

# 4200-4400 MHz

## 1. Band Introduction

The 4200-4400 MHz band is a shared band internationally reserved for radio altimeters installed on aircraft. The radio altimeter transmits radio frequency signals toward the ground and times how long it takes them to be reflected back to the aircraft receiver. Because speed, distance and time are all related to each other, the altimeter can determine the aircraft's distance from the surface. Radio altimeters are used on Federal (military and civilian), non-Federal aircraft.

## 2. Allocations

### 2a. Allocation Table

The frequency allocation table shown below is extracted from the Manual of Regulations & 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>
4200-4400 AERONAUTICAL RADIONAVIGATION 5.440 US261		Aviation (87)

**2b. Additional Allocation Table Information**

5.440 The standard frequency and time signal-satellite service may be authorized to use the frequency 4 202 MHz for space-to-Earth transmissions and the frequency 6 427 MHz for Earth-to-space transmissions. Such transmissions shall be confined within the limits of  $\pm 2$  MHz of these frequencies, subject to agreement obtained under No. 9.21.

US261 The use of the band 4200-4400 MHz by the aeronautical radionavigation service is reserved exclusively for airborne radio altimeters. Experimental stations will not be authorized to develop equipment for operational use in this band other than equipment related to altimeter stations. However, passive sensing in the Earth-exploration satellite and space research services may be authorized in this band on a secondary basis (no protection is provided from the radio altimeters).

### 3. Federal Agency Use

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

The following table identifies the frequency band, types of allocations, types of applications, and the number of frequency assignments by agency.

