406.1–410 MHz

1. Band Introduction

This band is used by Federal agencies primarily for conventional and trunked land mobile radio communication systems.[1] Systems used for the collection and transmission of hydrological and meteorological data are permitted to operate in this band on a limited basis. Radio astronomy continuum observations are also performed in this band.

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 (NTIA Manual), Chapter 4 – Allocations, Allotments and Plans.[2]

Table of Frequency Allocations

United States Table

Federal Table	Non-Federal Table	FCC Rule Part(s)
406.1-410 FIXED MOBILE RADIO ASTRONOMY US74 US13 US117 G5 G6	406.1-410 RADIO ASTRONOMY US74 US13 US117	Private Land Mobile (90)

2b. Additional Allocation Table Information

G5 In the bands 162.0125-173.2, 173.4-174, 406.1-410 and 410-420 MHz, use by the military services is limited by the provisions specified in the channeling plans shown in Sections 4.3.7 and 4.3.9 of the NTIA Manual.

G6 Military tactical fixed and mobile operations may be conducted nationally on a secondary basis: (a) to the meteorological aids service in the band 403-406 MHz; and (b) to the radio astronomy service in the band 406.1-410 MHz. Such fixed and mobile operations are subject to local coordination to ensure that harmful interference will not be caused to the services to which the bands are allocated.

US13 The following center frequencies, each with a channel bandwidth not greater than 12.5 kHz, are available for assignment to non-Federal fixed stations for the specific

[1] The 406.1-410 MHz band is part of the 406.1-420 MHz band that is used for Federal land mobile systems.

[2] National Telecommunications and Information Administration, *Manual of Regulations and Procedures for Federal Radio Frequency Management*, (NTIA Manual) available at www.ntia.doc.gov/osmhome/redbook/redbook.html,

purpose of transmitting hydrological and meteorological data in cooperation with Federal agencies, subject to the condition that harmful interference will not be caused to Federal stations:

Hydro Channels (MHz)			
169.425	170.2625	171.100	406.1250
169.4375	170.275	171.1125	406.1750
169.450	170.2875	171.125	412.6625
169.4625	170.300	171.825	412.6750
169.475	170.3125	171.8375	412.6875
169.4875	170.325	171.850	412.7125
169.500	171.025	171.8625	412.7250
169.5125	171.0375	171.875	412.7375
169.525	171.050	171.8875	412.7625
170.225	171.0625	171.900	412.7750
170.2375	171.075	171.9125	415.1250
170.250	171.0875	171.925	415.1750

New assignments on the frequencies 406.125 MHz and 406.175 MHz are to be primarily for paired operations with the frequencies 415.125 MHz and 415.175 MHz, respectively.

US74 In the bands 25.55-25.67, 73.0-74.6, 406.1-410.0, 608-614, 1400-1427 (see US368), 1660.5-1670.0, 2690-2700, and 4990-5000 MHz, and in the bands 10.68-10.7, 15.35-15.4, 23.6-24.0, 31.3-31.5, 86-92, 100-102, 109.5-111.8, 114.25-116, 148.5-151.5, 164-167, 200-209, and 250-252 GHz, the radio astronomy service shall be protected from unwanted emissions only to the extent that such radiation exceeds the level which would be present if the offending station were operating in compliance with the technical standards or criteria applicable to the service in which it operates. Radio astronomy observations in these bands are performed at the locations listed in US311.

US117 In the band 406.1-410 MHz, the following provisions shall apply:
(a) Stations in the fixed and mobile services are limited to a transmitter output power of 125 watts, and new authorizations for stations, other than mobile stations, are subject to prior coordination by the applicant in the following areas:
(1) Within Puerto Rico and the United States Virgin Islands, contact Spectrum Manager, Arecibo Observatory, HC3 Box 53995, Arecibo, PR 00612. Phone: 787-878-2612, Fax: 787-878-1861, E-mail: prcz@naic.edu.
(2) Within 350 km of the Very Large Array (34° 04' 44" N, 107° 37' 06" W), contact Spectrum Manager, National Radio Astronomy Observatory, P.O. Box O, 1003 Lopezville Road, Socorro, NM 87801. Phone: 505-835-7000, Fax: 505-835-7027, E-mail: nrao-rfi@nrao.edu.
(3) Within 10 km of the Table Mountain Observatory (40° 07' 50" N, 105° 14' 40" W) and for operations only within the sub-band 407-409 MHz, contact Radio Frequency Coordinator, Department of Commerce, 325 Broadway, Boulder, CO 80303. Phone: 303-497-6548, Fax: 303-497-3384.
(b) Non-Federal use is limited to the radio astronomy service and as provided by footnote US13.

