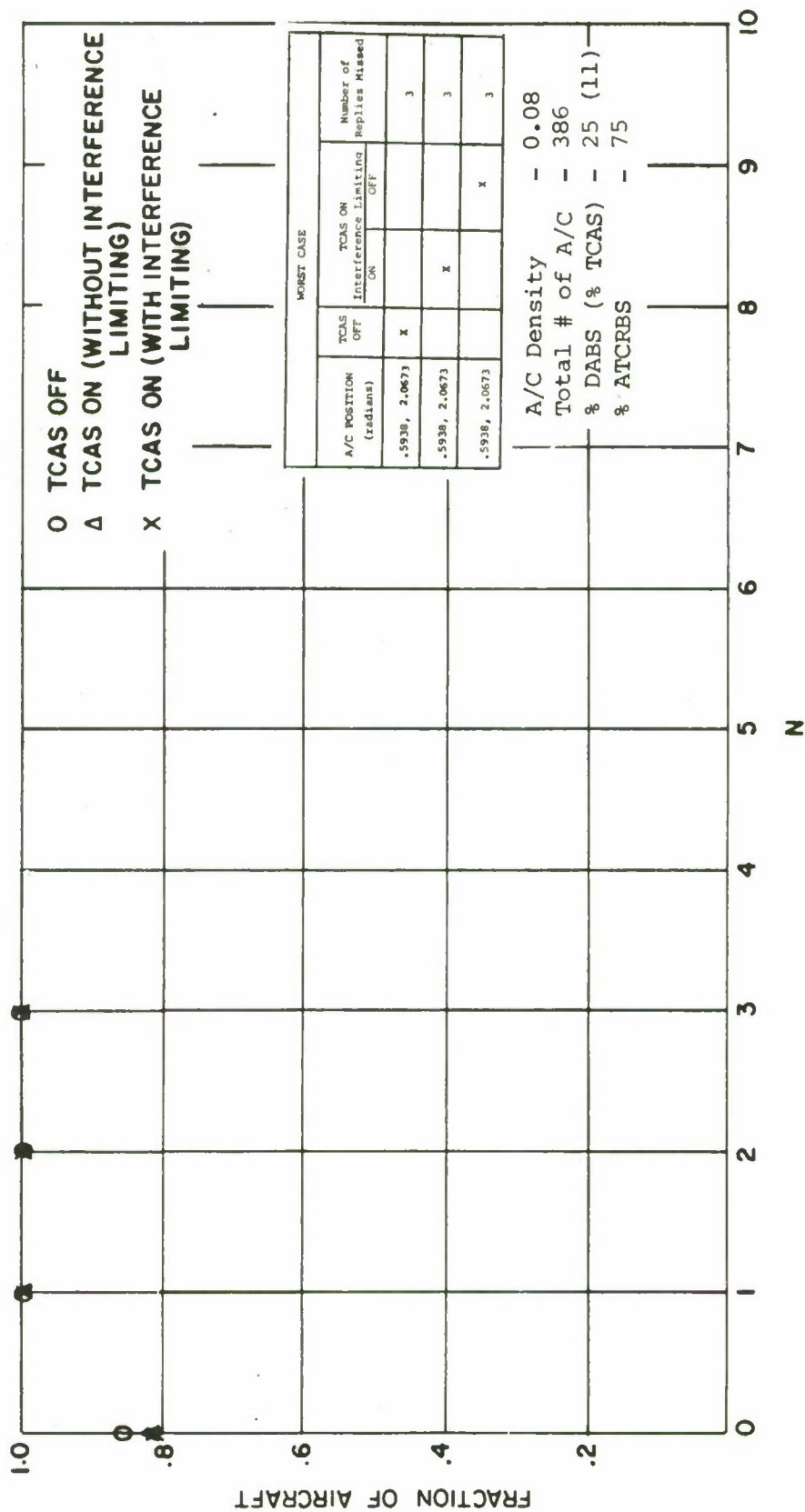


Figure B-5. Cumulative distribution for the number of missed interrogations (N) out of a possible 6 or 7 per mainbeam dwell for the Los Angeles DABS sensor. (ATCRBS transponders only)

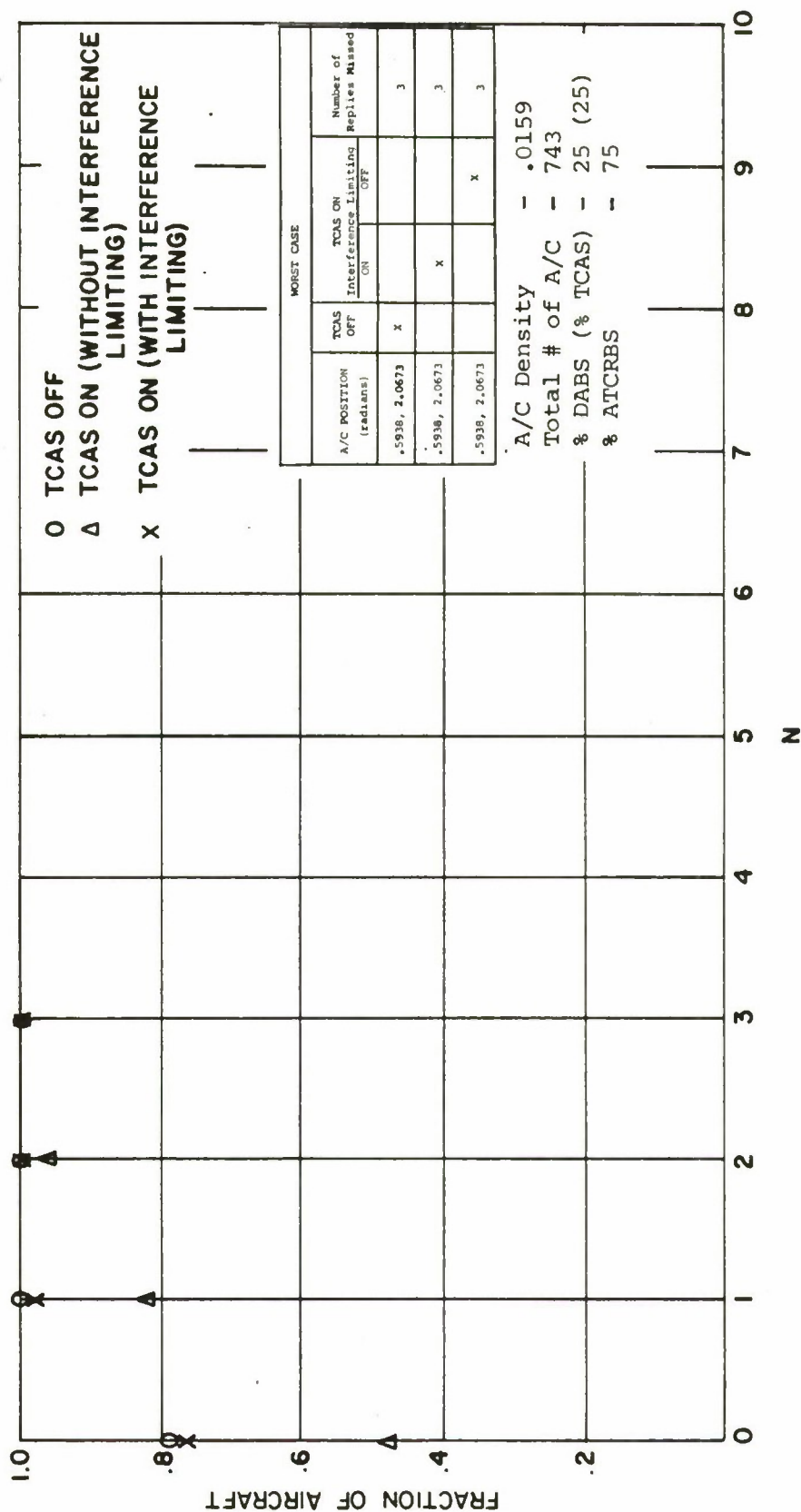


Figure B-6. Cumulative distribution for the number of missed interrogations (N) out of a possible 6 or 7 per mainbeam dwell for the Los Angeles DABS sensor. (ATCRBS transponders only)

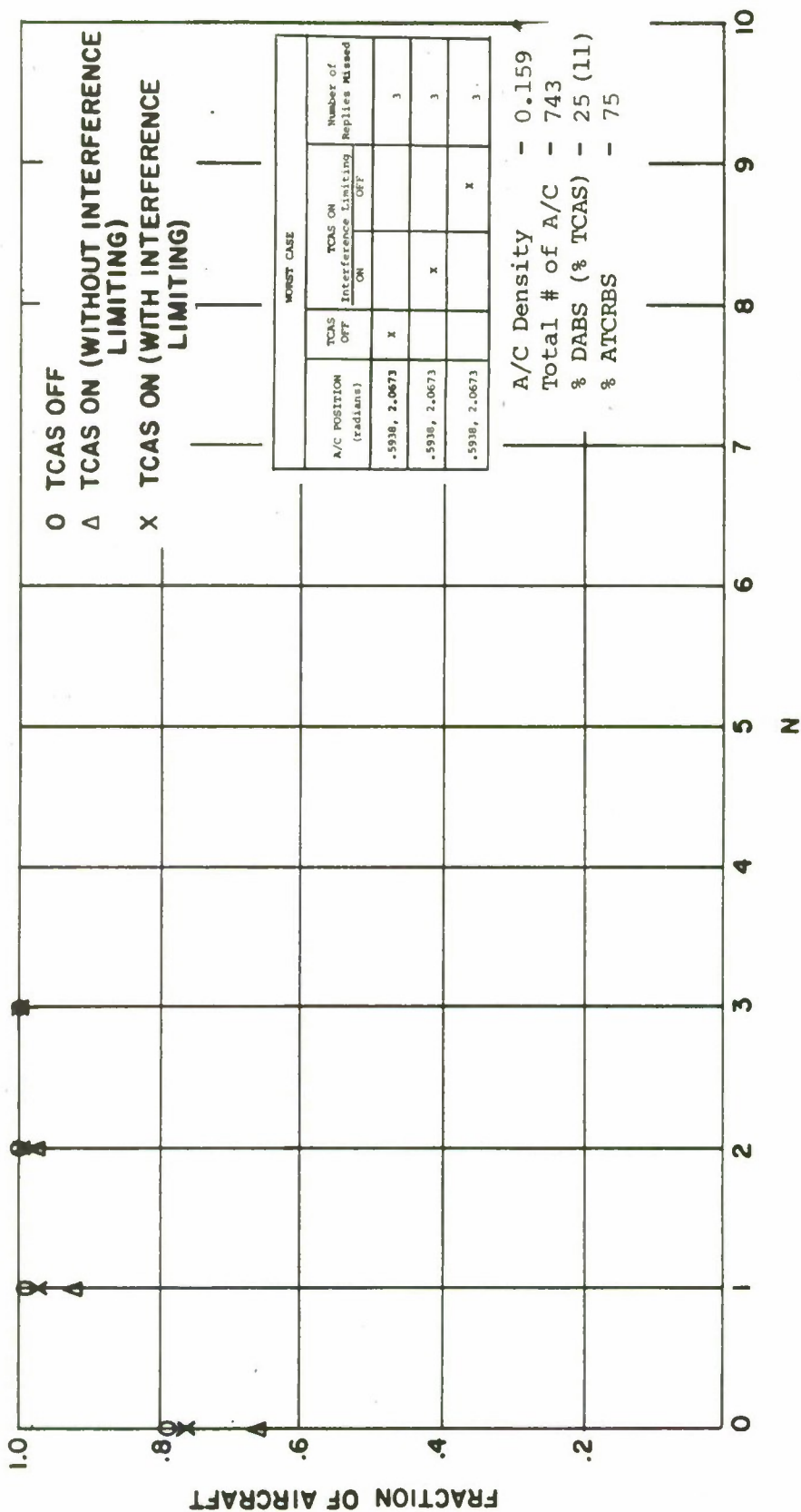


Figure B-7. Cumulative distribution for the number of missed interrogations (N) out of a possible 6 or 7 per mainbeam dwell for the Los Angeles DABS sensor. (ATCRBS transponders only)

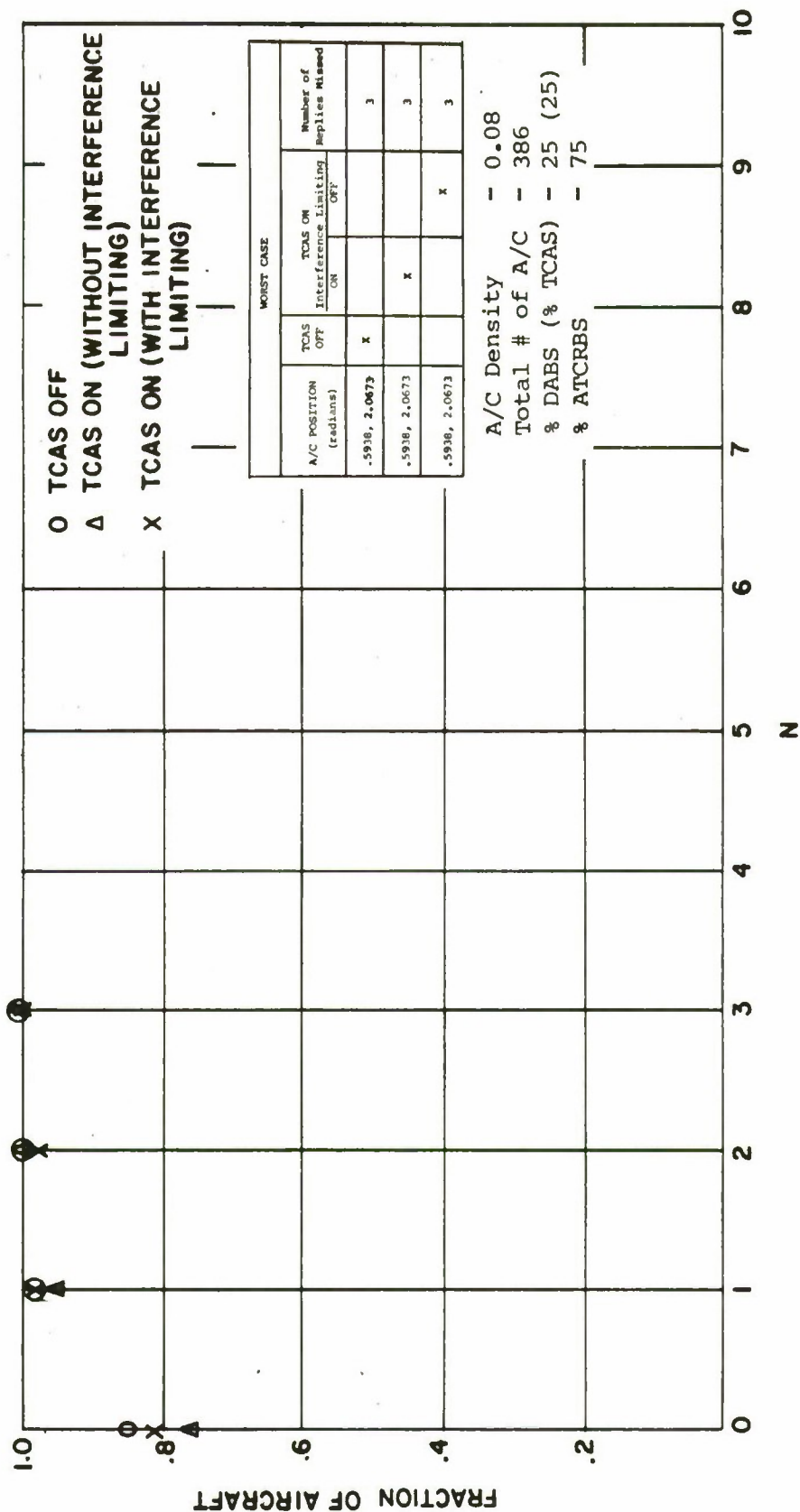


Figure B-8. Cumulative distribution for the number of missed interrogations (N) out of a possible 6 or 7 per mainbeam dwell for the Los Angeles DABS sensor. (ATCRBS transponders only)

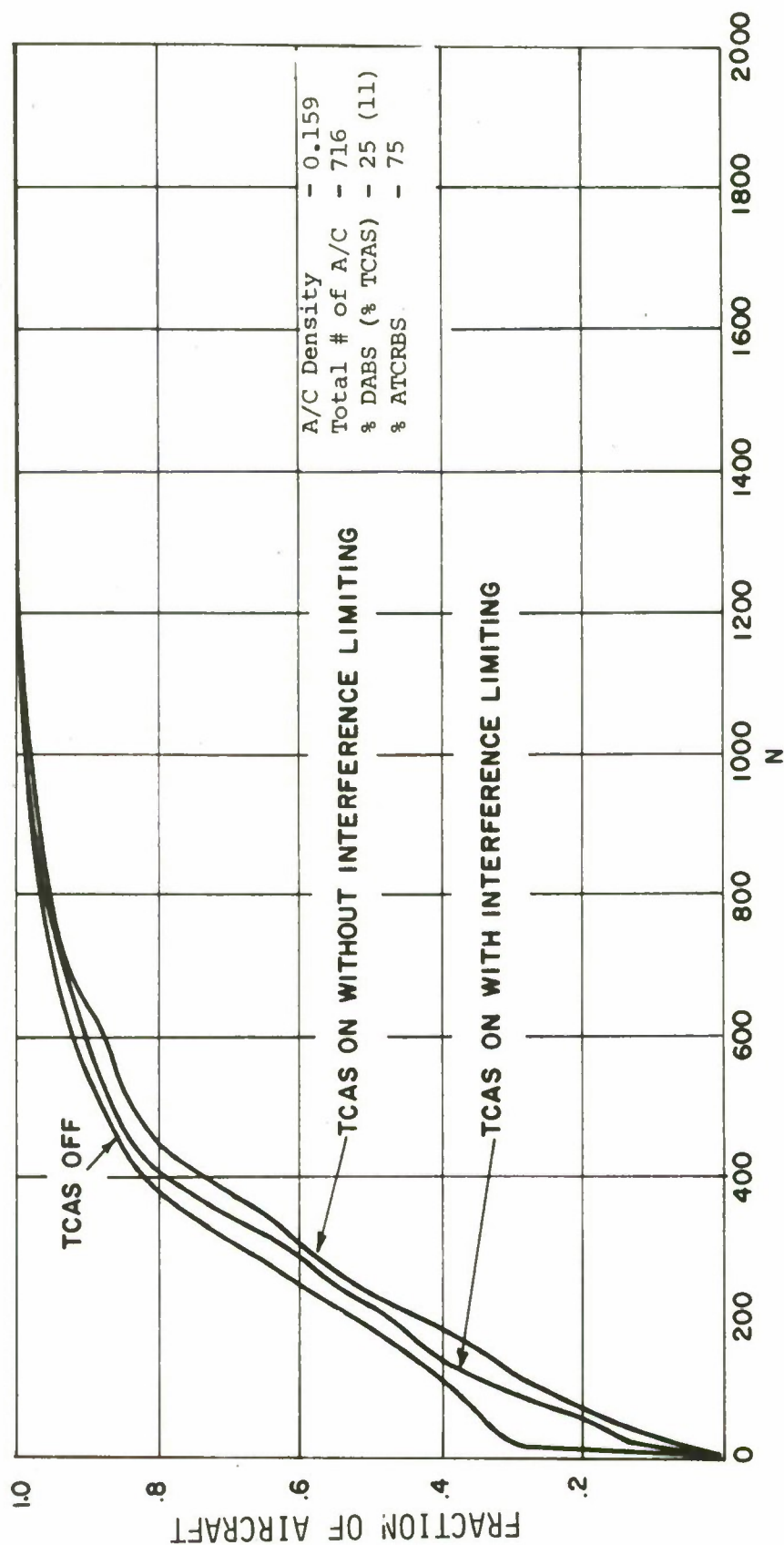


Figure B-9. Cumulative distribution for the total number of ATCRBS interrogations per second (N) received at the transponders. Long Beach simulations - no DABS sensors in the environment.

