

## SECTION 4

### SPECTRUM USAGE AND EQUIPMENT CHARACTERISTICS OF SYSTEMS IN THE 2700-2900 MHz BAND

#### INTRODUCTION

This section contains a description of the radiodetermination environment in the 2700-2900 MHz band. The present usage of the band by the various Government agencies and projected band usage through calendar year 1989 are discussed. Nominal equipment characteristics of radiodetermination stations operating in the 2700-2900 MHz band are also provided.

Because of concern over congestion in the 2700-2900 MHz band, a detailed investigation of present and future planned use of the band was conducted. The purpose of this investigation was to determine if the character of the 2700-2900 MHz band will change, and to identify future usage trends. New systems planned for the band were identified along with the new technology and signal processing techniques to be used by the new systems.

This information was obtained to aid in determining if future planned systems for the 2700-2900 MHz band can be accommodated, and to aid in identification of radar system performance guidelines which will enhance the accommodation of planned new systems.

#### SPECTRUM USAGE

##### Present Environment

TABLE 2 shows the distribution of Government equipments in the 2700-2900 MHz band by agency and station class. This data was based on the Government Master File (GMF), October 1980, and information obtained from the frequency management offices of the various Government agencies. The information given in TABLE 2 indicates the number of radiodetermination equipments authorized to operate in the band, and not the number of frequency assignments authorized to operate on. As of October 1980, the number of equipments authorized to operate in the 2700-2900 MHz band is 627. Figure 2 shows the location of all the equipments authorized to operate in the band. The difference between the number of equipments authorized to operate in the band and the number of frequencies authorized to operate on is due to the fact that several radiodetermination systems in the band have the capability to operate on two channels, and in many cases the A and B channels of the system operate on two different frequencies. Whether both channels of a system are operated on a single frequency, or on two frequencies, and the frequency distance between channels is determined through coordination with the FAA regional frequency coordinators.

The major users of the band are the Air Force and FAA with 35.2 percent and 35.4 percent of the equipments respectively. Figures 3 and 4 show the locations of the Air Force and FAA radars respectively. Other users of the band with a significant number of equipments are the Navy and Department of Commerce (DoC) with 11.6 and 10.8 percent respectively. The locations of the Navy and DoC radars are shown in Figures 5 and 6 respectively. The Army has approximately 2.7 percent of the equipments in the band. Most of the Army radars are on the White Sands Missile Test Range in New Mexico (see Figure 7).

TABLE 2

## USAGE OF THE 2700-2900 MHz BAND

AGENCY/SERVICE	STATION CLASS											NUMBER OF EQUIPMENTS	PERCENTAGE OF EQUIPMENTS
	RLS	RL	LR	MOB	MR	WXD	XC	XD	XR	XT			
FAA	208	8	5	0	0	0	0	0	0	0	0	221	35.2
AIR FORCE	100	24	63	1	3	0	5	2	2	22		222	35.4
NAVY	17	26	8	0	1	0	0	0	0	21		73	11.6
ARMY	5	0	10	0	2	0	0	0	0	0		17	2.7
COMMERCE	0	0	0	0	0	68	0	0	0	0		68	10.8
NSF	1	0	0	0	0	2	0	0	0	0		3	0.5
NASA	0	0	10	0	0	1	0	0	0	0		11	1.8
Non-Government	0	0	0	0	0	0	3	5	4	0		12	2.0
Number of Assignments	331	58	96	1	6	71	8	7	6	43		TOTAL 627	
Percentage of Assignments	52.7	9.2	15.3	0.2	1.0	11.3	1.3	1.1	1.0	6.9			

RLS - Surveillance Radar Station  
 RL - Radionavigation Land Station  
 LR - Radiolocation Land Station  
 MOB - Radio Beacon Mobile Station  
 MR - Radiolocation Mobile Station

WXD - Meteorological Radar Station  
 XC - Experimental Contract Developmental Station  
 XD - Experimental Developmental Station  
 XR - Experimental Research Station  
 XT - Experimental Testing Station

