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# SPECTRUM RESOURCE ASSESSMENT IN THE 5650-5925 MHz BAND



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U.S. DEPARTMENT OF COMMERCE • National Telecommunications and Information Administration



# SPECTRUM RESOURCE ASSESSMENT IN THE 5650-5925 MHz BAND

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## ABSTRACT

This report constitutes a Spectrum Resource Assessment of the 5650-5925 MHz band. Included is information on rules and regulations, allocations, technical standards, frequency assignments, system characteristics, and applicable compatibility analysis. Problems of concern to the U.S. Government usage of the band are identified, analyzed and recommendations made. Major issues concerned the introduction of a Fixed-Satellite Service (FSS) in the band and current usage of that portion of the band designated for Industrial, Scientific and Medical (ISM) purposes. It is concluded that power limitations for radars should be considered as an option to minimize potential interference problems with satellites which may become operational in the 5850-5925 MHz portion of the band. It is also concluded that in-band radiation limits be considered for the Industrial, Scientific and medical designated frequency at  $5800 \pm 75$  MHz to help protect Government investment and future Fixed-Satellite Service usage.

## KEY WORDS

Amateur Service  
Electromagnetic Compatibility  
5650-5925 MHz  
Fixed-Satellite Service  
ISM  
Radiolocation Service  
Restricted Radiation Devices

SECTION 1  
INTRODUCTION

BACKGROUND

The National Telecommunications and Information Administration (NTIA) is responsible for managing the radio spectrum allocated to the U.S. Federal Government. Part of NTIA's responsibility is to: "... establish policies concerning spectrum assignment, allocation and use, and provide the various departments and agencies with guidance to assure that their conduct of telecommunications activities is consistent with these policies" [United States Department of Commerce, 1978]. In support of these requirements, NTIA has undertaken a number of spectrum resource assessments. The objectives of these studies are to: assess spectrum utilization, identify existing and/or potential compatibility problems among the telecommunication systems which belong to various departments and agencies, provide recommendations for resolving any compatibility conflicts which may exist in the use of frequency spectrum, and recommend changes to improve spectrum management procedures. This spectrum resource assessment considers the 5650-5925 MHz frequency band.

In the United States the 5650-5925 MHz band has been a shared band with the primary allocation assigned to the Government radiolocation service with an industrial, scientific and medical (ISM) designation at 5800 + 75 MHz. Radio communication services operating within the ISM band must accept any harmful interference that may be experienced from the operation of ISM equipment. There is a secondary allocation to the amateur service; the amateurs must operate on a non-interference basis. Government allocation is for military radiolocation and is used for air-surveillance radar, transponder tracking, and positive aircraft guidance, missile and rocket tracking, telemetry, and ground facilities for development and testing of associated radio and radar equipment. There are only 21 non-Government assignments in the band and these are mainly assigned to developers and manufacturers of equipment and systems which support the Government effort in the band for test and evaluation purposes.

At the World Administrative Radio Conference (WARC) held in 1979, the portion of this band from 5850 to 5925 MHz was reallocated to the fixed, fixed-satellite (Earth-to-space), and mobile on a primary basis with radiolocation and amateur on a secondary basis in Region 2. An ad hoc committee (Ad Hoc 172) of the Interdepartment Radio Advisory Committee (IRAC) was tasked to assess and make recommendations concerning the impact of WARC-79 on Government allocations. The IRAC has recommended adding non-Government Fixed-Satellite Service (FSS) (Earth-to-space) in the 5850 to 5925 MHz portion of the band on a co-equal primary basis with the Radiolocation Service. The IRAC has recommended the addition of U.S. Footnote 245, which states that the FSS is limited to international systems and subject to case-by-case electromagnetic compatibility analysis. Because of this proposed change effecting the 5650-5925 MHz band a spectrum resource assessment of the band was warranted.

The IRAC, at its meeting on March 23, 1982 established Ad Hoc 183 with the following terms of reference:

"To develop and recommend to the IRAC spectrum management procedures that will allow implementation of the Fixed-Satellite Service in the frequency bands 3600-3700 MHz and 5850-5925 MHz, consistent with the National Table of Allocations as implemented as a result of WARC-79.