3. Federal Agency Use

3a. Federal Agency Frequency Assignments Table

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

Federal Frequency Assignment Table

406.1-410 MHz Band						
SHARED BAND						
	FIXED MOBILE RADIO ASTRONOMY					
	TYPE OF APPLICATION					
AGENCY	HYDROLOGIC OPERATIONS	LAND MOBILE OPERTIONS	OCEANOGRAPHIC OPERATIONS	POINT TO POINT DATA LINK	RESEARCH DEVELOPMENT TESTING EVALUATION	TOTAL
A	1	55		281		337
AF		465		8	1	474
AID		1				1
AOTC		1				1
AR	1	463		5		469
AUSC		4				4
BBG		1				1
CG		11		1		12
DHS		376		38		414
DOC	4	37	2	14		57
DOE	2	389		42		433
DOI	11	166		189		366
DOJ		606		9		615
ED		3				3
EPA	1	4				5
FAA		15		677		692
FCC		2				2
FDIC		2				2
FRS		46		1		47
GAO		2				2
GPO		1				1
GSA		9				9
HHS		68		11		79
HR		3				3
HUD		2				2
IBWC				5		5
L		4				4
LC		3		1		4
MC		2				2
N		29		5	2	36
NARA		4				4
NASA		127		4		131
NGAL		2				2
NSF		2				2

OPM		**1**				**1**
S		**114**				**114**
SBA		**2**				**2**
SEN		**7**				**7**
SI		**2**				**2**
SSA		**16**				**16**
T		**42**				**42**
TRAN		**4**				**4**
TVA	**1**	**112**		**36**		**149**
USCP		**3**				**3**
USPS		**836**		**3**		**839**
VA		**300**				**300**
TOTAL	**21**	**4344**	**2**	**1330**	**3**	**5700**

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 frequency assignments for the applications operating in the frequency band 406.1-410 MHz. Most of the frequency assignments in the Government Master File (GMF) are for systems that operate in the land mobile service. The agencies with the largest number of frequency assignments in this band in the GMF include the: Federal Aviation Administration, U.S. Postal Service, Department of the Army, Department of Justice, Department of the Air Force, Department of Energy, Department of Homeland Security, Department of Interior, and Department of Agriculture. Geographically, the largest concentrations of land mobile frequency assignments are in and around major metropolitan areas where there is a higher presence of Federal users. The greatest use in the band is land mobile communication systems.

