

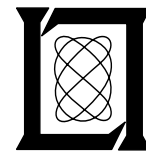
**Project Report
ATC-81**

Uplink Coverage Measurements in the Los Angeles Area for Passive BCAS

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7 November 1977

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16. Abstract Uplink (1030 MHz) measurement results are presented, based on data recorded by the Airborne Measurement Facility of the M.I.T. Lincoln Laboratory during normal landings and take-offs at the LAX, Van Nuys, and San Diego airports. The data presented are relevant to current investigations of passive beacon-based collision avoidance systems and include: (1) the interrogator environment as received; (2) its division between FAA and other interrogators; (3) its dependence on aircraft height during landings and take-offs; and (4) the availability of P2 pulses of sufficient strength for PRF (pulse repetition frequency) tracking. The number of interrogators was found to increase with the aircraft height at the rate of 2.5 to 3 interrogators per 1000 ft. P2 pulse tracking appears to be feasible down to 2000 ft. at LAX, and lower at San Diego.					
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1.0 INTRODUCTION

On 30 September and 1 October of last year (1976), Lincoln Laboratory's Airborne Measurement Facility* (AMF) flew three missions of landings and take-offs in the LA area, one each at the Los Angeles International (LAX), Van Nuys, and San Diego airports. The missions were intended to answer a number of questions raised in connection with current investigations of passive BCAS (beacon-based collision avoidance systems**):

- (1) How many interrogators make up the environment on 1030 MHz;
- (2) How are these divided between FAA (terminal and en-route) and other (mostly military) interrogators;
- (3) How does this environment depend on aircraft altitude during normal landings and take-offs; and
- (4) What is the power level of the P2 pulses received from each interrogator as a function of altitude, and are enough P2 pulses detectable to allow continuous tracking of the Pulse Repetition Frequencies (PRF's) of the local FAA interrogators.

Most interrogators in an area interrogate at fixed rates (PRF's), differing from interrogator to interrogator. This allows the "tracking" of each interrogator, i.e., the separation of its interrogations from the sum total of interrogations received.

* See Project Report ATC-60, 25 March 1976, "The Airborne Measurement Facility (AMF) System Description", G. V. Colby.

** See Bagnall and Kay, "A Review and Analysis of the Litchford Collision Avoidance System," October 1976, FAA-RD-77-1.

2.0 DATA COLLECTION AND PROCESSING

Figures 1 and 2 show the paths of the three AMF missions, superimposed on maps of the Los Angeles and San Diego areas. The maps are derived from the 1:500,000 Sectional Aeronautical Chart of the LA area, and indicate the principal interrogators observed in the data discussed below.

Twenty seconds of data were recorded at each of the 46 aircraft positions shown. A receiver threshold of -74 dBm (referred to the AMF input^{*}) was used everywhere except at position 16, where the threshold was -80 dBm.

The AMF Uplink Data Analysis Program was then run on each data segment. This program assembles received pulses into interrogations and suppressions, and counts each of these for the data span (here 20 sec), as well as in a normalized fashion (per sec). The program has a pulse repetition interval tracker, which separates the interrogation environment into the individual contributions by the interrogators of an area. The tracker can handle both fixed PRI's and also the 8-pulse stagger of the ATCBI-4's associated with the ASR-7's. The range of fixed PRI's tracked by the program is 1800 to 7200 μ s, corresponding to PRF values from 455 to 114 interrogations per sec.

For each tracked interrogator, the program calculates the PRF, the scan period, the mode interlace, the total number of interrogations received over a 20-sec period, the peak mainbeam power, and the average angle of arrival of the interrogations (accurate to ± 30 deg.). Interrogations outside the range of fixed PRI's mentioned above, and those with PRI anomalies are not tracked, but are listed by the analysis program. Scan period, etc., may be determined

* In these measurements, the cable loss between the antenna and the front end of the AMF was 4 dB.

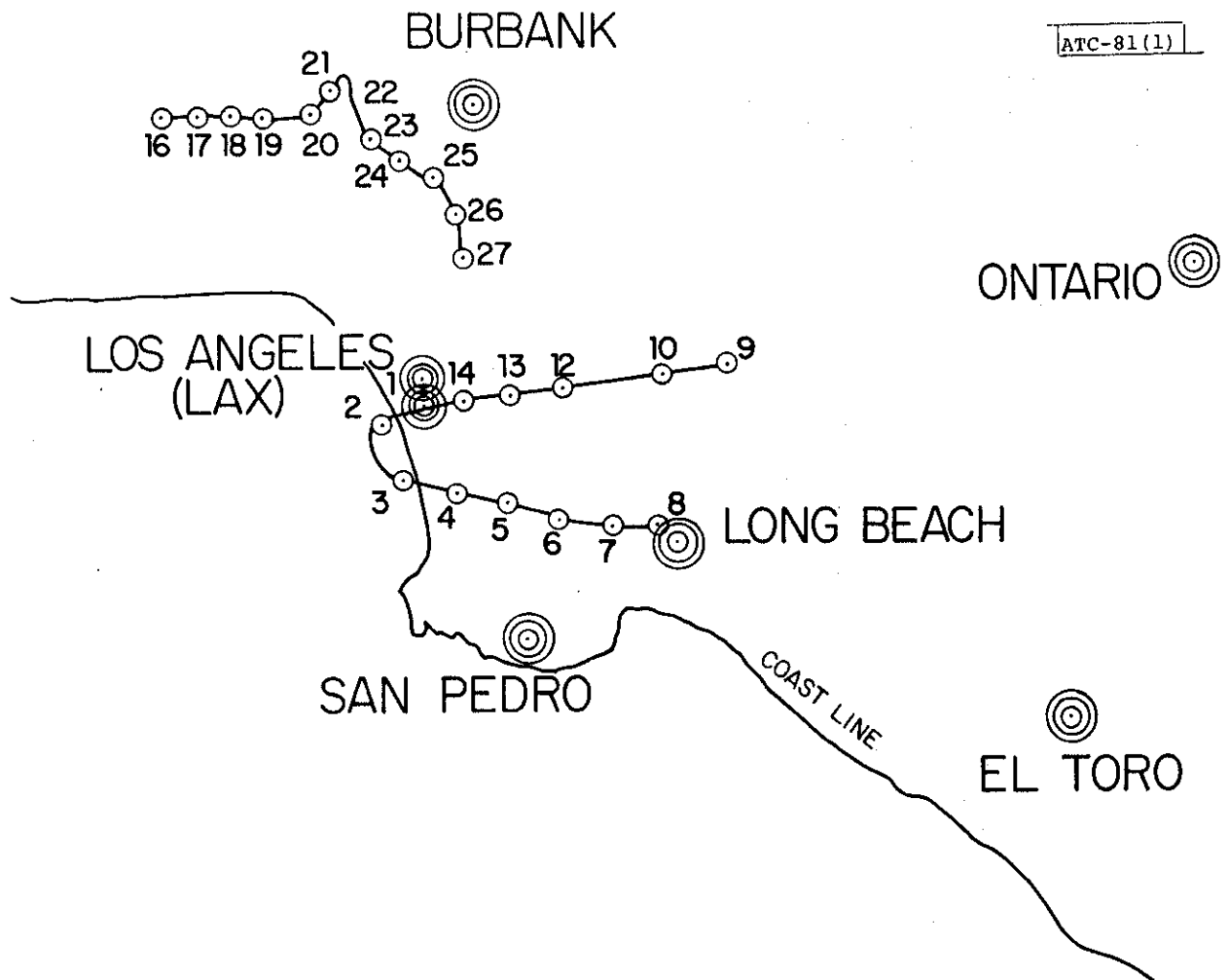


Fig. 1. Aircraft flight path for LA and Van Nuys missions.