To consider technical sharing parameters among airborne, shipborne, and terrestrial radar operations, and the proposed satellite systems.

To recommend to the IRAC an acceptable coordination procedure to be employed in siting the two earth terminals that are to be allowed (one on each Coast). In arriving at the proposed coordinated procedure, this Group shall recommend:

- (1) The equipment characteristics to be used for coordination purposes;
- (2) the propagation mode to be used in the coordination procedures; and,
- (3) the specific interference criteria to be used for the fixed-satellite and Radiolocation/Radionavigation systems."

The outputs from this Ad Hoc Group are expected to give needed guidance to the users of the 5850-5925 MHz band in resolving future compatibility problems.

#### OBJECTIVES

To assist in the development of spectrum management plans and policies, the following objectives are identified for this spectrum resource assessment.

1. Review and document the characteristics and deployment of existing and proposed systems within the 5650-5925 MHz band, including those which could be expected in response to the results of WARC-79 and other international or national agreements.
2. Evaluate electromagnetic compatibility (EMC) interactions to identify and document the potential problem areas which may have an impact on the efficient use of the spectrum, and evaluate the feasibility of sharing between existing and proposed services.
3. Recommend specific changes to the existing rules, regulations and frequency management practices which would improve overall management of the band.
4. Identify and outline specific problem areas requiring additional analysis, if any.

#### APPROACH

In order to accomplish the objectives of the 5650-5925 MHz Spectrum Resource Assessment, the following approach was used:

1. Identify WARC-79 changes and national recommendations that impact the band.
2. Identify the systems that are currently operating in the band, where they are deployed, and their technical characteristics by:
  - a. Using the Government Master File (GMF), the non-Government Master File (NGMF), previous NTIA reports, Systems Review File (SRF), and other Government reports to identify frequency assignments and usage for Government and non-Government operations.
  - b. Contacting Government frequency managers, using surveys of major equipment manufacturers, users, and measured data.
3. Identify future systems proposed for the band by using data in the IRAC/SPS system review process for Government systems and equipment, and information supplied by the Electromagnetic Compatibility Analysis Center (ECAC) of the Department of Defense.
4. Review the compatibility analysis of systems within the 5650-5925 MHz band accomplished by other Government agencies and those analyses made in support of the IRAC system review process.
5. Assess the present band utilization using the Radio Spectrum Measurement System (RSMS) van data obtained at certain locations in the United States.
6. Identify and analyze the potential EMC problems in the band.
7. Identify remaining key issues, that affect spectrum management of the band and make recommendations for their resolution.

## SECTION 2

### CONCLUSIONS AND RECOMMENDATIONS

#### INTRODUCTION

The 5650-5925 MHz band is presently used mainly by the Government (Military) Radiolocation Service. The main usage is by the various missile and rocket test ranges, Navy shipboard radars, and various land sites for air and sea defense search radars. There are a few non-Government assignments used by companies who develop systems or subsystems for the Government.

The Systems Review File shows eleven new systems under development from 1979 through 1981. There has been an increase in frequency assignments from 88 assignments in 1972 to 461 assignments in 1982. There has been a steady increase in band usage and new systems introduced in the band each year. Systems used in the 5650-5925 MHz band are considered crucial to the national defense by the various DOD agencies. There are a little over 1200 operating units corresponding to the frequency assignments.

For mobile land based radars and fixed site radars other than missile or rocket test ranges the use of frequencies in the band are coordinated through frequency management personnel of the various departments and agencies of the Government as listed in the Director of Field contacts for the coordination of the Use of Radio Frequencies, Section 3 (FCC, NTIA 1982). Shipboard radar frequencies are coordinated by fleet frequency management officers for best inter-fleet and ocean area compatibility. Missile and rocket test range frequency assignments and usage are coordinated by the various regional Area Frequency Coordinators (AFC) under the direction of the Range Commanders Council (RCC). Frequencies for given range operations are assigned on a daily basis, both intra-range and inter-range, for best compatibility between the various operating systems to be used in the exercises of that day.

Allocation changes adopted by WARC-79 resulted in proposed changes to the national allocation tables that affect the portion of the band from 5850-5925 MHz. The proposed change added the FSS (International systems up-link only) on a co-equal primary basis with the Radiolocation Service. This change introduced potential problem areas which were analyzed and the conclusions are presented below.

