

## **225-328.6 MHz**

### **1. Band Introduction**

The band 225-328.6 MHz is used for a diverse array of land-based, airborne, maritime, and satellite radio communications services by the military forces, National Guard units, Federal Aviation Administration (FAA), Coast Guard (CG), National Aeronautics and Space Administration (NASA), Department of Energy (DOE), and other Federal agencies. Tactical and non-tactical mobile communications, mobile-satellite communications, and air traffic control communications are the most prevalent uses.

The most extensive use of the band is for aeronautical communications systems by military and National Guard forces to provide tactical and non-tactical ground-to-ground, air-to-air, air-ground-air, and air-ship-air communications; and the band is used for Air-Traffic Control (ATC) at military air bases and aircraft carriers, and by the FAA at civilian airports used by military aircraft. The Coast Guard uses the band on its ships and aircraft to carry out its maritime search and rescue mission and for homeland security; and NASA uses the band for ATC communications on various aircraft.

The band 225-328.6 MHz is reserved for military uses by North Atlantic Treaty Organization (NATO), its member nations, and other U.S. allies. The band is harmonized among NATO-member nations for secure communications.

The band is also used for astronomical observations at several U.S. radio astronomy observatories. While not allocated to the radio astronomy service in the United States, the band 322.0-328.6 MHz is nevertheless covered under footnote US342 that states that “all practicable steps shall be taken to protect the radio astronomy service from harmful interference”. The band contains the hyperfine-structure line of deuterium at 327.38 MHz. The study of this line relates directly to studies of the origin of the universe and the cosmological synthesis of the elements. The detection of the line (achieved only in the last decade) required months of integration time and careful attention to interference mitigation.

## 2. Allocations

### 2a. Allocation Table

The frequency allocation table shown below is extracted from the Manual of Regulations And Procedures for Federal radio Frequency Management, Chapter 4 – Allocations, Allotments and Plans.

*Table of Frequency Allocations*

*United States table*

<b>Federal Table</b>	<b>Non-Federal Table</b>	<b>FCC Rule Part(s)</b>
225-235 FIXED MOBILE G27	225-235	
235-267 FIXED MOBILE	235-267	
5.111 5.199 5.256 G27 G100	5.111 5.199 5.256	
267-322 FIXED MOBILE G27 G100	267-322	
322-328.6 FIXED MOBILE	322-328.6	
US342 G27	US342	

**5.111** The carrier frequencies 2 182 kHz, 3 023 kHz, 5 680 kHz, 8 364 kHz and the frequencies 121.5 MHz, 156.8 MHz and 243 MHz may also be used, in accordance with the procedures in force for terrestrial radiocommunication services, for search and rescue operations concerning manned space vehicles. The conditions for the use of the frequencies are prescribed in Article **31** and in Appendix **13**. The same applies to the frequencies 10 003 kHz, 14 993 kHz and 19 993 kHz, but in each of these cases emissions must be confined in a band of  $\pm 3$  kHz about the frequency.

**5.199** The bands 121.45-121.55 MHz and 242.95-243.05 MHz are also allocated to the mobile-satellite service for the reception on board satellites of emissions from emergency position-indicating radiobeacons transmitting at 121.5 MHz and 243 MHz (see Appendix **13**).

**5.256A Additional allocation:** in China, the Russian Federation, Kazakhstan and Ukraine, the band 258-261 MHz is also allocated to the space research service (Earth-to-space) and space operation service (Earth-to-space) on a primary basis. Stations in the space research service (Earth-to-space) and space operation service (Earth-to-space) shall not cause harmful interference to, nor claim protection from, nor constrain the use and development of the mobile service systems and mobile-satellite service systems operating in the band. Stations in space research service (Earth-to-space) and space operation service (Earth-to-space) shall not constrain the future development of fixed service systems of other countries. (WRC-03)

**G27** In the bands 225-328.6 MHz, 335.4-399.9 MHz, and 1350-1390 MHz, the fixed and mobile services are limited to the military services.

**G100** The bands 235-322 MHz and 335.4-399.9 MHz are also allocated on a primary basis to the mobile-satellite service, limited to military operations.

