

SECTION 6

SAN FRANCISCO ENVIRONMENT

INTRODUCTION

This section discusses the feasibility of deploying the Limited Surveillance Radar (LSR) at eight proposed sites in the San Francisco area in the 2.7 to 2.9 GHz band. The LSR system characteristics and Interference-to-Noise Ratio (INR) criterion used in the investigation are discussed in Section 3. The procedure used to identify frequencies in the 2.7 to 2.9 GHz band at which the LSR can operate without performance degradation to the radars presently in the environment, or the LSR, is discussed in Section 4.

RADAR ENVIRONMENT OF 2.7 to 2.9 GHz BAND

The present radar environment for the San Francisco area was determined using information obtained from the Western Region FAA Frequency Manager, and the Government Master File. Comparison was made between the two sources, and differences resolved by contacting the FAA and DoD area frequency coordinators. It was determined that there are 23 radars in the San Francisco area operating in the 2.7 to 2.9 GHz band. TABLE 6-1 lists the location, nomenclature, and function of these radars. Figure 6-1 shows the location of these radars on a San Francisco area map. The equipment characteristics of the radars are given in TABLE 6-2.

LSR ENVIRONMENT

Eight potential LSR sites have been identified in the San Francisco area. TABLE 6-3 shows the approximate latitude/longitude locations for the LSR sites, and Figure 6-2 shows the location of the LSR radars in the San Francisco area.

LSR DEPLOYMENT

The following is a discussion of the feasibility of deploying LSRs at the eight proposed sites in the San Francisco area (see TABLE 6-3 and Figure 6-2) without degrading the performance of existing radars in the environment, or the LSR radars.

Merced LSR

The proposed Merced LSR site is located in the San Joaquin Valley. There is only one potential interfering radar to the Merced LSR. The Castle AFB AN/GPN-20 (Radar No. 13) is located approximately 6.7 miles from the proposed Merced LSR site. The Castle AFB radionavigation radar normally operates in the frequency diversity mode at 2715 and 2785 MHz. TABLE 6-4 shows the frequency bands denied by the Castle AFB AN/GPN-20 radar for operation of an LSR at Merced. Approximately 60 percent of the band can be used for operation of the Merced LSR.

TABLE 6-1

LOCATION OF 2.7 - 2.9 GHz RADARS IN SAN FRANCISCO AREA

<u>RADAR</u> <u>No.</u>	<u>CITY/BASE</u>	<u>NOMENCLATURE</u>	<u>LATITUDE</u>			<u>LONGITUDE</u>		
FAA		Airport Surveillance Radars						
1	Monterey	ASR-8	36	35	16	121	50	09
2	Fresno	ASR-4	36	46	51	119	43	06
3	Mountain View*	ASR-5	37	25	38	122	00	50
4	Oakland	ASR-7	37	42	23	122	13	27
5	Sacramento*	ASR-4	38	39	56	121	24	14
6	Marysville	ASR-5	39	07	49	121	27	35
FAA/Military		Test Range Surveillance Radars						
7	Panamint Valley	ASR-8	36	02	32	117	17	01
8	Owens Valley	ASR-8	36	37	07	118	01	42
Navy		Ground Control Approach Radars						
9	Lemoore	ASR-5	36	20	44	119	54	18
10	Alameda	MPN-11	37	47	23	122	19	20
11	Vallejo	MPN-5	38	05	06	122	16	52
Navy		Tracking Radars						
12	Monterey	APS-20	36	35	52	121	52	25
Air Force		Ground Control Approach						
13	Castle AFB	GPN-20	37	22	34	120	33	03
14	Hayward ANG	MPN-13	37	40	00	122	07	00
15	Camp Parks	MPN-13	37	42	00	121	54	00
16	Travis AFB	FPN-55	38	16	08	121	54	58
17	Mather AFB	MPN-13	38	33	51	121	17	19
18	Beale AFB	MPN-15	39	08	12	121	26	00
Air Force		AF Height Finding Radars						
19	Almaden	FPS-90	37	09	38	121	53	47
20	Almaden	MPS-14	37	09	38	121	53	47
21	Mt. Tamalpais	FPS-90	37	55	45	122	35	20
22	Point Arena	FPS-90	38	53	19	123	32	55
NOAA		Weather Radars						
23	Sacramento	WSR-57	38	35	00	121	29	00