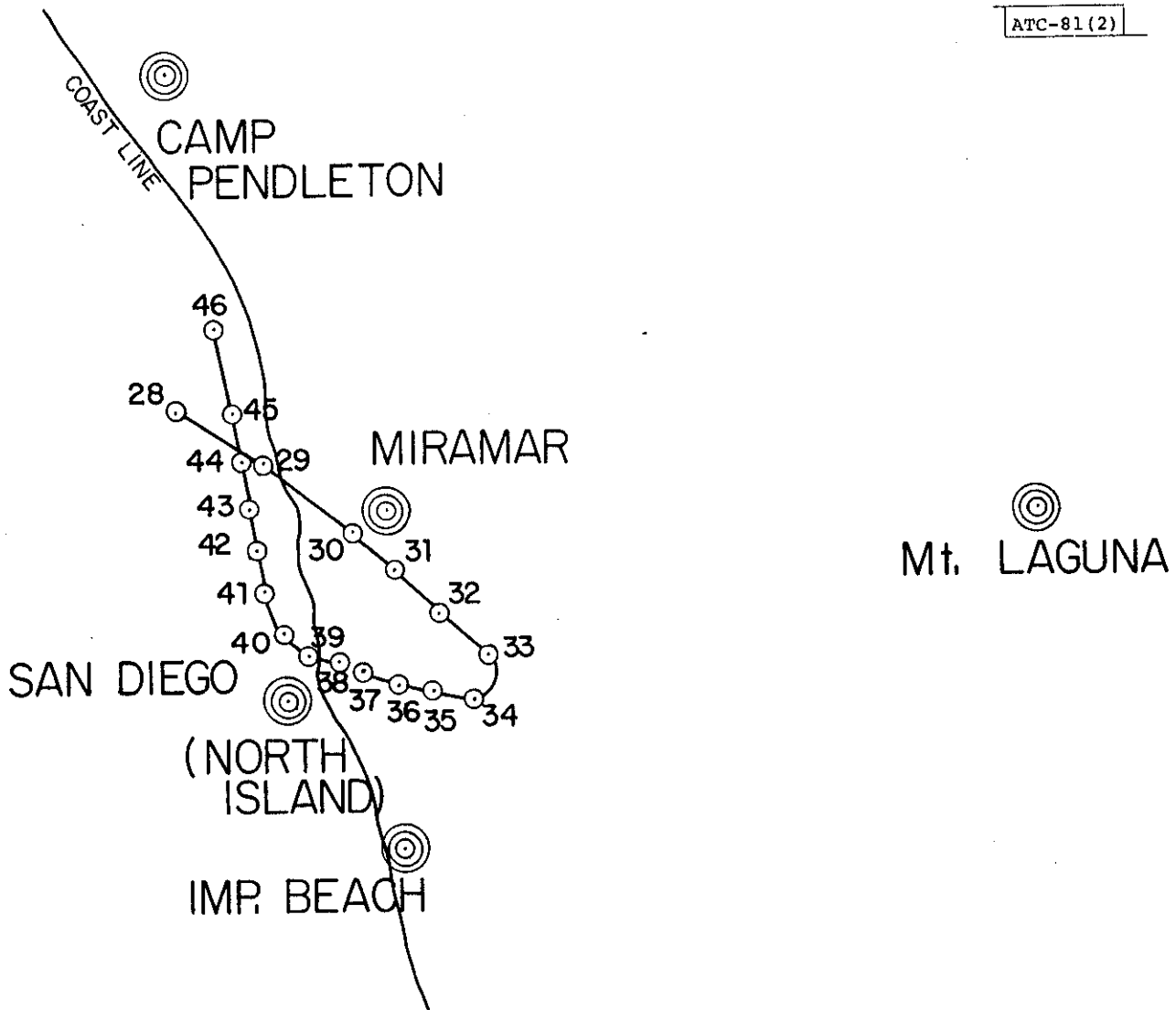


Fig. 2. Aircraft flight path for San Diego mission.

for some of these by hand, if necessary. The results tabulated below, however, refer only to interrogators tracked by the analysis program.

3.0 PRINCIPAL RESULTS

The "Interrogator Environment Tables" (Tables 1 through 9) contain all the information necessary to answer the four questions posed in Section 1. The first three tables show positions 1 - 14, the next three, positions 15 - 27, and the last three, positions 28-46, i.e., they refer to landings and take-offs at LAX, Van Nuys, and San Diego, respectively. The twenty right hand columns of these tables always represent the same twenty interrogators (9 FAA and 11 other), tracked by the analysis program.* The entries under the tracked interrogators alternate cyclically from table to table among:

- (a) Number of interrogations received in 20 sec;
- (b) Estimated angle of arrival of the interrogations;
- (c) Maximum mainbeam power observed.

The first table of each environmental triplet (showing the number of interrogations in 20 sec) gives this additional information:

- (a) Aircraft height above ground (HAG);
- (b) Total interrogations per sec;
- (c) Total suppressions per sec;
- (d) Total pulses seen by AMF per sec.

This organization of the Environment Tables makes it possible to determine the number of interrogations, their direction, and their maximum mainbeam

*The notation 4*12AC denotes a mode interlace pattern of 11112222AAAACCCC.

Table 1

Los Angeles Take-off and Landing.
 No. of Interrogations Received in 20 sec. (Tracked Interrogators Only).

		SCAM	MODE	NAME	PRF														
OTHER INTERROGATORS		NONE	A	F	437.6														
		10.9	4*2C	E	308.6														
		3.77	4*12AC	D	224.6														
		3.80	4*12AC	C	335.9														
		3.84	4*2AC	B	378.0														
		3.86	AC	Norton	273.9														
		9.8	12AC	Camp Pendleton	292.1														
		5.6	4*12AC	A	242.7														
		11.2	4*12AC	San Diego	303.5														
		12.02	2*2ACA	San Clemente	334.9														
FAA INTERROGATORS	ENROUTE	9.67	1AC	San Nicolas	359.4														
		4.72	AAC	Long Beach	337.1														
	TERMINAL	4.67	AAC	Miramar	350.0														
		6.00	AAC	Burbank	375.3														
		4.67	AAC	El Toro	390.2														
		4.67	AAC	Ontario	450.2														
		4.65	AAC	LAXASR7	378.6														
		4.67	AAC	LAX	405.2														
		12.02	2ACA	Mt. Laguna	330.2														
		12.00	2ACA	San Pedro	370.3														
TOTAL PULSES SEEN BY AMP PER SEC						1	2	3	4	5	6	7	8	9	10	11	12	13	14
TOTAL SUPPRESSIONS PER SEC						2291	2290	2663	3465	3740	3349	2786	2767	2600	2861	2861	2455	1726	
TOTAL INTERROGATIONS PER SEC						194	77	117	178	193	195	158	140	72	51	66	71	123	
AIRCRAFT HEIGHT ABOVE GROUND (FT)						100	1500	3200	4400	5700	6400	6400	7700	5700	3400	2600	2000	300	
AIRCRAFT POSITION						1	2	3	4	5	6	7	8	9	10	11	12	13	14

Table 2

Los Angeles Take-off and Landing.
 Estimated Angle of Arrival (deg). (Tracked Interrogators
 Only).