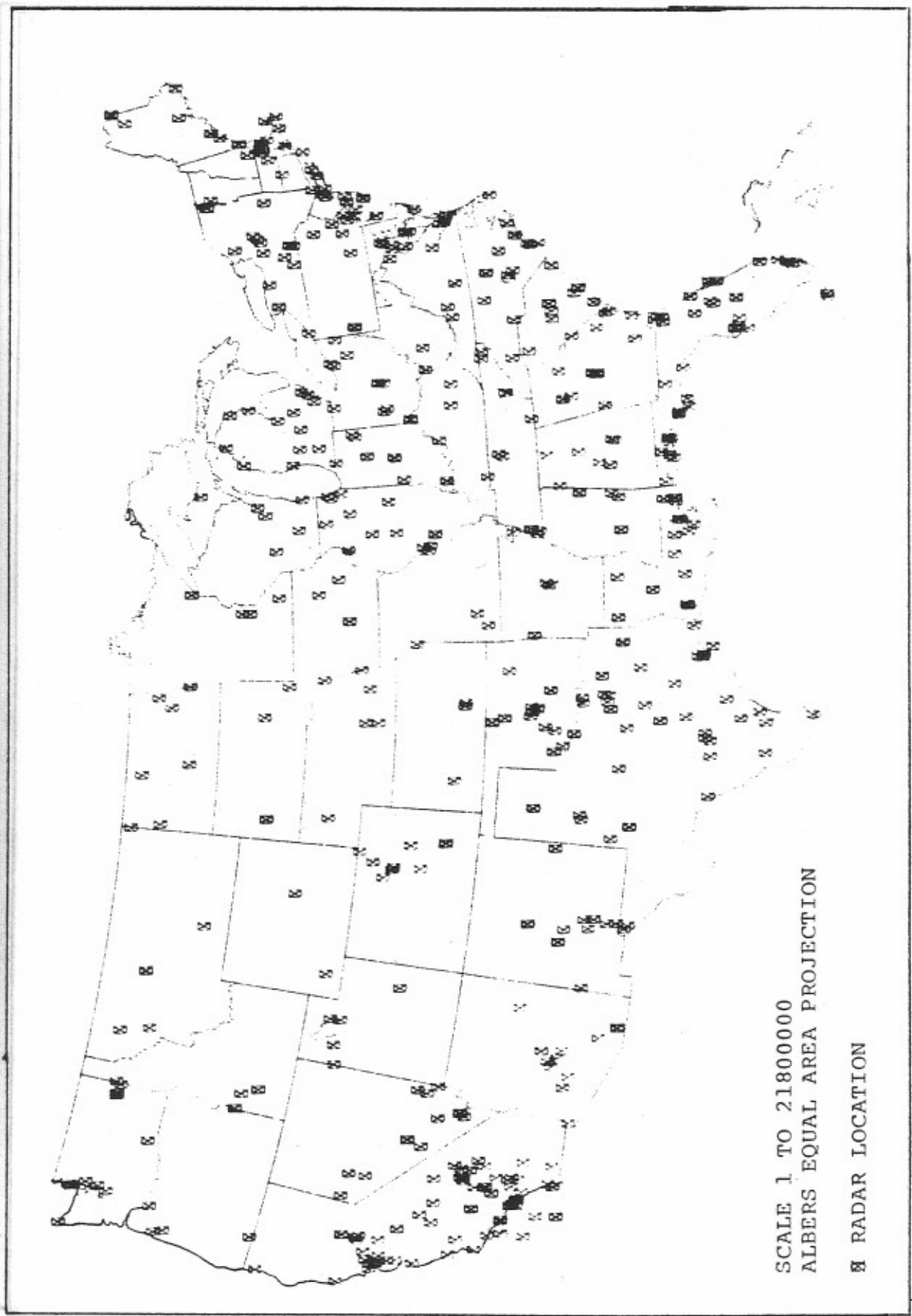


Figure 2. Radar Locations in the 2700-2900 MHz Band

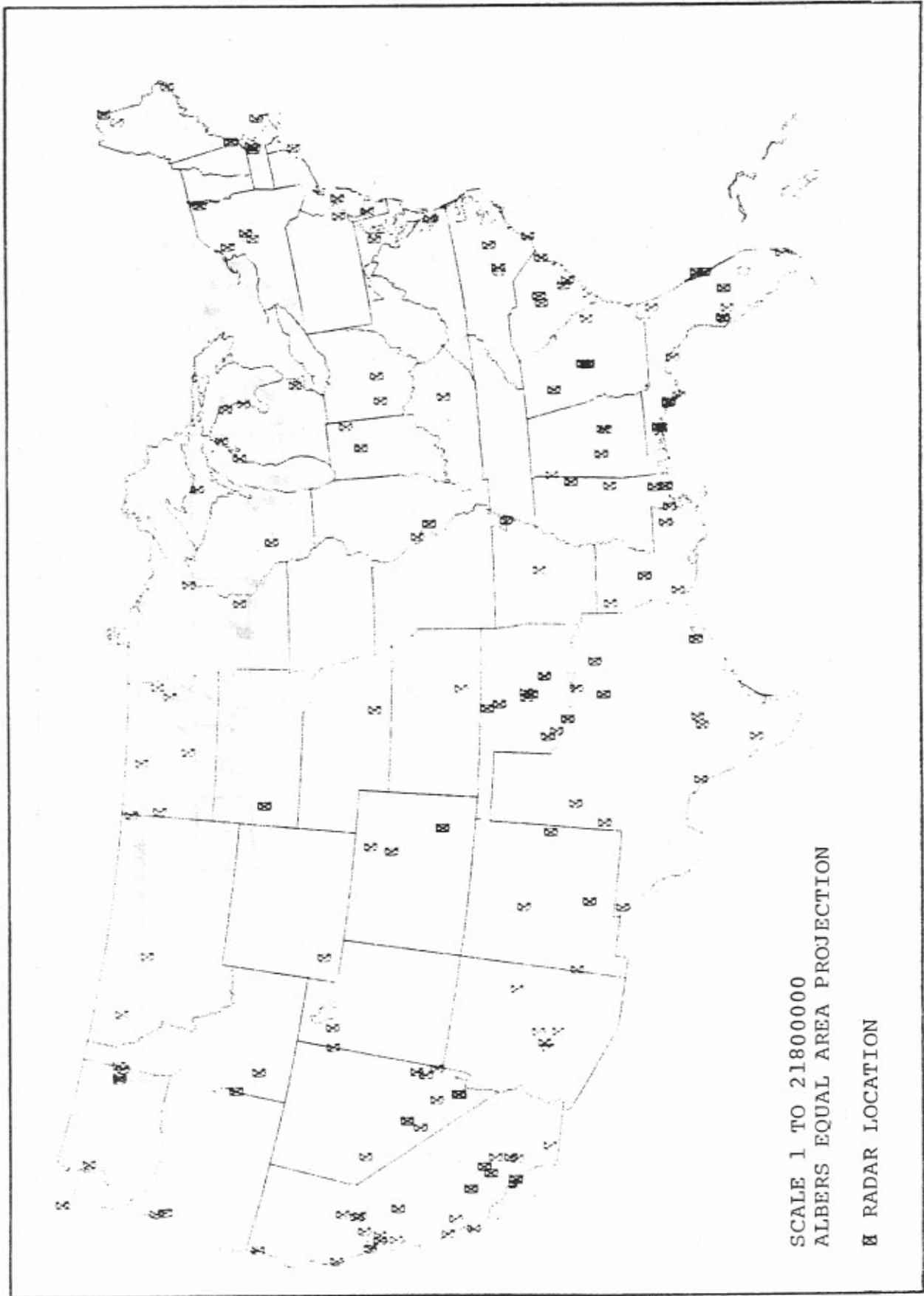


Figure 3. Air Force Radar Location in the 2700-2900 MHz Band

FIGURE 2. 2000 MHz Equal Area Projection for 1960-1965

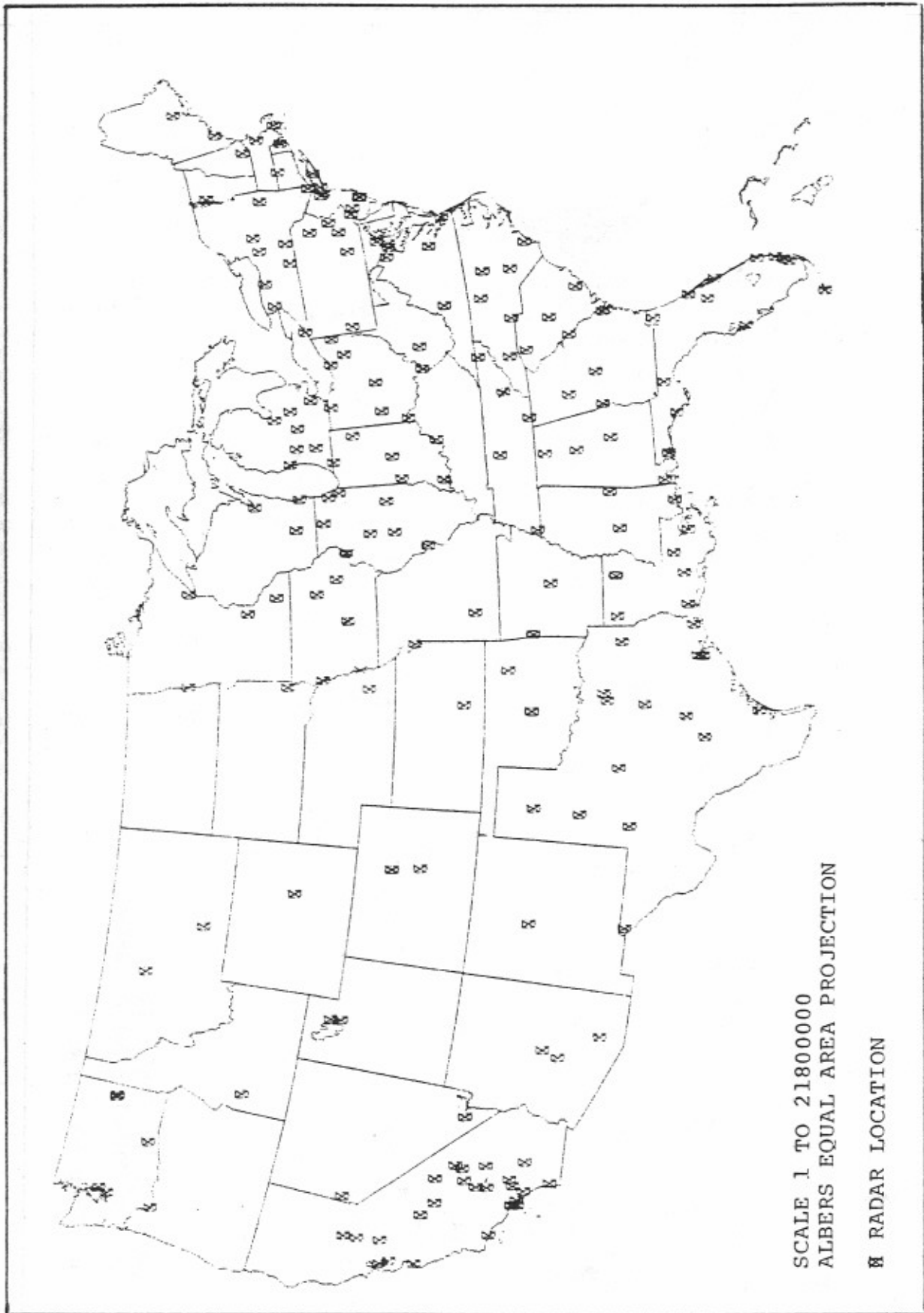


Figure 4. FAA Radar Locations in the 2700-2900 MHz Band

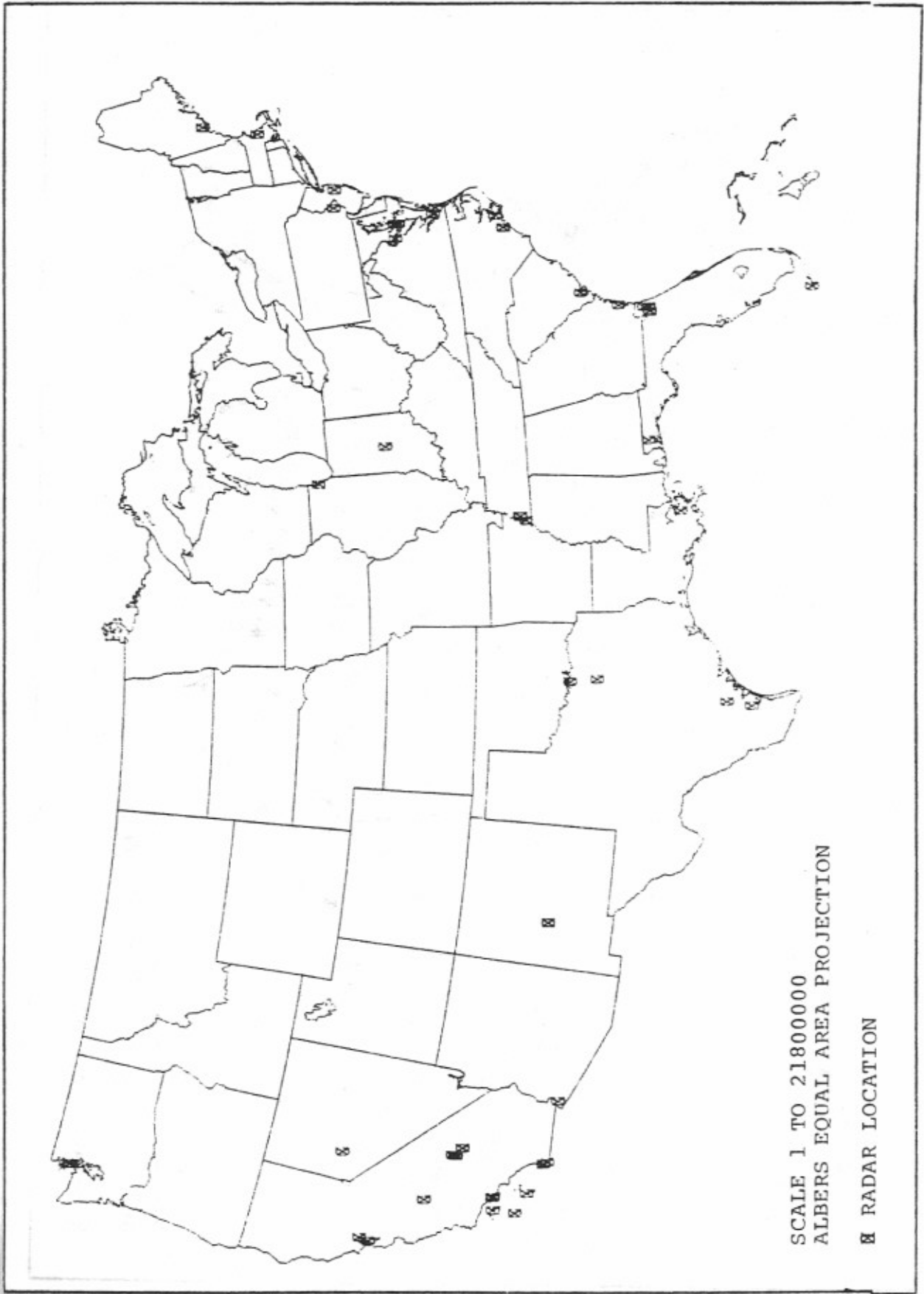