*Joint FAA/Military

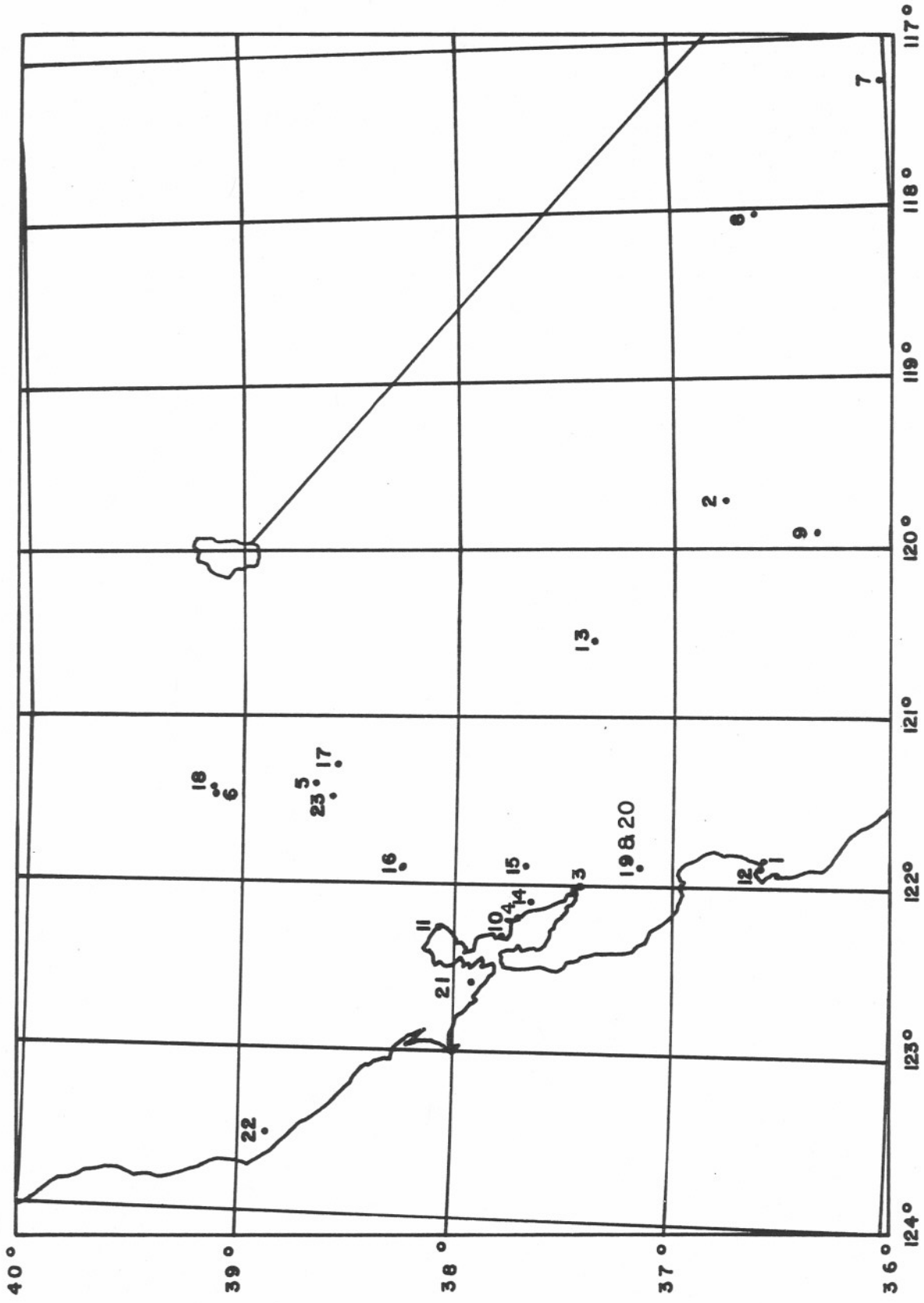


Figure 6-1. Location of Radars in the 2.7-2.9 GHz Band in the San Francisco Area.