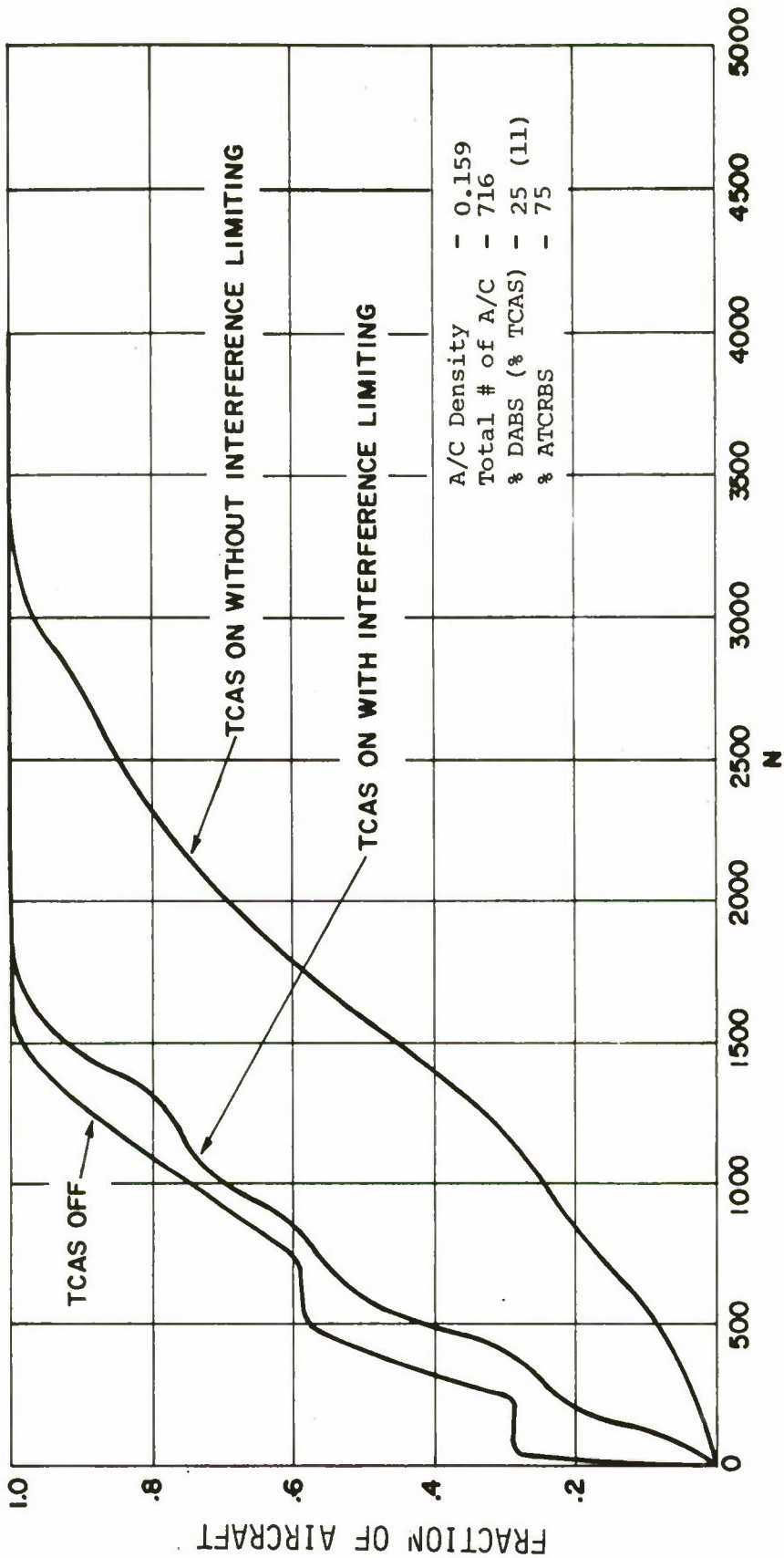


Figure B-10. Cumulative distribution for the total number of effective suppressions per second (N) received at the transponders. Long Beach simulations - no DABS sensors in the environment.

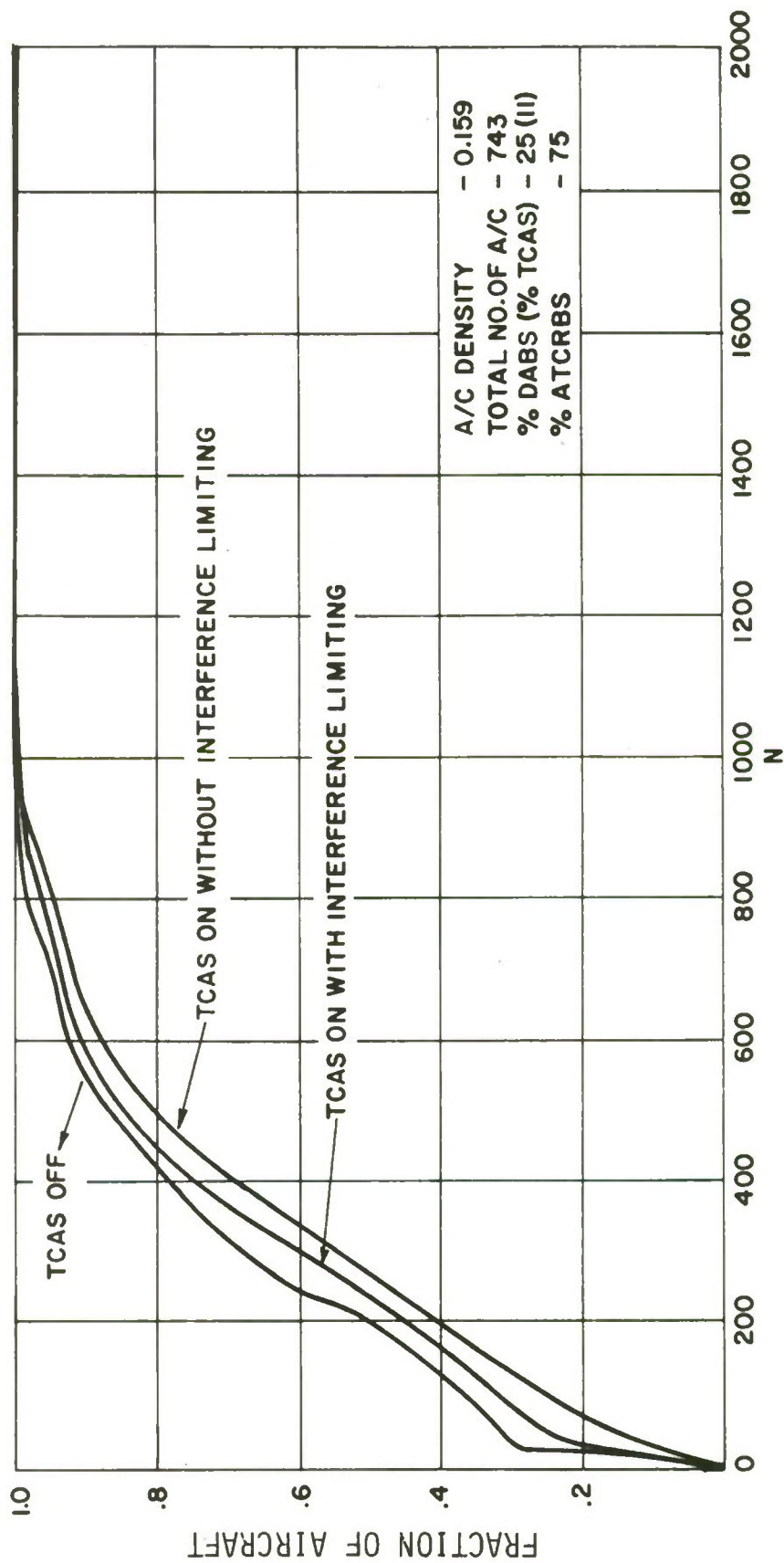


Figure B-11. Cumulative distribution for the total number of ATCRBS interrogations per second (N) received at the transponders. Los Angeles simulations.

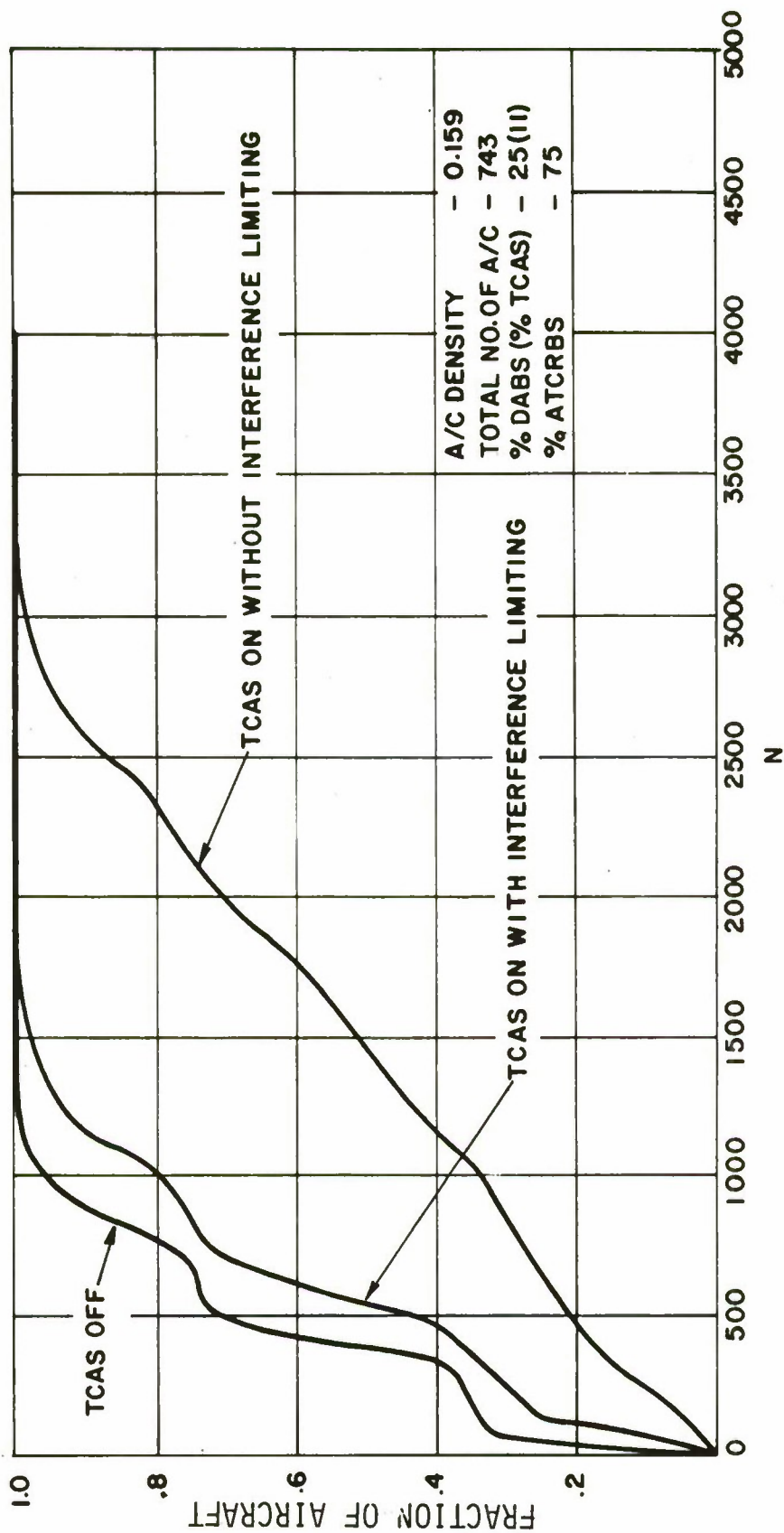


Figure B-12. Cumulative distribution for the total number of effective suppressions per second (N) received at the transponders. Los Angeles simulations.

APPENDIX C
TCAS SUBMODEL RESULTS

The following tables (C-1 through C-11) give TCAS submodel results for each of the simulations conducted in this analysis. Given are: 1) TCAS aircraft position, 2) the density of aircraft within 30 nmi about the TCAS-equipped aircraft, 3) the rate at which the TCAS-equipped aircraft transmits discretely addressed interrogations, and 4) the transmission power (at transmitter) of the TCAS-equipped aircraft. Also included are figures (C-1 through C-4) illustrating the locations of the TCAS-equipped aircraft that experienced interference-limiting.

The information in the tables is presented for the configurations shown in the following matrix:

CONDITION	TABLE NO.										
	1	2	3	4	5	6	7	8	9	10	11
With TCAS Interference- Limiting Function	X	-	X	-	X	X	-	X	-	X	X
Without TCAS Interference- Limiting Function	-	X	-	X	X	-	X	-	X	X	X
A/C per sq. nmi (within 30 nmi of LAX-4)	0.159	0.159	0.159	0.159	0.08	0.08	0.08	0.08	0.08	0.04	0.02
% A/C ATCRBS-equipped	75	75	75	75	75	75	75	46	46	75	75
% A/C DABS- equipped (% TCAS-equipped)	25 (11)	25 (11)	25 (25)	25 (25)	25 (11)	25 (25)	25 (25)	54 (25)	54 (25)	25 (11)	25 (11)

The legend given below is to be used in conjunction with Tables C-1 through C-11.

LAT	- Latitude in radians
LON	- Longitude in radians
ALT	- Altitude in feet
LOCAL DENSITY	- Density of A/C within 30 nmi of TCAS
INT RATE	- DABS interrogations per second transmitted by the TCAS unit
PWR	- TCAS transmission power at transmitter (watts)

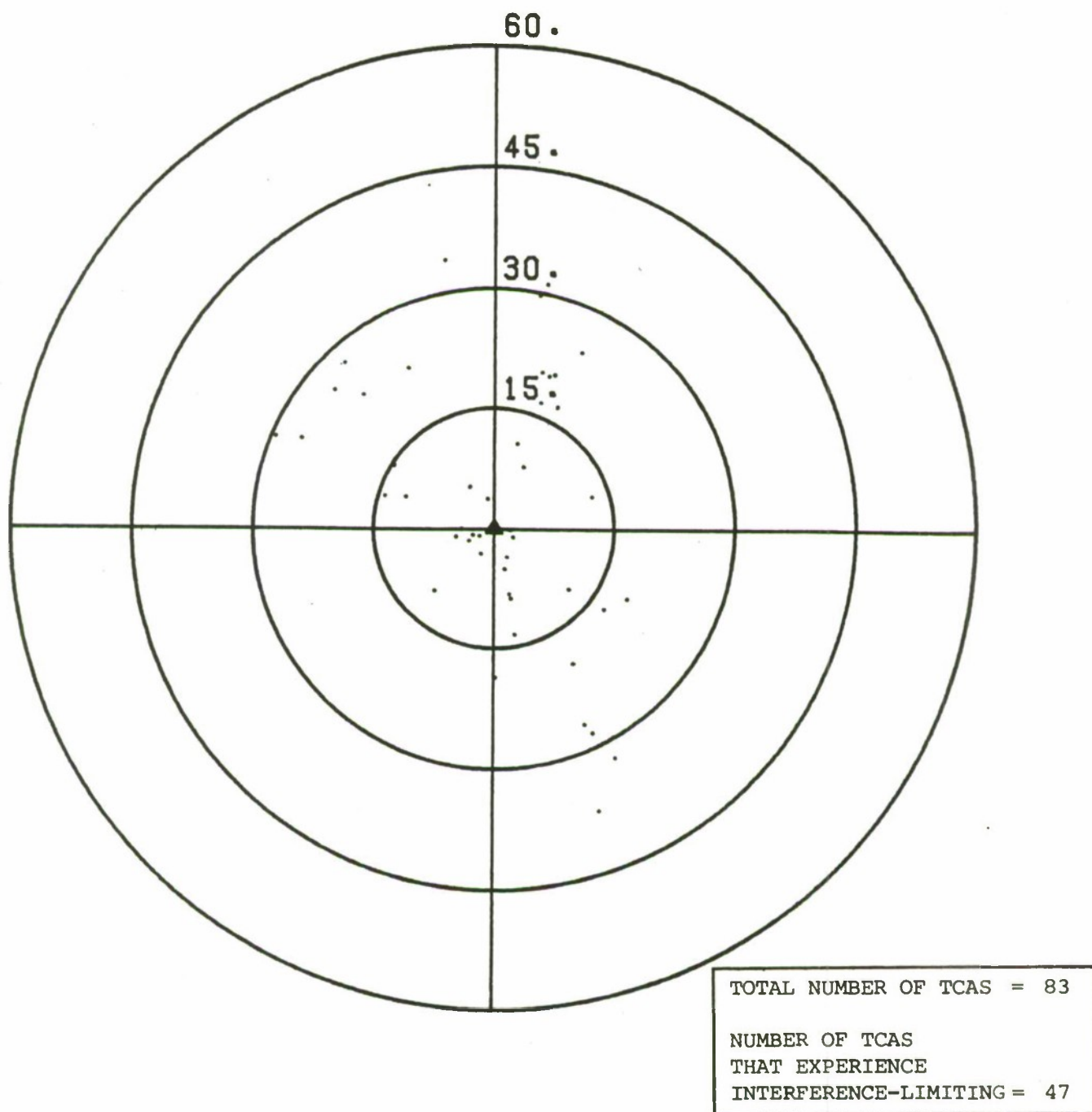


Figure C-1. Location of TCAS-equipped aircraft that experienced interference-limiting; Density = 0.159 A/C per square nmi, 25% DABS (11% TCAS). See TABLE C-1.