Figure 5. Navy Radar Locations in the 2700-2900 MHz Band

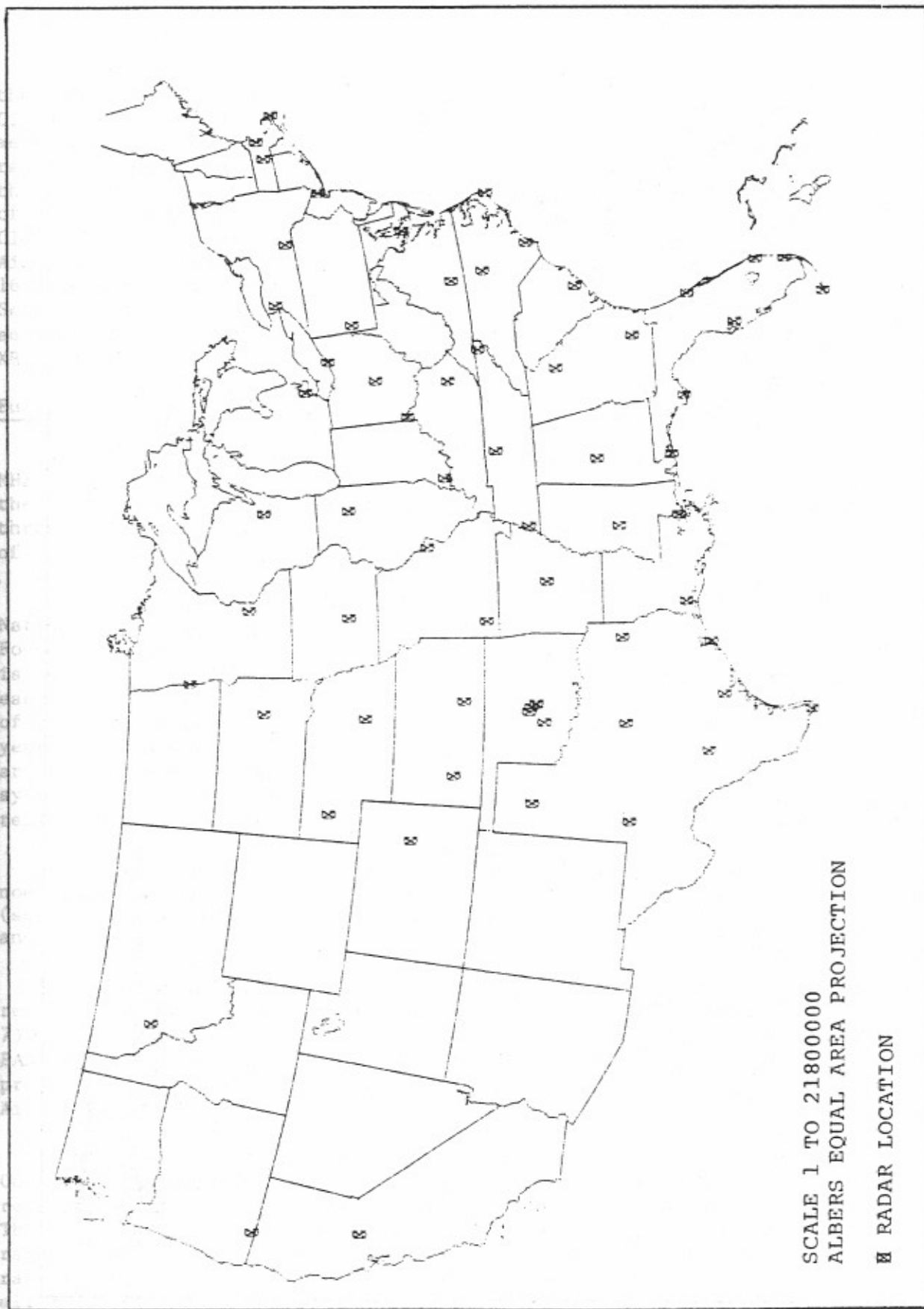


Figure 6. Department of Commerce Radar Locations in the 2700-2900 MHz Band

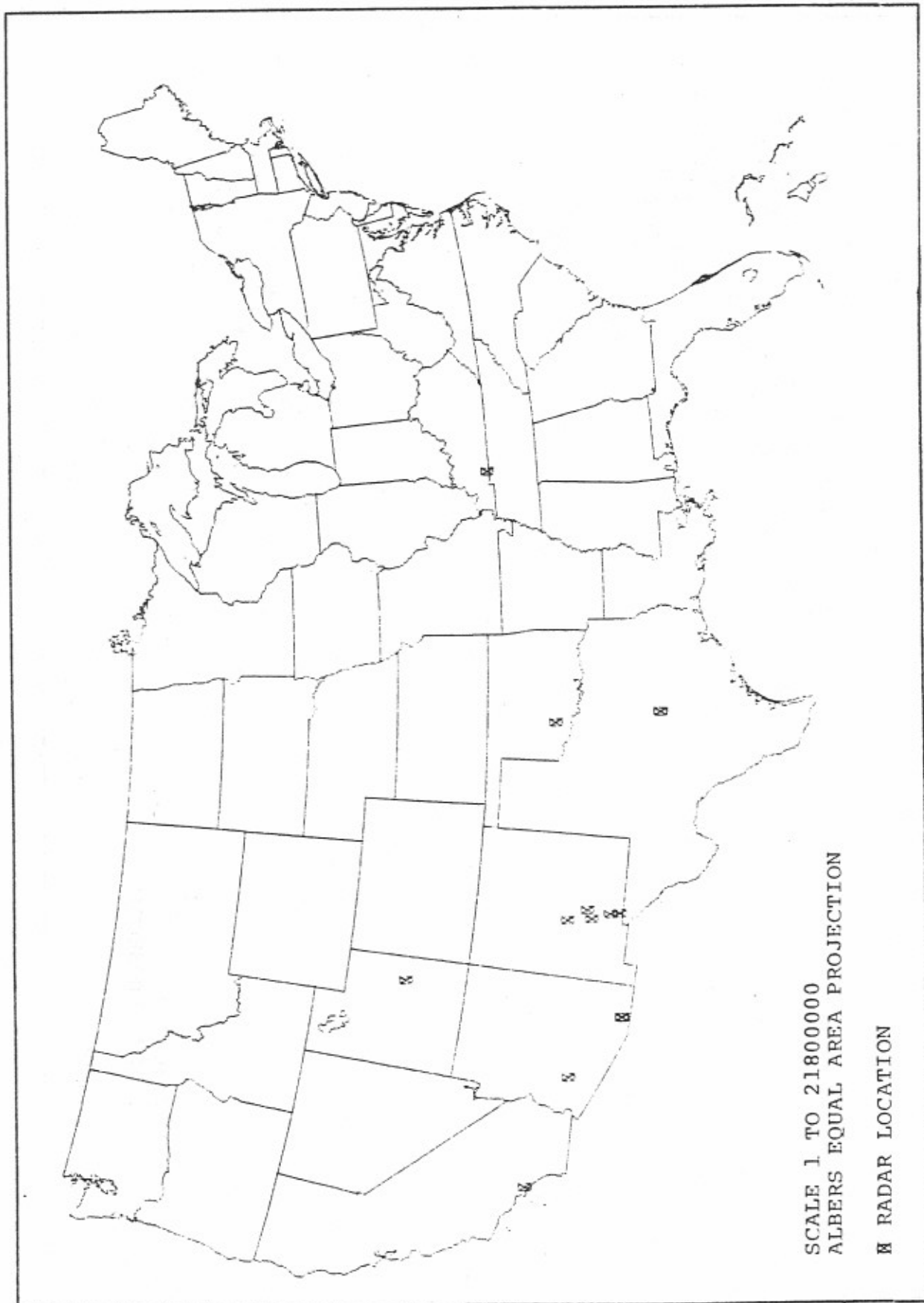


Figure 7. Army Radar Locations in the 2700-2900 MHz Band



TABLE 2 also shows that approximately 61.9 percent of the equipments in the 2700-2900 MHz band are in the Aeronautical Radionavigation Service (Station Classes RLS and RL). Therefore, a large majority of the radars in the band are aeronautical radionavigation radar systems. The aeronautical radionavigation radar systems in the band are the FAA Airport Surveillance Radars (ASR's) and the military Ground Control Approach (GCA) radars. Approximately 11.3 percent of the equipments in the band are in the Meteorological Aids Service (Station Class WXD). Sixty-eight of the seventy-one equipments in the Meteorological Aids Service belong to the DoC National Weather Service (NWS). Approximately 16.3 percent of the equipments in the band are in the secondary Radiolocation Service (Station Classes LR and MR). Approximately 10.3 percent of the equipments in the band are experimental radar stations (Station Classes XC, XD, XR, and XT).