#### General Conclusions

1. The 5650-5925 MHz band is a very important band for the military and to national defense systems. As shown in Figure 4 the band usage by the Government Radiolocation Service has grown steadily with a 43% growth from January 1979 through January 1982. Care must be taken to assure that new services introduced in the band do not hinder development of new systems vital to national defense or to cause harmful interference to present systems.
2. The band is well managed by Military Area Frequency Coordinators (AFC) and Military and Civilian government Frequency Management personnel.
3. The systems used in the band (predominantly radars and transponder systems) have the capability of tuning across most of the band.

4. Although there is an allocation, on a secondary basis to the amateur service, no use could be found in the band by the amateurs as corroborated by the American Radio Relay League (ARRL).
5. There is an ISM frequency designation at 5800 + 75 MHz, but no usage could be found in the band by ISM equipment. Since the most active frequency area in the band is between 5760-5775 MHz (as seen in Figure 2) a potential problem could exist if ISM usage were to proliferate in the future.
6. There is some potential usage of the band by restricted radiation devices, but at present they do not pose a significant interference problem.
7. Most usage of the 5850-5925 MHz portion of the band is by transponders and various test equipment, but only represents 8% of band assignments.
8. International Satellite Systems (Intelsat VI) may be coming into the band from 5850-5925 MHz. For two existing INTELSAT Earth station sites at Jamesburg, CA and Andover, ME there appears to be potential compatible operation with the present Radiolocation Service as shown in the analysis of Section 6.
9. The measurements made by the RSMS showed this band to be fairly active particularly around coastal areas and the various missile and rocket test ranges.

#### Specific Conclusions

10. The analysis of interference potential between a typical in-band radar and an INTELSAT VI receiver as given in Section 6 shows that co-channel operation is not possible without restriction on either the radar or the proposed satellite receiver.
11. The distance separation requirements for sharing between the FSS uplink transmissions and radiolocation transponders, as given in Section 6, are such for the Jamesburg, CA and Andover, ME sites that compatible operation should be possible.
12. Frequency separation between the FSS and many radars in the band can be an effective EMC management tool. Many radars can operate up to 5820 MHz with powers under 500 kW. For those radars that have megawatt pulse power capabilities the frequency separation will have to be in excess of 100 MHz.
13. Radar such as the AN/FPS-16 have spurious emissions, some 70 to 150 MHz above the fundamental which could possibly pose a problem even with frequency off-set from the satellite fundamental. A waveguide filter at the output of the radar transmitter may be an effective method to minimize this potential problem.

14. Radars whose tracking angles may cause mainbeam-to-mainbeam coupling with a communication satellite in the 5850-5925 MHz portion of the band would have to be limited to radiated powers of 69.8 dBW if the satellite transponder carries FM/TV or 92.4 dBW if the satellite transponder system is limited to FDM/FM or similar modulations for compatible operation.
15. The probability of a tracking radar mainbeam intercepting a communication satellite in geostationary orbit is on the order of  $1.5 \times 10^{-3}$ .
16. Figure 25 indicates the required separation distance between a field disturbance sensor (a restricted radiation device) and a typical radar receiver. The separation distances within the band are on the order of 26 to 29 km. This could pose a problem for some areas if the use of this type of device were to proliferate in the band.
17. Figure 26 indicates the required separation distance between low-power communications devices as used for the measurement of characteristics of materials and a typical radar receiver. The impact of such devices when operated within the given tolerances would pose little, if any, problems within the band.
18. Based on the potential use of restricted radiation devices in the band there is a need for adherence to the non-interference status of such devices to assume protection to vital defense systems.
19. To protect Government radiolocation operations a footnote similar to US 7 limiting the power that the amateur satellite service can transmit from a satellite in their allocated down-link at 5830-5850 MHz may be desirable.
20. The ISM designation from 5725-5875 MHz with unlimited radiated electric field within this designation poses a potential problem to radiolocation systems if new ISM equipments were designed for and heavily used in the band.

## RECOMMENDATIONS

The following are NTIA staff recommendations based on the technical findings contained in this report. Any action to implement these recommendations will be accomplished under separate correspondence by modification of established rules, regulations or procedures.