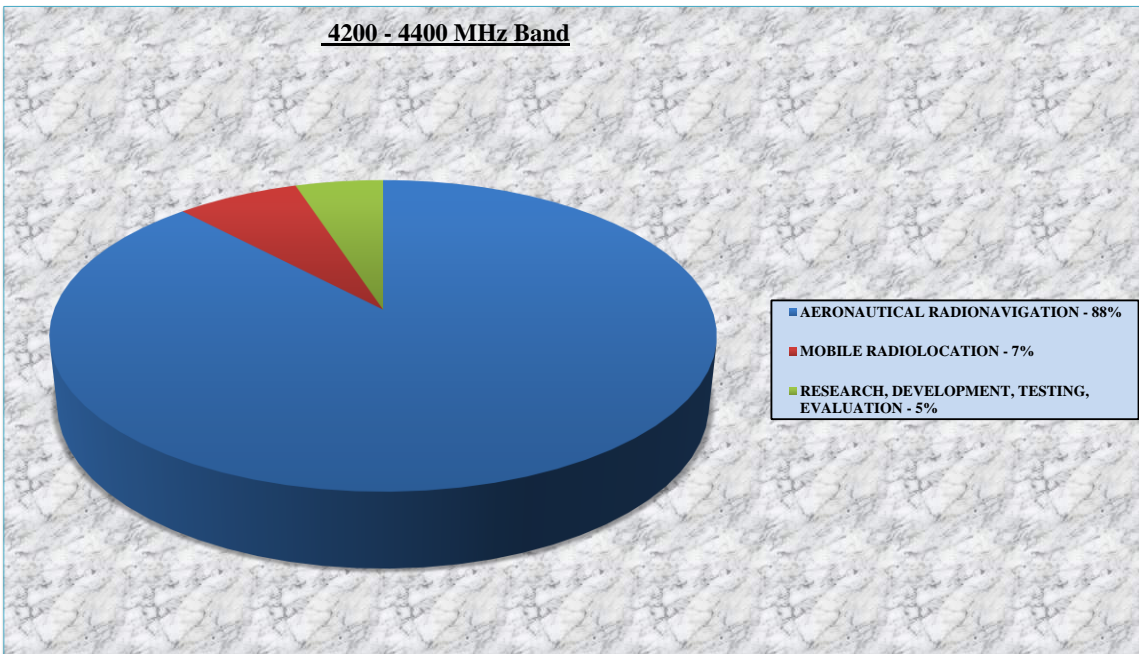
*Federal Frequency Assignment Table*

4200-4400 MHz Band				
SHARED BAND				
AERONAUTICAL RADIONAVIGATION				
TYPE OF APPLICATION				
AGENCY	AERONAUTICAL RADIONAVIGATION	MOBILE RADIO LOCATION	RESEARCH DEVELOPMENT TESTING EVALUATION	TOTAL
AF	7	9	4	20
AR	9			9
DOE	1			1
MC	46			46
N	46		2	48
<b>TOTAL</b>	<b>109</b>	<b>9</b>	<b>6</b>	<b>124</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. Passive use does not require authorization. Therefore, assignment counts in passive bands may not accurately represent the use.				

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### 3b. Percentage of Frequency Assignments Chart

The following chart displays the percentage of use for the services listed in the chart below for the frequency band 4200.0 – 4400.0 MHz. The greatest use in the band is aeronautical radionavigation.



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## 4. Frequency Band Analysis By Application

### 4a. Aeronautical Radionavigation Service

The 4200-4400 MHz band is used by the Federal Government and civil aviation for radio altimeters. The altimeters operate continually during flight, wherever the aircraft may travel. A radio altimeter is used to determine the altitude (height above terrain) of the aircraft for visual display to the pilot and for use by the Automatic Flight Control System during automatically controlled approaches and landings. The radio altimeter transmits radio frequency signals toward the ground and times how long it takes them to be reflected back to the aircraft receiver. Because speed, distance and time are all related to each other, the altimeter can determine the aircraft's distance from the surface. Radio altimeters are an integral and essential for flight navigation. Because of the precision and accuracy of radio altimeters at altitudes of 1000 feet or less, they are

used as a height controlling sensor in many aircraft automatic approach and landing systems. In many aircraft the radio altimeter is directly connected to the Ground Proximity Warning System which is designed to warn the pilot if the aircraft is flying too low or descending too quickly.

Radio altimeters operating in the 4200-4400 MHz band are utilized in aircraft throughout the Federal Government. The Federal agencies use radio altimeters on large and small fixed wing aircraft and helicopters. The National Aeronautics and Space Administration uses radio altimeters for Space Shuttle landings. Radio altimeters are also used on unmanned air vehicles, tactical weapons (missiles), and drone targets. The frequency assignments in the 4200-4400 MHz band permit the altimeter operations on many aircraft for a number of agencies for nationwide use. For civilian aircraft the authorization to use radio altimeters is obtained from the Federal Communications Commission and as such these frequency assignments are not recorded in the Government Master File (GMF).

. The Airbus 300 series, Boeing 700 series, and McDonnell Douglas DC and MD series of commercial aircraft also use radio altimeters. A pressure altimeter (also called barometric altimeter) which does not transmit radio frequency signals, is used on Federal Government, commercial aircraft and on most general aviation aircraft.

Radio altimeters have to be installed on commercial aircraft that are certified for Category II and III approaches and landings.<sup>1</sup> Radio altimeters are necessary for an altitude of 2,500 feet to landing for precision approaches, because they are more accurate than barometric altimeters. Below 200 feet, a pilot without a radio altimeter relies on Visual Flight Rules. Above 2,500 feet, pilots use the barometric altimeter, but they can use the radio altimeter to validate the barometric altimeter. Every aircraft needs to use the same reference to maintain vertical separation, so barometric altimeters are used by nearly all aircraft except for Category II and III landings.

The radio altimeters that operate in the 4200-4400 MHz band are either pulsed or frequency modulated continuous wave (FMCW) systems. The altitude measurement range of a pulsed radio altimeter is between 100 to 5000 feet above ground level. For FMCW type radio altimeters the altitude measurement range is between 100 to 2500 feet above ground level. Geographically, radio altimeters are used primarily in the areas around airports during aircraft approach and landing. Radio altimeters are typically left on during the entire flight; however the signal level at the surface of the Earth is extremely

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<sup>1</sup>. For automatic landing systems there different landing categories that are defined in terms of minimum visibility and decision height.