SCAN	MODE	NAME	PRF														
NONE	A	F	437.6	Off													
10.9	4*2C	E	308.6	R25 Take													
3.77	4*12AC	D	224.6	R25 Farthest													
3.80	4*12AC	C	335.9														
3.84	4*2AC	B	378.0														
3.86	AC	Norton	273.9	94 95 90 98 98 92 91													
9.8	12AC	Camp Pendleton	292.1														
5.6	4*12AC	A	242.7														
11.2	4*12AC	San Diego	303.5	128 128													
12.02	2*2ACA	San Clemente	334.9	203 203 176 176 184 184 132 132 187 187 200 200 204 204 172 172 213 213 206 206 208 208													
9.67	1AC	San Nicolas	359.4	229 229 233 233 245 245 200 200 267 267 204 204 256 256 213 213 179 179 245 245 208 208 247 247													
4.72	AAC	Long Beach	337.1	128 112 115 119 119 110 111 210 210 156 156 179 179 139 143													
4.67	AAC	Miramar	350.0	115 116 116 131 117 125 106 130 137 156 135 135 112 105													
6.00	AAC	Burbank	375.3	17 11 5 359 338 336 318 349 354													
4.67	AAC	El Toro	390.2	115 116 116 131 117 125 106 130 137 156 135 135 112 105													
4.67	AAC	Ontario	450.2	90 88 89 89 86 94 90 86 275 274													
4.65	AAC	LAXASR7	378.6														
4.67	AAC	LAX	405.2	56 18 345 316 292 302 318 272 278 275 274													
12.02	2ACA	Mt. Laguna	330.2	175 130 120 162 183 208 280 245 244 236 209 198													
12.00	2ACA	San Pedro	370.3	175 130 120 162 183 208 280 245 244 236 209 198													
TOTAL PULSES SEEN BY AMF PER SEC																	
TOTAL SUPPRESSIONS PER SEC																	
TOTAL INTERROGATIONS PER SEC																	
AIRCRAFT HEIGHT ABOVE GROUND (FT)																	
AIRCRAFT POSITION				1	2	3	4	5	6	7	8	9	10	11	12	13	14

Table 3

Los Angeles Take-off and Landing.
 Largest Mainbeam Power Seen (dBm). (Tracked Interrogators Only).

		SCAN	MODE	NAME	PRF														
OTHER INTERROGATORS		NONE	A	F	437.6	Off													
		10.9	4*2C	E	308.6	R25 Take													
		3.77	4*12AC	D	224.6	Par chest													
		3.80	4*12AC	C	335.9	R25 Land													
		3.84	4*2AC	B	378.0														
		3.86	AC	Norton	273.9	-56 -51 -52 -52 -58 -54 -64													
		9.8	12AC	Camp Pendleton	292.1														
		5.6	4*12AC	A	242.7														
		11.2	4*12AC	San Diego	303.5														
		12.02	2*2ACA	San Clemente	334.9	-59 -47 -58 -57 -59 -61 -63 -59 -63 -57 -53 -51 -58 -55 -68													
		9.67	1AC	San Nicolas	359.4	-51 -66 -53 -63 -57 -66 -61 -61 -57 -51 -54 -54 -66 -54 -49													
	FAA INTERROGATORS	TERMINAL	4.72	AAC	Long Beach	337.1	-61 -48 -44 -44 -42 -36 -37 -44 -42 -46 -49 -49												
4.67			AAC	Miramar	350.0	-54 -54 -57 -59													
6.00			AAC	Burbank	373.3	-55 -46 -54 -55 -58 -56 -51													
4.67			AAC	El Toro	390.2	-73 -58 -50 -56 -54 -56 -53 -50 -49 -47 -53 -57													
4.67			AAC	Ontario	450.2	-51 -53 -52 -55 -50 -49 -62 -56 -33													
4.65			AAC	LAXASR7	378.6	-37 -35 -31 -37 -43 -43 -48 -52 -43 -62 -32 -33													
4.67			AAC	LAX	405.2	-33 -31 -31 -38 -38 -41 -43 -46 -46 -42 -29 -35													
12.02			2ACA	Mt. Laguna	330.2	-53 -53 -63 -68 -62 -53 -58 -48 -63													
12.00			2ACA	San Pedro	370.3	-40 -32 -31 -29 -30 -41 -35 -37 -38 -48 -63													
TOTAL PULSES SEEN BY AMP PER SEC																			
TOTAL SUPPRESSIONS PER SEC																			
TOTAL INTERROGATIONS PER SEC																			
AIRCRAFT HEIGHT ABOVE GROUND (FT)																			
AIRCRAFT POSITION						1	2	3	4	5	6	7	8	9	10	12	13	14	

Table 4

Van Nuys Landing and Take-off.
 Estimated Angle of Arrival (deg). (Tracked Interrogators Only).

SCAN	MODE	NAME	PRF																					
NONE	A	F	437.6																					
10.9	4*2C	E	308.6																					
3.77	4*12AC	D	224.6																					
3.80	4*12AC	C	335.9																					
3.84	4*2AC	B	378.0																					
3.86	AC	Norton	273.9																					
9.8	12AC	Camp Pendleton	292.1																					
5.6	4*12AC	A	242.7																					
11.2	4*12AC	San Diego	303.5																					
12.02	2*2ACA	San Clemente	334.9	116	25	78	41	56									83	82	83	31				
9.67	1AC	San Nicolas	359.4	147	183	85	74	72									75	85	77	33				
4.72	AAC	Long Beach	337.1	46	22	31									46	64	42	60						
4.67	AAC	Miramar	350.0																					
6.00	AAC	Burbank	375.3	77	108	62	97	80	95	107									54	147	93	95	107	82
4.67	AAC	El Toro	390.2	84	23	36	24	42	42									68	11	75	88	59	78	59
4.67	AAC	Ontario	450.2	102	24									11	87	88	78	59						
4.65	AAC	LAXASR7	378.6	107	87	87	71	75									76	52	67	73	143			
4.67	AAC	LAX	405.2	150	107	76	33	125									105	118	91	100	68			
12.02	2ACA	Ht. Laguna	330.2																					
12.00	2ACA	San Pedro	370.3	87	154	102	106	93	12	14									84	46	35	48	26	
TOTAL PULSES SEEN BY AMF PER SEC				2441	4125	933	1071	1373	565	766									531	1644	2340	2293	2646	2772
TOTAL SUPPRESSIONS PER SEC				44	330	35	42	30	6	4									175	28	39	43	50	106
TOTAL INTERROGATIONS PER SEC				835	961	202	325	361	187	327									6	28	35	43	50	106
AIRCRAFT HEIGHT ABOVE GROUND (FT)				3600	3600	3000	2900	2500	1700	800									500	1700	2800	3800	3800	3800
AIRCRAFT POSITION				15	16	17	18	19	20	21									22	23	24	25	26	27

Table 5

Van Nuys Landing and Take-off.
 Estimated Angle of Arrival (deg). (Tracked Interrogators Only).