TABLE 6-2

CHARACTERISTICS OF 2.7-2.9 GHz RADARS IN SAN FRANCISCO AREA

STATION	CITY/BASE	EQUIPMENT NOMENCLATURE	ASSIGNED FREQUENCY (MHz)	PEAK POWER (kW)	OUTPUT TUBE TYPE	P. N. (μs)	PRF (PPS)	IF Bw (MHz)	NOISE LEVEL (dBm)	ANTENNA GAIN (dB)	ANTENNA HEIGHT (FT.)	ANTENNA TILT ANGLE (DEGREES)	ANTENNA SCAN RATE (RPM)	SCOPE RANGE (NM)	SIT ELEV (FT)
1	Monterey	ASR-8	2770 2855	1000	VA-87E	0.6	964	1.1,5*	-110	33.5 32.5	55		12.5	60	253
2	Fresno	ASR-4	2850 - 2860	400	5586+	0.833	840	2.7,5*	-106	34.0	26		13.0	60	332
3	Mountain View	ASR-5	2750 - 2760	500	5536+	0.833	1125	2.7,5*	-106	34.0	26	3.0	13.0	60	9
4	Oakland	ASR-7	2720 - 2730	600	DX276+	0.833	1002	2.7,5	-105	34.0	26	3.0	15.0	60	9
5	Sacramento	ASR-4	2860 - 2870	600	5586+	0.833	810	2.7,5*	-106	34.0	26	3.0	15.0	60	23
6	Marysville	ASR-5	2840 - 2850	600	5586	0.833	830	2.7,5*	-106	34.0	26		13.0	60	113
7	Paracent Valley	ASR-8	2735 2865	1000	VA-87E	0.6	1040	1.1,5*	-110	33.5 32.5	26		12.5	60	1342
8	Owens Valley	ASR-8	2830 2895	1000	VA-87E	0.5	1030	1.1,5*	-110	33.5 32.5	26		12.5	60	3692
9	Lemoore	ASR-5	2800 - 2810	400	VA-87E	0.6	700	1.1,5	-106	33.5 32.5			12.5	60	237
10	Alameda	AN/APN-11	2800	600	5586	0.5	1500	2.25	-102	33.0	14	3.5	20.0	30	15
11	Vallejo	AN/APN-5	2900	350		0.8	1200	1.5	-100	33.0	14		15 or 30	50	5
12	Monterey	AN/APS-20	2880	750		2.0	300	1.0	-111	30.0			10	200	46
13	Castle AFB	AN/GPN-20	2715 2785	550	8796	0.833	1040	1.2,5*	-105	33.5 32.5	26		15.0	60	190

* Normal and MTI IF Bw, respectively
+ FAA ASR radars may use 5586, DX276 or QKI643

TABLE 6-2 CONTINUED

CHARACTERISTICS OF 2.7-2.9 GHz RADARS IN SAN FRANCISCO AREA

ICRBN NO.	CITY/BASE	EQUIPMENT NOMENCLATURE	ASSIGNED FREQUENCY (MHz)	PEAK POWER (kW)	OUTPUT TUBE TYPE	P.W. (μs)	PRF (PPS)	IF BW (MHz)	NOISE LEVEL (dBm)	ANTENNA GAIN (dB)	ANTENNA HEIGHT (FT.)	ANTENNA TILT ANGLE (DEGREES)	ANTENNA SCAN RATE (RPM)	SCOPE RANGE (N/A)	SITE ELEV. (FT.)
14	Hayward ANG	AN/AFN-13	2800	700	8798	0.7	1100	2.26	-106	32.0	14	3.75	15	30	46
15	Camp Parks	AN/AFN-13	2800	700		0.7	1100	2.26	-106	32.0	14		15	30	
16	Travis AFB	AN/FPS-55	2800	400	8798	0.833	900	2.7, 5*	-106	34.0	26	4.25	13	60	68
17	Wether AFB	AN/AFN-13	2800	750	5586	0.7	1100	2.26	-106	32.0	14	5.5	15	30	79
18	Beale AFB	AN/AFN-15	2800	750		0.7	1100	2.26	-106	32.0	14	5.5	15	30	113
19	Almaden	AN/FPS-90	2780	5000	VSM-1143	2.0	278	1.0	-106	39.0	50	N.A	7.5RPM 20-30 CPM	200	3539
20	Almaden	AN/FPS-14	2795	5000	VSM-1143	2.0	278	1.0	-106	39.0	50	N.A	7.5RPM 20-30 CPM	200	3539
21	Mt. Tamalpais	AN/FPS-90	2825	5000	VSM-1143	2.0	356	1.0	-106	39.0	40	N.A	7.5RPM 20-30 CPM	200	2648
22	Point Arena	AN/FPS-90	2795	5000	VSM-1143	2.0	328	1.0	-106	39.0	39	N.A	7.5RPM 20-30 CPM	200	2373
23	Sacramento	WSR-57	2890	500	OK 729	0.5 4.0	545 164	4.5 0.75	-100 -108	36	258	-5 to 45	0 to 5	250	19

