1660-1660.5 MHz

1. Band Introduction

The Federal agencies perform radio astronomy research observations of the hydroxyl radical spectral lines for research of stellar and expansion velocities, validation theories of the origins, and evolution of the universe in this shared band.

The National Aeronautics and Space Administration operates the Deep Space Network system 70-meter diameter antenna and associated receivers in Goldstone, CA.

The Federal agencies are end users of non-Federal mobile-satellite service (space-to-Earth) communications. Providers include the London-based International Maritime Satellite Organization (INMARSAT) commercial satellite system, and the U.S.-based SkyTerra system.

The Federal Aviation Administration has operations for aeronautical emergency communications via the INMARSAT commercial satellites in the Aeronautical Mobile-Satellite (Route) Service during en-route oceanic flights.

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

Federal Table	Non-Federal Table	FCC Rule Part(s)
1660-1660.5 MOBILE-SATELLITE (Earth-to-space) US308 US309 US380 RADIO ASTRONOMY 5.341 5.351 US342		Satellite Communications (25) Aviation (87)

2b. Additional Allocation Table Information

5.341 In the bands 1 400-1 727 MHz, 101-120 GHz and 197-220 GHz, passive research is being conducted by some countries in a programme for the search for intentional emissions of extraterrestrial origin.

5.351 The bands 1 525-1 544 MHz, 1 545-1 559 MHz, 1 626.5-1 645.5 MHz and 1 646.5- 1 660.5 MHz shall not be used for feeder links of any service. In exceptional circumstances, however, an earth station at a specified fixed point in any of the mobile-satellite services may be authorized by an administration to communicate via space stations using these bands.

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 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. [1]

Federal Frequency Assignment Table

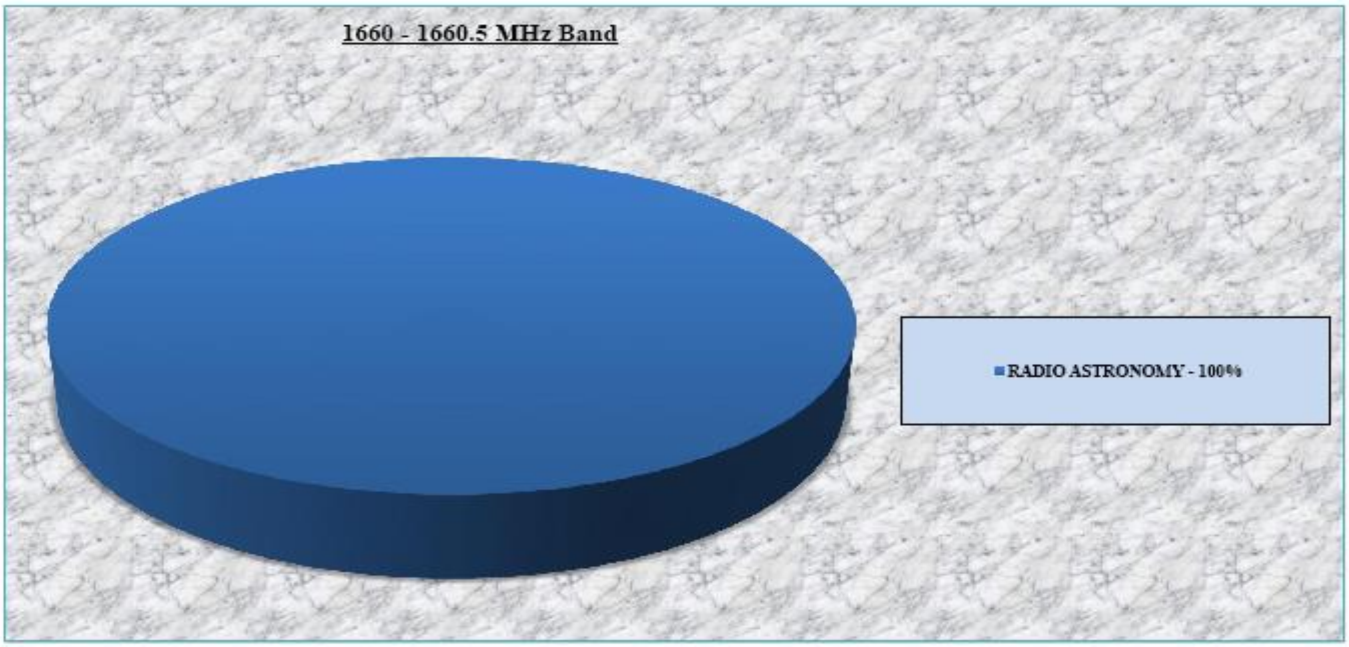
1660 - 1660.5 MHz Band				
SHARED BAND				
	MOBILE-SATELLITE (Earth-to-space)			
	RADIO ASTRONOMY			
	TYPE OF APPLICATION			
	RADIO ASTRONOMY			TOTAL
NASA	2			2
TOTAL	2			2
The number of actual systems, or number of equipments, may exceed and sometimes far exceed, the number of frequency assignments 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.				