#### Future Environment

In order to determine if the major new systems planned for the 2700-2900 MHz band can be accommodated, it was necessary to identify the projected use of the band by all Government agencies. Information on projected use of the band through calendar year 1989 was obtained from the frequency management offices of the various Government agencies.

The projected radar inventory for the FAA, Army, Navy, Air Force, DoC, National Aeronautics and Space Administration (NASA), and National Science Foundation (NSF) are shown in TABLES 3 through 9. The NEXRAD system deployment is projected for the DoC, FAA, and Air Force through calendar year 1990. For each agency, except the Army, Navy and Air Force, the tables show the number of expected systems operational for each nomenclature in a particular calendar year. The expected total number of system deployments for each year is shown at the bottom of each table. TABLES 3 and 7 through 9 also show the radar systems presently operating in the 2700-2900 MHz band that are planned for replacement by new radar systems.

The FAA plans to replace the Airport Surveillance Radar (ASR) nomenclatures ASR-4, ASR-5, and ASR-6 with ASR-7/8 or the new ASR-9 radar system (see TABLE 3). Deployment of the ASR-9 system is scheduled to begin in 1986 and be completed in 1990. The projected number of ASR-9 systems is 101.

The National Weather Service (NWS) of the Department of Commerce plans to replace the WSR-57 and WSR-74(s) radars with the NEXRAD radar system (see TABLE 7). Deployment of the NEXRAD radar system is scheduled to begin in 1986. The FAA and Air Force also plan to deploy the NEXRAD radar system. By 1990, it is projected that 135 NEXRAD radar systems will be deployed by the NWS, FAA, and Air Force.

The Navy and the Air Force also plan to replace many of their Ground Control Approach (GCA) radars in the 1980's. GCA nomenclatures planned for replacement include: AN/CPN-4; AN/FPN-47, 48 and 55; and AN/MPN-11, 13, and 14. These GCA radars are scheduled to be replaced by the AN/GPN-20 and AN/GPN-27 radars. The AN/GPN-20 and AN/GPN-27 are similar to the FAA ASR-7 and ASR-8 radars. In fact, the ASR-7, ASR-8, AN/GPN-20 and AN/GPN-27 radar systems are all manufactured by the same contractor. By the end of 1986, the Navy plans to replace all their GCA radars with the AN/GPN-27 or remote radar information via

TABLE 3

PROJECTED RADAR INVENTORY FOR FAA FOR CALENDAR YEARS 1980-1989  
IN 2700-2900 MHz BAND

NOMENCLATURE	CALENDAR YEAR									
	80	81	82	83	84	85	86	87	88	89
ASR-2	1	1	0	0	0	0	0	0	0	0
ASR-4	34	34	34	34	34	34	34	14	0	0
ASR-5	37	37	37	37	37	37	37	37	22	0
ASR-6	24	24	24	24	24	24	24	24	24	12
ASR-7	40	40	40	40	40	40	40	40	40	40
ASR-8	76	76	76	76	76	76	76	76	76	76
ASR-9**	0	0	0	0	0	0	3	24	50	86
AN/CPN-4A	1	1	1	1	1	1	1	1	1	1
AN/FPN-47	2	2	2	2	2	2	2	2	2	2
AN/FPS-6	3	3	3	3	3	3	3	3	3	3
AN/FPS-90	3	3	3	3	3	3	3	3	3	3
NEXRAD*	0	0	0	0	0	0	0	2	12	25
TOTAL	221	221	220	220	220	220	223	226	233	248

\*Projected FAA NEXRAD System Deployments for 1990 is 30.

\*\*Projected ASR-9 System Deployments for 1990 is 101.

TABLE 4

PROJECTED RADAR INVENTORY FOR ARMY FOR CALENDAR YEARS 1980-1989  
IN 2700-2900 MHz BAND

NOMENCLATURE	CALENDAR YEAR									
	80	81	82	83	84	85	86	87	88	89
TOTAL	17	17	17	17	17	17	17	17	17	17

TABLE 5

PROJECTED RADAR INVENTORY FOR NAVY FOR CALENDAR YEARS 1980-1989  
IN 2700-2900 MHz BAND

NOMENCLATURE	CALENDAR YEAR									
	80	81	82	83	84	85	86	87	88	89
TOTAL	73	71	70	67	66	66	66	66	66	66

TABLE 6

PROJECTED RADAR INVENTORY FOR AIR FORCE FOR CALENDAR YEARS 1980-1989  
IN 2700-2900 MHz BAND

NOMENCLATURE	CALENDAR YEAR									
	80	81	82	83	84	85	86	87	88	89
TOTAL	222	252	230	207	190	183	183	183	186	196

\*Projected Air Force NEXRAD Systems Deployments for 1990 is 20.