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low.<sup>2</sup> While commercial aircraft fly at altitudes below 5000 feet primarily during take-off and landing transitions from or to higher altitudes may result in increase signal levels at the ground. Also, these portions of a flight plan may involve banking of the aircraft, expanding the impact of the altimeter emission.

The radio altimeters operating in the 4200-4400 MHz band typically have a center frequency of 4300 MHz. Based on the frequency assignment data in the GMF, the emission bandwidths for a large majority of the radio altimeters used on Federal aircraft range from 20 MHz to 170 MHz. The accuracy with which the aircraft altitude is measured depends mainly on the bandwidth. For both FM/CW and pulsed radio altimeters, higher resolution measurements can be performed by using a wider bandwidth.<sup>3</sup> Radio altimeter use of the 4200-4400 MHz band allows for conveniently small equipment packages because this portion of the radio frequency spectrum permits good cloud penetration, requires modest amounts of power, and does not require highly directional antennas. The available bandwidth allows accurate measurements to be performed, and equipment can be produced that is small and light. Radio altimeter transmitter power levels range from 40 milliwatts to 5 watts. Some pulsed radio altimeters used for Federal research and development programs (e.g., missile testing) have peak power levels between 100 to 500 watts; however, they are restricted to operating in specific geographic areas (e.g., 100 kilometer radius around a military base). The transmit and receive antennas are broad-beamed downward looking with a nominal gain of approximately 10 dBi to allow the operation of the radio altimeter at moderate pitch and bank angles of the aircraft.

A series of spectrum surveys were performed by NTIA in several geographic areas.<sup>4</sup> While these surveys date to 1997, the use of the band has not changed significantly. Figures 1 through 3 summarize the measured received signal levels in the 4200-4400 MHz band. The measurements were performed over the 108 MHz to 19.7 GHz frequency range during a two week period and should be considered a snapshot of activity in the band. Extrapolation of the data measured in the spectrum surveys to general spectrum occupancy requires consideration of additional factors such as the missions performed in

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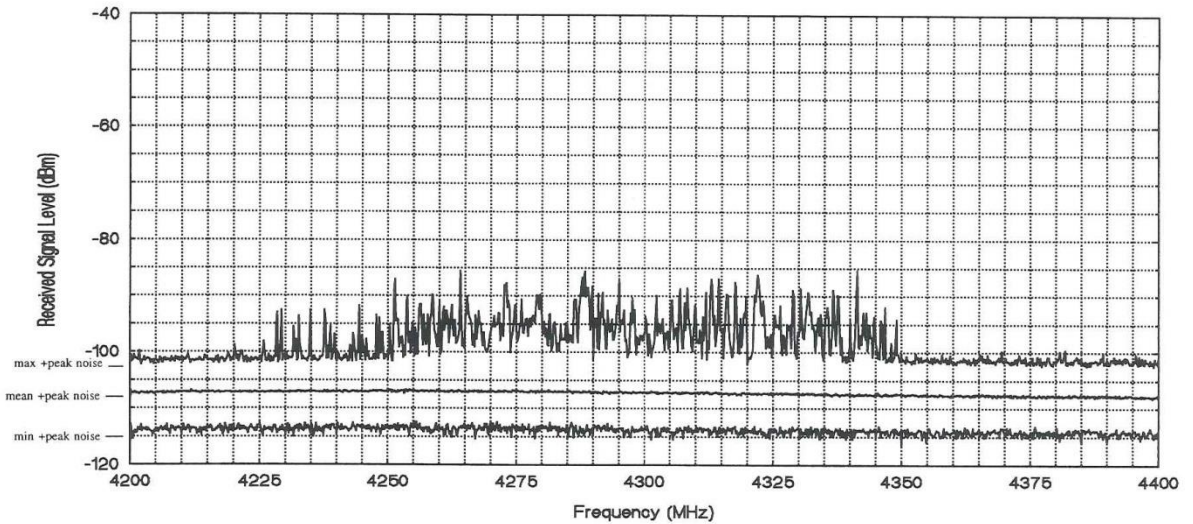
<sup>2</sup>. For example, a 1 Watt, 10 dBi gain, 120 MHz bandwidth radio altimeter on an aircraft operating at an altitude of 6000 meters (20,000 feet) has a received signal level at the surface of the Earth of approximately -132 dBW/MHz assuming a 0 dBi gain receive antenna.