It is recommended that:

1. The Ad Hoc 183 working group, which has been established by the IRAC to examine sharing between the Radiolocation and Fixed-Satellite Services, look at the issue involved in this SRA and consider using the sharing criteria developed in this report.
2. The Ad Hoc 180 of IRAC should recommend establishing in-band radiation limits in the proposed new ISM standards for the 5800  $\pm$  50 MHz ISM frequency designation to help protect the Government investment and future FSS usage.
3. Limits on transmitted power from amateur satellites which will allow compatible operation with the Radiolocation Service should be determined after the amateur-satellite system is specified.

SECTION 3  
RULES AND REGULATIONS

ALLOCATIONS

Prior to WARC 79, nationally, the 5650-5925 MHz band was allocated to the radiolocation service on a primary basis with the amateur service as secondary. There is an ISM band from 5725 to 5875 MHz, but at present there is very little use of this band for ISM purposes and nothing new planned for the near future as verified through the FCC.

Internationally, the allocations differ in that, from 5670-5725 MHz, deep space research is also a designated service on a secondary basis; 5725-5850 MHz is allocated to fixed-satellite (Earth-to-space) and radiolocation on a primary basis with amateur secondary in Region 1; and 5850-5925 MHz is now allocated to fixed, fixed-satellite (earth-to-space) and mobile on a primary basis in regions 1 and 3 with radiolocation as secondary in region 3.

The International Telecommunication Union (ITU) Radio Regulations, 1982, showed the agreed changes to the International Allocation Table as an output of WARC 1979. The IRAC recommended a new national frequency allocation table reflecting the ITU impacts. The United States did not accept certain decisions made by the WARC 79 and added protocol No. 38 to the Final Acts of the WARC 79 which stated in item 3 concerning this band "In the operation of stations in the Radiolocation Service on a primary basis in the band 430-440 MHz; 5650-5850 MHz..., cannot guarantee protection to or coordination with others services;". Table 1 shows the pre-WARC-79 international and National Allocation Table for the 5650-5925 MHz band in effect in 1981. Table 2 shows the new international and national frequency allocation table for the band as recommended by IRAC to become effective in 1982. There has been a change in the numbering system for the international footnotes, i.e., old footnote 320A has been modified and is new footnote 3644, old footnote 391 is now new footnote 3760.

Internationally, the 5850-5925 MHz portion of the band was redesignated to the Fixed, Fixed-Satellite (Earth-to-space) and Mobile Service on a co-equal primary basis with amateur and radiolocation as secondary in Region 2. Nationally, the IRAC has recommended adding non-Government Fixed-Satellite Service (Earth-to-space) in the 5850-5925 MHz portion of the band on a co-equal primary basis with the Radiolocation Service. The IRAC has also recommended adding U.S. 245 which states that the Fixed-Satellite Service is limited to international systems and subject to case-by-case electromagnetic compatibility analysis. The IRAC has also recommended only two sites, one on each coast. The rationale for IRAC recommendations comes from the U.S. position as outlined in the Department of State correspondence to the Communications Satellite Corporation that is copied in Appendix C.

WARC-79 granted the following new amateur-satellite allocations; 5650-5670 MHz (Earth-to-space) and 5830-5850 MHz (Space-to-Earth). Within the United States there is little or no use of this band by the amateurs. There are plans to develop an amateur capability in this band, but a program similar to OSCAR (ARRL, 1982) is needed before this can be accomplished. Of course, any developments along this line imply non-interference to any system operating on a primary basis within the 5650-5925 MHz band.