**US342** In making assignments to stations of other services to which the bands:

13360-13410 kHz	42.77-42.87 GHz*
25550-25670 kHz	43.07-43.17 GHz*
37.5-38.25 MHz	43.37-43.47 GHz*
322-328.6 MHz*	48.94-49.04 GHz*
1330-1400 MHz*	76-86 GHz
1610.6-1613.8 MHz*	92-94 GHz
1660-1660.5 MHz*	94.1-100 GHz
1668.4-1670 MHz*	102-109.5 GHz
3260-3267 MHz*	111.8-114.25 GHz
3332-3339 MHz*	128.33-128.59 GHz*
3345.8-3352.5 MHz*	129.23-129.49 GHz*
4825-4835 MHz*	130-134 GHz
4950-4990 MHz	136-148.5 GHz
6650-6675.2 MHz*	151.5-158.5 GHz
14.47-14.5 GHz*	168.59-168.93 GHz*
22.01-22.21 GHz*	171.11-171.45 GHz*
22.21-22.5 GHz	172.31-172.65 GHz*
22.81-22.86 GHz*	173.52-173.85 GHz*
23.07-23.12 GHz*	195.75-196.15 GHz*
31.2-31.3 GHz	209-226 GHz
36.43-36.5 GHz*	241-250 GHz
42.5-43.5 GHz	252-275 GHz

are allocated (\*indicates radio astronomy use for spectral line observations), all practicable steps shall be taken to protect the radio astronomy service from harmful interference. Emissions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service (*see ITU Radio Regulations* at Nos. **4.5** and **4.6** and Article **29**).

### 3. Federal Agency Use

#### 3a. Federal Agency Frequency Assignment Table

The following table identifies the frequency band, type(s) of allocations(s), types of application, and the number of frequency assignments by agency