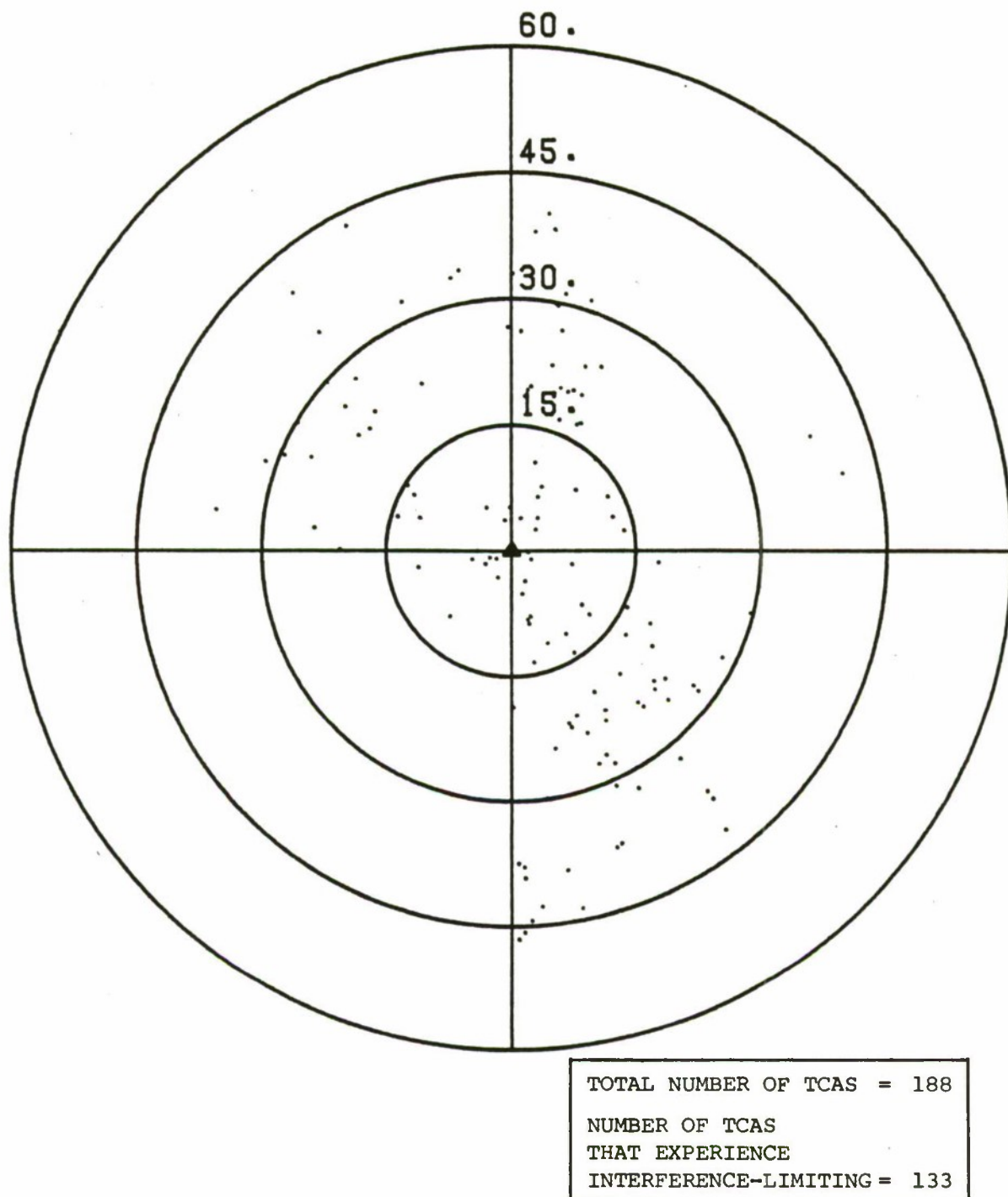


Figure C-2. Location of TCAS-equipped A/C that experienced interference-limiting; Density = 0.159 A/C per square nmi, 25% DABS (25% TCAS). See TABLE C-3.

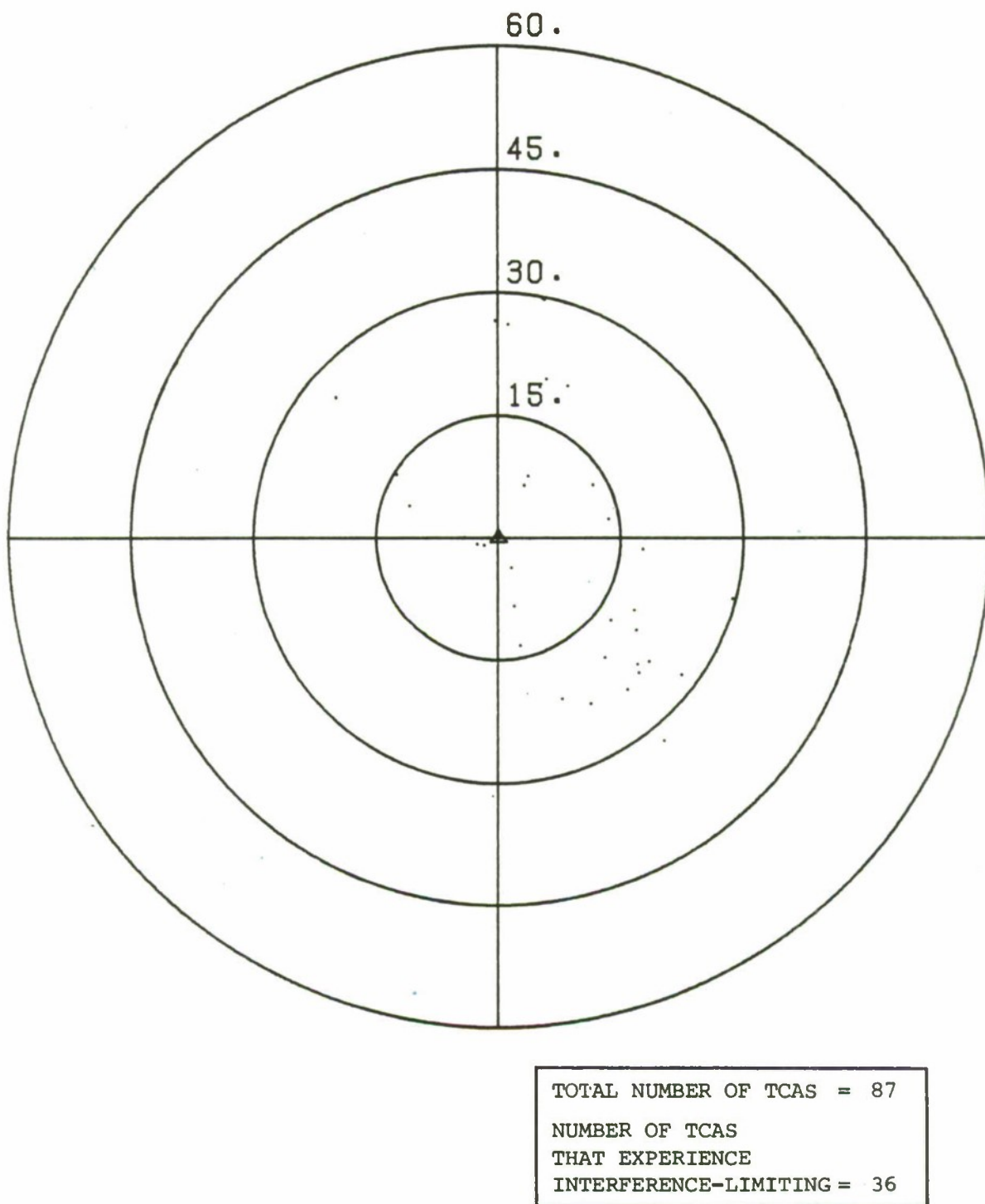


Figure C-3. Location of TCAS-equipped A/C that experienced interference-limiting; Density = 0.08 A/C per square nmi, 25% DABS (25% TCAS). See TABLE C-6.

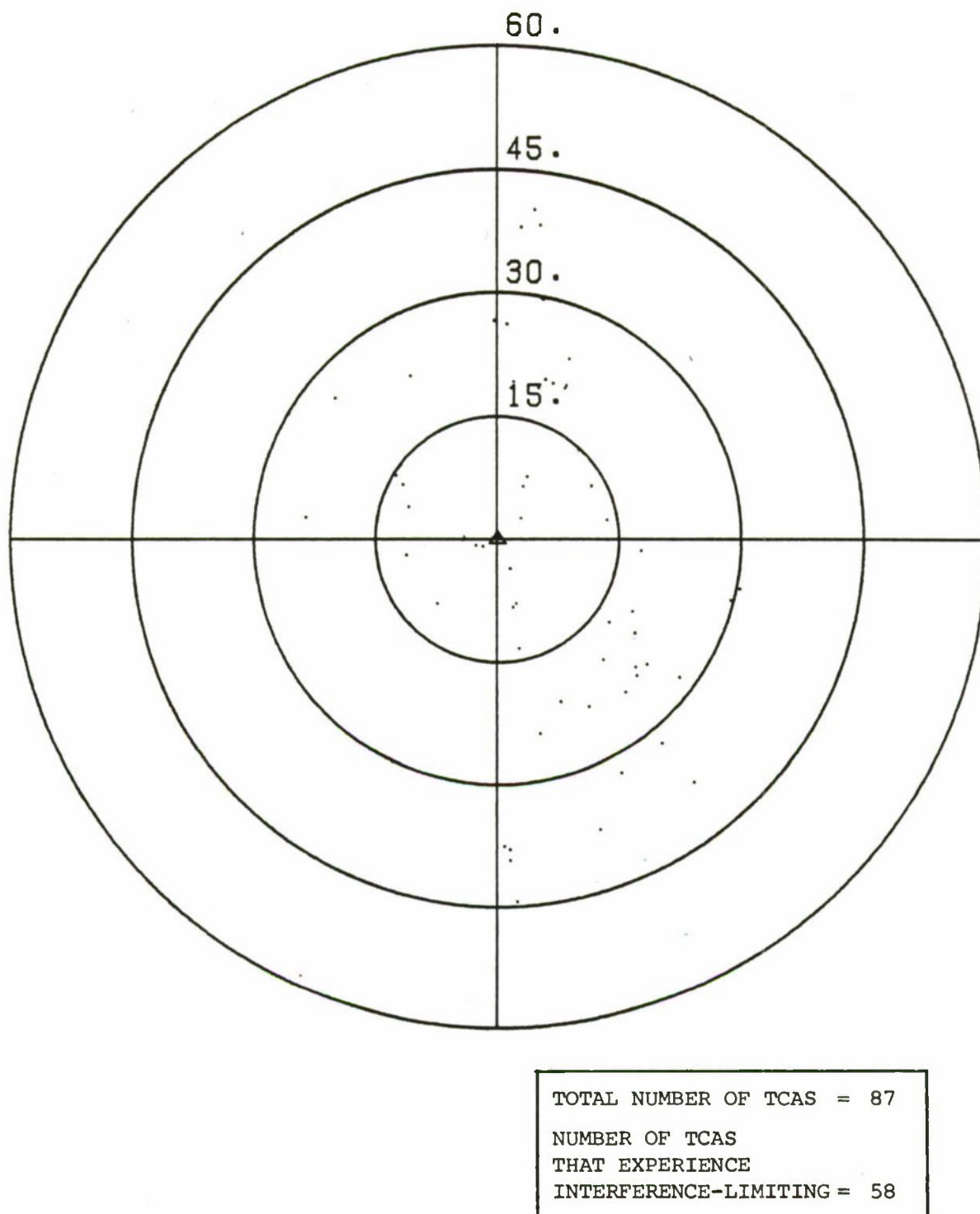


Figure C-4. Location of TCAS-equipped A/C that experienced interference-limiting; Density = 0.08 A/C per square nmi, 54% DABS (25% TCAS). See TABLE C-8.

TABLE C-1

LAT	LONG	ALT	LOCAL DENSITY	INT RATE	PWR	LAT	LONG	ALT	LOCAL DENSITY	INT RATE	PWR
.6625	2.06149	24218	.03482	1.43	500.	.59378	2.07125	800.	.12379	5.46	125.
.60665	2.05881	28719	.02371	1.43	300.	.59237	2.06740	1289.	.15537	18.15	125.
.59380	2.05244	9000.	.02016	4.54	500.	.59260	2.05792	1066.	.15137	17.22	125.
.59655	2.05389	8502.	.04350	6.47	500.	.59234	2.05710	456.	.15843	17.13	125.
.59591	2.05004	7500.	.01874	7.43	500.	.59591	2.05704	8502.	.05143	3.74	125.
.59266	2.05525	6000.	.09438	11.82	300.	.59320	2.06409	3500.	.11381	3.05	125.
.59345	2.05067	1998.	.15314	16.92	125.	.59374	2.07031	3535.	.13229	9.71	125.
.58755	2.05206	16000.	.05730	.35	300.	.59384	2.07432	8491.	.07213	5.10	125.
.58621	2.05547	10992.	.10009	.87	300.	.59486	2.07385	4996.	.12308	8.64	125.
.58422	2.05830	3503.	.11555	29.90	400.	.59230	2.06564	1000.	.16446	17.87	125.
.58467	2.06168	1394.	.15633	18.57	125.	.59225	2.07815	11002.	.04387	7.93	500.
.58099	2.05859	23831.	.08442	.01	300.	.59266	2.06517	100.	.16234	16.06	125.
.58198	2.05349	19994.	.18843	2.94	400.	.59159	2.07243	4995.	.09514	4.64	125.
.58674	2.05119	10494.	.14854	8.30	500.	.60129	2.07725	17000.	.03743	1.23	500.
.58467	2.05087	18320.	.12591	.57	500.	.55411	2.06753	6438.	.15431	12.77	125.
.58431	2.05116	2470.	.12379	11.07	125.	.59146	2.07222	9500.	.10747	7.14	125.
.58247	2.05188	3992.	.13610	9.92	125.	.59366	2.06675	3980.	.15845	18.91	125.
.58521	2.05215	3506.	.13793	19.96	125.	.59454	2.07306	5003.	.09458	7.75	125.
.57477	2.06323	4006.	.02476	3.37	500.	.59118	2.07057	21000.	.12045	5.16	125.
.58550	2.05251	5493.	.14147	19.36	125.	.60237	2.07633	21000.	.04173	2.54	500.
.57309	2.06605	7492.	.06189	5.55	300.	.55037	2.07025	7000.	.11707	6.50	125.
.57395	2.06616	5800.	.06189	13.44	500.	.60432	2.07462	24086.	.04421	1.56	500.
.58168	2.06303	3491.	.15335	21.47	125.	.60412	2.07430	6147.	.04845	8.07	500.
.58157	2.06594	1268.	.09256	17.03	300.	.60118	2.07111	5497.	.09136	5.27	125.
.57821	2.06914	2486.	.03537	.12	300.	.60485	2.07389	7580.	.04492	7.76	500.
.58117	2.06541	4504.	.15279	14.34	125.	.59481	2.06523	3800.	.15562	12.17	125.
.58414	2.06847	7539.	.14006	11.32	500.	.59368	2.05547	8000.	.14678	12.78	125.
.58372	2.06555	4283.	.15845	17.07	125.	.60196	2.06948	24090.	.08524	1.80	500.
.58461	2.07280	7000.	.18559	7.26	500.	.60202	2.06907	7177.	.08524	17.91	300.
.5504	2.06573	2461.	.16269	13.58	31.	.60008	2.05783	23994.	.11070	5.61	500.
.59020	2.05583	3876.	.16411	17.19	31.	.60225	2.05470	3818.	.08028	5.47	125.
.55032	2.06907	6000.	.14748	12.76	125.	.55715	2.06645	2995.	.13475	13.81	125.
.59202	2.08046	2500.	.13249	3.36	300.	.59825	2.05443	6236.	.12343	15.22	125.
.55040	2.06322	2503.	.16042	14.36	31.	.59810	2.06408	689.	.12556	16.59	125.
.59210	2.07871	14000.	.13678	.27	300.	.59537	2.06370	8996.	.13723	12.55	125.
.59158	2.08122	2698.	.13377	3.47	300.	.59814	2.06385	558.	.12449	10.23	125.
.59112	2.06692	2943.	.16343	20.67	31.	.60105	2.06444	3994.	.09136	16.72	125.
.59158	2.05706	2920.	.15916	17.55	31.	.60146	2.06414	4292.	.08382	8.53	125.
.59155	2.06592	1344.	.16537	20.61	31.	.60122	2.06508	10496.	.07922	8.86	500.
.55232	2.06814	2987.	.15057	16.34	11.	.55934	2.05266	2896.	.11503	16.81	125.
.59216	2.06756	1419.	.15526	15.70	31.	.59376	2.06220	2154.	.15420	13.45	125.
.59568	2.07584	3708.	.15654	9.14	125.						