TABLE 7

PROJECTED RADAR INVENTORY FOR DoC FOR CALENDAR YEARS 1980-1989  
IN 2700-2900 MHz BAND

NOMENCLATURE	CALENDAR YEAR									
	80	81	82	83	84	85	86	87	88	89
WSR-57	56	56	56	56	56	56	54	48	31	6
WSR-74S	8	8	8	8	8	8	8	8	8	8
AN/FPS-18	2	2	2	2	2	2	2	2	2	2
WDS-73	1	1	1	1	1	1	1	1	1	1
WDR-73	1	1	1	1	1	1	1	1	1	1
NEXRAD*	0	0	0	0	0	0	2	8	25	50
TOTAL	68	68	68	68	68	68	68	68	68	68

\* Projected DoC NEXRAD System Deployments for 1990 is 85.

TABLE 8

PROJECTED RADAR INVENTORY FOR NASA FOR CALENDAR YEARS 1980-1989  
IN 2700-2900 MHz BAND

NOMENCLATURE	CALENDAR YEAR									
	80	81	82	83	84	85	86	87	88	89
SPANDAR	1	1	1	1	1	1	1	1	1	1
REVLRT-2 VERLORT	2	2	2	2	2	2	2	2	2	2
AN/FPS-18	1	1	1	1	1	1	1	1	1	1
AN/MPS-19	6	6	6	6	6	6	6	6	6	6
ASR-7	1	1	1	1	1	1	1	1	1	1
TOTAL	11	11	11	11	11	11	11	11	11	11

TABLE 9

PROJECTED RADAR INVENTORY FOR NSF FOR CALENDAR YEARS 1980-1989  
IN 2700-2900 MHz BAND

NOMENCLATURE	CALENDAR YEAR									
	80	81	82	83	84	85	86	87	88	89
AN/FPS-18	2	2	2	2	2	2	2	2	2	2
AN/MPS-19	1	1	1	1	1	1	1	1	1	1
TOTAL	3	3	3	3	3	3	3	3	3	3

microwave link. The Navy AN/GPN-27 procurement specification is identical to the FAA ASR-8 radar systems. In general, military procurement of GCA radar systems in recent years have been similar to radars developed by the FAA.

The Army, NASA and NSF did not project any change in radar system deployments in the 2700-2900 MHz band. At the present time there are no known planned replacements for existing radiolocation systems in the band. The Air Force AN/FPS-116 is essentially an up-grade package for the AN/FPS-6 and AN/FPS-90 height-finder radars.

A summary of the projected radar inventory in the 2700-2900 MHz band for calendar years 1981 through 1989 for all agencies is shown in TABLE 10. The information in TABLE 10 indicates that the projected number of radar systems in the 2700-2900 MHz band will not change that significantly in the 1980's. However, the number of systems deployed in the band does not give a true indication of the spectrum usage of the band. In order to estimate the usage of the band, it is also necessary to take into consideration if radar systems operate with more than one channel on simultaneously (dual channel operation). There are several radar nomenclatures presently operating in the band which operate dual channels simultaneously. The ASR-8, AN/GPN-20 and AN/GPN-27 all have a frequency diversity capability. Also, the present projected requirement for the NEXRAD system is for two channels to operate simultaneously. One channel for reflectivity information, and one for doppler information. The FAA, DoC, Navy, and Air Force plan to significantly increase in the 1980's their number of systems which operate dual channels simultaneously. A summary of projected dual channel systems in the 2700-2900 MHz band for calendar years 1980 through 1989 is shown in TABLE 11. TABLE 11 shows a projected increase in dual channel systems from 85 to 242 systems which is a 184 percent increase

The projected numbers of operating channels for calendar years 1980 through 1989 in the 2700-2900 MHz band is shown in TABLE 12. The information in TABLE 12 was obtained by taking into consideration the total number of systems projected for the band (see TABLE 10), and adding the number of projected dual channel radars planned for the band (see TABLE 11). TABLE 12 shows that in the 1980's there will be a significant increase in the number of operating channels in the 2700-2900 MHz band. In fact, there is a projected increase of 22 percent in the number of operating channels in the 2700-2900 MHz band for the 1980's. However, the number of systems deployed in the band will remain fairly constant in the 1980's.

#### EQUIPMENT CHARACTERISTICS

The following is a summary of equipment characteristics of radar systems presently operating and planned for the 2700-2900 MHz band. A survey of nominal radar system equipment characteristics of presently operating and planned radar systems in the 2700-2900 MHz band was conducted using information from technical manuals and system characteristics provided in the IRAC Systems Review process.

The nominal radar system characteristics of radars presently operating in the band as of October 1980 are listed in TABLE 13 by service type, and the nominal radar system characteristics of new radar systems planned for the band (ASR-9 and NEXRAD) are listed in TABLE 14 by service type. TABLE 13 does not include the characteristics of all the experimental assignments in the band

TABLE 10

SUMMARY OF PROJECTED RADAR INVENTORY FOR CALENDAR YEARS 1980-1989  
IN 2700-2900 MHz BAND

AGENCY	CALENDAR YEAR									
	80	81	82	83	84	85	86	87	88	89
FAA	221	221	220	220	220	220	223	226	233	248
DoC	68	68	68	68	68	68	68	68	68	68
ARMY	17	17	17	17	17	17	17	17	17	17
NAVY	73	71	70	67	66	66	66	66	66	66
AIR FORCE	222	252	230	207	190	183	183	183	186	196
NASA	11	11	11	11	11	11	11	11	11	11
NSF	3	3	3	3	3	3	3	3	3	3
TOTAL	615	643	619	593	575	568	571	574	584	609

TABLE 11

SUMMARY OF PROJECTED DUAL CHANNEL SYSTEMS FOR CALENDAR YEARS 1980-1989  
IN 2700-2900 MHz BAND

AGENCY	CALENDAR YEAR									
	80	81	82	83	84	85	86	87	88	89
FAA	76	76	76	76	76	76	76	78	88	101
DoC	0	0	0	0	0	0	2	8	25	50
NAVY	4	10	16	24	32	37	44	44	44	44
AIR FORCE	5	25	28	32	32	32	32	34	37	47
TOTAL NUMBER DUAL CHANNEL SYSTEMS	85	111	120	132	140	145	154	164	194	242

## NOTES:

1. The total number of dual channel operating systems assumes that all ASR-8, AN/GPN-20, AN/GPN-27 and NEXRAD radars will operate dual channel.