[1] Passive use does not require an authorization. Therefore, assignment counts in passive bands may not represent the use very accurately.

3b. Percentage of Frequency Assignments Chart

1660 – 1660.5 MHz

The following chart displays the percentage of assignments for the applications listed in the chart legend below for frequency band 1660.0 – 1660.5 MHz. Currently the only service used in this band is radio astronomy. [1]



[1] Passive use does not require authorization. Therefore, assignment counts in passive bands may not represent the use very accurately.

4. Frequency Band Analysis By Application

4a. Radio Astronomy Service

Radio astronomy is defined as astronomy based on the reception of radio waves of cosmic origin.[1] 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.[2] 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.[3]

The 1660-1660.5 MHz band is part of the larger 1660-1670 MHz band that is used for both hydroxyl spectral line and continuum measurements. The hydroxyl spectral lines have been observed both in emission and absorption from several hundred different regions in our Galaxy. The study of these spectral lines provides insight into the initial stages of star formation that can be used in studies related to the origin and evolution of the universe. In the 1660-1660.5 MHz band, radio astronomy telescopes in the United States are combined with those in Europe to maximize the collecting area and the angular resolution that can be achieved for Very Long Baseline Interferometry measurements.

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[1]. NTIA Manual §6.1.1 at 6-12.

[2]. The preferred frequency bands for continuum and spectral line observations are specified in International Telecommunication Union-Radiocommunication Sector Recommendation RA.314-10.

[3]. 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.

The National Aeronautics and Space Administration operates the Deep Space Network (DSN) system 70-meter diameter antenna and associated receivers in Goldstone, CA for radio astronomy research observations of the hydroxyl radical spectral lines for research of stellar and expansion velocities, validation theories of the origins, and evolution of the universe.

Federal and university radio astronomy research activities are interrelated and complementary. A list of the radio astronomy facilities that perform observations in the 1660-1660.5 MHz band are provided in Table 1.

Table 1.

Facility	Latitude	Longitude
Arecibo, PR	18-20-38 N	66-45-09 W
Socorro, NM	34-04-43 N	107-37-04 W
Green Bank, WV	38-25-59 N	79-50-23 W
Pie Town, NM	34-18-00 N	108-07-00 W
Kitt Peak, AZ	31-57-00 N	111-37-00 W
Los Alamos, NM	35-47-00 N	106-15-00 W
Fort Davis, TX	30-38-00 N	103-57-00 W
North Liberty, IA	41-46-00 N	91-34-00 W
Brewster, WA	48-08-00 N	119-41-00 W
Owens Valley, CA	37-14-00 N	118-17-00 W
Saint Croix, VI	17-46-00 N	64-35-00 W
Mauna Kea, HI	19-49-00 N	155-28-00 W
Hancock, NH	42-56-00 N	71-59-00 W
NASA Deep Space Network, CA	35-25-33 N	116-53-23 W

Radio astronomers employ radio telescopes, highly sensitive receivers with large, high-gain antennas, to detect the weak signals from space. Because the desired signals are so weak and the receivers are so sensitive, radio telescopes are highly susceptible to interference.[4] A typical radio astronomy telescope receives only about one-trillionth of a watt even from the strongest cosmic source. Radio astronomers can only control the electromagnetic signal environment at the receiver and this creates a potential incompatibility with other spectrum users. Radio observatories are usually built in remote locations with surrounding terrain that provides natural shielding from interference sources. Nonetheless, effective spectrum management is critical to protect the radio telescopes from harmful interference. Sources of potential interference are spurious, harmonic, and adjacent band emissions from satellite and airborne transmitters, and aggregate interference from licensed and unlicensed ground-based transmitters.