<sup>3</sup>. The accuracy and resolution of radio altimeters is usually limited to a few feet due to the limited availability of bandwidth (200 MHz).

<sup>4</sup>. National Telecommunications and Information Administration, NTIA Report 97-334, *Broadband Spectrum Survey at San Diego, California* (December 1996); National Telecommunications and Information Administration, NTIA Report 97-336, *Broadband Spectrum Survey at Los Angeles, California* (May 1997); National Telecommunications and Information Administration, NTIA Report 99-367, *Broadband Spectrum Survey at San Francisco, California* May-June 1995 (July 1999).

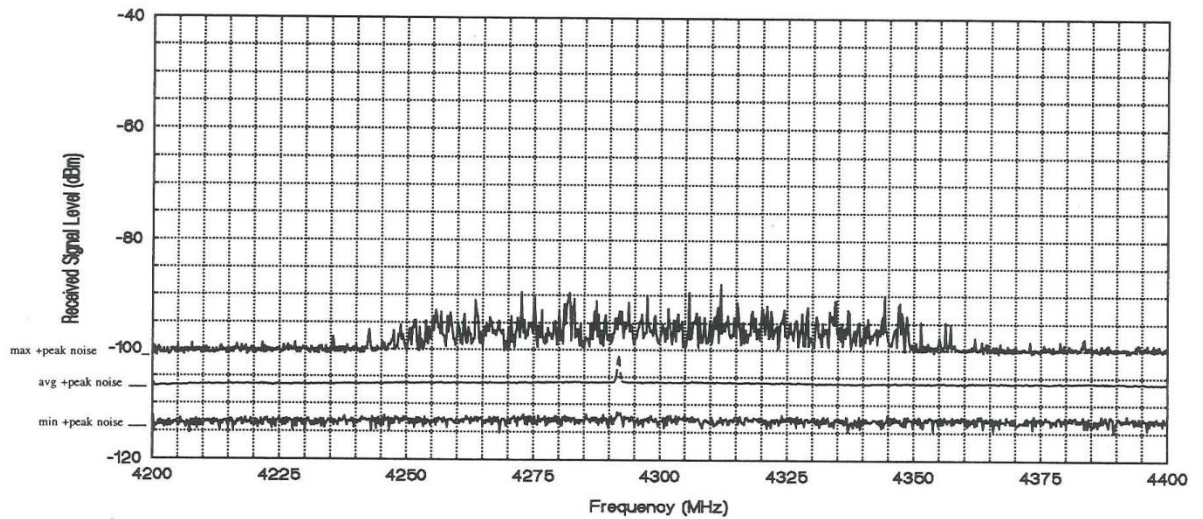
the band, new systems being developed to operate in the band, the measurement area, the measurement site, and the measurement system parameters. The three curves in each figure represent the maximum peak, mean peak, and minimum peak signal levels received at each frequency.

Measurements in the San Francisco area are shown in Figure 1, where there is observed evidence of radio altimeter signals between 4225 MHz and 4350 MHz.