TABLE C-2

LAT	LONG	ALT	LOCAL DENSITY	INT RATE	PWR	LAT	LONG	ALT	LOCAL DENSITY	INT RATE	PWR
.50425	2-05149	24218.	.04482	1.94	500.	.53378	2-07125	800.	.12379	14.15	500.
.50455	2-05391	29713.	.02771	1.62	500.	.53237	2-05740	1289.	.15577	40.24	500.
.51380	2-05244	3000.	.02016	4.53	500.	.53260	2-05732	1065.	.15137	37.92	500.
.51395	2-05399	8502.	.04330	5.16	500.	.53234	2-05710	656.	.15845	35.72	500.
.51541	2-05044	7500.	.01974	7.43	500.	.53591	2-07504	8002.	.06189	19.60	500.
.52265	2-05325	6000.	.09408	12.02	500.	.55920	2-09403	5500.	.01731	3.46	500.
.52005	2-05067	1998.	.15314	51.14	500.	.53374	2-07331	3655.	.13258	40.78	500.
.53765	2-05395	18009.	.07350	.38	500.	.53594	2-07432	9491.	.07213	14.10	500.
.53421	2-05347	10992.	.10039	.85	500.	.53486	2-07385	996.	.12304	34.91	500.
.53422	2-05330	3503.	.11355	27.26	500.	.55920	2-05554	100.	.15446	42.93	500.
.53767	2-05158	1494.	.15533	61.10	500.	.55925	2-07815	11002.	.07937	8.09	500.
.53094	2-05899	23851.	.04442	.01	500.	.53256	2-05577	100.	.15234	37.52	500.
.53198	2-05347	10994.	.10030	3.13	500.	.53759	2-07349	4995.	.07514	13.22	500.
.53574	2-05113	10494.	.14874	7.96	500.	.55019	2-07323	17000.	.05749	1.17	500.
.53467	2-05097	19320.	.12571	.60	500.	.53411	2-05733	6438.	.15431	38.93	500.
.53433	2-05115	2470.	.12379	42.30	500.	.53742	2-07222	9500.	.10787	17.71	500.
.53242	2-05188	3592.	.10510	38.02	500.	.53566	2-05674	3988.	.15345	52.67	500.
.53521	2-06215	3506.	.13793	47.88	500.	.53564	2-07306	5003.	.03959	21.26	500.
.53477	2-05323	4006.	.02476	3.36	500.	.53718	2-07057	23000.	.12036	5.33	500.
.53550	2-05251	3493.	.14147	43.46	500.	.60237	2-07533	21000.	.04173	2.70	500.
.53909	2-05505	9492.	.05199	3.86	500.	.53837	2-07026	7004.	.11707	25.97	500.
.53705	2-05615	5500.	.06139	11.61	500.	.60432	2-07452	24000.	.04421	1.62	500.
.53768	2-05303	5491.	.13385	58.86	500.	.60412	2-07430	6147.	.01345	7.82	500.
.53157	2-05594	1268.	.02255	17.08	500.	.60119	2-07111	5497.	.03196	18.52	500.
.53821	2-05914	24486.	.03537	.08	500.	.60495	2-07399	7500.	.04432	7.99	500.
.53717	2-05641	4503.	.13279	47.19	500.	.53401	2-05520	3800.	.15552	66.99	500.
.53514	2-05947	7539.	.14006	10.82	500.	.53568	2-05547	8000.	.14678	29.23	500.
.53473	2-05355	4203.	.13945	61.75	500.	.60196	2-06348	24000.	.09594	2.82	500.
.53861	2-07230	7000.	.08559	5.83	500.	.60202	2-05307	7177.	.09574	17.53	500.
.53004	2-05573	2861.	.16269	59.14	500.	.60008	2-05780	23994.	.11070	5.93	500.
.53020	2-05580	3876.	.16411	62.90	500.	.60229	2-05970	3810.	.08028	19.80	500.
.53033	2-05507	5000.	.18748	40.27	500.	.53715	2-05445	2995.	.13475	37.34	500.
.53202	2-04346	2500.	.03289	3.24	500.	.53925	2-05440	6236.	.12343	36.85	500.
.53040	2-05322	2503.	.15032	67.47	500.	.539810	2-05408	689.	.12536	24.07	500.
.53210	2-07371	16000.	.03578	.20	500.	.53967	2-05370	8994.	.13733	23.70	500.
.53158	2-08122	2698.	.03077	3.29	500.	.53814	2-05385	558.	.12449	22.96	500.
.53112	2-05602	2943.	.16340	44.09	500.	.60105	2-05448	3994.	.09136	32.40	500.
.53168	2-05706	2920.	.15915	50.04	500.	.60146	2-05414	4292.	.06362	31.01	500.
.53155	2-05592	1344.	.16597	44.58	500.	.60122	2-05308	10498.	.07922	9.84	500.
.53232	2-05914	2981.	.15057	43.96	500.	.53984	2-05266	2806.	.11565	27.05	500.
.53216	2-05755	1919.	.13926	43.84	500.	.53376	2-05320	2151.	.13420	37.92	500.
.53568	2-07584	3008.	.05639	9.05	500.						

TABLE C-3
(Page 1 of 2)

LAT	LONG	ALT	LOCAL DENSITY	INT RATE	PWR	LAT	LONG	ALT	LOCAL DENSITY	INT RATE	PWR
.60425	2.06189	24210.	.05882	2.11	500.	.58734	2.06118	3995.	.14961	20.08	31.
.59329	2.06173	1255.	.15739	5.63	31.	.58674	2.06119	10498.	.14854	7.85	500.
.60665	2.05881	28719.	.10271	1.50	500.	.58467	2.06087	18320.	.12591	.51	500.
.59700	2.05452	7493.	.10929	8.97	500.	.58433	2.06116	2470.	.12379	8.80	31.
.60129	2.05454	5922.	.03714	4.57	500.	.57821	2.06118	5316.	.02157	2.32	500.
.59342	2.05962	10497.	.14501	7.77	500.	.58242	2.06182	3992.	.10613	8.97	125.
.59063	2.06162	1266.	.15951	7.96	31.	.58833	2.06193	4500.	.15137	18.82	31.
.59220	2.06027	2991.	.15314	5.91	31.	.58229	2.06207	1998.	.10575	8.89	125.
.59980	2.05244	9000.	.02016	4.60	500.	.58440	2.06210	1997.	.12697	8.07	31.
.59955	2.05389	8502.	.04350	2.72	125.	.58521	2.06215	3506.	.13793	14.41	31.
.59720	2.05280	2500.	.02723	6.95	500.	.57477	2.06223	4006.	.02476	3.52	500.
.59704	2.05230	8493.	.02193	6.90	500.	.58550	2.06251	5493.	.14147	14.90	31.
.59527	2.05253	5427.	.03183	6.84	125.	.58516	2.06257	4497.	.08205	6.43	125.
.59560	2.05185	3500.	.02122	7.54	500.	.58667	2.06254	1451.	.15067	14.04	31.
.59581	2.05036	2885.	.01733	5.28	500.	.58518	2.06284	9500.	.13935	7.84	125.
.59541	2.05044	7500.	.01874	7.47	500.	.58706	2.06257	8492.	.15137	12.35	31.
.59266	2.05525	6000.	.09408	11.81	500.	.57658	2.06232	6008.	.03643	9.18	500.
.59255	2.05425	1621.	.08099	9.98	500.	.58147	2.06217	2597.	.09797	11.77	125.
.59135	2.05604	3405.	.11459	7.31	125.	.58020	2.06210	2603.	.07392	9.22	125.
.59082	2.05606	3405.	.11601	12.64	500.	.58624	2.06330	3498.	.14996	14.55	31.
.59043	2.05645	3401.	.12317	7.72	125.	.57972	2.06367	2503.	.06826	8.96	125.
.59005	2.06067	1998.	.15314	12.32	31.	.57931	2.06594	2228.	.06402	7.01	125.
.58765	2.05206	16000.	.05753	.37	500.	.57909	2.06605	9492.	.06169	5.80	500.
.58890	2.05764	4480.	.13228	9.56	125.	.57905	2.06616	5500.	.06189	6.52	125.
.58621	2.05547	10992.	.10009	.76	500.	.58105	2.06572	13494.	.08700	1.70	500.
.58780	2.05886	1694.	.14784	15.90	31.	.58768	2.06603	5491.	.15385	17.29	31.
.58773	2.05845	1693.	.14147	11.52	31.	.58119	2.06592	2166.	.08736	9.10	125.
.58818	2.06005	1692.	.13652	11.34	31.	.58157	2.06594	1268.	.09266	7.55	125.
.58011	2.05417	3003.	.14819	14.27	31.	.58399	2.06499	2505.	.12485	5.95	125.
.58253	2.05610	5922.	.03608	5.66	500.	.58169	2.06612	704.	.09231	7.74	125.
.58781	2.05992	2994.	.08524	9.73	500.	.58645	2.06797	304.	.15067	7.37	31.
.58246	2.05667	6498.	.14572	12.42	31.	.58688	2.06375	6495.	.15244	15.23	31.
.58808	2.06053	1997.	.08983	12.16	500.	.58658	2.06408	908.	.15137	8.68	31.
.58422	2.05830	3503.	.14819	15.44	31.	.57821	2.06914	24466.	.03537	.08	500.
.58398	2.05805	4513.	.11247	9.51	125.	.58572	2.06665	7491.	.14289	10.79	31.
.58289	2.05753	3496.	.11565	9.04	125.	.58717	2.06641	4504.	.15279	8.74	31.
.58778	2.06048	1225.	.09832	6.21	125.	.58614	2.06947	7539.	.14006	11.31	500.
.58537	2.05941	3003.	.14784	15.35	31.	.58905	2.06386	1096.	.15986	12.85	31.
.58677	2.05941	1494.	.12945	7.04	31.	.58873	2.06555	4203.	.15845	9.28	31.
.58099	2.05899	23851.	.15433	13.75	31.	.58938	2.06497	2495.	.16092	10.54	31.
.58720	2.05396	0.	.08442	.01	500.	.58972	2.06491	7496.	.16340	9.84	31.
.58198	2.05949	10994.	.14854	16.43	31.	.58621	2.07140	7000.	.08559	6.28	500.
			.10080	2.83	500.	.59004	2.06573	2881.	.16269	13.76	31.
						.59005	2.07054	10492.	.12839	6.30	500.

TABLE C-3
(Page 2 of 2)

LAT	LONG	ALT	LOCAL DENSITY	INT RATE	PWR	LAT	LONG	ALT	LOCAL DENSITY	INT RATE	PWR
.59020	2.06550	3876.	.16411	17.64	31.	.59334	2.06546	8500.	.16234	7.37	31.
.59033	2.06907	6000.	.14748	8.40	31.	.59337	2.06334	2188.	.16517	14.83	31.
.59032	2.06567	8500.	.16375	6.22	31.	.59343	2.07026	7004.	.11707	6.47	125.
.59202	2.08046	2500.	.03289	3.29	500.	.59374	2.06536	2991.	.16022	15.79	31.
.59040	2.06322	2503.	.16092	14.33	31.	.59432	2.07448	24021	.08421	1.43	500.
.59210	2.07871	16000.	.03678	.25	500.	.60223	2.07448	4492.	.04527	6.61	500.
.59358	2.08122	2698.	.03077	3.34	500.	.60412	2.07430	6147.	.04845	6.52	500.
.59268	2.07368	9454.	.07746	2.74	125.	.60380	2.07339	6500.	.05553	3.67	125.
.59112	2.06602	2943.	.16340	.00	0.	.59446	2.07111	5497.	.09196	4.92	125.
.59205	2.07040	7010.	.12980	9.02	125.	.59485	2.06536	2593.	.15845	11.44	31.
.59402	2.07891	4502.	.03961	3.09	125.	.60485	2.07389	7500.	.04492	7.99	500.
.59338	2.07975	4603.	.06720	3.27	125.	.59481	2.06520	3800.	.15562	11.99	31.
.59475	2.07916	8494.	.03997	7.93	500.	.59418	2.06758	19994.	.12732	3.63	500.
.59168	2.06706	2920.	.15916	17.79	31.	.59568	2.06547	8000.	.14678	10.08	31.
.59072	2.06353	4496.	.16022	17.67	31.	.60196	2.06948	24000.	.08594	2.66	500.
.59607	2.08040	8498.	.03678	9.21	500.	.60202	2.06907	7177.	.08524	7.67	125.
.59155	2.06592	1344.	.16587	.00	0.	.60008	2.06780	23994.	.11070	5.51	500.
.59232	2.06814	2987.	.15067	18.00	31.	.60229	2.06870	3610.	.08028	5.47	125.
.59216	2.06756	1919.	.15526	16.58	31.	.59817	2.06537	3493.	.12520	10.79	31.
.59568	2.07684	3008.	.05659	1.98	125.	.60032	2.06663	6495.	.10646	11.97	125.
.59378	2.07125	800.	.12379	5.58	125.	.59829	2.06563	4496.	.12379	16.72	31.
.59237	2.06740	1289.	.15597	15.55	31.	.59470	2.06375	2597.	.15491	10.58	31.
.59260	2.06792	1066.	.15137	14.08	31.	.60019	2.06606	4541.	.10893	11.17	31.
.59483	2.08266	8497.	.02617	4.96	500.	.60218	2.06643	3495.	.07781	12.30	125.
.59234	2.06710	656.	.15845	13.38	31.	.59715	2.06445	2995.	.13475	10.85	31.
.59591	2.07634	8532.	.06189	3.77	125.	.59794	2.06449	1017.	.12697	8.41	31.
.59736	2.07948	23000.	.08315	.50	500.	.59900	2.06473	6497.	.12025	16.90	31.
.59920	2.08439	9500.	.10181	3.17	500.	.59825	2.06440	6236.	.12343	11.42	31.
.59374	2.07031	3655.	.13228	10.14	125.	.59810	2.06408	689.	.12556	7.80	31.
.59584	2.07492	8491.	.07215	6.10	125.	.60000	2.07000	4396.	.10646	7.25	125.
.59909	2.08227	9500.	.02865	5.57	500.	.59697	2.06370	8996.	.13723	10.01	31.
.59753	2.07537	8495.	.12874	7.10	125.	.60363	2.06544	5007.	.06331	4.74	125.
.59705	2.07550	4007.	.08755	6.45	125.	.59814	2.06385	558.	.12449	7.95	31.
.59486	2.07086	4996.	.12308	8.10	125.	.60112	2.06458	2303.	.09125	10.13	125.
.59230	2.06564	100.	.16446	17.63	31.	.60020	2.06432	4500.	.10964	14.77	31.
.59925	2.07915	11002.	.04987	7.86	500.	.59703	2.06354	9494.	.13652	10.31	31.
.59659	2.07292	6495.	.10257	9.47	125.	.60715	2.06597	5097.	.04350	8.51	500.
.59256	2.06517	100.	.16234	16.44	31.	.60105	2.06486	3994.	.09196	10.83	125.
.59882	2.07246	7464.	.10681	7.83	125.	.60424	2.06486	1341.	.05906	3.08	125.
.59759	2.07349	4995.	.09514	8.43	125.	.59798	2.06450	5830.	.12626	11.94	31.
.60129	2.07925	17000.	.03749	1.15	500.	.60369	2.06461	5494.	.06083	5.46	125.
.59411	2.06753	6438.	.15491	13.50	31.	.60146	2.06444	4292.	.08162	9.15	125.
.59742	2.07222	9500.	.10787	7.10	125.	.59576	2.06292	4497.	.14784	12.11	31.
.59366	2.06675	3988.	.15845	18.72	31.	.60751	2.06510	9500.	.04244	3.94	500.
.59854	2.07306	5003.	.09868	7.96	125.	.59896	2.06345	8500.	.11813	11.40	125.
.60015	2.07460	8494.	.07357	4.29	125.	.59447	2.06241	7500.	.15208	8.67	125.
.59718	2.07057	23000.	.12096	5.29	500.	.60122	2.06308	10498.	.07922	1.86	125.
.60148	2.07574	9500.	.05305	1.81	125.	.59894	2.06266	2806.	.11565	10.97	125.
.59373	2.06610	5679.	.16092	20.40	31.	.59376	2.06220	2151.	.15420	7.40	31.
.59411	2.06656	10492.	.15739	7.04	125.	.60693	2.06299	8500.	.07759	3.32	500.
.60237	2.07633	21000.	.04173	2.64	500.						