[4]. The receivers used by radio astronomers can detect signals that are typically 60 dB below thermal noise, whereas the signal levels for normal radiocommunication systems are typically 20 dB above thermal noise.

Spectrum contours for the facilities shown in Table 1 can be computed based on the maximum permissible interference level necessary to protect radio astronomy service receivers. The maximum permissible interference level necessary to protect radio astronomy service and DSN receivers are specified in International Telecommunication Union recommendations.[5] The spectrum contour is computed using a 0 dBi gain for the radio astronomy receive antenna[6]; a maximum allowable equivalent isotropically radiated power level of 10 dBW/MHz for a ground-based transmitter;[7] and a terrain dependent propagation model.[8] The statistical and environmental parameters used with the terrain profile in calculating the propagation loss are shown in Table 2.

Table 2.

Parameter	**Value**
Refractivity	301 N-units
Conductivity	0.005 S/M
Permittivity	15
Humidity	10
Reliability	50 percent
Confidence	50 percent
Radio Climate	Continental Temperate
Antenna Polarization	Vertical
Transmit Antenna Height	3 meters
Receive Antenna Height	Extracted from Terrain Database

The radio astronomy facility latitude and longitude in Table 1 represents the center point for the contour.

The spectrum contours for the radio astronomy facilities performing observations in the 1660-1660.5 MHz band are shown in Figures 1 through 8.

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[5]. Recommendation ITU-R RA.769-1, *Protection Criteria Used For Radioastronomical Measurements* (1995); Recommendation ITU-R SA.1157, *Protection Criteria for Deep Space Research* (1995).

[6]. Recommendation ITU-R RA.1031-1, *Protection of the Radioastronomy Service in Frequency Bands Shared with Other Services*.

[7]. This equivalent isotropically radiated power level is consistent with levels permitted for mobile systems used in the Advanced Wireless Systems service, Personal Communications Service, and Cellular service.

[8]. The propagation loss for the spectrum contours are computed using the Irregular Terrain Model in the point-to-point mode and three second U.S. Geological Survey topographic data. A detailed description of the Irregular Terrain Model is available at http://flattop.its.bldrdoc.gov/itm.html.