* Normal and MTI IF Bw respectively.

TABLE 6-3

PROPOSED LOCATIONS OF LSRs IN SAN FRANCISCO AREA

<u>RADAR NUMBER</u>	<u>CITY</u>	<u>LATITUDE</u>	<u>LONGITUDE</u>
24	Merced	37 17 --	120 31 --
25	Modesto	37 38 --	120 57 --
26	Livermore	37 42 --	121 49 --
27	Stockton	37 54 --	121 14 --
28	Concord	37 59 --	122 03 --
29	Napa County	38 13 --	122 17 --
30	Santa Rosa	38 31 --	122 49 --
31	Chico	39 48 --	121 51 --

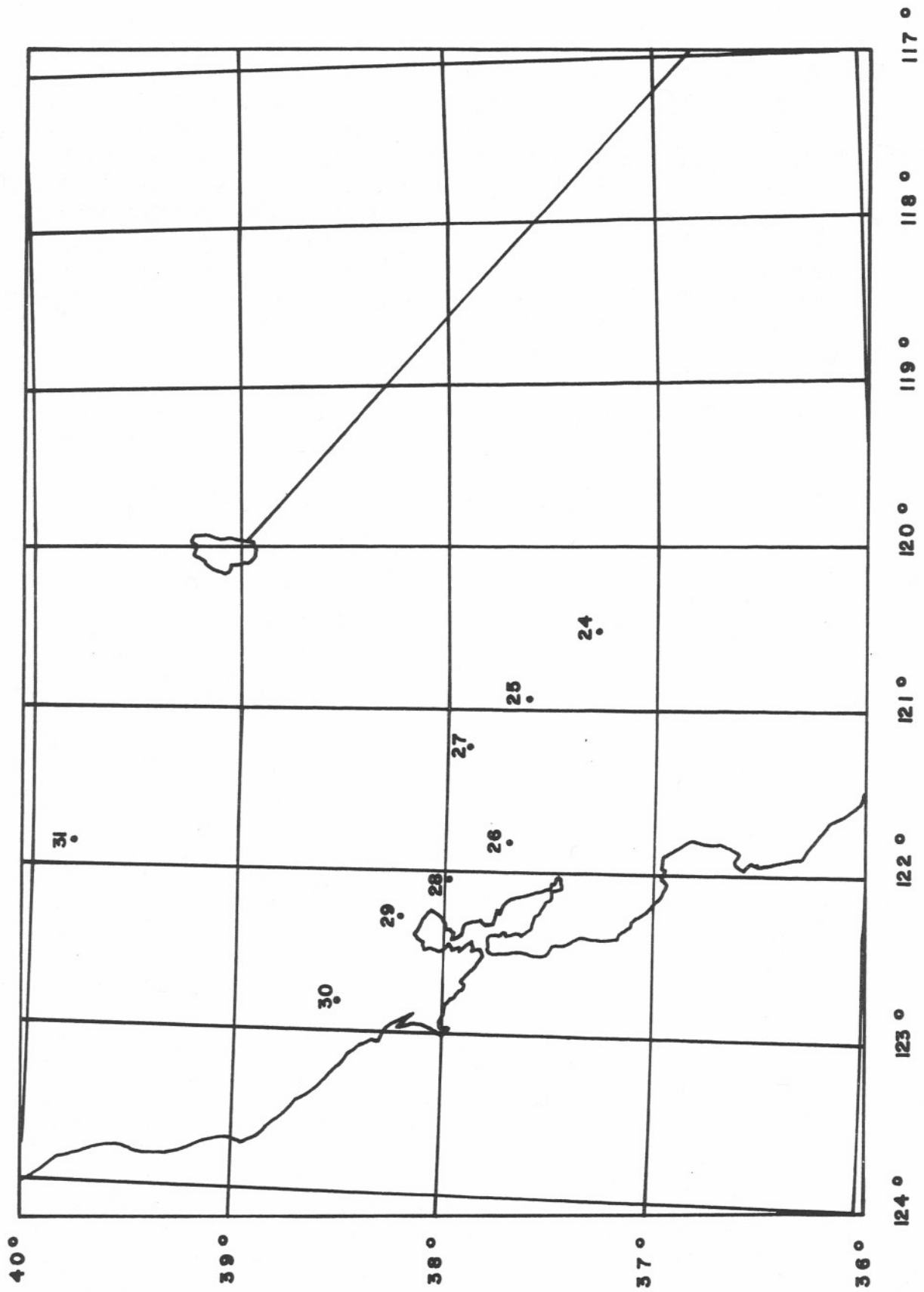


Figure 6-2. Proposed Location of Limited Surveillance Radars (LSRs) in the San Francisco Area.

TABLE 6-4

MERCED LSR SITE

RADAR NO.	P_t (dBm)	G_t (dBi)	OTR (dB)	L_p (dB)	REQUIRED OFR (dB)	DENIED FREQUENCY BAND (MHz)
13	87.4	26.5	6.0	134	63.9	2700-2735 2765-2805

2	2	2		2		2
7	7	7		8		9
0	3	6		0		0
0	5	5		5		0



 Usable Frequency Band: 60%

Modesto LSR

There are six radars in the San Francisco area which could potentially interfere with an LSR located at Modesto. TABLE 6-5 lists the potential interfering radars, and the denied frequency band of each potential interfering radar. The height-finding radars (Radars Nos. 19 and 20) will only interfere with the LSR when they are nodding at the bearing of the Modesto LSR. TABLE 6-5 shows that approximately 76 percent of the band is available for operation of an LSR at Modesto.

Livermore LSR

The proposed Livermore LSR site is located in the Livermore Valley east of the San Francisco Bay. Livermore Valley has mountain ranges or hills on all four sides. There are eight radars in the San Francisco area which could potentially interfere with an LSR located at Livermore. TABLE 6-6 lists the potential interfering radars, and the denied frequency band for each potential interfering radar. When considering all the potential interfering radars, 26.5 percent of the 2.7 to 2.9 GHz band can be used for operation of an LSR at Livermore.