SCAN	MODE	NAME	PRF															
NONE	A	F	437.6	West														
10.9	4*2C	E	308.6	Farthest						R16 Land								
3.77	4*12AC	D	224.6	R16 Take Off														
3.80	4*12AC	C	335.9	Farthest SE														
3.84	4*2AC	B.	378.0															
3.86	AC	Norton	273.9	88														
9.8	12AC	Camp Pendleton	292.1															
5.6	4*12AC	A	242.7															
11.2	4*12AC	San Diego	303.5															
12.02	2*2ACA	San Clemente	334.9	179	164	140	150	149				154	152	154	147	136		
9.67	1AC	San Nicolas	359.4	206	192	195	224	210	149				206	193	196	208	147	
4.72	AAC	Long Beach	337.1	125	105	118							120	130	145	139		
4.67	AAC	Miramar	350.0															
6.00	AAC	Burbank	375.3	17	53	73	92	82	76	79	99	78	46	12	351	349		
4.67	AAC	El Toro	390.2	118	85	100	96	108	92				123	123	88	130		
4.67	AAC	Ontario	450.2	81	66							95	91	88	89			
4.65	AAC	LAXASR7	378.6															
4.67	AAC	LAX	405.2	133	114	93	108	114				128	138	150	153	159		
12.02	2ACA	Mt. Laguna	330.2															
12.00	2ACA	San Pedro	370.3	141	120	116	112	137	136	154				129	131	143	146	141
TOTAL PULSES SEEN BY AMF PER SEC																		
TOTAL SUPPRESSIONS PER SEC																		
TOTAL INTERROGATIONS PER SEC																		
AIRCRAFT HEIGHT ABOVE GROUND (FT)																		
AIRCRAFT POSITION				15	16	17	18	19	20	21	22	23	24	25	26	27		

Table 6

Van Nuys Landing and Take-off.
Largest Mainbeam Power Seen (dBm). (Tracked Interrogators Only).

		SCAN	MODE	NAME	PRF																
OTHER INTERROGATORS		NONE	A	F	437.6																
		10.9	4*2C	E	308.6	West															
		3.77	4*12AC	D	224.6	Farthest															
		3.80	4*12AC	C	335.9	R16 land															
		3.84	4*2AC	B	378.0	R16 Take off															
		3.86	AC	Norton	273.9	Farthest SE															
		9.8	12AC	Camp Pendleton	292.1																
		5.6	4*12AC	A	242.7																
		11.2	4*12AC	San Diego	303.5																
		12.02	2*2ACA	San Clemente	334.9	-56	-69	-68	-71	-73											
		9.67	1AC	San Nicolas	359.4	-52	-62	-67	-67	-64	-62	-57	-59	-57	-55						
	FAA INTERROGATORS	TERMINAL	4.72	AAC	Long Beach	337.1	-63	-73	-75							-58	-51	-52	-51		
4.67			AAC	Miramar	350.0																
6.00			AAC	Burbank	375.3	-49	-53	-50	-46	-50	-46	-44	-46	-48	-39	-39	-43	-45			
4.67			AAC	El Toro	390.2	-58	-67	-68	-70	-74	-75	-56	-59	-56	-55	-55	-53				
4.67			AAC	Ontario	450.2	-56	-72							-61	-56	-52	-51				
4.65			AAC	LAXASR7	378.6	-43	-55	-63	-66	-58							-48	-46	-47	-46	-39
4.67			AAC	LAX	405.2	-39	-49	-64	-66	-55							-46	-43	-48	-38	-34
12.02			2ACA	Mt. Laguna	330.2												-62	-59			
12.00			2ACA	San Pedro	370.3	-42	-50	-53	-48	-55	-66	-63	-46	-44	-46	-45	-44				
TOTAL PULSES SEEN BY AMP PER SEC																					
TOTAL SUPPRESSIONS PER SEC																					
TOTAL INTERROGATIONS PER SEC																					
AIRCRAFT HEIGHT ABOVE GROUND (FT)																					
AIRCRAFT POSITION					15	16	17	18	19	20	21	22	23	24	25	26	27				

Table 7

San Diego Landing and Take-off.
 No. of Interrogations Received in 20 secs. (Tracked
 Interrogators Only).

		SCAN	MODE	NAME	PRF					
OTHER INTERROGATORS		NONE	A	F	437.6			Off	3821 5903 5693 1231 5707	
		10.9	4*2C	E	308.6	1274 501		Land	Take	
		3.77	4*12AC	D	224.6	70 65 69 96		R27	R27	31 71
		3.80	4*12AC	C	335.9	70 65 62 96				51 103 80
		3.84	4*2AC	B	378.0	203 134 108 23 25 199 54 126 14 6 30 35 61 47				
		3.86	AC	Norton	273.9					
		9.8	12AC	Camp Pendleton	292.1	197 123 113 66 56 62				27 65 94 123 48 101
		5.6	4*12AC	A	242.7	290 125 228 312 321 142 143 110 201				6 137 326 661 360 255 11 155
		11.2	4*12AC	San Diego	303.5	117 100 218 65 327 207 90 126 143 127				155 668 483 188 77 42 46 37 96
		12.02	2*2ACA	San Clemente	334.9	88 71 64 81 29 68 30 26 63				29 75 87 81 42 36 37 78
		9.67	1AC	San Nicolas	359.4	62 63 65				33 54 27 49
		FAA INTERROGATORS TERMINAL		4.72	AAC	Long Beach	337.1			
4.67	AAC			Miramar	350.0	94 116 151 167 106 85 103 86 51 73			89 89 122 199 126 82 7 88	
6.00	AAC			Burbank	375.3					
4.67	AAC			El Toro	390.2	65 64				54 60 9 37
4.67	AAC			Ontario	450.2					
4.65	AAC			LAXASR7	378.6					
4.67	AAC			LAX	405.2					8 56
ENROUTE				12.02	2ACA	Mt. Laguna	330.2	52 64 30 41 24 44 37 78 12 74 28 74 45 48		
		12.00	2ACA	San Pedro	370.3	55 415 319 270 431 354 2033 1907 138 250 243				
		TOTAL PULSES SEEN BY AMP PER SEC				1483 1828 1884 1519 2097 354 2033 1907 138 250 243			310 2529 1553 1208 1745 1931 2120 2053 1802	
		TOTAL SUPPRESSIONS PER SEC				303 415 319 270 431 354 2033 1907 138 250 243			35 306 331 300 294 281 329 419 276	
		TOTAL INTERROGATIONS PER SEC				156 107 186 142 155 147 354 389 118 116 90 92			18 254 83 84 279 421 436 278 361	
		AIRCRAFT HEIGHT ABOVE GROUND (FT)				5200 5300 4700 5200 5000 3300 2200 2100 1500 800			300 300 2300 3200 3700 4700 5400 6400 6600	
		AIRCRAFT POSITION				28 29 30 31 32 33 34 35 36 37			38 39 40 41 42 43 44 45 46	

Table 8

San Diego Landing and Take-off.
 Estimated Angle of Arrival (deg). (Tracked Interrogators
 Only).

		SCAN	MODE	NAME	PRF		
OTHER INTERROGATORS		NONE	A	F	437.6		315 320 315 314 308
		10.9	4*2C	E	308.6	185 208 227 221 233 225 262 258 239	
		3.77	4*12AC	D	224.6	217 213 223	R27 Land R27 Take Off 209 205
		3.80	4*12AC	C	335.9	171 192 199 205 228	206 187 155
		3.84	4*2AC	B	378.0	184 207 227 224 232 252	
		3.86	AC	Norton	273.9		
		9.8	12AC	Camp Pendleton	292.1	340 318 290 293 299 322 323 329	315 336 334 336 334 3
		5.6	4*12AC	A	242.7	186 207 227 224 232 223 245 253	250 236 204 217 213 200
		11.2	4*12AC	San Diego	303.5	131 157 184 219 238 258 270 292 274 264	259 133 159 171 166 168 168 161 152
		12.02	2*2ACA	San Clemente	334.9	272 261 276 278 261 257 270 292 292 261	279 281 267 266 265 264 263 261
		9.67	1AC	San Nicolas	359.4	267 258 258	262 253 263 262
	FAA INTERROGATORS TERMINAL		4.72	AAC	Long Beach	337.1	
		4.67	AAC	Miramar	350.0	113 116 33 321 309 322 329 312 337 328	14 17 30 66 90 100 130 142
		6.00	AAC	Burbank	375.3		
		4.67	AAC	El Toro	390.2	331 296	339 336 337 329
		4.67	AAC	Ontario	450.2		
		4.65	AAC	LAXASR7	378.6		
		4.67	AAC	LAX	405.2		
ENROUTE			12.02	2ACA	Mt. Laguna	330.2	104 91 93 84 79 65 50 72 100 100
		12.00	2ACA	San Pedro	370.3	307 309 302 307 308 310 308 305 299 100	317 322 322 337 318
TOTAL PULSES SEEN BY AMF PER SEC							
TOTAL SUPPRESSIONS PER SEC							
TOTAL INTERROGATIONS PER SEC							
AIRCRAFT HEIGHT ABOVE GROUND (FT)							
AIRCRAFT POSITION					28 29 30 31 32 33 34 35 36 37	38 39 40 41 42 43 44 45 46	