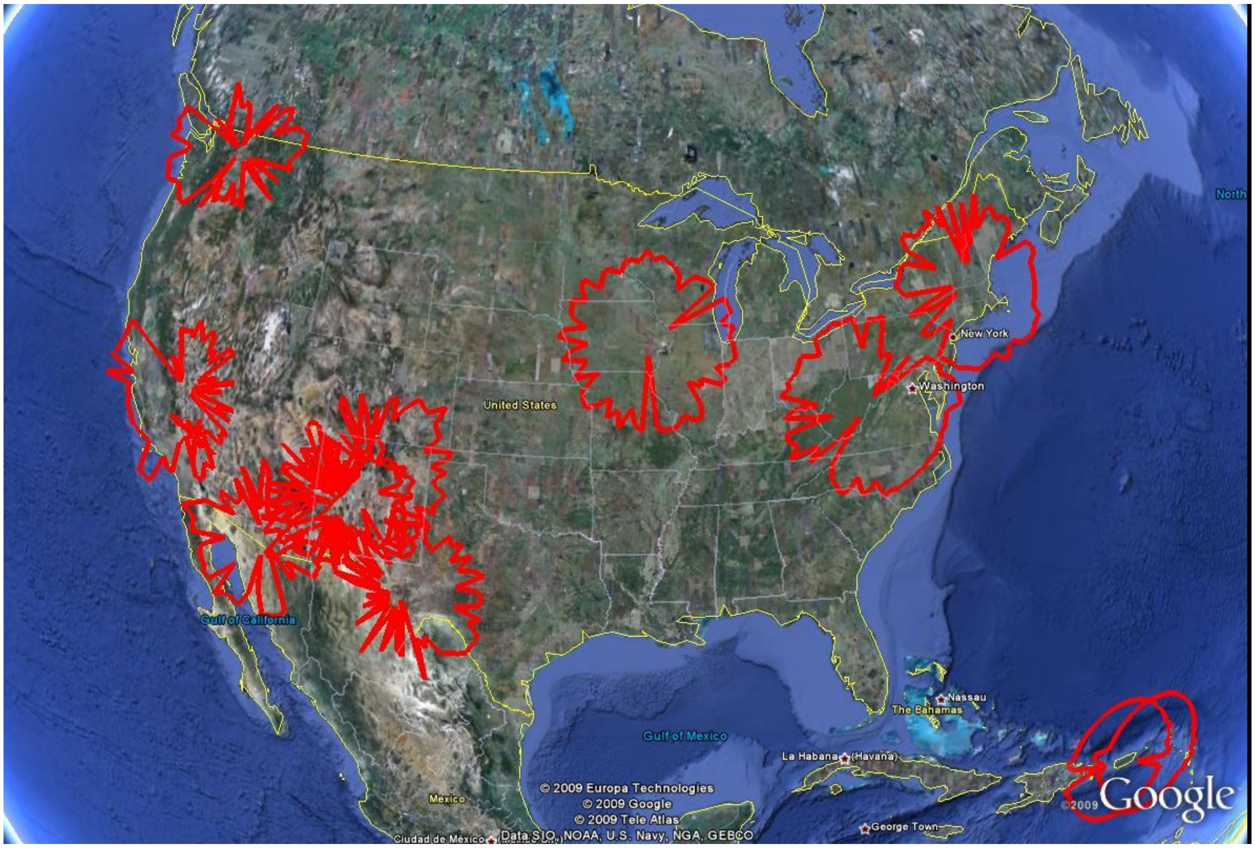

Figure 1.