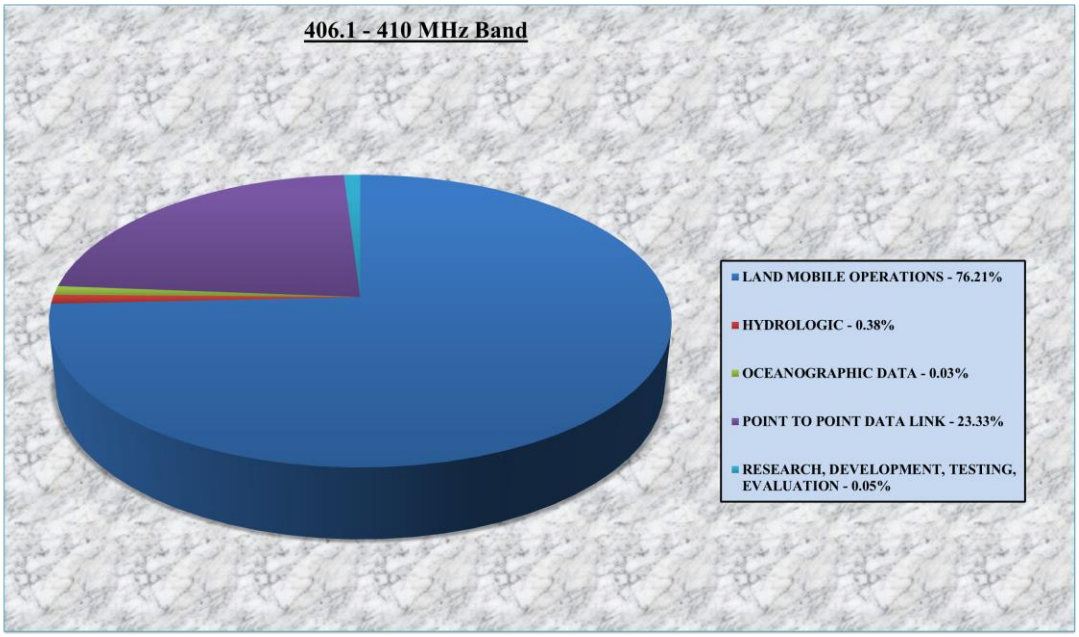

Figure 1: Percentage of Frequency Assignments By Application

4. Frequency Band Analysis By Radio Service

4a. Land Mobile Service

The land mobile service is defined as a mobile service between base stations and land mobile stations, or between land mobile stations. The Federal agencies use this band for conventional and trunked land mobile voice and low data rate communication systems in support of law enforcement, security, transportation, natural resources, emergency and disaster, and medical and administrative duties. The communication systems operating in

this frequency band are used for the delivery of mail, promoting public safety and efficiency in traveling via air, water, and land; interdicting entry of illegal persons and substances into the United States; establishing communications between disaster areas and relief forces; ensuring the swift search and rescue of human life; protecting the national forests, parks and farmlands; bringing to justice perpetrators of Federal crimes; and ensuring the security of energy generation and distribution networks. The communication systems operating in this band are used by Federal emergency response and public safety organizations which conduct large-scale exercises to prepare for and respond to a wide variety of emergencies and disasters.

The Coast Guard operates communication systems in this band that are used for the coordination of maritime rescue operations. Rescue 21 is an advanced search and rescue communication system that will be used by the Coast Guard to more effectively locate and assist boaters in distress. Rescue 21 will consist of approximately 300 coastal communication sites nationwide operating in the 162-174 MHz and 406.1-420 MHz bands, with communication consoles in over 250 Coast Guard facilities, communication equipment on over 650 Coast Guard vessels, and over 3000 portable radios.

The Department of Commerce, National Weather Service, operates communication systems in the 406.1-410 MHz band for gathering and disseminating meteorological data. One example is relaying meteorological information at airports in support of the Automated Surface Observing System which transmits meteorological information to aircraft. There are also frequencies designated under footnote US13 that are shared with local governments and used for transmitting hydrological and meteorological data.

Federal agencies also have mission requirements to operate communication systems on board aircraft on an intermittent basis in the 406.1-410 MHz band.[3] These may involve, for example, situations where Federal law enforcement officials may have to board an aircraft during a pursuit situation.[4]

After January 1, 2008, all land mobile systems operating in the 406.1-420 MHz band were required to migrate to 12.5 kHz narrowband technology. Section 4.3.9 of the NTIA Manual specifies the channel plan where frequencies in the 406.1-410 MHz band are paired with frequencies in the 410-420 MHz band for duplex operation. To date, not all agencies have complied with the required migration to 12.5 kHz technology. Table 2 provides a distribution of the emission bandwidths for the frequency assignments in the 406.1-410 MHz band. NTIA has instituted specific processes to accommodate continued use of 25 kHz systems to prevent interference to other agencies implementing and operating narrowband technology systems.[5]

Table 2: Distribution of Emission Bandwidths in the 406.1 to 410 MHz Band

[3] The 406.1-410 MHz band is allocated for the fixed and mobile services. The mobile service consists of the aeronautical, land, and maritime mobile services.

[4] NTIA Manual 8.2.56.

[5] NTIA Manual 4.3.7.