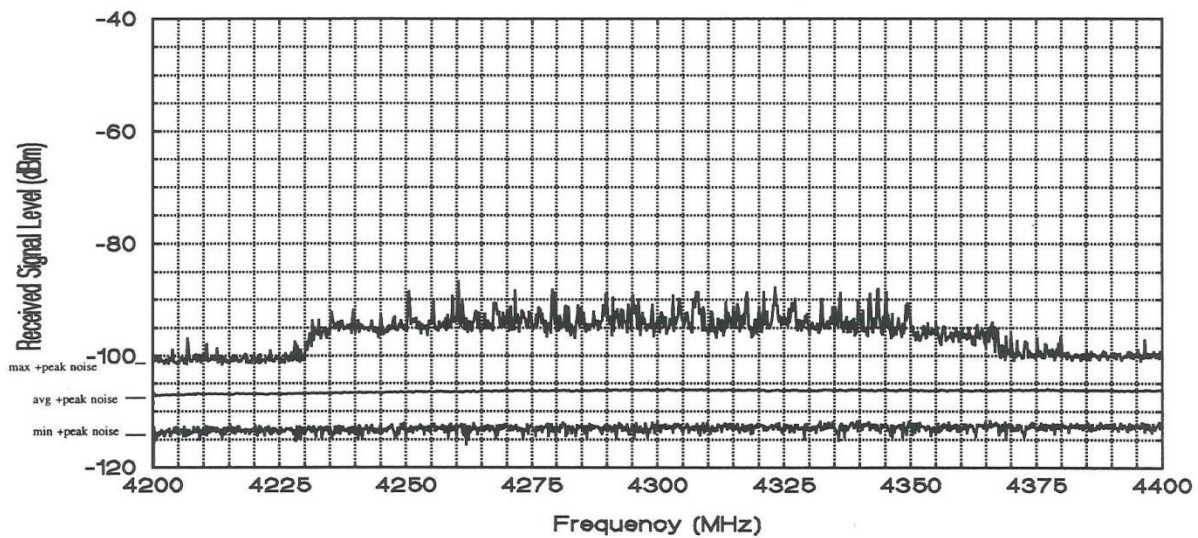
**Figure 1.** Spectrum Survey Graph in the 4200-4400 MHz Band in San Francisco, CA.

Measurements in the Los Angeles area are shown in Figure 2, where there is observed evidence of radio altimeter signals on frequencies between 4245 MHz and 4350 MHz.



**Figure 2.** Spectrum Survey Graph in the 4200-4400 MHz Band in Los Angeles, CA.

Measurements in the San Diego area are shown as Figure 3, where there is observed evidence of radio altimeter signals on frequencies between 4230 MHz and 4370 MHz.



**Figure 3.** Spectrum Survey Graph in the 4200-4400 MHz Band in San Diego, CA.

Although the measurement system used in the spectrum surveys was not designed to specifically detect signals from aircraft they show the received signal levels from radio altimeters are well contained within the band. In fact, the measured received signal levels range between 4225-4375 MHz which is consistent with the range of emission bandwidths for radio altimeters.

#### **4b. Standard Frequency and Time-Satellite (Space-to-Earth) Service**

The Federal Government does not operate any systems in the standard frequency and time-satellite (space-to-Earth) service.

#### **4c. Earth Exploration-Satellite (Passive) Service**

The Federal Government is not using the 4200-4400 MHz band for passive sensing operations at this time.



#### **4d. Space Research (Passive) Service**

The Federal Government is not using the 4200-4400 MHz band for space research (passive) operations at this time.

#### **5. Planned Use**

According to the Federal Aviation Administration and International Civil Aviation Organization radio altimeters will remain an essential element of the modernized air traffic control system.<sup>5</sup> The spectrum used by radio altimeters will be needed indefinitely.

There are no plans to operate any systems in the standard frequency and time-satellite (space-to-Earth) service.

There are no plans to perform Earth exploration-satellite (passive) or space research (passive) operations in this band.

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<sup>5</sup>. National Telecommunications and Information Administration, NTIA Special Publication 00-40, *Federal Radar Spectrum Requirements* (May 2000) at 42.