Stockton LSR

The proposed Stockton LSR is located in the San Joaquin Valley. There are five radars which could potentially interfere with an LSR located at Stockton (see TABLE 6-7). Three of the potential interfering radars are height-finding radars located at Almaden (Radars Nos. 19 and 20) and Mt. Tamalpais (Radar No. 21). The other two potential interfering radars are the Sacramento weather radar (Radar No. 23), and a proposed LSR at Modesto (Radar No. 25). TABLE 6-7 shows the denied frequency band for each of the potential interfering radars. Approximately 81 percent of the band is available for frequency assignment to an LSR located at Stockton.

Concord LSR

Eight radars in the San Francisco area were identified as potential interfering radars if an LSR is located at Concord (see TABLE 6-8). Two of the potential interfering radar propagation paths (Vallejo AN/MPN-5 and Travis AFB AN/FPN-55) were identified as possible ducting paths. Also, the path between the proposed Napa County LSR and the Concord LSR was identified as a possible ducting path. Three height-finding radars (Radar Nos. 19, 20, and 21) could also potentially interfere with an LSR located at Concord. When considering all the potential interfering radars, 40.5 percent of the 2.7 to 2.9 GHz band can be used for operation of an LSR at Concord. TABLE 6-8 shows the available frequencies for operation of an LSR at Concord.