Table 9

San Diego Landing and Take-off.
Largest Mainbeam Power Seen (dBm). (Tracked Interrogators Only).

		SCAN	MODE	NAME	PRF					
OTHER INTERROGATORS		NONE	A	F	437.6			Off	-55 -54 -57 -56 -52	
		10.9	4*2C	E	308.6	-46 -47 -45 -49 -54 -66 -47 -43	Land	Take		
		3.77	4*12AC	D	224.6	-63 -64 -63	R27	R27	-67 -62	
		3.80	4*12AC	C	335.9	-55 -68 -61 -59 -53			-47 -47 -56	
		3.84	4*2AC	B	378.0	-51 -57 -48 -54 -46 -53				
		3.86	AC	Norton	273.9					
		9.8	12AC	Camp Pendleton	292.1	-52 -59 -53 -46 -51 -55 -63			-56 -63 -60 -55 -57 -64	
		5.6	4*12AC	A	242.7	-45 -53 -53 -46 -44 -45 -45 -42 -61 -41 -39 -39 -50			-42 -39 -44 -42 -44 -43 -45 -49 -50 -49	
		11.2	4*12AC	San Diego	303.5	-53 -46 -44 -45 -45 -45 -56 -55 -42 -39 -39 -38 -53			-46 -33 -40 -44 -46 -48 -49 -50 -53	
		12.02	2*2ACA	San Clemente	334.9	-55 -53 -54 -48 -59 -52 -59 -68 -64 -51 -51 -54			-47 -51 -52 -54 -56 -56 -56 -56 -56	
9.67	IAC	San Nicolas	359.4	-65 -59 -48				-58 -65 -56 -63 -56		
FAA INTERROGATORS		4.72	AAC	Long Beach	337.1				-62	
		4.67	AAC	Miramar	350.0	-45 -41 -29 -35 -37 -49 -47 -60 -50 -57			-48 -44 -42 -43 -41 -46 -49 -50	
		6.00	AAC	Burbank	375.3					
		4.67	AAC	El Toro	390.2	-59 -60				-58 -57 -68 -64
		4.67	AAC	Ontario	450.2					
		4.65	AAC	LAXASR7	378.6					
		4.67	AAC	LAX	405.2					-58 -60
		12.02	2ACA	Mt. Laguna	330.2	-63 -41 -44 -44 -43 -45 -48 -47 -45 -54				-59 -50 -50 -48 -48 -51 -41 -49
12.00	2ACA	San Pedro	370.3	-57 -57 -61 -57 -62 -69 -69 -59 -65				-56 -56 -53 -55 -51 -41 -49		
TOTAL PULSES SEEN BY AMF PER SEC										
TOTAL SUPPRESSIONS PER SEC										
TOTAL INTERROGATIONS PER SEC										
AIRCRAFT HEIGHT ABOVE GROUND (FT)										
AIRCRAFT POSITION					28 29 30 31 32 33 34 35 36 37			38 39 40 41 42 43 44 45 46		

power for a given interrogator and aircraft position. For example (from Tables 1, 2, and 3) at position 8, the AMF received 152 interrogations in 20 seconds from San Pedro, arriving from the southwest (245 deg) with a maximum mainbeam power of -35 dBm (in a total environment of 140 interrogations, 776 suppressions, and 2767 pulses per sec).

Although the P2 powers are not output by the analysis program directly, the P2 power may be estimated to have a power level approximately 20 dB below the mainbeam power. For the San Pedro example, the P2 power level would be about -55 dBm.

3.1 Interrogator Population

The Environment Tables answer Questions (1) and (2) of Section 1 (about the environment on 1030 MHz, and about its division between FAA and other interrogators) by counting columns with entries in them. This counting has been done in Table 10, which shows the number of interrogators and their types seen at each position, and the aircraft height at those positions.

Figure 3 presents plots of the corresponding three parts of Table 10 for LAX, Van Nuys, and San Diego, showing the number of different types of interrogators versus height (above ground).

3.2 Altitude Dependence

The plots of Figure 3 answer Question (3) of Section 1 (about the dependence of the environment upon altitude). Note that the FAA interrogators, which predominate in the LAX and Van Nuys areas, are less significant in the San Diego area.

Figure 4 presents another view of the height-type-number dependence. In this figure, landings have been separated from take-offs, and plotted as

Table 10

Number of Tracked Interrogators (FAA and Other) as a Function of Height Above Ground.

AIRPORT		Aircraft Position	Height Above Ground (ft)	FAA Interrogators	Other Interrogators	Total Interrogators
LAX	VAN NUYS	1	100	1	0	1
		2	1500	5	2	7
		3	3200	6	2	8
		4	4400	8	4	12
		5	5700	8	4	12
		6	6400	8	4	12
		7	6400	8	4	12
		8	7700	9	4	13
	9	5700	9	4	13	
	10	3400	8	4	12	
	12	2600	7	2	9	
	13	2000	5	1	6	
	14	300	1	0	1	
	VAN NUYS	15	3600	7	2	9
16		3600	7	2	9	
17		3000	6	2	8	
18		2900	5	2	7	
19		2500	5	2	7	
20		1700	3	0	3	
21		800	2	0	2	
22		500	1	0	1	
23		1700	5	0	5	
SAN DIEGO	VAN NUYS	24	2800	7	2	9
		25	3800	6	2	8
		26	3800	8	4	12
		27	3800	8	4	12
		28	5200	4	9	13
		29	5300	4	9	13
	SAN DIEGO	30	4700	3	9	12
		31	5200	3	7	10
		32	5000	3	7	10
		33	3300	3	7	10
		34	2200	3	7	10
		35	2100	3	7	10
		36	1500	3	5	8
		37	800	2	5	7
		38	300	0	2	2
		39	1300	2	4	6
		40	2300	2	5	7
		41	3200	3	5	8
42	3700	3	5	8		
43	4700	4	6	10		
44	5400	3	7	10		
45	6400	4	5	9		
46	6600	6	6	12		