Emission Bandwidth	Percentage of Frequency Assignments
Less than 8 kHz	0.3
12.5 kHz	85.8
25 kHz	13.8
Greater than 25 kHz	0.1

Unlike commercial communication systems where licensees are issued based on geographic areas designated by the Federal Communications Commission (e.g., Major Trading Area, Basic Trading Area) Federal agencies are authorized to use a frequency under specified conditions, which place limitations on the transmission characteristics (e.g., power, antenna gain) and the operational area. The operational area for a land mobile system can be specified in terms of the base station location (latitude and longitude) and a radius of operation for the associated mobile and portable stations. For agencies with intermittent communication requirements where the location is unknown the operational area can be specified: on a nationwide basis; within a state or multiple states; or within a geographic area. For example, Federal law enforcements agents performing undercover operations or providing protection as the President travels throughout the country must have communications capabilities for a limited duration (e.g., two to three days) typically on short notice (e.g., 24 hours or less). Federal emergency response and public safety organizations must respond to a wide variety of emergencies and disasters, such as hurricanes, wildfires, earthquakes, and industrial accidents; that can occur at anytime throughout the country. In order to address these intermittent communications requirements a land mobile system is authorized under an area frequency assignment.

In the 406.1-410 MHz band, a channel plan is employed to distribute channels among the Federal agencies. Subject to agreement, channels identified for one agency may be used by another agency. There are some channels designated for smaller agencies that do not have designated channels in the plan or for use when an agency cannot find an available channel within the channel plan. Sections 4.2.3 and 4.2.4 of the NTIA Manual designate channels in the 406.1-410 MHz band that are identified for use by all Federal agencies under certain geographic restrictions and with no protection from interference. In the Federal spectrum management process, the channel plan provide a structure within which agencies select frequencies providing a certain degree of flexibility that support nationwide operations. This plan does not convey a right to or ownership of the identified channels and agencies must still obtain frequency assignments from NTIA to use their identified channels.

Section 4.3.16 of the NTIA Manual designates frequencies in the 406.1-410 MHz band that are available for assignment to all Federal agencies to satisfy law enforcement and public safety incident response interoperability communication requirements.[6] The frequencies are also available to non-Federal entities for interoperability communication

[6] NTIA Manual 4.3.16.

to enable joint Federal and non-Federal operations for law enforcement and incident response.

In the early 1990s, NTIA recognized that the use of trunked radio technology could increase the efficiency and utility of spectrum resources within the Federal land mobile bands.[7] The Military Departments individually invested significant funds supporting fixed facility infrastructure requirements at many bases, posts, camps, and stations and continue to rely on this proven technology. In an effort to increase the use of trunking by the Federal agencies, NTIA sponsored the Federal Specialized Mobile Radio (FedSMR) program. The FedSMR program uses frequencies in the 406.1-420 MHz band to offer trunked radio service in five urban areas on the East Coast.[8] The purpose of FedSMR program was to provide spectrum efficient trunked radio communications to Federal agencies. However, the FedSMR program has seen limited success, and is primarily used by Federal agencies that are not heavy users of the land mobile bands. For example, in Washington, D.C., the main users of FedSMR are the Smithsonian Institution, the National Archives, the National Zoo and the U.S. Holocaust Memorial. The FedSMR program currently supports over 2100 subscribers.[9]

Federal agencies are examining the development of shared trunked radio systems to satisfy their communication requirements. Because of the limited number of users, a dedicated Federal trunked radio system may only be viable in heavily populated metropolitan areas. However if Federal users were able to share trunked systems in the less populated areas with non-Federal users this would maximize spectrum usage. The lack of clear regulatory policy and procedures has limited to some extent the implementation of trunked networks that are shared by Federal and non-Federal users. To begin addressing this problem Section 8.2.47 was added to the NTIA Manual providing guidance for shared Federal and non-Federal land mobile systems.