TABLE 12

SUMMARY OF PROJECTED NUMBER OF OPERATING CHANNELS FOR CALENDAR YEARS  
1980-1989 IN 2700-2900 MHz BAND

	CALENDAR YEAR									
	80	81	82	83	84	85	86	87	88	89
TOTAL NUMBER OF SYSTEMS IN BAND (TABLE 10)	615	643	619	593	575	568	571	574	584	609
TOTAL NUMBER OF DUAL OPERATING SYSTEMS 1 (TABLE 11)	85	111	120	132	140	145	154	164	194	242
TOTAL NUMBER OF OPERATING CHANNELS	700	754	739	765	715	713	725	738	778	851

## NOTES:

1. The total number of dual channel operating systems assumes that all ASR-8, AN/GPN-20, AN/GPN-27 and NEXRAD radars will operate dual channel.

TABLE 13

SYSTEM CHARACTERISTICS OF RADARS PRESENTLY  
OPERATING IN THE 2700-2900 MHz BANDAeronautical Radionavigation

Peak Power: 0.4-1.4 MW  
 Pulse Width: 0.5-0.83  $\mu$ s  
 PRF: 700-1500 pps  
 Antenna Gain: 31-34 dBi (cosecant squared)  
 Sensitivity: -112 to -104 dBm  
 Noise Figure: 2.5-4.75 dB

Meteorological Aids

Peak Power: 0.5-0.56 MW  
 Pulse Width: 0.5-1.0  $\mu$ s (short pulse)  
 4.0  $\mu$ s (long pulse)  
 PRF: 545-658 (short pulse)  
 164 (long pulse)  
 Antenna Gain: 38 dBi (parabolic dish)  
 Sensitivity: -108 to -100 dBm  
 Noise Figure: 4.0 dB

Radiolocation

Peak Power .250-3.5 MW  
 Pulse Width: .8 - 2.0  $\mu$ s  
 PRF: 300-1200 pps  
 Antenna Gain: 30-39 dBi  
 Sensitivity: -110 to -106 dBm  
 Noise Figure: 4.0-8.0 dB

TABLE 14

SYSTEM CHARACTERISTICS OF RADARS PLANNED  
FOR THE 2700-2900 MHz BANDAeronautical Radionavigation

Peak Power: 1.32 MW  
 Pulse Width: 1.05  $\mu$ s  
 PRF: 700-1200 pps  
 Antenna Gain: 32-34 dBi  
 Sensitivity: -108 dBm  
 Noise Figure: 4.5 dB

Meteorological Aids

Peak Power: 1.0 MW  
 Pulse Width: 1.0  $\mu$ s  
 PRF: 300-1300 pps  
 Antenna Gain: 45.1 dBi  
 Sensitivity: -110 dBm  
 Noise Figure: 4.0 dB



The range of peak transmitter output power of Aeronautical Radionavigation and Meteorological Aids radars is between 0.4 and 1.4 MW. The majority of the Radiolocation radars have a peak transmitter output power of approximately 3.5 MW. The range of radar transmitter pulse widths of existing and planned radars operating in the 2700-2900 MHz band is 0.5 to 4.0  $\mu$ s. The replacement of the WSR-57 and WSR-74(s) radars will remove all the 4.0  $\mu$ s pulse width radars. After the WSR radars are removed, all the radars in the band will have pulse widths between 0.5 and 2.0  $\mu$ s. The Pulse Repetition Frequency (PRF) of existing radar and radars planned for the band range between 100 and 1500 pulses per second. At the present time there are no known radars operating or planned for the band which employ chirped (FM) or phase coded pulses.

Several different types of antennas are used by radars in the 2700-2900 MHz band. All the Aeronautical Radionavigation radars use a shaped beam reflector which produces a cosecant-squared elevation pattern. The antenna gain of the Aeronautical Radionavigation radars range between 31 and 34 dBi. The Meteorological radars have parabolic dish antennas with pencil beams, and a gain of 32 to 45.1 dBi. The type of Radiolocation radar antennas is varied with antenna gains between 32 and 39 dBi. Some of the later model radars have antennas with several feed horns.

The receivers of radar systems presently operating and planned for the band have sensitivities between -112 and -100 dBm, and noise figures between 2.5 and 8 dB. The receiver system of radars presently operating in the 2700-2900 MHz band use conventional normal, log normal and Moving Target Indicator (MTI) signal processing techniques. New systems, ASR-9 and NEXRAD, planned for the band will use doppler signal processing with inphase and quadrature (I and Q) channels. The FAA ASR-9 radar will also use adaptive thresholding techniques. The receiver signal processing techniques used in these new radars will be more susceptible to interference than the conventional normal and MTI channel signal processing used in radars presently operating in the 2700-2900 MHz band.

In summary, the system characteristics of radars in the band are homogeneous in nature with no complex wave forms (chirped or phase coded pulse) used. For more detailed radar system characteristic information, Appendix D contains a compendium of system characteristics by nomenclature for the major systems presently operating and planned for the 2700-2900 MHz band.