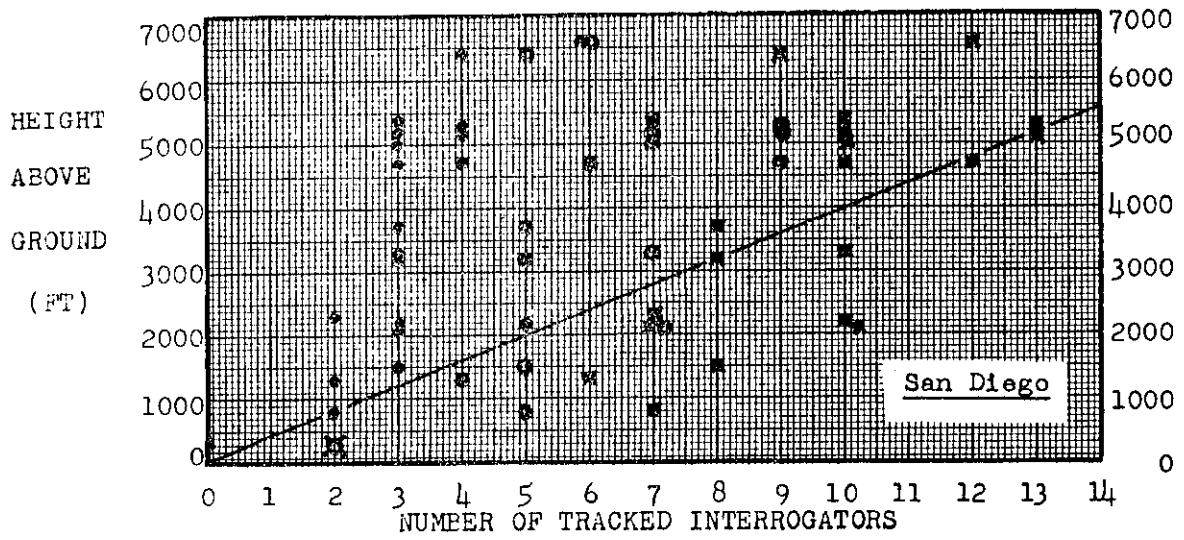
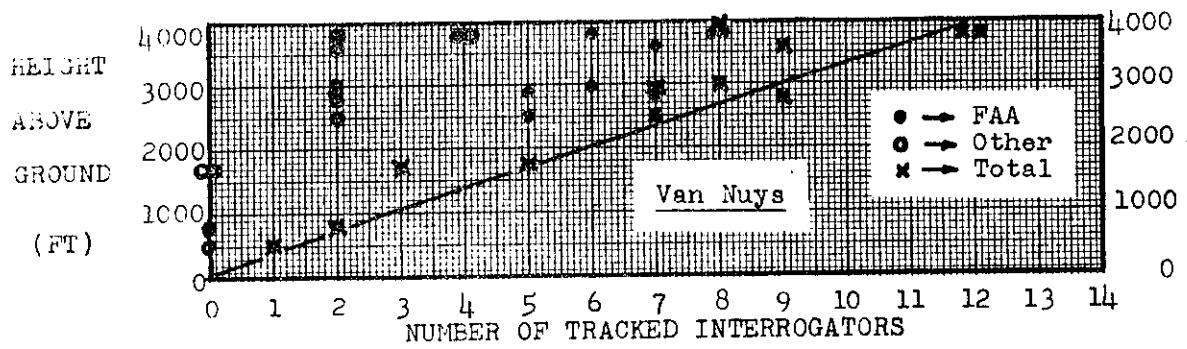
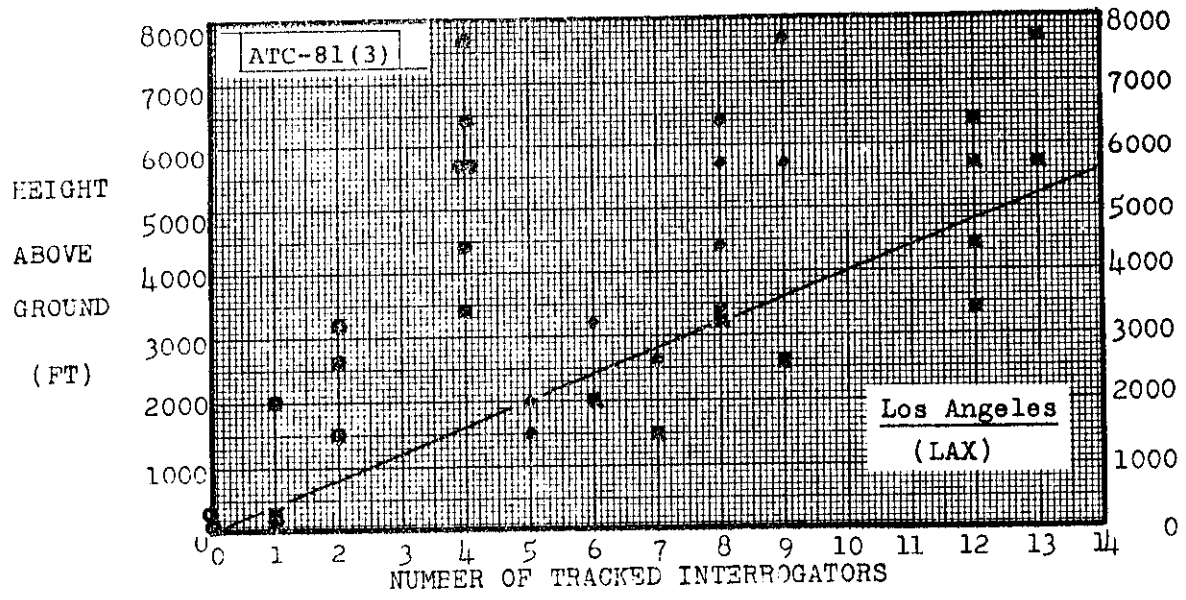


Fig. 3. Number of tracked interrogators as a function of height.