Along the Mexican and Canadian borders the United States must share the 406.1-410 MHz band. Within a 90.1 mile-(145 kilometer-) sharing zone along the United States and Mexican border the 406.1-410 has been divided into two equal sub-bands. The United States can operate land mobile systems in the Mexican sub-band in the sharing zone if agreed to power-flux density limits are met. Within a 75 mile sharing zone along the United States and Canadian border, the 406.1-410 MHz band is equally divided into 12.5 kHz band segments, thereby cutting the availability of channels in half in the border area. The United States is not permitted to operate land mobile systems in the Canadian band segments within the sharing zone. Additional details regarding the sharing arrangements

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[7] National Telecommunications and Information Administration, NTIA Report 93-300, *Land Mobile Spectrum Efficiency: A Plan for Federal Government Agencies to Use More Spectrum-Efficient Technology* (October 1993).

[8] The original FedSMR program included systems in the following cities: Boston, MA, New York, City, Baltimore/Washington DC, Philadelphia, PA, and Norfolk, VA. Currently FedSMR only operates in Washington, DC; Baltimore, MD; and Norfolk, VA.

[9] A breakdown of the current subscribing agencies in the Washington DC area is provided in the United States Department of Commerce *Strategic Spectrum Plan 2007 Version*, at 24 available at http://www.ntia.doc.gov/osmhome/spectrumreform/Spectrum_Plans_2007/Commerce_%20Strategic_%20Spectrum_%20Plan_Nov2007.pdf.

in the 460.1-410 MHz band with Mexico and Canada can be found in Chapter 3 of the NTIA Manual. Given the increasing need for communications for Federal law enforcement and security along these two borders, the limitations on access to the 406.1-410 MHz band can make the identification of assignable channels difficult.

Federal agencies use commercial services such as the cellular phone service, personal communications service, and BlackBerry devices for non-critical administrative functions. In many cases, however, due to remote locations or unique mission requirements, the use of commercial services is not possible. Often no other reliable commercial services exist in the areas where Federal agencies are required to operate (e.g., National Forests or on military reservations). Where commercial service is available, it may not penetrate buildings or other areas where Federal agencies require indoor coverage. The functions performed by many Federal agencies require rapid push-to-talk connections, security and broadcast capabilities which are not provided by commercial service providers. Commercial services often cannot satisfy the encryption requirements of many Federal agencies. In addition, during emergencies, commercial services may be inoperable, or overwhelmed by commercial traffic. For these reasons, many agencies operate their own land mobile systems to support mission essential communication functions. In order to implement cost efficient land mobile systems (e.g., fewer number of base stations) that provide coverage over large geographic areas and in buildings, these systems must operate below 1 GHz.[10] The 406.1-410 MHz band is especially suited for urban environments due to lower background noise and the ability to propagate effectively along urban streets and penetrate buildings for indoor coverage.

Typical transmitters at fixed locations (base stations and repeaters) have power levels in the range of approximately 100 to 110 watts, with some lower power levels for transmitters that are used for short range communications. Mobile transmitters have similar or lower powers levels. Portable transmitters typically have transmit power levels of 6 watts or less. Figure 2 shows the distribution of transmitter power levels for the frequency assignments in the 406.1-410 MHz band. Many frequency assignments in the GMF include base, mobile, and portable transmitters, and thus there can be various transmitter power levels.

[10] The radiowave propagation losses are lower at lower frequencies, which means that the coverage area is larger.