1660-1660.5 MHz
Radio Astronomy Spectrum Contours

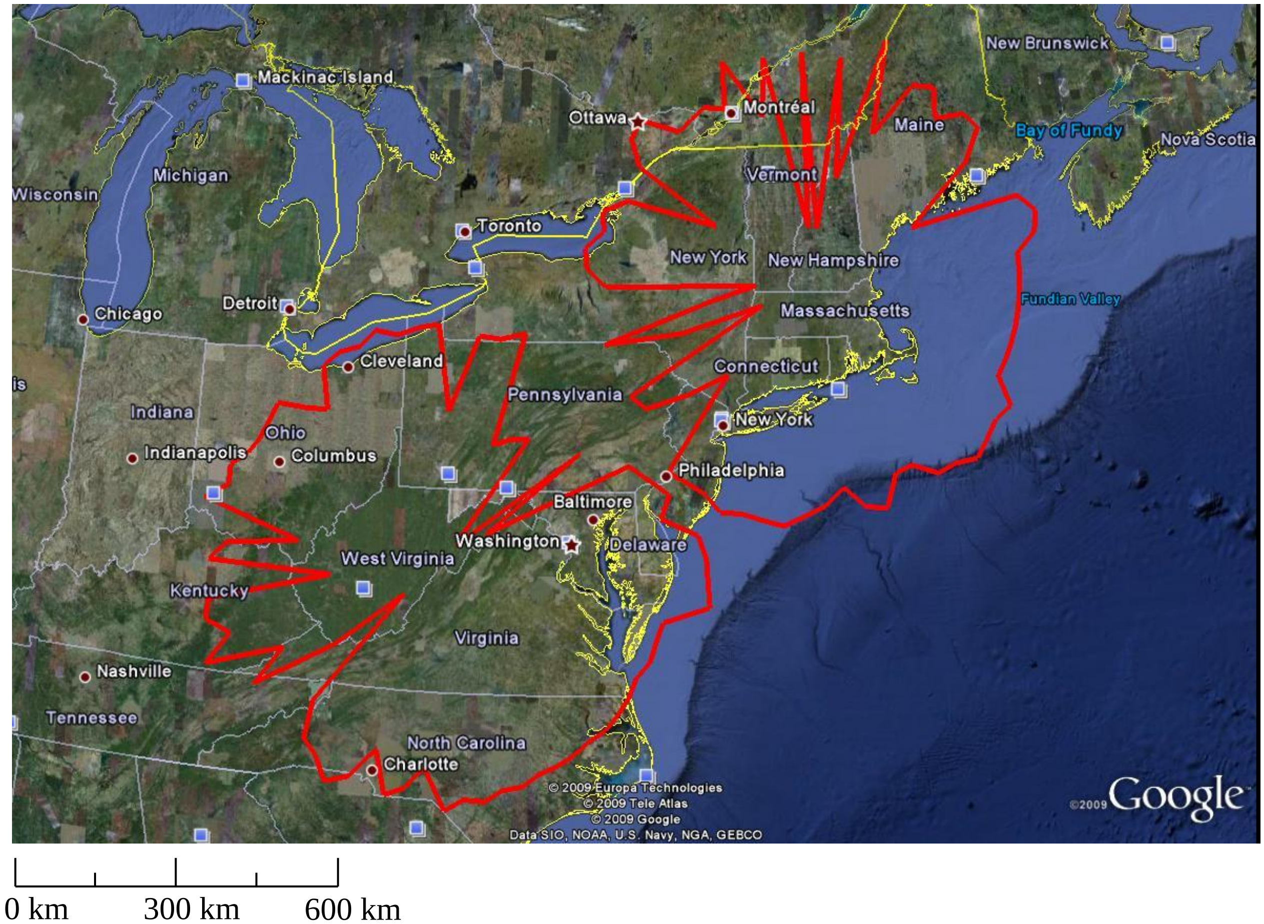

Figure 2.

Hancock, NH and Green Bank, WV
1660-1660.5 MHz
Radio Astronomy Spectrum Contours

Figure 3.

North Liberty, IA
1660-1660.5 MHz
Radio Astronomy Spectrum Contour

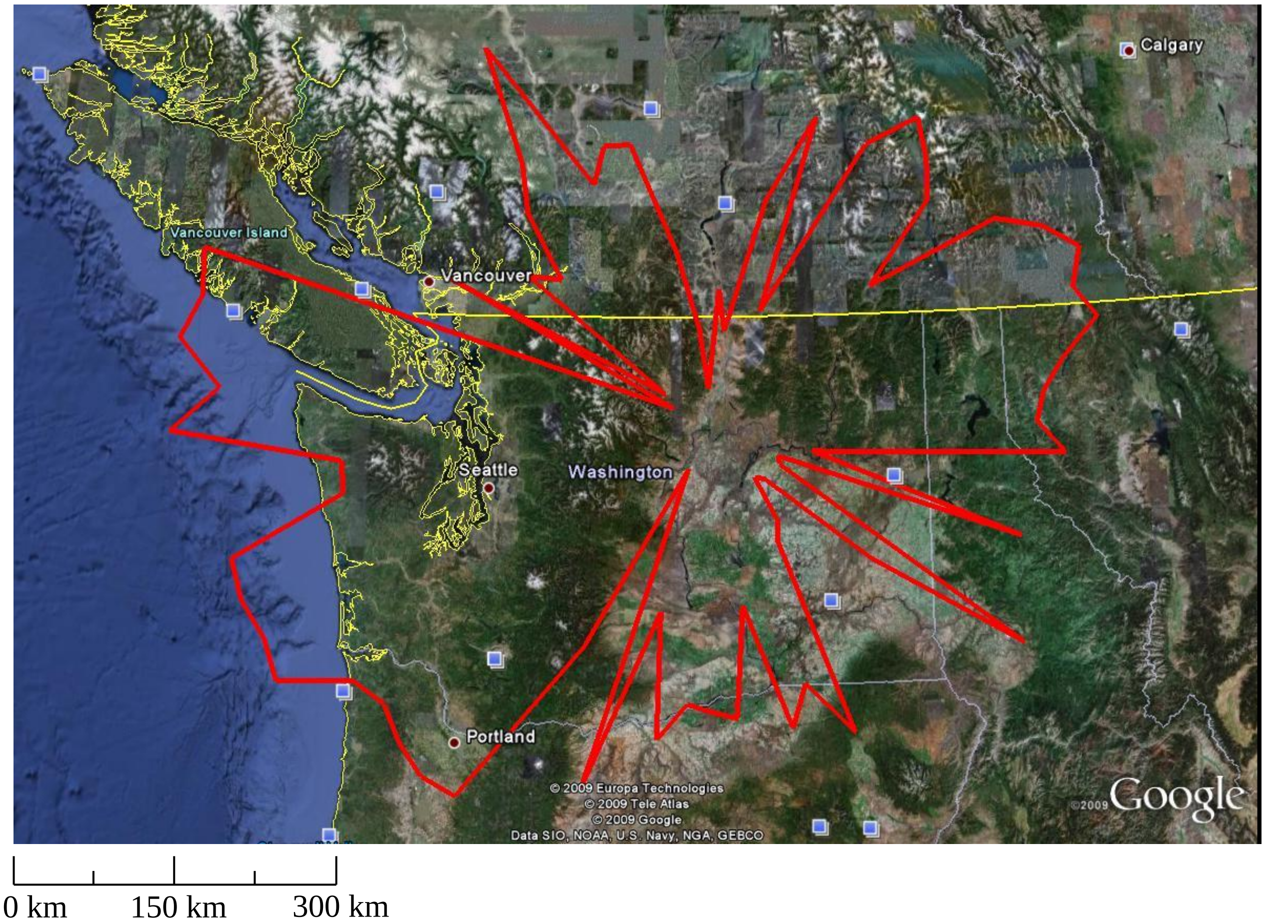

Figure 4.