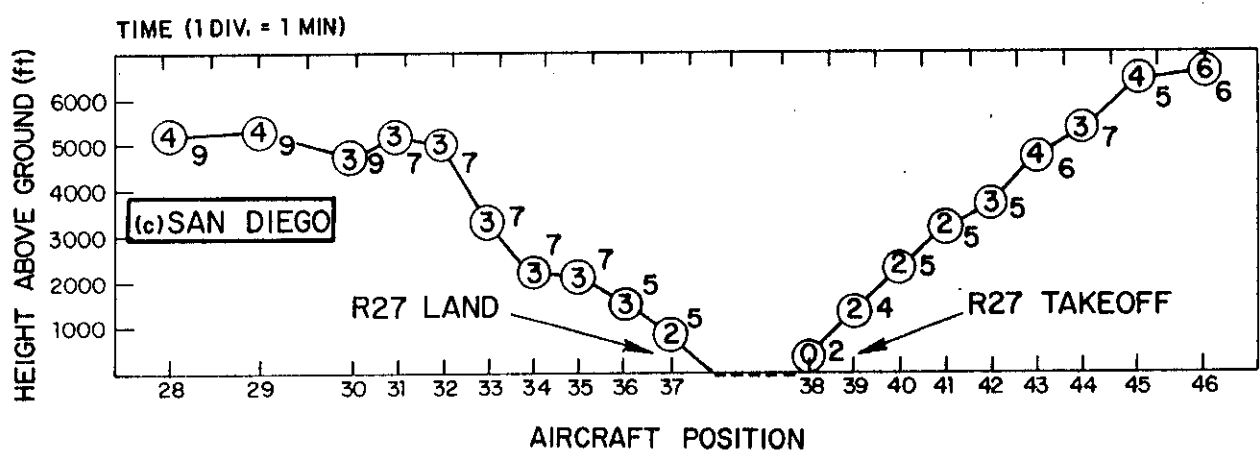
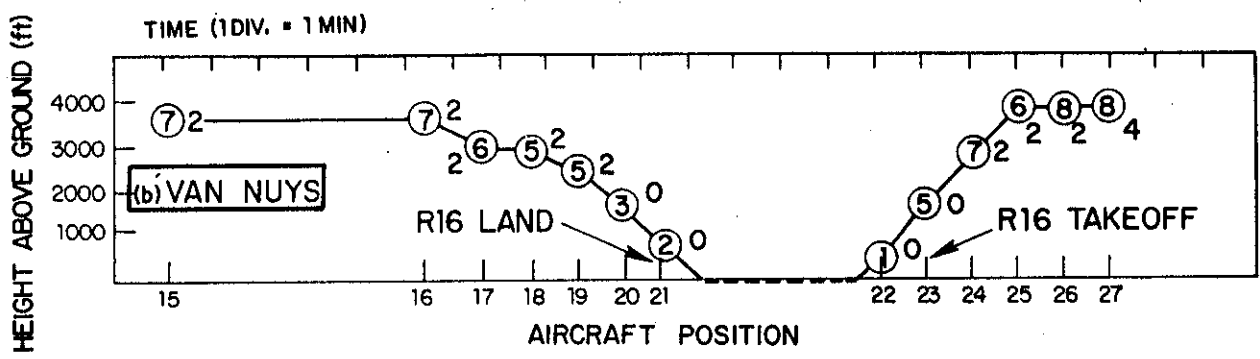
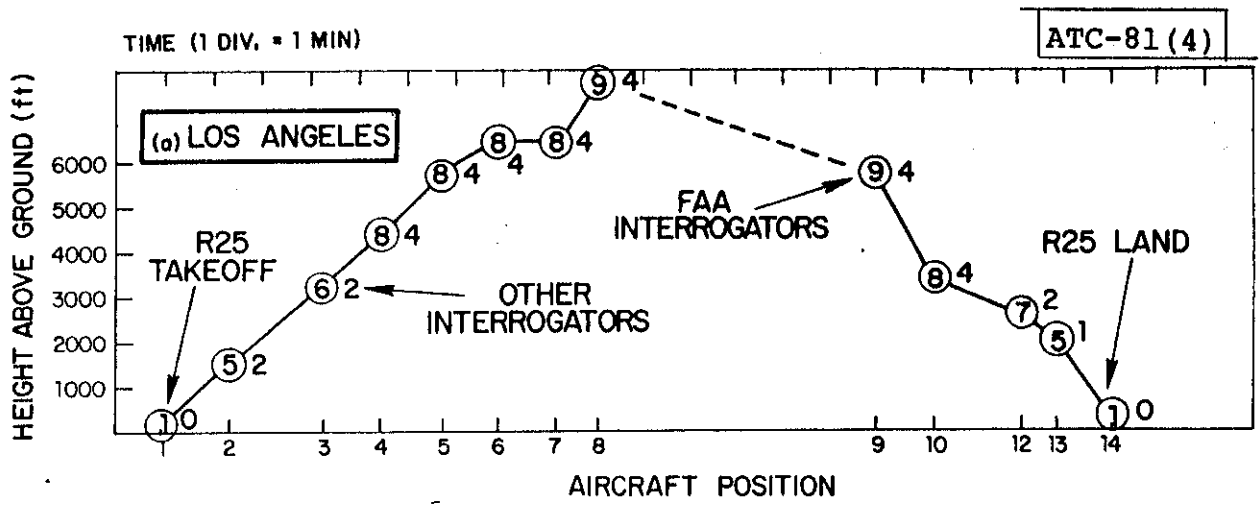


Fig. 4. Number of interrogators tracked during landings and take-offs vs altitude.

a function of time. For each position, a small circle centered at the proper height (above ground) contains the number of FAA interrogators which were tracked there. The number of other interrogators tracked at each altitude is written next to the circle.

3.3 P2 Pulse Tracking

Figure 5 presents data relevant to the problem of passive tracking of P2 pulses, posed in Question (4) of Section 1. Part (a) of the figure is a plot of the maximum power received from the FAA interrogators near LAX. The plotted values have been obtained from six selected columns of Table 3. Since the corresponding plot of P2 pulse power would be approximately 20 dB below the curves shown (as explained in paragraph 3.0) the figure can be used to answer Question (4) about the sufficiency of trackable P2 pulses for any assumed receiver threshold. Part (b) of Figure 5 is similar to Part (a), except that it refers to the San Diego area. Here selected values of Table 9 have been plotted.

4.0 ADDITIONAL RESULTS

4.1 ECAC File Adjustments

The AMF analysis program does not automatically associate interrogators of an area with the different PRFs detected and tracked by the program. This assignment of PRFs to real interrogators must be done manually. The usual method of doing this is to find the PRF in the ECAC Interrogator File nearest to the PRF tracked by the program, and then check the other parameters. When identification is made, the interrogator location (latitude and longitude)

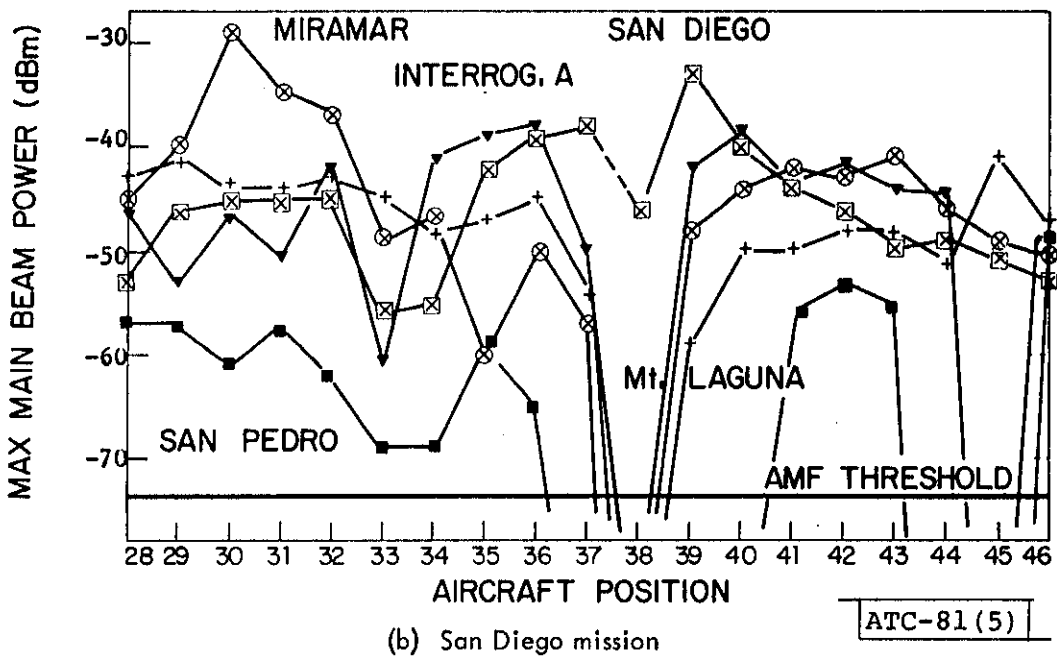
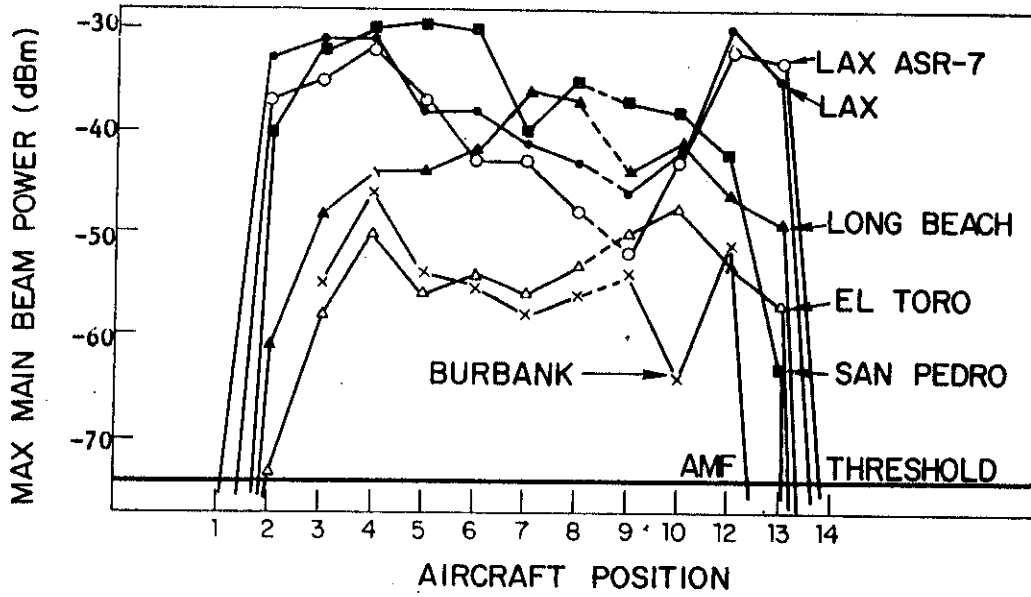