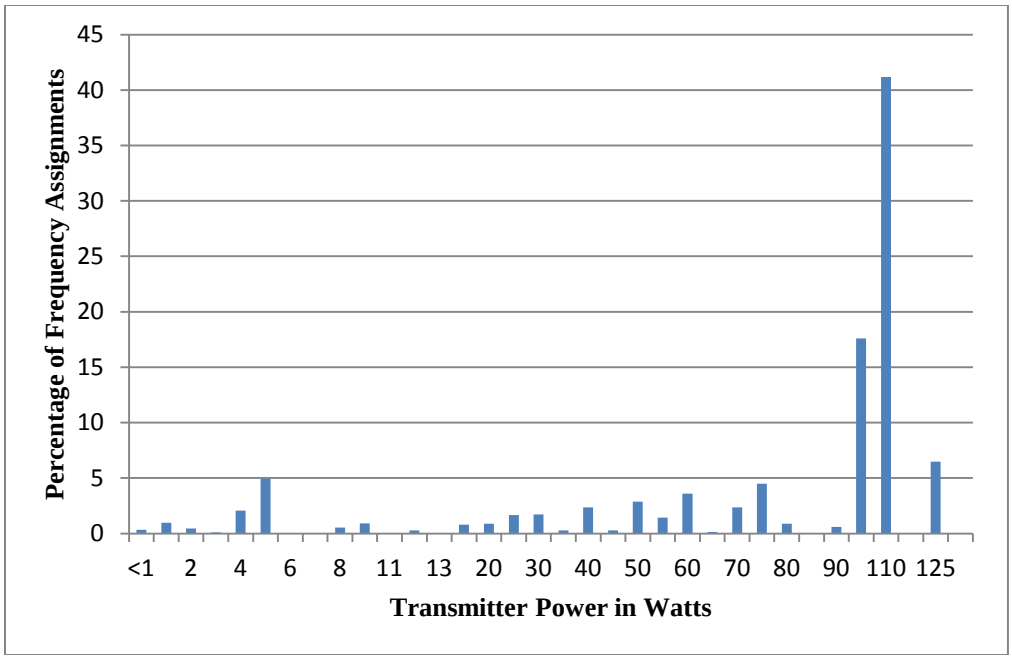

Figure 2: Distribution of Fixed Station Transmitter Power Levels in the 406.1-410 MHz Band

Figure 3 shows the distribution of antenna heights above ground level for frequency assignments in the 406.1-410 MHz band. Over 40 percent of the assignments have antenna heights of less than 20 meters, and 75 percent are less than 40 meters. Typical fixed station antenna installations would be on buildings or towers. Mobile stations typically have antenna heights in the range of 1 to 2 meters, and are generally mounted on vehicles. Portable stations have antenna heights that are less than 2 meters, but can be considerably higher when used within a building or an aircraft.

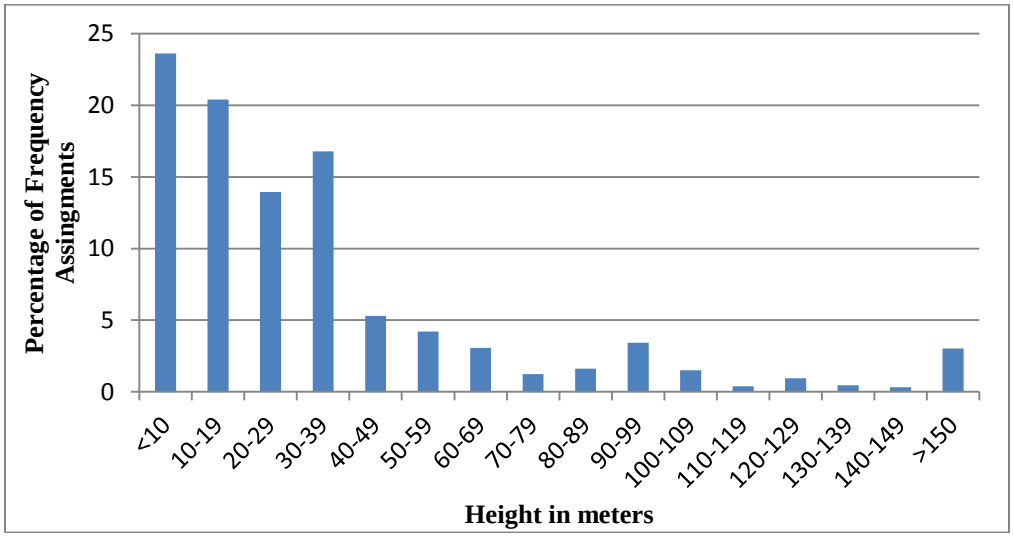

Figure 3: Distribution of Fixed Station Antenna Height Above Ground Level in the 406.1 - 410 MHz Band

Figure 4 shows the distribution of antenna gain values for the frequency assignments in the 406.1-410 MHz band. Most fixed station antennas have gain values ranging from 6 to 9 dBi, and typically employ collinear and yagi antennas.[11] Mobile stations typically have omni-directional antennas with gain values of less than 3 dBi. Portable stations employ omni-directional whip antennas, often with negative gain values.