Brewster, WA
1660-1660.5 MHz
Radio Astronomy Spectrum Contours

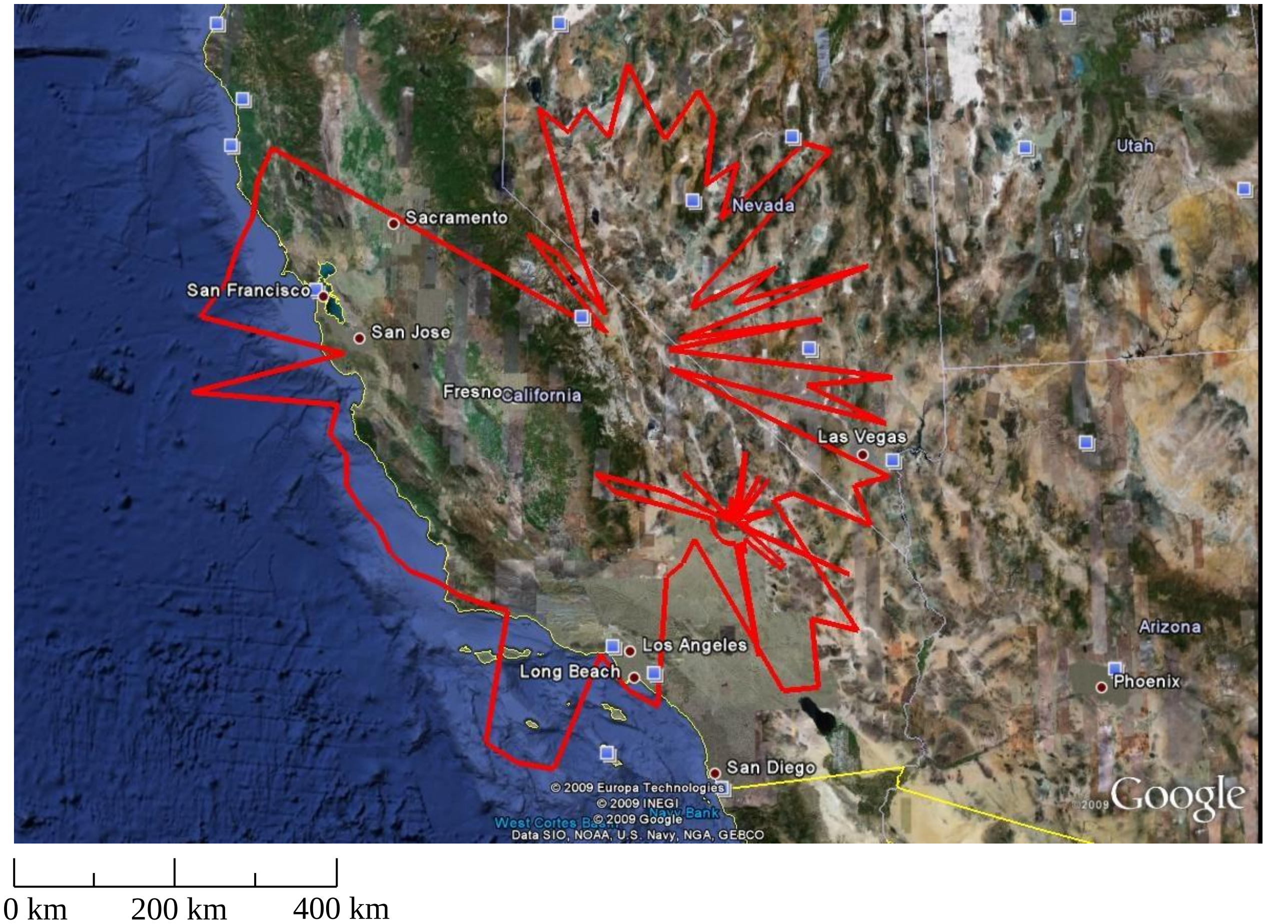

Figure 5.