TABLE 1  
PRE MARC-79 FREQUENCY ALLOCATIONS FOR THE 5650-5925 MHz BAND

INTERNATIONAL			UNITED STATES			
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocations 3	Non-Government Allocations 4
5470-5650  MARITIME RADIONAVIGATION Radiolocation  386 387			5470-5600	G, NG US50 US65	MARITIME RADIONAVIGATION Radiolocation G56	MARITIME RADIONAVIGATION Radiolocation
			5600-5650	G, NG 387 US51 US65	MARITIME RADIONAVIGATION METEOROLOGICAL AIDS Radiolocation G56	MARITIME RADIONAVIGATION METEOROLOGICAL AIDS Radiolocation
5650-5670  RADIOLOCATION Amateur 388 389			5650-5925	G, NG 391 US 34 US 100	RADIOLOCATION	Amateur
5670-5725  RADIOLOCATION Amateur Space Research (Deep Space) 388 389 389A			(ISM 5800 ± 75 MHz)		62	
5725-5850 FIXED-SATELLITE (Earth-to-Space) RADIOLOCATION Amateur 354 388 390 391 391A	5725-5850  RADIOLOCATION Amateur  389 391 391A					
5850-5925 FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE 391	5850-5925 RADIOLOCATION Amateur 391	5850-5925 FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE Radiolocation 391				
5925-6425  FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE			5925-6425	NG		FIXED FIXED-SATELLITE (Earth-to-Space) NG41

Footnotes Applicable to the 5650-5925 MHz band in the U.S.

- 391 - The frequency 5800 MHz is designated for industrial, scientific and medical purposes. G missions must be confined within the limits ± 75 MHz of that frequency. Radiocommunication services operating within those limits must accept any harmful interference that may be experienced from the operation of ISM equipment.
- US34 - The only non-Government service permitted in the bands 220-225 MHz, 1215-1300 MHz, 2300-2450 MHz and 5650-5925 MHz is the amateur service. The amateur service shall not cause harmful interference to the radiolocation service.
- G2 - In the bands 216-225, 420-425, 1300-1400, 2300-2450, 2700-2900, 5650-5925 and 9000-9200 MHz, the Government radiolocation is limited to the military services.

TABLE 2

## PROPOSED POST WARC-79 FREQUENCY ALLOCATIONS FOR THE 5650-5925 MHz BAND

INTERNATIONAL			UNITED STATES		
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Govt Alloc 3
5650-5725	RADIOLOCATION Amateur Space Research (Deep Space)  664 801 803 804 805		5650-5850   (ISM 5800 ± 75 MHz)	664 806 808	RADIO   G2
5725-5850	5725-5850  RADIOLOCATION Amateur 803 805 806 808				
5850-5925 FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE  806	5850-5925 FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE Amateur Radiolocation 806	5850-5925 FIXED FIXED-SATELLITE (Earth-to-Space) MOBILE Radiolocation 806	5850-5925	806 US245	RADIO   G2

Footnotes Applicable to the 5650-5925 MHz band in the U.S.

- 664 - In the bands 435-438 MHz, 1260-1270 MHz, 2400-2450 MHz, 3400-3410 MHz (in regions 2 and 3 only), 5650-5670 MHz, the amateur-satellite service may operate subject to not causing harmful interference to other services operating in accordance with the Table (See new 435). Administrations authorizing such use shall insure that only harmful interference caused by emissions from a station in the amateur-satellite service is immediately estimated in accordance with the provisions of No. 2741. The use of the bands 1260-1270 MHz and 5650-5670 MHz by the amateur-satellite service is limited to the Earth-to-Space direction.
- 806 - The band 5725-5875 MHz (center frequency 5800 MHz) is designated for industrial, scientific and medical purposes. Communication services operating within this band must accept harmful interference which may be caused by these applications. ISM equipment operating in this band is subject to the provisions of No. 1815.
- 808 - The band 5830-5850 MHz is also allocated to the amateur-satellite service (space-to-earth) on a secondary basis.
- G2 - In the bands 216-225, 420-450 (except as provided in US217), 890-900, 928-945, 1300-1400, 2300-2450, 2700-2900, 5650-5925, and 9000-9200 MHz, the Government radiolocation is limited to military services.
- US245 - The Fixed-Satellite-Service is limited to international systems and subject to case-by-case electromagnetic compatibility analysis.

The major portion of this band is now occupied by Government radiolocation limited to the military service for radar tracking, to transmit command signals to airborne vehicles being tracked, and to receive status information from the vehicles. Military telemetering and terrestrial telecommand operations are authorized in the bands when conducted as an integral part of the operation of authorized stations in the radiolocation service. Such telemetering and terrestrial command operations are conducted on a secondary basis to the authorized stations operating in accordance with the national table of frequency allocations.