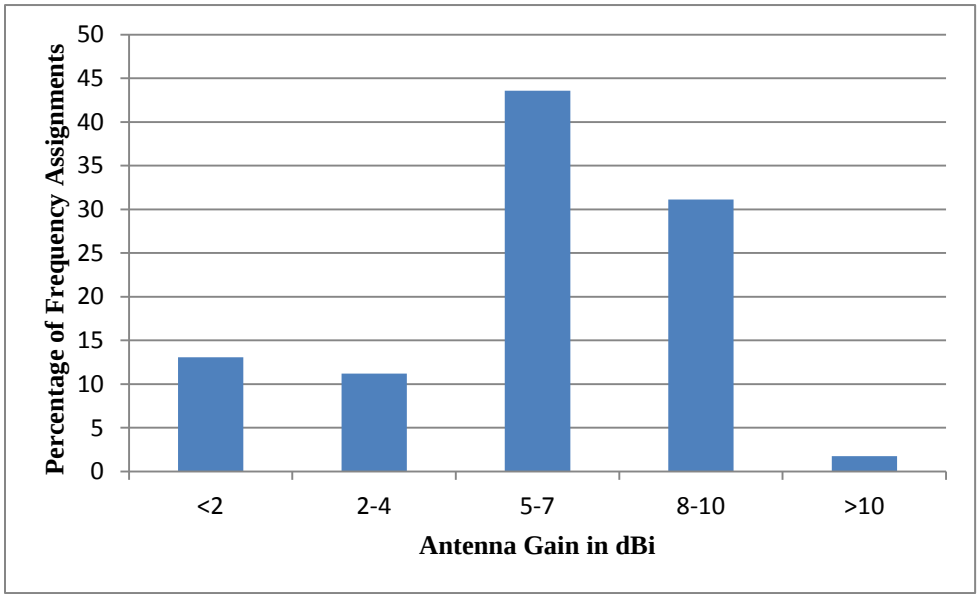

Figure 4: Distribution of Fixed Station Antenna Gain in the 406.1–410 MHz Band

NTIA performed a study that showed the interference analysis methodology used in assigning frequencies for land mobile systems could be improved to allow greater frequency re-use.[12] Increasing frequency re-use by identifying more interference-free frequencies that can be assigned enables a more efficient use of the land mobile frequency bands. In light of the increasing demands for land mobile communications spectrum, and to improve spectrum efficiency, Federal spectrum managers must use frequency assignment methods that accurately represent interference to and from systems in the environment. To achieve this goal, the methodology described in Telecommunications Industry Association (TIA) Telecommunications Systems Bulletin 88-B (TSB-88-B) will be used for assigning frequencies in the Federal land mobile frequency bands.[13] Implementation of the TSB-88-B methodology will help avert

[11] Fixed station antennas are chosen for the shape of the coverage area to minimize required transmit power and to minimize interference to other systems.

[12] National Telecommunications and Information Administration, NTIA Report 07-447, *Assessment of Federal and Non-Federal Land Mobile Radio Frequency Assignment Methodologies* (May 2007).

[13] Telecommunications Industry Association, *Wireless Communications System Performance in Noise Limited Situations Recommended Methods for Technology Independent Modeling*, TSB.88-1-C (May 2008).

imminent future land mobile spectrum shortages faced by Federal agencies, particularly in spectrally congested environments.

4b. Fixed Service

The fixed service is defined as a radiocommunication service between specified fixed points. The Federal agencies operate a small number of fixed point-to-point communication systems in the 406.1-410 MHz band. These systems are used for backhaul traffic to and from repeaters and ship-to-shore communication systems. Fixed service systems operating in this band also include base station to repeater, repeater to repeater, or repeater to base station systems used in conjunction with a land mobile communication system.