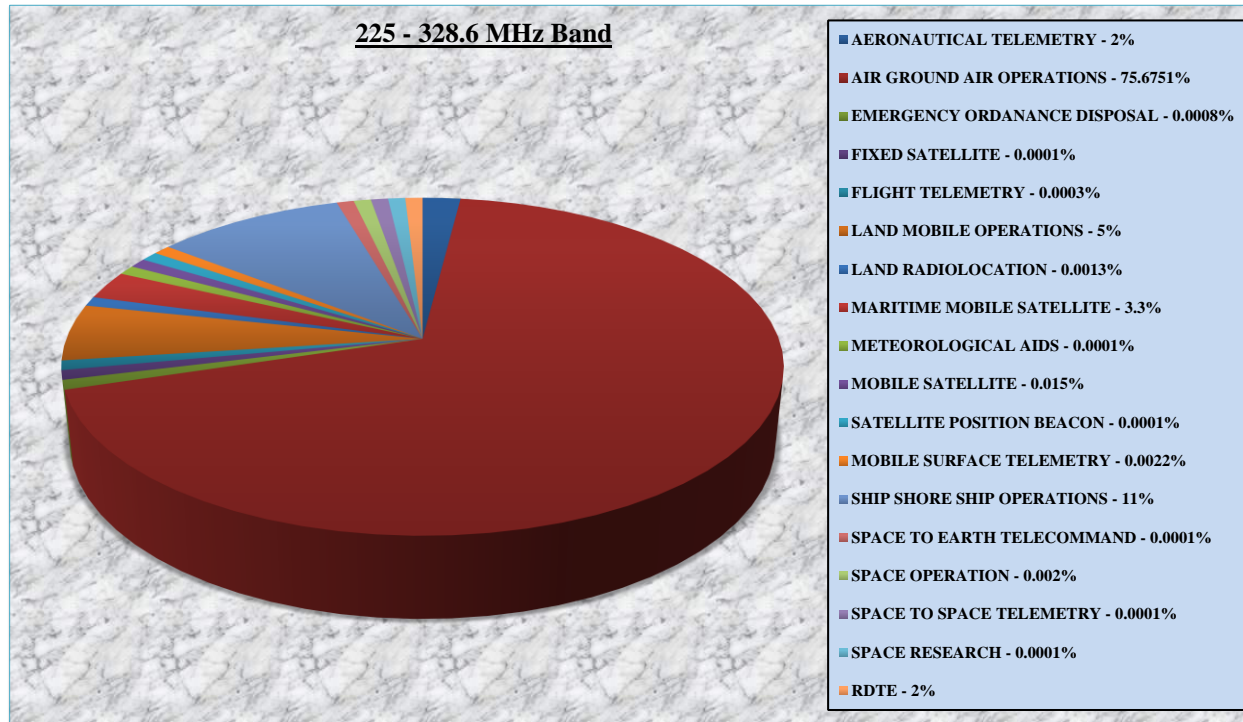
*Federal Frequency Assignment Table*

225-328.6 MHz Band																	
FEDERAL EXCLUSIVE BAND																	
AGENCY	TYPE OF APPLICATION																
	FIXED MOBILE																
	AERONAUTICAL TELEMETRY	AIR GROUND AIR OPERATIONS	EMERGENCY ORDNANCE DISPOSAL	FIXED SATELLITE	FLIGHT TELEMETRY	LAND MOBILE OPERATIONS	LAND RADIOLOCATION	MARITIME MOBILE SATELLITE	MOBILE SATELLITE	SATELLITE POSITION BEACON	MOBILE SURFACE TELEMETRY	POINT TO POINT DATA LINK	SHIP SHORE SHIP OPERATIONS	SPACE OPERATION	SPACE TO EARTH TRACKING	RESEARCH DEVELOPMENT TESTING EVALUATION	TOTAL
A		2															2
AF	4	3832		15	2	629	5		19			39	2	2		246	4795
AR		829				86						452	1			32	1400
CG		127											4			1	132
DHS		315															315
DOE		8			8				1	1				2		20	40
DOI		1															1
FAA		3906															3906
MC		729				122					51	7				37	946
N	11	1616	2	58		95		576	334		29	16	414		320	189	3660
NASA		32				6				1							39
VA						3											3
<b>TOTAL</b>	<b>15</b>	<b>11397</b>	<b>2</b>	<b>73</b>	<b>10</b>	<b>941</b>	<b>5</b>	<b>576</b>	<b>354</b>	<b>2</b>	<b>80</b>	<b>514</b>	<b>421</b>	<b>4</b>	<b>320</b>	<b>525</b>	<b>15239</b>

The number of actual systems, or number of equipments, may exceed and sometimes far exceed, the number of frequency assignments in a band. Also, a frequency assignment may represent, a local, state, regional, or nationwide authorization. Therefore, care must be taken in evaluating bands strictly on the basis of assignment counts or percentages of assignments.

### 3b. Percentage of Frequency Assignments Chart

The following chart displays the percentage of assignments for the applications operating in the chart legend below for the frequency band 225-328.6 MHz. The greatest use of the band is for Air/Ground/Air operations.



## 4. Frequency Band Analysis by Application

The band 225-328.6 MHz has been reserved for military operations by NATO and within the individual NATO member countries. The military nature of this band has also been maintained by certain allied and friendly nations outside the NATO alliance such as Australia, Israel, New Zealand, and Saudi Arabia; and by the European Cooperation Partner nations and the Partners for Peace nations.

### 4a. Mobile-Satellite Communications

Satellites operating in the mobile-satellite service in this band are used by the military services and the Coast Guard. The military mobile-satellite communications networks in the band serve ships at sea, aircraft, land-based forces, and a variety of other U.S. military fixed and mobile terminals used by mobile users. The bands 225-322 MHz and 335.4-399.9 MHz are the only bands below 7250 MHz available for Federal Government

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mobile-satellite communications, and the narrowband satellite links are frequently the only reliable means of communications.<sup>1</sup>

The military makes extensive use of the mobile-satellite service operating in this band because the electromagnetic waves can penetrate foliage, inclement weather, and urban terrain including concrete-reinforced buildings. Small antennas can be used at the earth terminals making it easy to transport the stations. There are numerous satellite earth terminals currently in use by the military, many of which are small and portable enough to be carried deep into theaters of operation.