TABLE C-4
(Page 1 of 2)

LAT	LONG	ALT	LOCAL DENSITY	INT RATE	PWR	LAT	LONG	ALT	LOCAL DENSITY	INT RATE	PWR
.60425	2.06149	24218.	.05482	2.04	500.	.58734	2.06118	3995.	.14961	55.19	500.
.59329	2.06173	1255.	.15739	41.22	500.	.58674	2.06110	10494.	.14854	7.98	500.
.60665	2.05881	28719.	.02971	1.47	500.	.58467	2.06087	18320.	.12591	.57	500.
.59700	2.05852	7493.	.10929	9.63	500.	.58433	2.06116	2470.	.12379	43.67	500.
.60129	2.05854	5922.	.03714	3.59	500.	.57421	2.06168	5316.	.02157	2.87	500.
.59342	2.05962	10477.	.14501	7.29	500.	.58242	2.06188	3992.	.10610	36.49	500.
.59063	2.06162	1266.	.15951	60.07	500.	.58833	2.06193	4500.	.15137	66.50	500.
.59220	2.06027	2991.	.15314	34.21	500.	.58229	2.06207	1994.	.10575	28.31	500.
.59980	2.05244	9000.	.02016	4.50	500.	.58440	2.06210	1997.	.12697	43.80	500.
.59655	2.05789	8502.	.04350	6.76	500.	.58521	2.06215	3506.	.13793	48.11	500.
.59720	2.05280	2500.	.02123	6.99	500.	.57477	2.06223	4006.	.02476	3.71	500.
.59704	2.05230	8493.	.02193	6.31	500.	.58550	2.06251	5493.	.14147	45.41	500.
.59527	2.05253	5427.	.03183	11.58	500.	.58016	2.06253	4497.	.08205	17.04	500.
.59560	2.05145	3500.	.02122	7.42	500.	.58667	2.06254	1451.	.15067	50.22	500.
.59581	2.05036	2885.	.01733	5.39	500.	.58518	2.06284	9500.	.13935	15.75	500.
.59511	2.05044	7500.	.01874	7.31	500.	.58706	2.06257	8492.	.15137	22.52	500.
.59266	2.05225	6000.	.09408	13.41	500.	.57658	2.06332	6004.	.03643	8.90	500.
.59235	2.05425	1621.	.08099	9.26	500.	.58147	2.06413	2597.	.09797	20.12	500.
.59135	2.05608	3405.	.11459	13.90	500.	.58020	2.06320	2603.	.07392	16.96	500.
.59082	2.05606	3405.	.11601	11.41	500.	.58624	2.06330	3498.	.14996	53.68	500.
.59043	2.05645	3401.	.12237	25.24	500.	.57972	2.06363	2503.	.06826	12.98	500.
.59005	2.05667	1998.	.15314	49.85	500.	.57931	2.06594	2228.	.06402	12.30	500.
.58765	2.05206	16000.	.05730	.27	500.	.57909	2.06605	9492.	.06189	6.51	500.
.58690	2.05744	4460.	.13248	34.84	500.	.57905	2.06616	5500.	.06189	14.50	500.
.58621	2.05547	10992.	.10009	1.41	500.	.58105	2.06572	13494.	.08700	2.20	500.
.58928	2.06056	1097.	.14784	42.73	500.	.58768	2.06303	5491.	.15345	68.33	500.
.58790	2.05886	1694.	.14147	36.14	500.	.58119	2.06392	2166.	.08736	16.46	500.
.58773	2.05565	1693.	.13652	36.08	500.	.58157	2.06594	1268.	.09266	16.91	500.
.58818	2.06007	1692.	.14019	46.58	500.	.58399	2.06495	2505.	.12485	34.64	500.
.58011	2.05417	3003.	.03608	4.85	500.	.58169	2.06618	704.	.09231	16.62	500.
.58233	2.05610	5492.	.08524	9.48	500.	.58645	2.06397	304.	.15067	41.48	500.
.58741	2.05992	2994.	.14572	53.81	500.	.58688	2.06375	6495.	.15244	46.89	500.
.58246	2.05667	6498.	.08983	11.43	500.	.58658	2.06408	908.	.15137	43.96	500.
.58808	2.06053	1997.	.14019	47.58	500.	.58721	2.06714	24480.	.03537	.07	500.
.58398	2.05805	4513.	.11247	22.02	500.	.58572	2.06765	7491.	.14289	32.32	500.
.58422	2.05330	3503.	.11565	30.03	500.	.58717	2.06641	4508.	.15279	46.36	500.
.58299	2.05753	3496.	.09432	15.76	500.	.58614	2.06647	7539.	.14006	10.98	500.
.58778	2.06048	1225.	.14184	50.64	500.	.58905	2.06386	1096.	.15946	60.29	500.
.58537	2.05941	3003.	.12945	42.96	500.	.58073	2.06555	4203.	.15845	63.02	500.
.58697	2.06168	1494.	.15633	59.86	500.	.58938	2.06497	2495.	.16092	69.58	500.
.58099	2.05899	23851.	.08842	.01	500.	.58972	2.06419	7496.	.16340	34.20	500.
.58720	2.06096	0.	.14854	40.50	500.	.58861	2.07280	7000.	.08559	6.91	500.
.58198	2.05949	10994.	.10060	2.93	500.	.59004	2.06573	2861.	.16269	59.34	500.
						.59005	2.07054	10492.	.12839	7.38	500.

TABLE C-4
(Page 2 of 2)

LAT	LONG	ALT	LOCAL DENSITY	INT RATE	PWR	LAT	LONG	ALT	LOCAL DENSITY	INT RATE	PWR
.59020	2.06580	3876.	.16411	66.18	500.	.59334	2.06596	8500.	.16234	26.15	500.
.59033	2.06907	6000.	.14748	39.26	500.	.59213	2.06798	2188.	.16517	66.70	500.
.59032	2.06567	8500.	.16375	30.15	500.	.59837	2.07026	7004.	.11707	25.05	500.
.59040	2.06746	2500.	.03289	3.07	500.	.59374	2.06536	2991.	.16022	49.45	500.
.59040	2.06742	2503.	.03289	65.83	500.	.60432	2.07462	24000.	.04421	1.55	500.
.59210	2.07071	16000.	.03678	3.30	500.	.60423	2.07444	4492.	.04527	5.88	500.
.59358	2.08122	2698.	.03077	3.25	500.	.60423	2.07444	6147.	.04845	7.79	500.
.59268	2.07368	9494.	.07746	13.63	500.	.60360	2.07349	6500.	.05553	10.27	500.
.59112	2.06602	2943.	.16340	49.11	500.	.60118	2.07111	5497.	.09196	18.14	500.
.59205	2.07040	7010.	.12980	23.21	500.	.59446	2.06536	2593.	.15445	51.94	500.
.59402	2.07491	4502.	.03961	11.21	500.	.60485	2.07389	7500.	.04492	7.59	500.
.59338	2.07475	4603.	.06720	20.30	500.	.59481	2.06520	3800.	.15562	70.61	500.
.59475	2.07716	8494.	.03997	7.49	500.	.59818	2.06758	19994.	.12132	3.40	500.
.59168	2.06706	2920.	.15916	51.11	500.	.59568	2.06547	8000.	.14678	29.31	500.
.59072	2.06353	4496.	.16022	72.29	500.	.60196	2.06948	24000.	.08594	2.57	500.
.59607	2.08040	8498.	.03678	9.48	500.	.60202	2.06707	7177.	.08524	16.80	500.
.59155	2.06592	1344.	.16587	46.16	500.	.60008	2.06780	23994.	.11070	5.41	500.
.59232	2.06814	2987.	.15067	44.88	500.	.60229	2.06870	3810.	.08028	20.34	500.
.59216	2.06756	1919.	.15526	43.20	500.	.59817	2.06577	3493.	.12520	34.47	500.
.59568	2.07664	3008.	.05659	9.04	500.	.60032	2.06663	6495.	.10446	18.03	500.
.59591	2.07604	8502.	.06189	19.46	500.	.59829	2.06563	4496.	.12379	37.84	500.
.59736	2.07948	23000.	.04315	.19	500.	.59470	2.06375	2597.	.15491	49.76	500.
.59920	2.08409	9500.	.01981	3.23	500.	.60018	2.06636	4441.	.10893	36.82	500.
.59374	2.07031	3655.	.13228	39.37	500.	.60218	2.06643	3495.	.07781	20.80	500.
.59843	2.08246	8497.	.02617	5.00	500.	.59715	2.06445	2995.	.13475	38.91	500.
.59234	2.06710	658.	.15845	35.98	500.	.59744	2.06469	1017.	.12697	28.60	500.
.59591	2.07604	8502.	.06189	19.46	500.	.59900	2.06473	6497.	.12025	32.07	500.
.59920	2.08409	9500.	.01981	3.23	500.	.59825	2.06440	6236.	.12343	36.62	500.
.59374	2.07031	3655.	.13228	39.37	500.	.59810	2.06408	689.	.12556	26.53	500.
.59843	2.08246	8497.	.02617	5.00	500.	.60000	2.07000	4996.	.10646	20.55	500.
.59909	2.08227	9500.	.02845	5.88	500.	.59697	2.06370	8996.	.13723	20.54	500.
.59453	2.07057	8495.	.12874	29.06	500.	.60363	2.06544	3007.	.06331	19.29	500.
.59705	2.07550	4007.	.06755	13.10	500.	.59814	2.06385	558.	.12449	24.85	500.
.59486	2.07086	4996.	.12368	38.25	500.	.60112	2.06458	2303.	.09125	29.26	500.
.59230	2.06564	100.	.16446	42.67	500.	.60020	2.06432	9494.	.10964	34.48	500.
.59259	2.07292	6495.	.10257	24.21	500.	.59703	2.06354	9494.	.13652	19.71	500.
.59656	2.06577	100.	.16234	38.72	500.	.60105	2.06597	5097.	.04350	8.60	500.
.59682	2.07246	7464.	.10681	22.38	500.	.60424	2.06446	1441.	.05906	11.43	500.
.59759	2.07349	4995.	.09514	19.21	500.	.59798	2.06450	5830.	.12626	41.64	500.
.60129	2.07925	17000.	.03749	1.28	500.	.60369	2.06461	5494.	.06083	17.60	500.
.59411	2.06753	6436.	.15491	39.50	500.	.60146	2.06414	4292.	.08382	32.04	500.
.59742	2.07222	9500.	.10787	18.78	500.	.59576	2.06292	4497.	.14784	48.77	500.
.59366	2.06675	3988.	.15845	52.12	500.	.60751	2.06510	9500.	.04244	3.83	500.
.59854	2.07306	5003.	.09868	21.67	500.	.59846	2.06335	8500.	.11813	21.97	500.
.60015	2.07460	8494.	.07357	14.41	500.	.60122	2.06241	7500.	.15208	39.55	500.
.59718	2.07057	23000.	.12096	5.34	500.	.60122	2.06308	10498.	.07922	9.88	500.
.60148	2.07574	9500.	.05305	10.93	500.	.59894	2.06266	2806.	.11565	25.27	500.
.59373	2.06410	5679.	.16092	59.34	500.	.59376	2.06220	2151.	.15420	37.27	500.
.59411	2.06656	10492.	.15739	15.17	500.	.60893	2.06299	8500.	.02759	3.14	500.
.60237	2.07633	21000.	.04173	2.69	500.						

TABLE C-5

LAT	LON	ALT	LOCAL DENSITY	INT RATE	PWR
.60645	2.03881	28719.	.01556	.38	500.
.59541	2.05044	7500.	.00955	1.53	500.
.59005	2.06067	1998.	.08099	19.24	500.
.58621	2.05547	10992.	.05073	1.14	500.
.58967	2.05158	1494.	.08111	22.30	500.
.58198	2.05749	10994.	.05199	1.96	500.
.58674	2.05113	10454.	.07781	5.24	500.
.58467	2.05087	18320.	.06508	.51	500.
.59433	2.04116	2470.	.05356	13.65	500.
.57477	2.05323	4006.	.01470	.57	500.
.57105	2.05616	5500.	.03325	5.95	500.
.58157	2.06594	1268.	.04941	7.21	500.
.57821	2.05914	24486.	.02016	.01	500.
.58514	2.05947	7539.	.07342	5.80	500.
.58473	2.05555	4203.	.08419	21.04	500.
.59020	2.05580	3876.	.08539	19.43	500.
.59033	2.05997	6000.	.07816	15.35	500.
.59202	2.08946	2500.	.01698	2.56	500.
.59210	2.07871	16000.	.01874	.13	500.
.59358	2.08122	2698.	.01430	2.61	500.
.59155	2.06592	1344.	.08530	15.05	500.
.59568	2.07684	3008.	.02971	5.67	500.
.59237	2.05740	1289.	.08099	13.52	500.
.59250	2.05792	1066.	.07322	15.15	500.
.59234	2.05710	656.	.08276	12.21	500.
.59591	2.07604	8502.	.03218	5.61	500.
.59920	2.08409	9500.	.08844	4.27	500.
.59374	2.07031	3655.	.06861	14.50	500.
.59486	2.07086	4996.	.06366	14.81	500.
.59925	2.07815	11002.	.02582	.95	500.
.59759	2.07349	4995.	.05093	9.86	500.
.60237	2.07633	21000.	.01945	.11	500.
.59837	2.07026	7804.	.06225	9.46	500.
.59481	2.06520	3800.	.07832	25.84	500.
.60196	2.06948	24600.	.04562	1.53	500.
.60008	2.05780	23994.	.05013	1.66	500.
.59825	2.05440	6236.	.06549	15.44	500.
.59810	2.05408	689.	.05720	10.95	500.
.60105	2.06448	3994.	.04931	15.62	500.
.60122	2.05308	10498.	.04244	5.72	500.

TABLE C-6

LAT	LONG	ALT	LOCAL DENSITY	INT RATE	PWR	LAT	LONG	ALT	LOCAL DENSITY	INT RATE	PWR
59329	2-03173	1255	.70347	3.93	125	59032	2-06567	8500	.08559	10.63	500
59365	2-03881	28719	.71555	.35	500	59202	2-08046	2500	.01638	2.46	500
59419	2-03454	5432	.71945	.96	500	59210	2-07871	1500	.01874	.12	500
59220	2-03027	2991	.70722	4.72	125	59358	2-04122	2650	.01970	2.53	500
59720	2-03280	2500	.01495	2.04	500	59205	2-07040	7010	.06755	8.00	500
59541	2-03044	7500	.70355	1.63	500	59402	2-07891	5500	.01910	5.76	500
59255	2-03424	1521	.74203	4.76	500	59338	2-07475	4693	.03456	10.40	500
59382	2-03606	3403	.03836	6.69	500	59155	2-06592	1344	.08630	6.97	125
59342	2-03643	3401	.05225	3.06	125	59568	2-07684	3698	.02971	5.73	400
59005	2-03267	1998	.08079	9.21	125	59237	2-05740	1288	.08073	5.26	125
58621	2-03547	1092	.05093	1.34	500	59260	2-05792	1056	.07922	5.13	125
58928	2-03058	1097	.07675	10.19	125	59240	2-06710	550	.08276	5.26	125
58773	2-03855	1693	.07177	7.41	125	59591	2-07604	8500	.03218	5.65	500
58818	2-03033	1592	.07796	10.24	125	59920	2-08409	9500	.00894	.19	500
58253	2-03610	5492	.4527	4.77	500	59374	2-07531	3550	.05831	6.17	125
58246	2-03667	4498	.04843	6.22	500	59452	2-07957	8495	.06578	9.27	500
58808	2-03053	1997	.07719	11.37	125	59705	2-07550	4007	.03658	6.05	500
58398	2-03805	4513	.05820	9.07	500	59486	2-07086	4990	.08366	3.59	125
58778	2-03049	1825	.07575	10.28	125	59525	2-07815	11000	.02582	.76	500
58537	2-03941	3003	.06514	4.55	125	59759	2-07349	4995	.05393	2.00	125
58957	2-03168	1494	.08311	5.47	125	59237	2-07633	31000	.01945	.99	500
58720	2-06096	0	.07816	9.34	125	59334	2-05546	8500	.08418	11.03	500
58198	2-05949	10594	.05193	2.10	500	59837	2-07026	7000	.06225	9.49	500
58674	2-03119	10494	.07781	5.77	500	58680	2-07349	6560	.02723	1.36	500
58437	2-06207	1830	.04534	.51	500	59446	2-05536	2593	.08064	4.23	125
58433	2-06116	2470	.03506	13.80	500	59481	2-06520	3800	.07852	6.26	125
58832	2-06193	4500	.07422	12.27	125	586196	2-05948	21600	.04552	1.53	500
58229	2-03207	1994	.05517	8.92	500	58008	2-06780	23994	.05013	1.38	500
58477	2-03323	4006	.01463	.53	500	59817	2-06577	3490	.06649	6.70	125
58667	2-03254	1451	.07322	6.48	125	58032	2-06663	5450	.07764	4.56	125
58510	2-03284	7800	.07498	8.60	500	58035	2-06606	4541	.05836	6.38	125
57972	2-06563	2503	.03784	5.83	500	59794	2-06469	1017	.06755	4.30	125
57905	2-06616	5500	.03325	6.03	500	59825	2-06440	6235	.06544	5.34	125
58115	2-03592	2165	.04559	7.06	500	59810	2-06408	689	.05723	11.24	500
58157	2-06554	1268	.04891	7.42	500	58032	2-06544	3000	.03183	7.97	500
58169	2-06618	704	.04835	6.73	500	58012	2-06458	2363	.04981	4.39	125
58668	2-03373	6490	.08064	6.50	125	58015	2-06448	3998	.04751	4.84	125
57821	2-06914	2486	.02315	.91	500	58024	2-06486	1341	.03183	5.46	500
58572	2-06465	7491	.07675	10.18	500	59798	2-06250	2830	.05449	5.99	125
58614	2-06047	7539	.07592	5.94	500	58035	2-06250	2830	.05449	5.99	125
58873	2-03555	4263	.08418	5.08	125	59576	2-03252	4497	.07575	3.44	125
58020	2-05580	1876	.08650	7.31	125	59836	2-03233	8500	.06245	9.64	500
59032	2-06087	6200	.07816	14.67	500	59447	2-06241	7560	.07416	3.28	125
						58012	2-06538	14998	.04244	5.60	500