4c. Radio Astronomy Service

Radio astronomy is defined as astronomy based on the reception of radio waves of cosmic origin. The service is unique in that it involves only passive systems. Since the signals received emanate from natural sources, radio astronomers have no control over the power, the frequency, or other characteristics of the emissions. The spectrum used is based on physical phenomena rather than expected growth, as is the case for most other radio services. Using terrestrial radio telescopes, radio astronomers can observe cosmic phenomena at frequencies ranging from 15 MHz to over 800 GHz. To meet the needs of radio astronomy, frequencies at regular intervals across this range must be protected from interference in the vicinity of the radio astronomy observatories. The basic plan of spectrum management for radio astronomy is to protect small bands across the range for continuum observations, while choosing those bands so they contain the spectral lines of greatest scientific interest. Radio astronomy has contributed much to the science of astronomy and has produced numerous technical innovations that have benefitted radiocommunications and humankind in general. It has provided information on the atmospheric absorption of radio waves, important in the area of telecommunications and communications technology.[14]

The radio astronomy service shares primary allocation status in the band 406.1-410 MHz with the fixed and land mobile (except aeronautical mobile) services in the United States and worldwide. This band is one of the radio astronomy service preferred frequency bands for continuum observations.[15] Radio astronomy observations in the 406.1-410 MHz band may be made at the facilities shown in Table 3.

[14] An overview of applications of astronomical techniques and devices that benefit the public is contained in National Telecommunications and Information Administration, NTIA Report 99-35, *Radio Astronomy Spectrum Planning Options* (April 1998) at Appendix B.

[15] International Telecommunications Union-Radiocommunication Sector Recommendation RA.314-10, *Preferred Frequency Bands for Radio Astronomical Measurements* (2003).

Table 3: Radio Astronomy Observation Facilities in the 406.1-420 MHz Band

Facility	Location
Allen telescope Array, Hat Creek, CA	Rectangle between latitudes 40° 00' N and 42° 00' N and between longitudes 120° 15' W and 122° 15' W.
NASA Goldstone Deep Space Communications Complex, Goldstone, CA	80 kilometer radius centered on 35° 20' N, 116° 5[illegible] W.
National Astronomy and Ionosphere Center, Arecibo, PR	Rectangle between latitudes 17° 30' N and 19° 00' N and between longitudes 65° 10' W and 68° 00' W.
National Radio Astronomy Observatory, Socorro, NM	Rectangle between latitudes 32° 30' N and 35° 30' N and between longitudes 106° 00' W and 109° 00' W.
National Radio Astronomy Observatory, Green Bank, WV	Rectangle between latitudes 37° 30' N and 39° 15' N and between longitudes 78° 30' W and 80° 30' W.
National Radio Astronomy Observatory, Very Long Baseline Array Stations Brewster, WA Fort Davis, TX Hancock, NH Kitt Peak, AZ Los Alamos, NM Mauna Kea, HI North Liberty, IA Owens Valley, CA Pie Town, NM Saint Croix, VI	80 kilometer radius centered on: 48° 08' N 119° 41' W 30° 38' N 103° 57' W 42° 56' N 71° 59' W 31° 57' N 111° 37' W 35° 47' N 106° 15' W 19° 48' N 155° 27' W 41° 46' N 91° 34' W 37° 14' N 118° 17' W 34° 18' N 108° 07' W 17° 45' N 64° 35' W
Owens Valley Radio Observatory, Big Pine, CA	Two contiguous rectangles, one between latitudes 36° 00' N and 37° 00' N and between longitudes 117° 40' W and 118° 30' W and the second between latitudes 37° 00' N and 38° 00' N and between longitudes 118° 00' W and 118° 50' W.

5. Planned Use

The Federal use of this band for voice communication systems operating in the land mobile service is expected to remain the same; however, if additional requirements for transmitting data are developed, the demand for spectrum will increase.

Trunked radio systems that are shared by multiple Federal agencies may provide some relief of spectrum crowding in this band.

As commercial systems expand coverage and provide additional capabilities, Federal agencies may be able to use these services to satisfy communication requirements for limited administrative functions; however, there will still be a continuing requirement for

the agencies to operate land mobile systems to provide communication in support of their specific missions.

The deployment of land mobile communication systems that are shared between Federal and non-Federal users are expected to increase the demands for spectrum in this band.

The fixed service use in this band is expected to continue indefinitely.

The radio astronomy continuum observations performed in this band are expected to continue indefinitely.