The Federal use of the band for mobile satellites was initiated in 1978 with the Navy's Fleet Satellite Communications System (FLTSATCOM), a constellation of five geostationary satellites operating in the band 235-322 MHz, channelized into the downlinks at 243.855-269.95 MHz and corresponding uplinks in the band 292.85-317.325 MHz.<sup>2</sup> The Navy began upgrading the FLTSATCOM in the 1990s with the UHF Follow-On (UFO) satellites. The UFO satellites offer increased communications channel capacity over the same frequency spectrum used by the previous FLTSATCOM systems. Each UFO satellite has 39 channels with a total 555 kHz bandwidth. The satellite payload comprises 21 narrowband channels at 5 kHz each and 17 relay channels at 25 kHz.<sup>3</sup> These channels are used by the military agencies for tactical communications on land, ships, submarines, and aircraft. The Coast Guard also uses channels on the military satellites on some of their ships.<sup>4</sup>

The Department of Defense (DOD) Defense Satellite Communications System (DSCS-III) series of geostationary satellites operating in the 7- and 8- GHz bands also carry a transponder in this band called the single channel transponder (SCT) that provides communications for emergency action messages to the forces. The Military, Strategic, and Tactical Relay Satellite (MILSTAR) geostationary satellite also has mobile-satellite capability in this band, with a transponder that provides four Air Force Satellite Communications (AFSATCOM IIR) channels and a fleet broadcast channel.<sup>5</sup>

### 4b. Aeronautical Mobile Air-to-Ground-to-Air and ATC Communications

The military agencies, National Guard units, the Coast Guard, and the FAA are the heaviest users of the band 225-328.6 MHz, using the band for critical air-to-ground-to-air communications systems. The military agencies and National Guard units use the band 225-328.6 MHz for various types of aeronautical communications, e.g., for training flights and air-traffic-control functions such as ground control, approach control, enroute aircraft separation, and in-flight refueling services. The Air Force, Army, Navy, and the FAA have

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<sup>1</sup> Statement by VADM H.A. Browne, USDEPCINCSpace, SWarF 2000 Interim Report, July 18, 2000.

<sup>2</sup> *Department of Defense Interface Standard, Interoperability Standard for Single-Access 5-kHz and 25 kHz Satellite Communications Channels*, MIL-STD-188-181A, Appendix A, March 31, 1997.

<sup>3</sup> Fact Sheet, *Ultra High Frequency Follow-On (UFO) Program*, PMW 146, Navy Communications Satellite Programs, Program Executive Officer for Space, Communications, and Sensors, San Diego, CA, Revised March 1, 1999.

<sup>4</sup> *Spectrum Management for the 21<sup>st</sup> Century, The President's Spectrum Policy Initiative*, Dept. of Commerce, March 2008, at B-215. (The Federal Strategic Spectrum Plan).

<sup>5</sup> *Milstar Satellite Overview*, Lockheed Martin Fact Sheet, January 10, 2002.

thousands of frequency assignments for air-to-ground-to-air communications in the band 225-328.6 MHz. Most of these assignments are to ground stations.

The Coast Guard uses the band on its maritime search-and-rescue aircraft and other aircraft for air-to-ground-to-air communications. The military agencies, National Guard units, and the FAA make extensive use of the band 225-328.6 MHz which alleviates possible impact of the national airspace civilian air-to-ground-to-air communications operating in the bands within 117.975-137 MHz. Thus, the Federal use of the band 225-328.6 MHz for aeronautical communications plays an important part in national defense and security, and to control the nation's airspace.

The band 225-328.6 MHz is also used for essential communications by a number of other agencies such as NASA, DOE, and DOC. NASA uses the band for aircraft communications, and for International Space Station (ISS) communications during Extravehicular Activity (EVA); and DOC uses the band on National Oceanographic and Atmospheric Administration (NOAA) hurricane-hunter aircraft, and on ground stations to communicate with other hurricane-hunter aircraft.

#### **4c. Air-to-Ground-to-Air and Air-to-Air Aeronautical Mobile Communications**

The military agencies use the band 225-328.6 MHz for a major tactical communications system to provide anti-jam, secure, frequency-hopping radio communications for tactical air-to-air and air-to-ground-to-air communications. The uses include coordination and vectoring of aircraft to targets, and large scale training exercises.

For example, the major radio communications systems are deployed on all rotary wing aircraft, and are used by all operational aviation units, air traffic services, and units. The radio communications system enables interoperability communications among Air Force, Navy, Army, and NATO units.

#### **4d. Search and Rescue Communications on 243 MHz**

The footnotes 5.111, 5.199, and 5.256 were adopted by the International Telecommunication Union and are incorporated into the U.S. Table of Frequency Allocations. Among other things, these footnotes provide for the use of the 243 MHz frequency for search and rescue purposes.