TABLE C-7

LAT	LONG	ALT	LOCAL DENSITY	INT RATE	PWR	LAT	LONG	ALT	LOCAL DENSITY	INT RATE	PWR
55325	2-05173	1255	.08367	15.76	500	55332	2-06567	8500	.08559	10.71	500
56665	2-03881	2419	.11356	.30	500	55332	2-08045	2500	.11528	2.57	500
56129	2-03454	5822	.11765	1.31	500	59210	2-07871	10000	.10176	.10	500
55220	2-05027	2511	.07922	10.28	500	59358	2-08122	3698	.01430	2.53	500
55720	2-05280	2500	.11443	2.74	500	59235	2-07040	7010	.06755	7.80	500
55341	2-03044	7500	.11765	1.51	500	59432	2-07891	4500	.10192	6.17	500
55275	2-05425	1421	.13459	4.76	500	59338	2-07475	4500	.13365	9.42	500
55382	2-05005	3400	.13455	7.12	500	59155	2-06592	1344	.04650	14.74	500
55143	2-05645	3401	.05275	12.11	500	59568	2-07484	3668	.12271	5.74	500
55005	2-05067	1986	.08097	20.04	500	59237	2-05740	1289	.08393	11.27	500
56621	2-05547	10492	.05093	1.29	500	55260	2-05792	1066	.07922	14.18	500
58928	2-05058	1097	.07675	16.83	500	59234	2-05710	450	.08273	11.51	500
58772	2-05865	1593	.07129	17.02	500	55591	2-07604	8300	.13214	5.30	500
58818	2-05005	1692	.17745	16.34	500	59320	2-08409	9500	.00844	.18	500
58252	2-05610	4992	.04327	4.90	500	59374	2-07031	3652	.08431	14.84	500
58245	2-05647	6498	.04845	6.18	500	59352	2-07057	8475	.06578	8.96	500
58808	2-05053	1397	.07710	15.14	500	59705	2-07553	4007	.13679	4.75	500
58398	2-05805	4513	.05810	8.97	500	59446	2-07685	4994	.13355	14.55	500
58778	2-05048	1025	.07477	15.45	500	59225	2-07815	1100	.22382	.83	500
58537	2-05941	3593	.06514	15.38	500	59259	2-07149	4985	.25343	9.36	500
58967	2-05168	1494	.13311	21.66	500	60137	2-07633	21000	.11443	.14	500
58726	2-05896	0	.07816	15.97	500	55334	2-06546	8500	.18414	12.01	500
58198	2-05949	1394	.05199	2.12	500	59837	2-07026	7094	.16235	9.56	500
58674	2-05119	13494	.07781	5.85	500	60306	2-07449	6500	.08723	14.39	500
58467	2-05027	14320	.06528	.31	500	59446	2-06336	2591	.08034	18.09	500
58432	2-06116	2470	.16355	12.77	500	59481	2-06320	3800	.07932	25.38	500
58833	2-05193	4500	.17322	24.80	500	60196	2-06948	8468	.14578	1.52	500
58223	2-05287	1944	.05217	9.09	500	60008	2-05782	23994	.05013	1.41	500
57477	2-05323	4006	.01450	.36	500	59817	2-05377	3492	.15649	16.93	500
58667	2-06254	1451	.07922	18.41	500	60432	2-06663	6492	.05644	14.92	500
58518	2-05284	909	.07498	7.23	500	60019	2-06605	4541	.03836	14.87	500
57372	2-05563	2503	.13784	6.01	500	59794	2-06469	1017	.06753	13.36	500
57905	2-05615	5306	.13325	5.62	500	59825	2-06548	6236	.06443	15.81	500
58119	2-05592	2166	.04859	7.25	500	59810	2-05508	680	.06721	11.99	500
58157	2-06594	1268	.04891	7.51	500	60362	2-05544	5097	.03183	7.58	500
58169	2-06618	704	.04845	7.15	500	60112	2-06438	2303	.04881	14.01	500
58688	2-05375	6495	.08034	17.63	500	60105	2-06448	3994	.04931	16.46	500
57821	2-05914	24465	.02016	.01	500	60424	2-06486	1341	.03183	5.03	500
58572	2-05465	7491	.07675	11.37	500	59720	2-06359	5830	.05549	18.55	500
58614	2-05847	7539	.07392	3.44	500	60359	2-06461	5494	.03218	5.46	500
58873	2-05555	4203	.08418	20.33	500	59576	2-06292	4497	.07675	18.56	500
55020	2-05580	3876	.08630	19.65	500	59826	2-06335	8500	.06295	14.13	500
59933	2-05907	4000	.07416	14.38	500	59447	2-06241	7500	.07916	11.77	500
						60122	2-06308	10498	.04244	5.75	500

TABLE C-8

59329	2.03473	155.5	0.8347	17.39	31.	59332	2.084567	8504.	0.8337	8.34	123.
60553	2.03881	28719.	0.1335	31	500.	59202	2.08046	2500.	0.1398	4.19	500.
60129	2.03454	5422.	0.1395	3.83	500.	59210	2.07871	1300.	0.1874	0.99	500.
59240	2.03027	2991.	0.7922	20.88	125.	59258	2.08122	2698.	0.1459	4.20	500.
59720	2.03280	2300.	0.1483	3.59	500.	59205	2.07940	701.3	0.6753	7.49	125.
55541	2.03344	7500.	0.0955	3.79	500.	59402	2.07891	4302.	0.1313	5.67	500.
59255	2.03425	1621.	0.4219	9.35	500.	59338	2.07475	4603.	0.3435	3.57	125.
59382	2.03606	3405.	0.5836	3.75	125.	59155	2.05592	1344.	0.0636	19.83	125.
59043	2.03545	3401.	0.5225	4.20	125.	59568	2.07684	3108.	0.2971	12.88	500.
59305	2.03067	1938.	0.8039	18.83	31.	59257	2.06749	1889.	0.0899	17.41	125.
58621	2.03347	10922.	0.5073	2.74	500.	59260	2.06792	1766.	0.1422	13.38	125.
58928	2.06058	1897.	0.3763	20.43	31.	59234	2.06713	636.	0.0275	17.52	125.
58773	2.03865	1693.	0.7109	17.09	125.	59591	2.07404	8502.	0.5218	9.30	500.
58818	2.03005	1692.	0.7745	16.87	31.	59920	2.08409	9300.	0.0884	0.24	500.
58252	2.03610	5492.	0.4927	12.40	500.	59374	2.07031	3655.	0.5851	12.39	125.
58246	2.03667	6498.	0.4945	15.40	500.	59452	2.07957	8495.	0.5574	5.76	125.
58808	2.05033	1897.	0.7110	19.74	31.	59705	2.07350	4007.	0.3618	4.00	125.
58398	2.05835	4513.	0.5810	11.01	125.	59486	2.07086	1996.	0.2655	10.98	125.
58778	2.06048	1225.	0.6765	21.08	31.	59925	2.07815	11002.	0.2582	0.99	500.
58337	2.03941	1803.	0.5314	17.33	125.	59755	2.07349	4995.	0.3093	4.48	125.
58967	2.03168	1494.	0.9311	24.97	31.	60237	2.07633	21000.	0.1945	0.16	500.
58720	2.03095	0.	0.7815	21.57	31.	59334	2.05544	8524.	0.8418	7.00	125.
58198	2.03943	10994.	0.5139	3.30	500.	59837	2.07025	7004.	0.6225	3.73	125.
58674	2.05119	10494.	0.7791	9.65	500.	60180	2.07343	5501.	0.1273	6.36	500.
58457	2.06087	18320.	0.5508	0.51	500.	59446	2.06336	2592.	0.3854	13.94	125.
58433	2.05116	2470.	0.5335	17.48	125.	59481	2.05520	3890.	0.7852	15.73	125.
58832	2.06193	4000.	0.7922	24.38	31.	60196	2.06948	24006.	0.4552	1.43	500.
58429	2.06207	1994.	0.5317	8.74	125.	60008	2.04780	21990.	0.9013	1.34	500.
57477	2.05323	4706.	0.1430	1.40	500.	59817	2.05577	3493.	0.5643	13.34	125.
58667	2.06254	1451.	0.7922	19.34	31.	60032	2.05563	6493.	0.5514	10.85	125.
58518	2.06284	950.	0.7478	12.59	500.	60019	2.06636	4541.	0.5536	12.33	125.
57972	2.05363	2303.	0.3784	7.27	125.	59794	2.06469	1617.	0.6753	11.12	125.
57905	2.05616	3000.	0.3825	14.49	500.	59825	2.05440	6236.	0.0549	11.23	125.
58119	2.05592	2164.	0.4559	12.01	125.	59810	2.06408	468.	0.5672	8.47	125.
58137	2.06394	1268.	0.4881	12.53	125.	60362	2.05544	3707.	0.1103	9.25	125.
58169	2.06618	704.	0.4445	12.09	125.	60112	2.05458	2303.	0.4811	10.30	125.
58688	2.05375	5495.	0.8044	21.68	125.	60105	2.06448	3494.	0.4971	10.50	125.
57821	2.05914	2486.	0.2215	0.71	500.	60424	2.05486	1341.	0.3193	10.25	125.
58572	2.04465	7491.	0.7575	9.44	125.	59798	2.06350	5830.	0.6549	11.80	125.
58014	2.06847	7339.	0.7332	11.46	500.	60369	2.06441	5494.	0.5214	2.40	125.
58873	2.05330	4203.	0.7413	12.08	31.	59576	2.05292	4497.	0.7575	13.72	125.
59020	2.03580	3875.	0.8531	12.06	31.	59856	2.05335	4500.	0.5293	7.42	125.
55033	2.06907	6303.	0.7815	6.44	125.	59447	2.05241	7500.	0.7815	11.26	125.
						60122	2.05308	13498.	0.4244	6.20	500.

TABLE C-9

LAT	LONG	ALT	LOCAL DENSITY	INT RATE	PWR	LAT	LONG	ALT	LOCAL DENSITY	INT RATE	PWR
.59329	2.06173	1255.	.08347	50.04	500.	.59012	2.06567	8500.	.08559	23.06	500.
.60665	2.05881	20719.	.01556	.38	500.	.59202	2.06046	2500.	.01698	4.51	500.
.60119	2.05454	5922.	.01945	3.66	500.	.59210	2.07871	16000.	.01874	.11	500.
.59220	2.06027	2991.	.07922	51.02	500.	.59358	2.08122	2698.	.01450	4.23	500.
.59720	2.05280	2500.	.01465	5.71	500.	.59205	2.07040	7010.	.06755	23.43	500.
.59541	2.05044	7500.	.00955	3.85	500.	.59402	2.07891	4502.	.01910	9.44	500.
.59255	2.05425	1621.	.04209	10.04	500.	.59338	2.07475	4403.	.03466	21.52	500.
.59032	2.05606	3405.	.05836	14.74	500.	.59155	2.06592	1344.	.08650	61.75	500.
.59043	2.05645	3401.	.06225	26.46	500.	.59568	2.07684	3008.	.02971	12.85	500.
.59005	2.06047	1998.	.08099	62.71	500.	.59237	2.06740	1289.	.08099	42.21	500.
.58621	2.05547	1092.	.05093	2.49	500.	.59260	2.06792	1066.	.07922	38.96	500.
.58928	2.06358	1097.	.07675	61.87	500.	.59234	2.06710	656.	.08276	43.66	500.
.58773	2.05865	1693.	.07109	47.55	500.	.59591	2.07604	8502.	.03218	9.15	500.
.58818	2.06005	1692.	.07746	65.13	500.	.59920	2.08409	9500.	.00884	.31	500.
.58233	2.05610	5992.	.04527	12.41	500.	.59374	2.07031	3655.	.06861	37.74	500.
.58246	2.05667	6498.	.04845	16.01	500.	.59453	2.07057	8495.	.06578	16.71	500.
.58808	2.06053	1997.	.07110	63.53	500.	.59705	2.07550	4007.	.03608	14.39	500.
.58398	2.05805	4513.	.05800	28.39	500.	.59466	2.07086	4996.	.06366	37.04	500.
.58778	2.06046	1225.	.07675	56.89	500.	.59925	2.07815	11002.	.02582	1.24	500.
.58537	2.05941	3003.	.06614	44.10	500.	.59759	2.07349	4995.	.05093	16.24	500.
.58937	2.06168	1494.	.08311	65.55	500.	.60237	2.07633	21000.	.01945	.09	500.
.58720	2.06096	0.	.07816	53.62	500.	.59334	2.06546	8500.	.08418	23.95	500.
.58198	2.05949	10994.	.05199	3.42	500.	.59837	2.07026	7004.	.06225	19.22	500.
.58674	2.06119	10494.	.07781	9.93	500.	.60380	2.07349	6500.	.02123	6.44	500.
.58467	2.06087	18320.	.06508	.51	500.	.59486	2.06536	2593.	.08064	57.11	500.
.58433	2.06116	2470.	.06366	45.62	500.	.59401	2.06520	3400.	.07552	66.13	500.
.58833	2.06193	4500.	.07922	79.07	500.	.60186	2.06948	24000.	.04562	1.62	500.
.58229	2.06207	1994.	.05517	35.02	500.	.60008	2.06780	23994.	.06013	1.45	500.
.57477	2.06323	4006.	.01450	1.42	500.	.59817	2.06577	3493.	.06449	35.24	500.
.58667	2.06254	1851.	.07922	63.54	500.	.60032	2.06663	6495.	.05694	29.35	500.
.57972	2.06563	2503.	.03784	19.21	500.	.60019	2.06606	4441.	.05816	32.26	500.
.57905	2.06616	5500.	.03325	14.16	500.	.59794	2.06469	1017.	.06755	32.63	500.
.58119	2.06592	2166.	.04669	23.29	500.	.59825	2.06440	6236.	.06449	32.41	500.
.58157	2.06594	1268.	.04881	26.16	500.	.59810	2.06408	689.	.06720	28.81	500.
.58169	2.06618	704.	.04845	25.98	500.	.60363	2.06544	3007.	.03183	22.82	500.
.58688	2.06375	6495.	.08064	55.93	500.	.60112	2.06458	2303.	.04881	35.45	500.
.57821	2.06914	24866.	.02016	.01	500.	.60105	2.06448	3994.	.04951	36.79	500.
.58572	2.06465	7491.	.07675	34.66	500.	.60424	2.06486	1341.	.03183	17.92	500.
.58614	2.06847	7539.	.07392	11.59	500.	.59798	2.06350	5300.	.06449	37.80	500.
.58873	2.06555	4203.	.08418	62.76	500.	.60369	2.06461	5494.	.03218	21.25	500.
.59020	2.06580	3876.	.08630	62.01	500.	.59586	2.06292	4497.	.06755	44.79	500.
.59033	2.06907	6000.	.07816	31.97	500.	.59896	2.06335	8500.	.06295	19.83	500.
						.59447	2.06241	7500.	.07816	25.60	500.
						.60122	2.06308	10498.	.04244	6.18	500.

TABLE C-10

.60665	2.05881	28719.	.00924	.29	500.
.58621	2.05547	10992.	.02723	.63	500.
.58198	2.05949	10994.	.02723	1.25	500.
.58467	2.06087	18320.	.03431	.51	500.
.58433	2.06116	2470.	.03431	5.70	500.
.57477	2.06323	4006.	.00849	.24	500.
.58157	2.06554	1268.	.02546	4.31	500.
.57821	2.06914	24486.	.01026	.01	500.
.58873	2.06555	4203.	.04173	8.24	500.
.55032	2.06907	6500.	.03855	6.67	500.
.55202	2.08046	2500.	.00743	1.33	500.
.59155	2.06592	1344.	.04138	8.14	500.
.55568	2.07684	3008.	.01415	4.75	500.
.55237	2.06740	1289.	.03961	7.14	500.
.55591	2.07604	8502.	.01521	4.62	500.
.59920	2.08409	9500.	.00531	.12	500.
.55755	2.07249	4995.	.02405	5.86	500.
.60237	2.07633	21006.	.00990	.05	500.
.59837	2.07026	7004.	.03004	4.34	500.
.59481	2.06520	3800.	.03890	9.96	500.
.60196	2.06948	24000.	.02122	.32	500.
.60105	2.06448	3994.	.02440	7.30	500.
.60122	2.06308	10498.	.02122	2.62	500.

TABLE C-11

LAT	LOX	ALT	LOCAL DENSITY	INT RATE	PWR
.58621	2.05547	10992.	.01238	.35	500.
.58198	2.05949	10994.	.01203	.07	500.
.58467	2.06087	18320.	.01485	.51	500.
.58433	2.06116	2470.	.01485	.80	500.
.57477	2.06323	4006.	.00354	.05	500.
.58157	2.06554	1268.	.01167	.11	500.
.57821	2.06914	24486.	.00424	.01	500.
.59033	2.06907	6500.	.01804	.81	500.
.59759	2.07249	4995.	.01112	.55	500.
.60237	2.07633	21000.	.00475	.05	500.
.60196	2.06948	24000.	.01026	.30	500.
.60122	2.06308	10498.	.01203	1.35	500.

APPENDIX D
MODEL DESCRIPTION

GENERAL

The computerized model used to simulate TCAS operation in the DABS/ATCRBS environment consists of a statistical TCAS submodel merged with the deterministic ECAC DABS/ATCRBS/AIMS Performance Prediction Model (PPM).^a The model is coded in FORTRAN V and its predictions are computed using a Univac 1110 computer at ECAC. The DABS/ATCRBS/AIMS PPM consists of a number of subroutines that simulate the operation of DABS and ATCRBS sensors and transponders. The performance of an interrogator of interest (I_0) is predicted based on computed transponder reply records, fruit rates, and target-detection/code-validation data tabulated during one complete revolution of the I_0 mainbeam.

The TCAS routine models the operation of all the airborne TCAS interrogators in the environment. It generates average rates at which TCAS emissions (DABS interrogations, ATCRBS interrogations, and suppressions) arrive at each airborne transponder. These TCAS signals are then merged with the signal environment generated by the ground-system interrogators to predict transponder and interrogator performance.

The combined model simulates TCAS operation (both with and without interference-limiting) to evaluate the impact of TCAS on ground-system performance. A more detailed description of the TCAS routine and the DABS/ATCRBS PPM follows.

^aThe merging of the statistical TCAS submodel with the deterministic DABS/ATCRBS/AIMS PPM is explained later.

DABS/ATCRBS/AIMS PPM

The DABS/ATCRBS/AIMS PPM is the basis for the TCAS modeling and analysis effort. The PPM was originally developed as part of the DABS Spectrum Management Program to provide air-traffic-control performance prediction capability in future environments where ATCRBS and the proposed DABS will coexist.