### SUMMARY OF WARC-79 CHANGES

The WARC-79 changes in the international allocations and resultant changes in the national allocations will have a significant impact on the development of future systems and planning for the 5650-5925 MHz band. In region 2, prior to WARC-79, radiolocation was the primary service. Nationally, the band was allocated exclusively to the Government (military) Radiolocation Service on a primary basis. Many of the radar systems in the band were designed to tune across the entire band. With the 5850-5925 MHz portion of the band now allocated to radiolocation and fixed-satellite service on a shared co-equal basis, essentially that 30 percent of the band may require restricted operations by the large power radars (500 kW and above). New radar systems with like powers may not be able to be designed to operate in this upper portion of the band because of EM incompatibility with the FSS. Section 6 analyzes the impact, and Section 7 discusses the resultant frequency management issues.

The WARC-79 allocations also show the amateur-satellite service at 5650-5770 MHz limited to the Earth-to-space direction and 5830-5850 MHz for the space-to-Earth direction, all on a secondary basis. Coordination by the amateur-satellite stations with, and under, conditions established by the DOD Area Frequency Coordinators in the area of certain test ranges may be necessary to protect Government radiolocation operations.

### TECHNICAL STANDARDS

The general technical standards, which are more stringent than those specified in the ITU Radio Regulations, of Chapter 5 of the NTIA Manual contain minimum performance requirements and design objectives applicable to transmitters, receivers, and antennas used in Government radio services. As of January 1979, stations transmitting in the 5650 to 5925 MHz band are required by Section 5.2.3 to have frequency and spurious tolerances as follows:

STATION TYPE	FREQUENCY TOLERANCE (Parts per Million)	SPURIOUS TOLERANCES (See Notes)
1. Radionavigation Stations		
1.1 radar	1250	J
1.2 other than above	1250	E
2. Radiolocation Stations		
2.1 radar	1250	J
2.2 other than above	1250	E
3. Earth Stations	20	K
4. Space Stations	20	K

Existing systems in the space service, replacement equipment for those systems, and a new system designed or in process of being designed as of 11/24/70 may have a tolerance no greater than 50 ppm.

### Spurious Tolerance

E The standards for spurious signals which limit the mean power of any emission supplied to the antenna transmission line, as compared with the mean power of the fundamental, shall be in accordance with the following:

1. On any frequency removed from the assigned frequency by more than 75 percent, up to and including 150 percent of the authorized bandwidth, at least 25 decibels attenuation;
2. On any frequency removed from the assigned frequency by more than 150 percent, up to and including 300 percent of the authorized bandwidth, at least 35 decibels attenuation;
3. On any frequency removed from the assigned frequency by more than 300 percent of the authorized bandwidth, for transmitters with mean power of 5 kilowatts or greater, at least 80 decibels attenuation and for transmitters with mean power less than 5 kilowatts, at least 43 plus 10 log (mean power of the fundamental in watts) decibels attenuation (i.e., 50 microwatts absolute level).

J The spurious tolerances for radionavigation radars and radiolocation radars in the 5650-5925 MHz band are found in Sections 5.3.1 and 5.3.2 (Radar Spectrum Engineering Criteria) of the NTIA Manual.

K Development of spurious tolerances is pending.

### RADAR STANDARDS

Radar Spectrum Engineering Criteria (RSEC) apply to Government radar systems. RSEC specifications are contained in Part 5.3 of the NTIA Manual [NTIA, Sept. 1981]. The specific technical requirements of RSEC for the 5650-5925 MHz band fall under the Group B and C categories of radars. The details for computing emission bandwidth and emission level, as well as the criteria for antenna pattern, frequency tolerance, tunability, rejection of spurious responses, and measurement accuracy, are given in Sections 5.3.1 through 5.3.3 of the RSEC.

Along with the above technical standards, other standards have been developed by the Inter-Range Instrumentation Group (IRIG) under the Range Commanders Council which are applicable to this band. Since the various rocket and missile test ranges are users of this band, they have organized groups under the Range Commanders Council to manage the radio frequency spectrum assigned for their use and to set standards for the major systems and subsystems which use that spectrum to insure compatibility.

Following is a list of some of the IRIG documents that have been issued as guidelines and/or standards for systems used in the 5400-5900 MHz band.