The frequency 243 MHz is used on the radios onboard most Federal aircraft as a special channel, called a "guard" channel that is used for distress and safety purposes, including search and rescue. The 243 MHz channel is always activated on aircraft and ground systems even though another channel may be in use on a transceiver operating in the band. For example, a military aircraft in distress could make an emergency distress call for assistance on 243 MHz, and all other aircraft or ground stations in the area would hear it immediately and take action.

#### **4e. Ship-to-Shore-to-Ship and Ship-to-Ship Maritime Mobile Communications**

The Navy, Coast Guard, and NASA use the band 225-328.6 MHz for tactical and non-tactical operations such as ship-to-air-to-ship and ship-to-ship for clear and secure voice communications. The Coast Guard also uses the band for a secure data communications link.<sup>6</sup>

#### **4f. Land Mobile and Fixed Service Point-to-Point Communications**

The military agencies use the band 225-328.6 MHz for tactical and non-tactical land mobile and fixed service point-to-point communications. The most extensive use is by the Army's Area Common User System (ACUS), consisting of both land mobile and fixed communications systems. The mobile version uses mobile subscriber equipment (MSE) that functions like a cellular communications network, capable of providing communications to many users.

The fixed communications part of the ACUS is a high capacity line-of-sight point-to-point radio system. The radio provides voice and data communications over paths up to 70 miles. The system can use various data rates, with the highest being 34 Mbps, and it has a feature that provides a spectrum scan to detect spectrum congestion to identify frequencies to maximize link availability.

#### **4g. Aeronautical Telemetry**

The Navy makes extensive use of the band for aeronautical telemetry, and DOE also uses the band for this purpose. The Navy uses the band for flight testing of military aircraft. The military agencies also use this band for telemetry systems for rocket testing.

#### **4h. Research and Development, Testing, and Evaluation**

The military agencies use the band for research, development, testing, and evaluation of various types of communications and sensing systems. The military agencies operate training center instrumentation systems in this band for data links connecting battle simulation systems on participants' platforms (airborne, shipborne, or surface) to central processing facilities.

#### **4.i Radio Astronomy Observations**

Radio astronomy observations of the 322.0-328.6 MHz band, including the deuterium line, are carried out at a number of U.S. radio observatories, including the Massachusetts Institute of Technology Haystack Radio Observatory, the Allen Radio Telescope, the 305-meter Arecibo Radio Observatory in Puerto Rico operated by SRI International, Universities Space Research Association, and Universidad Metropolitana under cooperative agreement with the National Science Foundation (NSF), the Green Bank Telescope, the Very Large Array and the Very Long

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<sup>6</sup> Federal Strategic Spectrum Plan at B-16.



Baseline Array of the National Radio Astronomy Observatory, which is operated by Associated Universities, Inc. or the NSF.

## 5. Planned Use

The Navy has launched the next generation mobile satellites, termed the Mobile User Objective System (MUOS) that use the bands 243.525-270.05 MHz and 280-320 MHz. The MUOS is undergoing testing and is not fully operational as of September, 2014. The MUOS will use wideband-code-division-multiple-access (WCDMA) technology, the same technology as some forms of the third generation (3G) commercial cellphone technology.<sup>7</sup> The MUOS enables communications to various terminal devices such as handhelds, laptops, and personal communications units. To support legacy systems, the MUOS will use a narrowband system of 64 kbps/channel and below.<sup>8</sup>

Radio astronomy observations in the 322-328.6 MHz band are expected to continue at federally-funded radio astronomy observatories.

Other than the radio astronomy usage and the increased mobile-satellite communications, the planned Federal use of the 225-328.6 MHz band in the foreseeable future will essentially remain the same as the current usage.

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<sup>7</sup> “The Mobile User Objective System”, J.D. Oetting and T. Jen, John Hopkins Applied Physic Lab, Technical Digest, Volume 30, No. 2, 2011. (Document provided to NTIA by Arthur R. DeLeon, Navy Spectrum Management Office.)

<sup>8</sup> *Mobile User Objective System (MUOS)*, brochure, Navy Communications Satellite Program Office, San Diego, CA, (Updated October 2004).