The DABS/ATCRBS/AIMS PPM is a time-event-store computer algorithm that uses the known deployed equipment locations and characteristics (ATCRBS interrogators, DABS sensors, and airborne transponders) to simulate air-traffic-control operations, and to evaluate system performance. The model consists of a number of subroutines that are discussed below. The standard input characteristics consist of the two basic categories listed in TABLE D-1.

TABLE D-1
DABS/ATCRBS/AIMS PPM INPUTS

Sensor/Interrogator Environment	Transponder Environment
Latitude	Latitude
Longitude	Longitude
Site Elevation/Antenna Height	Altitude
Output Power	Output Power
Receiver Sensitivity	Receiver Sensitivity
Sidelobe Supression Type	Mode Capability
Pulse Repetition Frequency	Antenna Type
Mode Interlace	
Antenna	
Mainbeam Gain/Width	
Sidelobe Gain/Width	
Backlobe Gain/Width	
Scan Rate	

DABS/ATCRBS/AIMS ALGORITHMSInput

The simulation cycle for the DABS/ATCRBS/AIMS PPM is one pulse-repetition period (PRP) of the interrogator-of-interest, I_0 . For DABS sensors, one PRP is defined as the time between transmissions of all-call interrogations. A flow diagram of the DABS/ATCRBS/AIMS PPM is shown in Figure D-1. Subroutine INPUT, shown in the figure, performs the basic functions of compiling input data, performing the interrogator-file radius cull, and ordering of the environmental data into the appropriate arrays for efficient access by later routines.

Channel Management

The main loop of program execution begins in subroutine ACTIVE. In ACTIVE, all DABS sensors search their active target list to determine which targets, based on last reported range and azimuth, are expected to be in the mainbeam during the present simulation cycle. The active target list is constructed for all DABS sensors in the simulated environment. The target-list update is based on the results of past discretely addressed transactions attempted with DABS-equipped aircraft.

DABS Scheduling

After completing the channel management portion of the program in subroutine ACTIVE, program control is passed to subroutine ROLCAL. ROLCAL establishes the all-call and roll-call interrogation times for the present simulation cycle. Roll-call transactions are scheduled to the appropriate targets in decreasing range order and are spaced so as to avoid a) synchronous garble and b) overlapping of the transmitted and received signals.

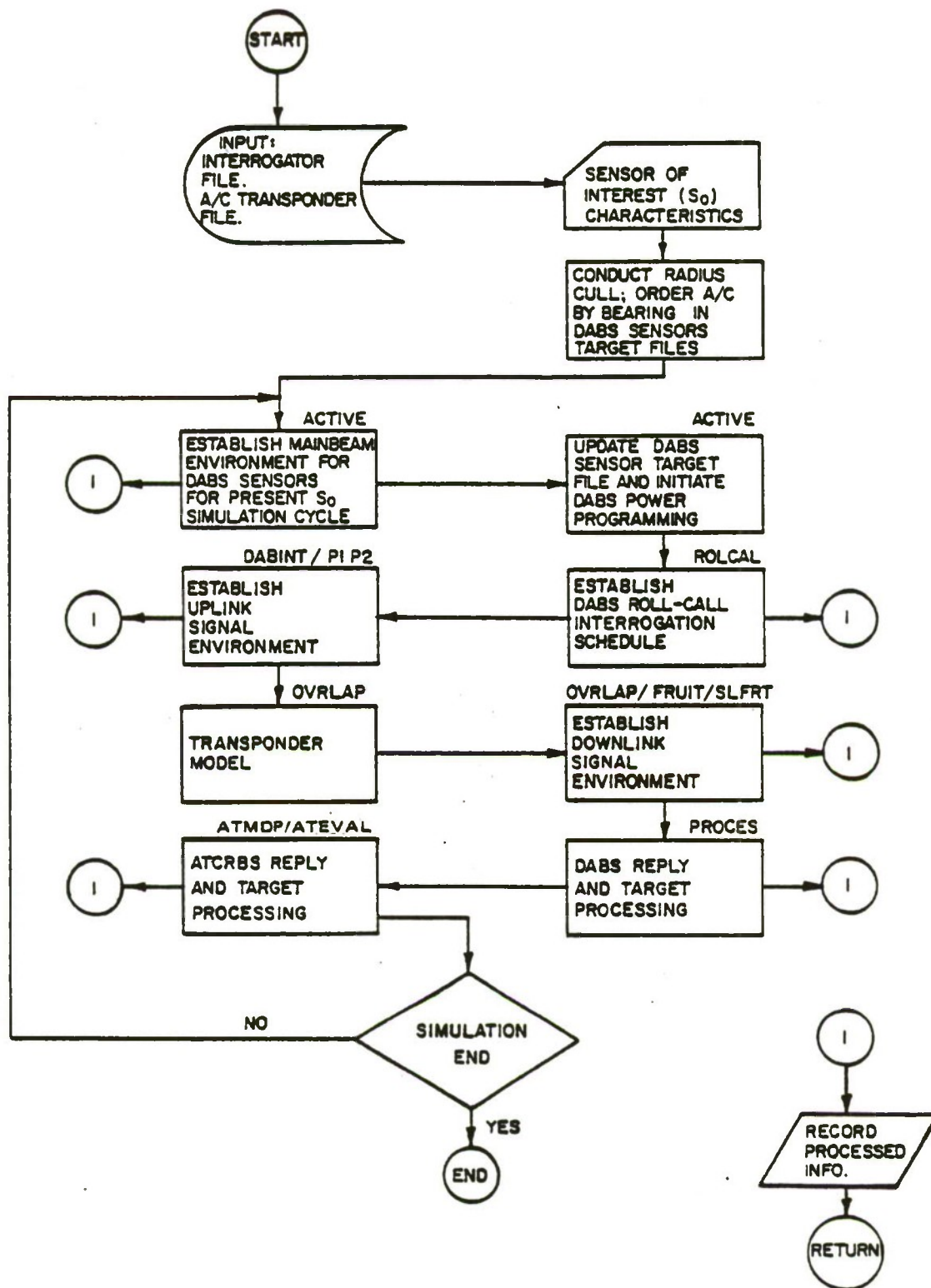


Figure D-1. Flow chart of DABS PPM major submodel functions.

Uplink Power Cull

The arrival times of all interfering interrogations and suppressions from all ground sensors at each DABS- or ATCRBS-equipped aircraft in the I_0 mainbeam are established in subroutines DABINT and P1-P2.^a First, the coupling between each ground sensor and each I_0 mainbeam A/C is determined, based on the sensor rotation rate and the elapsed time from the last simulation cycle. Subroutine PLOSS is accessed to calculate the received signal strength at the transponder, based on free-space path loss plus over-the-horizon attenuation, sensor output power, cabling losses, and sensor and aircraft antenna gains. If the signal level is greater than the transponder sensitivity, the interrogation time or sidelobe suppression time is stored in the appropriate array.

Transponder Models

Subroutine OVLAP simulates the operation of the transponder. For either a DABS- or ATCRBS-equipped aircraft, the arrival time of the I_0 interrogation is compared with the arrival times of each type of interfering signal (other interrogation or SLS). OVLAP then determines whether the I_0 interrogation signal is decoded depending on the dead time attendant to each interfering signal. Overlapping interference signals are assumed to garble desired signals to the extent that they cannot be decoded regardless of the relative power differential. Other interference devices, such as false sidelobe suppressions and intermode garble, are also checked by the transponder model. The model then prints out the reply arrival times at I_0 generated by the signal environment for all replies that pass the downlink power cull. These times are based on the transmission time of the interrogation, the two-way propagation time, and the processing time at the transponder.

^aThe mainbeam dwell of aircraft for both the Long Beach ATCRBS interrogator and the LAX4 DABS sensor was 0.051 seconds.

Downlink Power Cull

The calculation of nonsynchronous reply arrival times is accomplished in subroutines FRUIT and SLFRT, with FRUIT determining I_0 mainbeam arrival times and signal strengths and SLFRT performing the same operations for the I_0 sidelobes and backlobe. The model calculates the arrival time and signal strength of fruit replies to the I_0 . Those replies that are received above the sensors MTL (typically -86 dBm) are retained for the processor routines.

DABS Processor

Several target evaluators are built into the model to accommodate variations in the types of FAA processors. The basic routine is subroutine PROCES, which simulates the processing of DABS all-call and roll-call replies. PROCES receives arrival times of each type of reply, both synchronous and nonsynchronous fruit, entering the processor. The fruit arrival times are compared for overlaps, and a determination is made as to whether the valid replies are decoded correctly (based on the location and length of the error, the type of overlapping reply, and the relative signal strengths).

ATCRBS Processor

The simulation of the ATCRBS processor, subroutine ATEVAL, maintains hit and miss counts for each in-process target, and correlates replies whose time-of-arrival places them in the range bin appropriate to the type of processor used with the I_0 . The times-of-arrival are also used to determine reply overlaps. Garble flags are maintained for each target in the course of simulating code validation processes.

ATCRBS MODE OF DABS PROCESSOR

The primary differences between target detection for the ATCRBS processor associated with the DABS sensor and the traditional ATCRBS processor are

azimuth determination via monopulse and target-to-track correlation. Because amplitude-monopulse azimuth determination can be accomplished with a single pulse, the number of desired target replies can be minimized. Improved target records can be obtained via the target-to-track update process.

Approximately six ATCRBS-Only interrogations will be transmitted during the mainbeam dwell time of a DABS sensor. These replies are correlated in range, azimuth, and high-confidence code bits to obtain target declaration and code estimates. Target parameters are updated on each scan based on the new target formations.

Output

The model outputs are summarized in TABLE D-2. The outputs from the DABS and ATCRBS target processors are fed back to the beginning of the simulation cycle, subroutine ACTIVE. Another cycle is then initiated, based on the completion of roll-call transactions, the acquisition of new targets by all-call, and the transition of old targets out of the mainbeam of the I_0 .

TCAS SIMULATION ROUTINE

The performance predictions computed using the DABS/ATCRBS/AIMS PPM are based on environmental interrogator/transponder interactions tabulated during one complete scan (4.62 seconds for both LAX-4 and Long Beach) of the selected interrogator-of-interest (I_0). Each transponder's reply history is computed, in its entirety, based on its reply record to I_0 during the I_0 mainbeam dwell (0.051 seconds). During this interval of time, any terminal area transponder distribution could not shift in such a way that would result in a significant change in TCAS transmission rates.^a A statistical TCAS submodel was therefore developed to provide the DABS/ATCRBS/AIMS PPM with arrival rates of TCAS and RBX signals at each transponder in the modeled environment. This is accomplished by establishing arrays that store the arrival rates of four types

^aThe maximum terminal area aircraft speed is about 300 nmi/hr.

TABLE D-2
DABS/ATCRBS/AIMS PPM OUTPUTS

Transponder Performance

Probability of reply to the I_o for each aircraft
Target run lengths
Reply histories
Reply arrival times
Location of missed replies in run length
Cause of missed replies
Identity of interferer

Interrogator-of-Interest Performance

Fruit rate after each simulation cycle
ATCRBS
All call
Roll call
Fruit reply times and garbles
Valid reply times
ATCRBS target detection summaries
Target declaration
Code validation indicator
Azimuth and range
Target start and end azimuths
DABS transactions
Reply times
Garble conditions
Azimuth and range

of signals that may arrive at each transponder from the deployed TCAS and RBX. The four signal types are:

1. ATCRBS interrogations
2. ATCRBS suppressions
3. DABS interrogations with the address of the DABS target transponder
4. DABS interrogations with an address other than that of the DABS target transponder.

The antenna couplings used in the TCAS submodel are illustrated in Figure D-2. These patterns are derived from measured data for the Boeing 727 antenna/airframe configuration. Note that the DABS/ATCRBS/AIMS PPM uses a nominal transponder antenna gain of -2.5 dBi.

Simulation of RBX/TCAS

The subroutine RBXRUN of the TCAS submodel simulates the DABS formatted signals that communicate between each TCAS-equipped aircraft and each RBX in the environment. One RBX unit is located at each terminal ATCRBS site. The RBX transmits squitters, using a DABS-formatted signal, once every 4 seconds. Each TCAS-equipped aircraft within 25 nmi of the RBX interrogates the RBX at an average rate of once every 4 seconds.^a The path loss from each RBX and TCAS to each aircraft in the environment is calculated to determine the RBX/TCAS signal arrival rates. These arrival rates are then stored in the appropriate arrays.

Simulation of TCAS/ATCRBS

TCAS-equipped aircraft use the 4-step sequence shown in Figure D-3 to interrogate ATCRBS-equipped aircraft. The peak power transmitted is 250 watts (referred to the antenna). The sequence begins with the top antenna. A

^aBeyond 25 nmi, the TCAS interrogation rate to RBX units was computed as $0.25/(R \times 6 - 144)$ per second, where R is the range in nmi. This results in a linear monotonic decrease in the interrogation rate as a function of range.

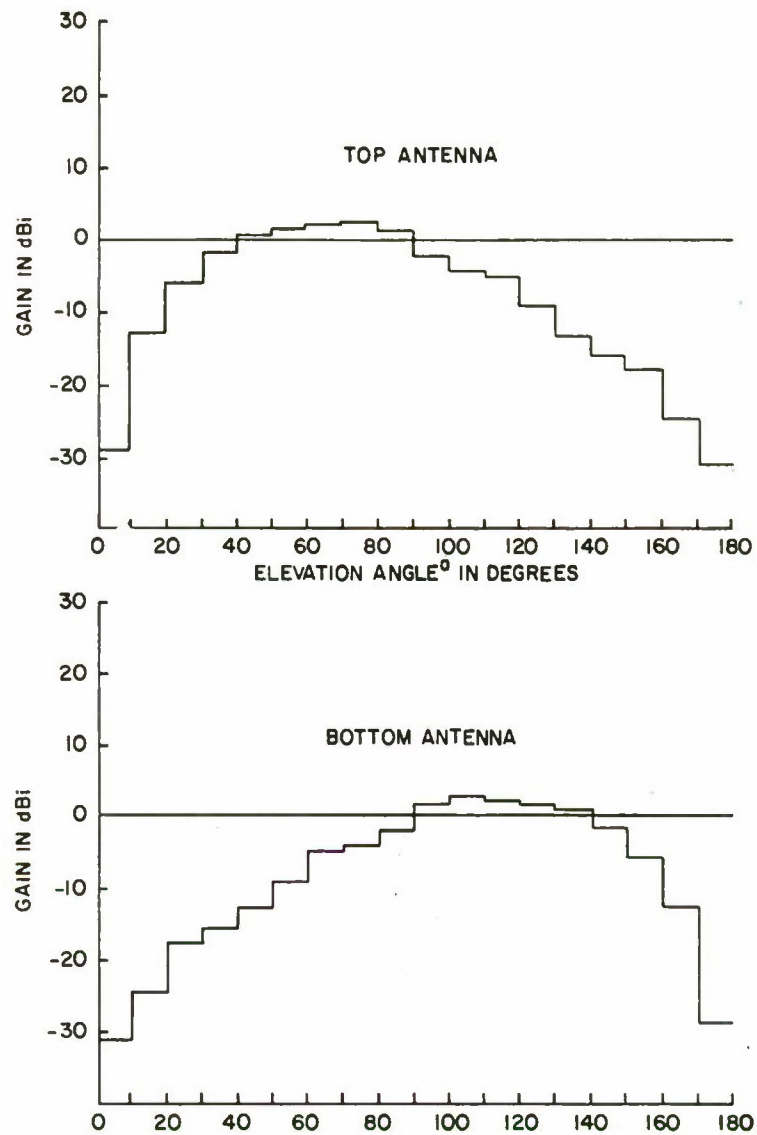


Figure D-2. Quantized vertical antenna patterns^b assumed for TCAS and deployed aircraft.

^aElevation angles: 0° - directly above aircraft, 180° - directly below aircraft.

^bAntenna patterns derived from those of a 727 air frame.

NOTES: I DENOTES MODE C ATCRBS - ONLY
ALL-CALL INTERROGATION
S DENOTES SUPPRESSION PAIR

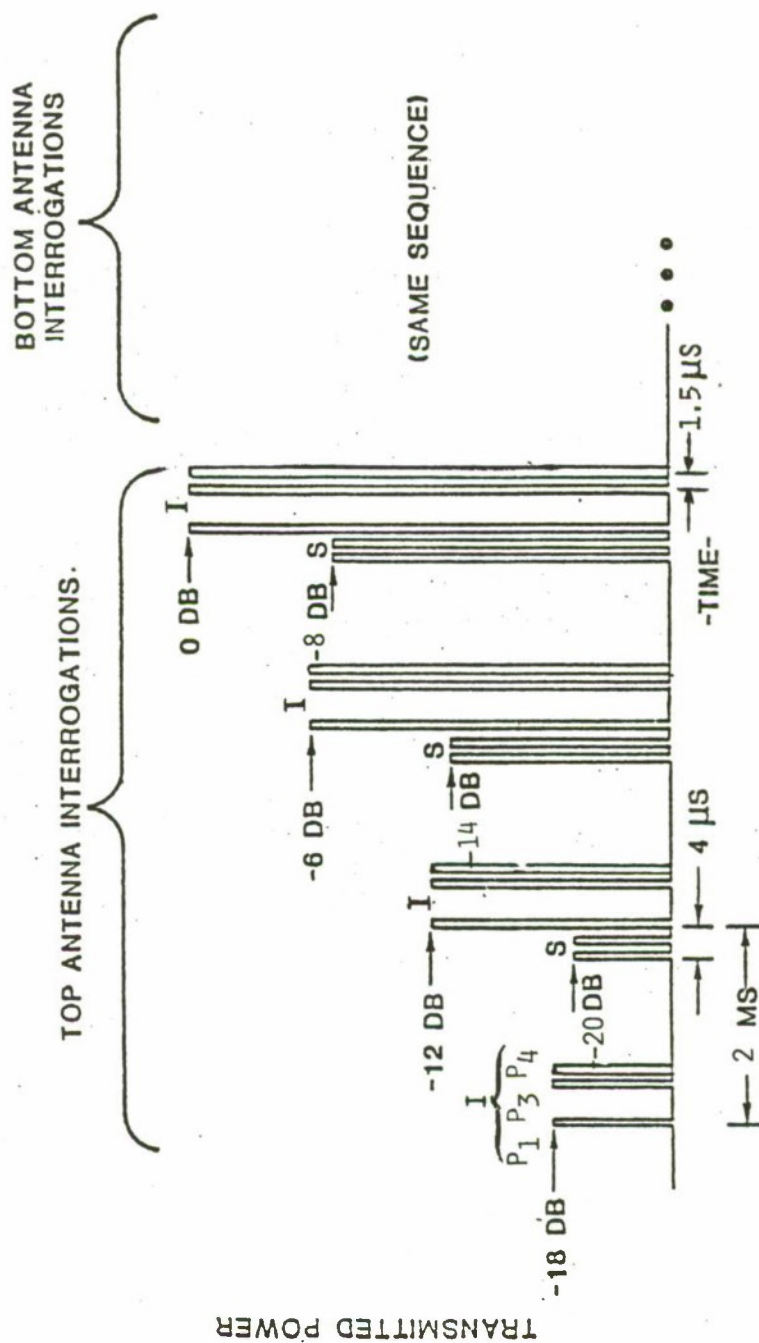


Figure D-3. TCAS/ATCRBS mode transmissions.

low-power interrogation (-18 dB) is followed by a suppression pulse pair (-20 dB) approximately 2 ms later, that precedes by 4 μ s a second interrogation at -12 dB. This pattern is repeated in 6 dB steps until maximum interrogation power is reached. The entire 4-step sequence is then transmitted from the bottom antenna. The procedure is repeated once per second.