Napa County LSR

The Napa County LSR is located at the North end of the San Francisco/San Pablo Bay. Because the proposed LSR site is located near the North end of the Bay, propagation ducting phenomena, which occurs approximately 50 percent of the time in the Bay area, significantly increases the potential of interference to the proposed Napa County LSR. There are 12 radars in the San Francisco area

TABLE 6-5
MODESTO LSR SITE

RADAR NO.	P _t (dBm)	G _t (dBi)	OTR (dB)	L _p (dB)	REQUIRED OFR (dB)	DENIED FREQUENCY BAND (MHz)
13	87.4	26.5	6.0	159	38.9	2707-2723 2777-2793
19	97	39	0	216	10	2778-2782
20	97	39	0	216	10	2793-2797
21	97	39	0	205	21	2823-2827
24	80	22.5	0	187	5.5	No Assigned Frequency (4MHz)
27	80	22.5	0	186	6.5	No Assigned Frequency (4MHz)

2 2 2 2 2 2
 7 7 7 7 7 8 8
 0 0 2 7 9 2 2
 0 7 3 7 7 3 7



Usable Frequency Band: 76%

TABLE 6-6
LIVERMORE LSR SITE

RADAR NO.	P_t (dBm)	G_t (dBi)	OTR (dB)	L_p (dB)	REQUIRED OFR (dB)	DENIED FREQUENCY BAND (MHz)
3	87	27	6.0	195	3	2748-2762
4	88	27	6.0	173	26	2712-2735
10	88	26	10.4	171	22.6	2792-2805
14	89	25	7.5	180	16.5	2797-2803
15	89	25	7.5	131	65.5	2723-2859
19	97	39	0	195	31	2776-2782
20	97	39	0	195	31	2791-2797
21	97	39	0	167	59	2807-2833 2761-2786

2	2	2	2
7	7	8	9
0	1	5	0
0	2	9	0




 Usable Frequency Band: 26.5%

TABLE 6-7

STOCKTON LSR SITE

RADAR NO.	P _t (dBm)	G _t (dBi)	OTR (dB)	L _p (dB)	REQUIRED OFR (dB)	DENIED FREQUENCY BAND (MHz)
19	97	39	0	191	35	2774-2783
20	97	39	0	191	35	2789-2798
21	97	39	0	186	40	2817-2829
23	87	36	0	200	13	2888-2892
25	80	22.5	0	187	5.5	No Assigned Frequency (4 MHz)

2		2	2	2	2		2	2	2
7		7	7	7	7		8	8	8
0		7	8	8	9		1	2	8
0		4	3	9	8		7	9	8



 Usable Frequency Band: 31%

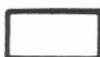
TABLE 6-8
CONCORD LSR SITE

RADAR NO.	P _t (dBm)	G _t (dBi)	OTR (dB)	L _p (dB)	REQUIRED OFR (dB)	DENIED FREQUENCY BAND (MHz)
4	88	27	6.0	196	3	2718-2732
11	86	26	6.0	139*	57	2748-2832
16	86	27	6.0	142*	55	2752-2828
19	97	39	0	198	28	2777-2782
20	97	39	0	198	28	2792-2797
21	97	39	0	160	66	2754-2836 2890-2900
23	87	36	0	174	39	2879-2896
29	80	22.5	0	153*	39.5	No Assigned Frequency (12MHz)

* Potential ducting path.

2	2	2	2		2	2	2
7	7	7	7		8	8	9
0	1	3	4		3	7	0
0	8	2	8		2	9	0



 Usable Frequency Band: 40.5%

which could potentially interfere with an LSR located at the Napa County Airport. TABLE 6-9 lists the potential interfering radars, and the denied frequency band for each potential interfering radar. Five of the potential interfering radar propagation paths were identified as potential ducting paths. The Mt. Tamalpais height-finding radar (Radar No. 21) is line-of-sight with the proposed LSR site, and denies the LSR located at Napa County Airport approximately 79.5 percent of the band even for LSR antenna mainbeam coupling to the height-finding radar antenna backlobe.