Fig. 5. Maximum power levels of received interrogations.

in the ECAC Interrogator File is further checked for consistency with the measured angle of arrival, measured mainbeam power, and number of interrogations received.

The identification process is often hampered by inaccuracies in the Interrogator File. Fourteen of the 20 PRF's tracked by the program have been identified with real interrogators (as indicated by the names in the Environment Tables) despite the fact that 9 of the 14 appeared in the Interrogator File with one or more parameters in need of adjustment (see Table 11).

4.2 Unidentified Interrogators

Unidentified interrogators (called A, B, C, D, E, and F in the Environment Tables) must be "located" entirely by the measured parameters given in the tables, most of all, by the angle of arrival. This procedure locates interrogators A, B, E (and, probably, C as well) somewhere southwest of the San Diego path, off the coast, perhaps 10 nm west of North Island. Interrogator D is probably much further off the coast, southwest (215 deg) of San Diego. The omni-directional interrogator F is somewhere northwest (315 deg) of San Diego, perhaps off the coast near Camp Pendleton.

4.3 Environment Table Notes

(a) The large number of interrogations per sec at positions 1 and 14 (see Table 1) results from the fact that these positions are just off the ground, over the runways at LAX where reflected suppressions combine into false Mode 1 and 2 interrogations.

(b) At positions 4 through 8, an omnidirectional interrogator on Mode 2, with a PRI of 4071 μ s followed by one of 20358 μ s, regularly, contri-

Table 11

AMF-Measured Interrogator Parameters at Variance with 2-5-76
ECAC File.

INTERROGATOR	PARAMETER OF DIFFERENCE	ECAC FILE 2-5-76	MEAS'D VALUE 10-1-76
San Pedro	RPM	6	5
Mt. Laguna	PRF	241	330.2
Long Beach	PRF MODE	415 A	337.1 AAC
Burbank	RPM	15	10
San Nicolas Is.	MODE	A	1AC
San Clemente Is.	PRF MODE RPM	300 A 16	334.9 4*2ACA 5
San Diego	PRF MODE RPM	300 A 20	303.5 4*12AC 5.5
Cp. Pendleton	PRF MODE	295 A	292.1 12AC
Norton AFB	PRF MODE	275 A	273.9 AC

buted about 60 interrogations per sec. It seemed to be located just south of Long Beach. It is an interrogator on 4071 μ s (PRF = 221) which is on the air 2 times, and then off the air 4 times, repeatedly.

(c) At position 16 (see Table 4), the 330 interrogations per sec are mainly due to an interrogator on 320 PRF, to the southwest (mode interlace 1/2/A, scan period = 7.8 sec). Many sidelobe interrogations from this interrogator were received, partially because of the enhanced receiver sensitivity used at this one position (-80 dBm instead of the usual -74 dBm).

(d) At position 27, most of the 106 interrogations per sec come from an interrogator with an unstable PRI of 5052 ± 2 μ s interrogating on Mode 2, located somewhere to the west (about 960 interrogations in 20 sec).

(e) An omnidirectional interrogator on 100 PRF (Mode A) was observed from position 29 to position 36 of the San Diego mission. Many interrogations (1200 to 1800 in 20 sec) were received from it during positions 30 through 34. Its angles of arrival seem to place it on the coast between North Island and Imperial Beach.

(f) The excessive number of interrogations at position 39 (554 per sec) comes from another omnidirectional interrogator seen only at this one point. Its PRF (910 per sec) is unusually high. Its Mode A interrogations are coming from the southeast at -70 dBm. It might be located somewhere between Tijuana and Imperial Beach (about 800 interrogations in 20 sec).

(g) Some interrogations with irregular PRI have been seen during these three missions. An interrogator ("Z1") with a 26- μ s jitter in its PRI (8687 μ s followed by 8713 μ s, repeatedly) was seen through most

of the Van Nuys mission, contributing 2 to 3 interrogations per sec (mode interlace A/C, scan = 3.72 sec). Interrogator Z1 is presumably located just south of LAX.

(h) A second interrogator ("Z2") with highly irregular PRI of period 9 (full period: 6810, 2831, 2831, 3051, 2831, 2831, 3881, 2831, 2831 μ s) was noted through the first part of the San Diego mission (positions 28-40), contributing perhaps 7-8 interrogations per sec (Mode C, scan = 7.78 sec). Interrogator Z2 is probably on the coast south of Long Beach.

(i) Another interrogator ("Z3") with irregular PRI of period 7 (full period: 4107, 4107, 4107, 4107, 4117, 4900, 4094 μ s) was noted contributing 3 interrogations per sec during positions 24 - 27 of the Van Nuys flight (mode interlace 1/2/A/C, scan = 5.8 sec). Its interrogations were arriving from the southeast at a rather high level (-40 dBm). Interrogator Z3 might be located near Inglewood.

(j) Finally, a fourth interrogator ("Z4") with irregular PRI of period 7 (full period: 4607, 5692, 3354, 4143, 4916, 5107, 5108 μ s) was seen at positions 17 and 18. Interrogator Z4 contributed 2 to 3 interrogations per sec (mode interlace 1/2/A/C, scan = 5.87 sec) at a low power level (-70 dBm), arriving from the southeast.

5.0 CONCLUSIONS

The AMF measurements indicate a visible interrogator population increasing with height during normal landings and take-offs at the three selected LA area airports (see Table 10 and Figures 3 and 4). The number of FAA and other interrogators visible to the AMF increases rapidly with aircraft height

and then tends to become constant above an altitude of approximately 3000 ft. The actual number of interrogators seen and the FAA/other ratio are area dependent.

The behavior of FAA interrogators is generally predictable from the ECAC Interrogator File for the area, but other interrogators are either on or off according to time of day and day of the week, and a significant number of interrogators not included in the ECAC file are generally received. Although the total number of received interrogators is not exactly a linear function of altitude (see Fig. 3), a linear function does provide a first-order approximation for altitudes up to about 6000 ft., where the rate is 2.5 interrogators per 1000 ft. for LAX and San Diego, and 3 interrogators per 1000 ft. for Van Nuys.