This technique of using increased power interrogations preceded by a suppression pulse pair is used to divide the surrounding ATCRBS aircraft population into smaller population subsets to facilitate efficient tracking by the TCAS computer system. This technique, referred to as "Whisper-Shout," is discussed in Reference 5.

The basic task in the simulation of the ATCRBS mode of TCAS is path-loss calculations required to determine which interrogations or suppressions of the sequence are received above transponder sensitivity by all aircraft in the environment. The appropriate suppression and interrogation arrival rate arrays are established accordingly.

Simulation of TCAS/DABS

TCAS tracks DABS-equipped aircraft both in altitude and range. Each DABS aircraft transmits a DABS-formatted reply at a minimum rate of once per second. Initially, the TCAS-equipped aircraft will discern the presence of a DABS aircraft by monitoring replies containing the DABS-equipped aircraft altitude and identity. The frequency of the TCAS-equipped aircraft subsequent surveillance transmissions to the DABS-equipped aircraft is dependent upon the relative range and altitude separations of the aircraft. The separation-distance/TCAS-surveillance rate parameters, and ECAC's modeling procedures, are discussed below.

Two DABS interrogation arrival rate arrays are maintained for each DABS-equipped aircraft. One contains arrival rates of DABS interrogations addressed to that particular aircraft, and the other contains arrival rates of DABS interrogations addressed to other DABS aircraft.

The TCAS routine uses the following step-by-step procedure to generate the DABS signal environment at each aircraft due to each TCAS in the environment:

1. Compute the power levels of DABS replies received by the TCAS from all other DABS-equipped aircraft and eliminate from consideration those aircraft whose replies are received below the TCAS-equipped aircraft MTL.

2. Compute the horizontal and vertical boundaries of the TCAS track volume and determine if the subject DABS aircraft is contained in this volume. The vertical boundary is fixed at ± 5000 feet. The horizontal boundary varies with the TCAS-equipped aircraft interference-limiting state which is a function of the local TCAS- and DABS-equipped aircraft distribution. If the TCAS-equipped aircraft is operating at full-power, the horizontal boundary extends to 12.66 nmi. If the TCAS-equipped aircraft's power is reduced to 125 watts or to 31.25 watts due to interference-limiting, the horizontal boundary is reduced to 7.66 nmi. If the TCAS-equipped aircraft has reduced power by 12 dB and still cannot satisfy the interference-limiting inequality, then the horizontal track boundary collapses to zero and TCAS transmissions cease. If the aircraft is within the track volume, then it is assumed the aircraft is in the roll-call state. The rate of interrogation is computed to be the number of interrogations made over the 10-second roll-call sequence, divided by 10. The entries in the sequence shown in TABLE D-3 are the maximum number of interrogations allowed to produce one valid reply during each 1-second scan of the 10-second roll-call sequence.

The results of a Lincoln Laboratory computer analysis¹² giving the probability of successfully decoding a DABS reply as a function of both the

¹²McDonald, T. S., BCAS DABS Reply Processing Performance Analysis, Report No. 42W-5062, Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, MA, 8 October 1976.

fruit level which is related to the local aircraft density (within 30 nmi) and received power level^a was used in the procedure described above (and in the following steps). The results of that analysis, as presented in Reference 2, are shown in Figure D-4. As an example, consider an aircraft at a range

TABLE D-3
ROLL CALL SCAN/INTERROGATION CONSTRAINTS

Scan	Maximum Number Of Interrogations
1	5
2	4
3	3
4	2
5	2
6	2
7	2
8	2
9	2
10	2

of 5 nmi and assume that its replies to TCAS transmissions are received at -60 dBm. Furthermore, assume that the local aircraft density is 0.12 aircraft per square nmi. Then the probability of correctly receiving a reply is, from Equation D-1, $P_{12} = P_0(-60.0) \times P_{06}(-60 - 10(\log 2)) \approx 0.77$.

At this point, the model computes the required interrogation rate to this transponder to elicit 1 reply per second. This is accomplished using Monte Carlo techniques in conjunction with the probability of decode, and the scan/interrogation table.

^aEach aircraft was assumed to transmit 150 fruit replies per second. Fruit replies from aircraft at ranges of up to about 30 nmi are received at a TCAS above MTL, and are the signals that predominate in garbling elicited replies to the extent that they cannot be decoded. This rate was selected based on the average ATCRBS interrogation rate (about 200/s) computed using the DABS/ATCRBS/AIMS PPM.

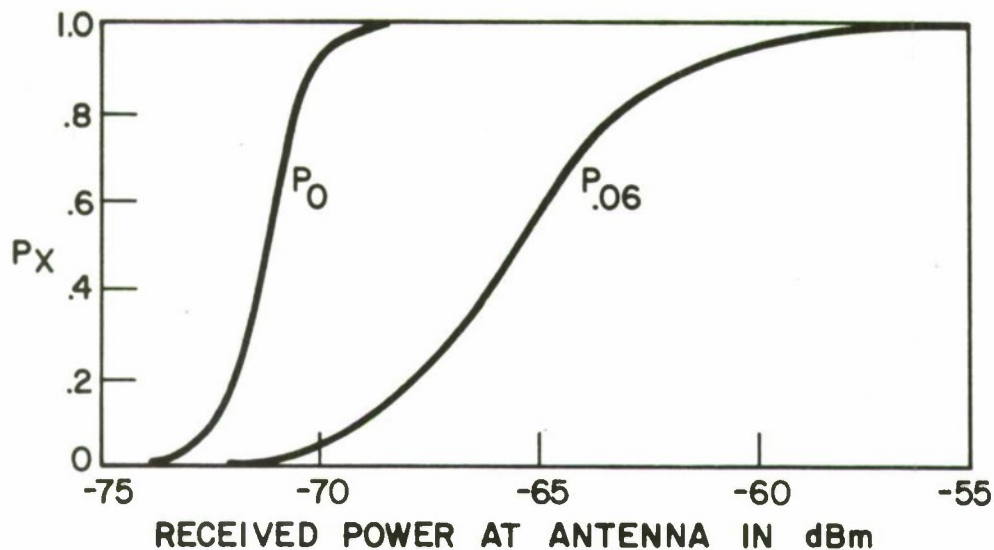


Figure D-4. Assumed probability for correctly receiving a reply (P_x) as a function of received power for aircraft densities of 0 (P_0) and 0.06 ($P_{0.06}$) aircraft/sq. nmi.^a

$$P_x = P_0 (P) \times P_{0.06} (P - 10 (\log \frac{x}{.06})) \quad (D-1)$$

where

P_x = probability of reply detection

P = received power at antenna (dBm)

P_0 = probability of detection at 0 density

$P_{0.06}$ = probability of detection at .06 density

x = aircraft density (aircraft/sq. nmi)

^aNote that the $P_{0.06}$ curve is shifted to the right by 3 dB from the Reference 2 curve to reflect the deletion of error-correction coding from the TCAS/DABS reply data field.

3. If the DABS aircraft is within the vertical boundary but outside the horizontal boundary of the track volume, calculate the "Time of Earliest Encounter," TE, ($TE = \text{range}/\text{maximum closure rate}$). The closure rate is defined to be 600 nmi/hr for all terminal area encounters. If TE is less than 76 seconds ($TE < 76$ corresponds to a range separation of less than 12.66 nmi), the aircraft is assumed to be roll-called as described above.^a If TE is greater than 76 seconds, the aircraft will be either interrogated for acquisition and/or placed in dormancy for a period of $TE - 70$ seconds ($TE - 40$ if limited). The acquisition/dormancy interrogation sequence is described below in step 4.

4. The rate at which TCAS will interrogate aircraft through acquisition interrogation is computed as follows. There are 4 acquisition trials consisting of six 1-second scans. The maximum interrogator failures for a given trial/scan are shown in TABLE D-4.

TABLE D-4
ACQUISITION SCAN/TRIAL INTERROGATION CONSTRAINTS

SCAN	ACQUISITION TRIAL			
	1	2	3	4
1	3	2	1	1
2	3	2	1	0
3	3	2	1	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0

^aIf the TCAS-equipped aircraft is in an interference-limiting state, replace 76 with 46.

The model uses 1) the test data mentioned above (Reference 13) and the received aircraft signal level to compute the probability of decode, and 2) the acquisition trial/scan table to compute the resultant acquisition interrogation rate.

Initially the model computes the length of time (TS) required for a TCAS-equipped aircraft to receive two correlating decodable replies separated by less than 41 seconds.^a If after three iterations of this procedure, two correlating replies from an aircraft have not been decoded, the acquisition interrogation rate to that aircraft is assumed to be zero. For aircraft whose replies are correlated, the following procedure is used. Acquisition interrogations are transmitted in accordance with the acquisition trial/scan table. For example, in the first scan of the first trial as many as four interrogations may be transmitted, one successful and three unsuccessful. If two successful interrogations are made in any given scan, or one successful interrogation is made during any given 6-scan trial,^b acquisition terminates and the aircraft is placed in dormancy for a period T_D of TE-70 (TE-40 if limited) seconds. If no decodable replies are elicited during any given 6-scan trial, the TCAS-equipped aircraft waits for a period, T_H , up to 40 seconds to detect a squitter reply or a reply elicited by another TCAS interrogator from that aircraft. If no decodable replies are received, then two correlating replies separated by less than 41 seconds are required to begin a new acquisition sequence. If a decodable reply is received, the trial counter is incremented and the following 6-scan trial/failure entries are used.

The three cases discussed below summarize the averaging techniques used to compute the appropriate acquisition interrogation rates for: 1) aircraft

^aA target is purged from surveillance processing if a second correlating reply is not received within 40 seconds of the first reply. These replies may be either replies elicited by another TCAS-equipped aircraft or unelicited replies (squitter).

^bA 6-scan interrogating sequence is terminated only if two replies are received during a single scan.

that are acquired and placed in dormancy; 2) aircraft purged from acquisition between trials; and 3) aircraft that are not acquired and not purged.

The acquisition interrogations rate, R_A , to aircraft beyond the track volume were computed as follows:

CASE 1 For aircraft acquired and placed in dormancy

$$R_A = I_A / (N_S + T_D + \sum_{i=1}^n T_{Hi})$$

where

R_A = acquisition interrogation rate (per second)
 I_A = number of acquisition interrogations
 N_S = number of elapsed interrogation scans (1 scan is 1 second)
 T_D = dormancy time (seconds)
 T_{Hi} = time (seconds) between each trial until squitter reply (or reply elicited by other TCAS) is received, where n denotes number of elapsed trials. Note that the sum goes to n whereas between n trials there are only $(n-1)$ squitter waiting periods. The extra waiting period corresponds to the waiting time following dormancy necessary to detect another squitter reply and thus trigger repetition of the procedure.

CASE 2 For aircraft that are not acquired and the 4-trial sequence is terminated with less than 4 trials due to failure to detect a squitter reply between any given trial.

$$R_A = I_A / (N_S + \sum_{i=1}^n T_{Hi} + T_s)$$

T_s = length of time (seconds) required for a TCAS-equipped aircraft to receive two correlating decodable replies separated by less than 41 seconds. This time is included,

since the aircraft is purged from surveillance processing if, after 40 seconds, a squitter reply is not decoded. Two correlating replies separated by less than 41 seconds are then required to repeat the procedure. All other terms are defined under CASE 1 above.

CASE 3 For aircraft that are not acquired and the 4-trial sequence is completed without receipt of an elicited reply.

$$R_A = 19 / (N_s + \sum_{i=1}^4 T_{Hi})$$

19 = maximum number of interrogations during the 4-trial/6-scan sequence. All other quantities are defined under Case 1 above. Following T_{H4} the trial counter is set equal to 1 and the trial/scan sequence is repeated.

Interference-Limiting

The TCAS model will initially assume a peak TCAS output power of 250 watts at the antenna. The number of DABS interrogations and ATCRBS interrogations made by a TCAS-equipped aircraft are counted as well as the number of TCAS-equipped aircraft within squitter range.^a Substituting these computed quantities into the TCAS interference-limiting equation, Equation 1, the TCAS submodel determines if power should be reduced. If so, power and sensitivity are reduced by 6 dB and the entire procedure is repeated. If the inequality is not satisfied after two 6 dB reductions, then collision-avoidance activity for that particular TCAS-equipped aircraft is terminated.^b

It should be noted that the TCAS submodel is cycled twice for each

^aTCAS-equipped aircraft within squitter range refers to those aircraft whose replies are received at a power level such that a reply may be decoded at least once every 40 seconds.

^bAccording to design, the inequality is tested on a second-by-second basis.

simulation. This is necessary to generate accurate acquisition interrogation rates. As mentioned above, replies are monitored by TCAS-equipped aircraft and serve to initiate and continue the acquisition procedure. These replies include not only the 1/s minimum squitter reply rate but also those replies elicited by other TCAS-equipped aircraft. Therefore, the first simulation cycle is designed strictly to determine the average reply rate of each DABS-equipped transponder in the selected environment.

Model/Submodel Interface

The computed steady-state TCAS signal environment is then merged with the DABS/ATCRBS/AIMS PPM by randomly scheduling (uniform distribution) transmission times. A flow diagram of the TCAS simulation routine is shown in Figure D-5.

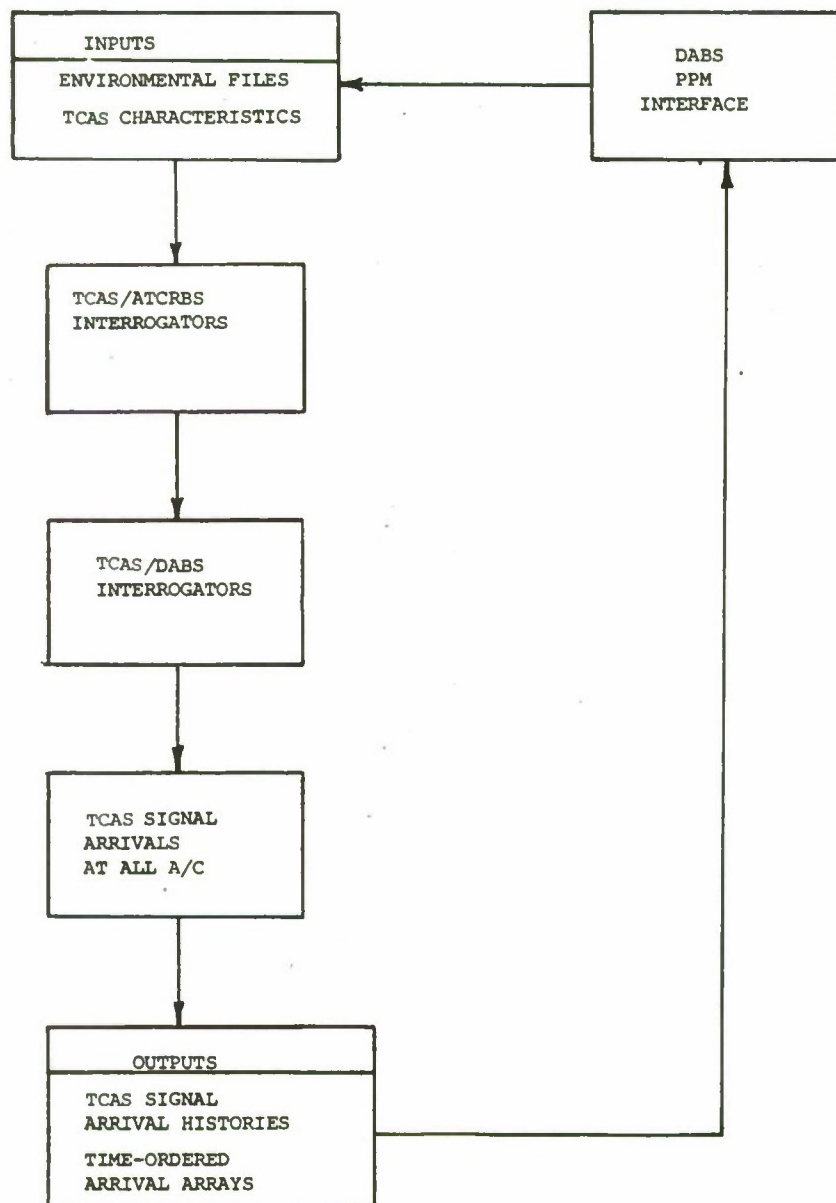


Figure D-5. TCAS flow diagram.

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