Using the procedure given in Section 4 for determining the required frequency separation from radars in the environment, there are no available frequency assignments for the Napa County LSR. However, this does not mean that an LSR cannot be deployed at the Napa County Airport without performance degradation to the radar system. A worst case measured height-finding radar emission spectrum (see Appendix A) was used in this analysis. An accurate measurement of the Mt. Tamalpais radar emission spectrum may show that the Mt. Tamalpais radar would not deny deployment of an LSR at the Napa County Airport. Also, if necessary, a waveguide filter could be used in the Mt. Tamalpais radar which would permit deployment of an LSR at the Napa County Airport.

Santa Rosa LSR

There are nine radars in the San Francisco area which could potentially interfere with an LSR located at Santa Rosa. TABLE 6-10 lists the potential interfering radars, and the denied frequency band for each of the potential interfering radars. Six of the potential interfering radar propagation paths were identified as possible ducting paths. Four height-finding radars (Radar Nos. 19 through 22) were identified as possible interfering radars. It is difficult to preclude degradation in the Santa Rosa LSR if the height-finding radars at Almaden and Mt. Tamalpais nod at the bearing of the LSR. When considering all potential interfering radars, 33 percent of the 2.7 to 2.9 GHz band can be used for operation of an LSR at Santa Rosa. TABLE 6-10 shows the available frequencies for operation of an LSR at Santa Rosa.

Chico LSR

There are no radars in the 2.7 to 2.9 GHz band within 50 statute miles of the proposed LSR site at Chico. Therefore, 100 percent of the band is available for frequency assignment of an LSR at Chico.

TABLE 6-9

NAPA COUNTY LSR SITE

RADAR NO.	P _t (dBm)	G _t (dBi)	OTR (dB)	L _p (dB)	REQUIRED OFR	DENIED FREQUENCY BAND (MHz)
3	87	27	6.0	162*	36	2728-2769
4	88	27	6.0	146*	53	2700-2754
10	88	26	10.4	145*	48.6	2758-2822
11	86	26	6.0	134*	62	2734-2846
14	89	25	7.5	161*	35.5	2778-2809
15	89	25	7.5	190	6.5	2798-2802
16	86	27	6.0	184	12	2798-2802
19	97	39	0	184	42	2771-2784
20	97	39	0	184	42	2786-2799
21	97	-13**	0	134	74.5	2741-2900
23	87	36	0	208	5	2888-2892
28	80	22.5	0	153	39.5	No Assigned Frequency (12MHz)

* Potential ducting path

** Height-finding radar backlobe to LSR mainbeam

2	2	2
7	8	9
0	0	0
0	0	0



 Usable Frequency Band: 0% (See text for possible solution techniques)

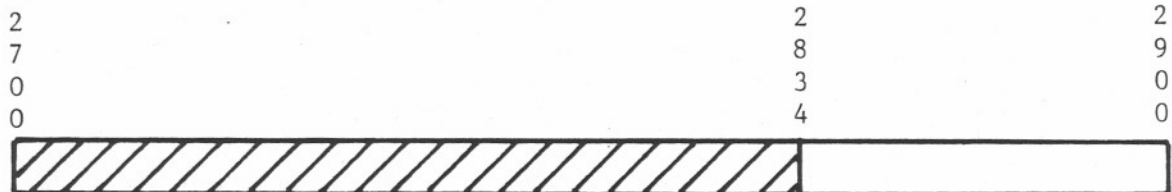
TABLE 6-10

SANTA ROSA LSR SITE

RADAR NO.	P _t (dBm)	G _t (dBi)	OTR (dB)	L _p (dB)	REQUIRED OFR (dB)	DENIED FREQUENCY BAND (MHz)
3	87	27	6.0	157*	41	2724-2772
4	88	27	6.0	152*	47	2700-2747
10	88	26	10.4	152*	41.6	2769-2815
11	86	26	6.0	189	7	2798-2802
14	89	25	7.5	151*	45.5	2769-2815
19	97	-13**	0	151*	57.5	2764-2788
20	97	-13**	0	151*	57.5	2799-2803
21	97	-13**	0	147	61.5	2807-2834 2759-2789
22	97	39	0	200	26	2792-2797

*Potential ducting path.

**Height-finding radar backlobe to LSR mainbeam



Usable Frequency Band: 33%