Owens Valley, CA and NASA Deep Space Network, CA
1660-1660.5 MHz
Radio Astronomy Spectrum Contours

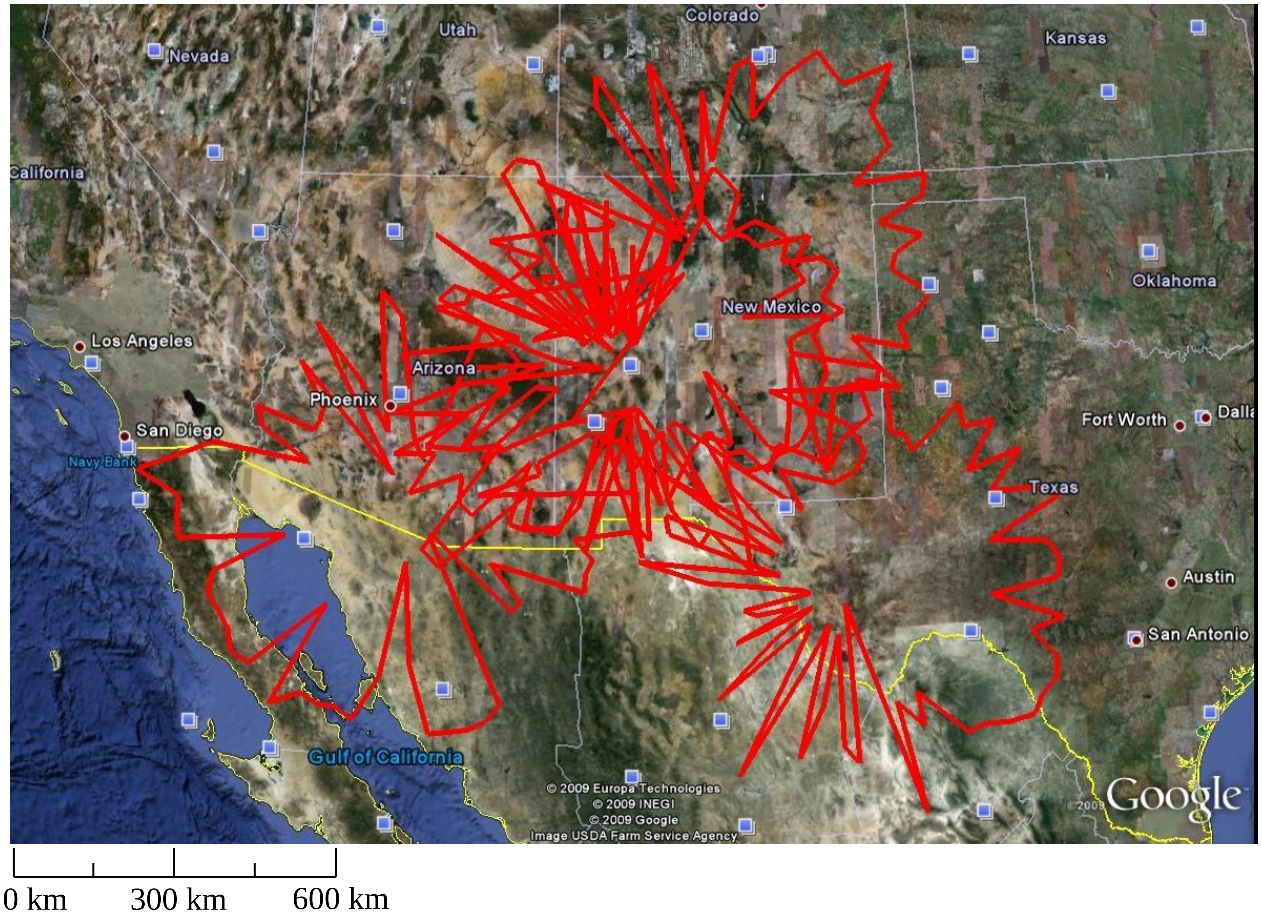

Figure 6.

Kitt Peak, AZ, Socorro, NM, Pie Town, NM, Los Alamos, NM, Fort Davis, TX
1660-1660.5 MHz
Radio Astronomy Spectrum Contours

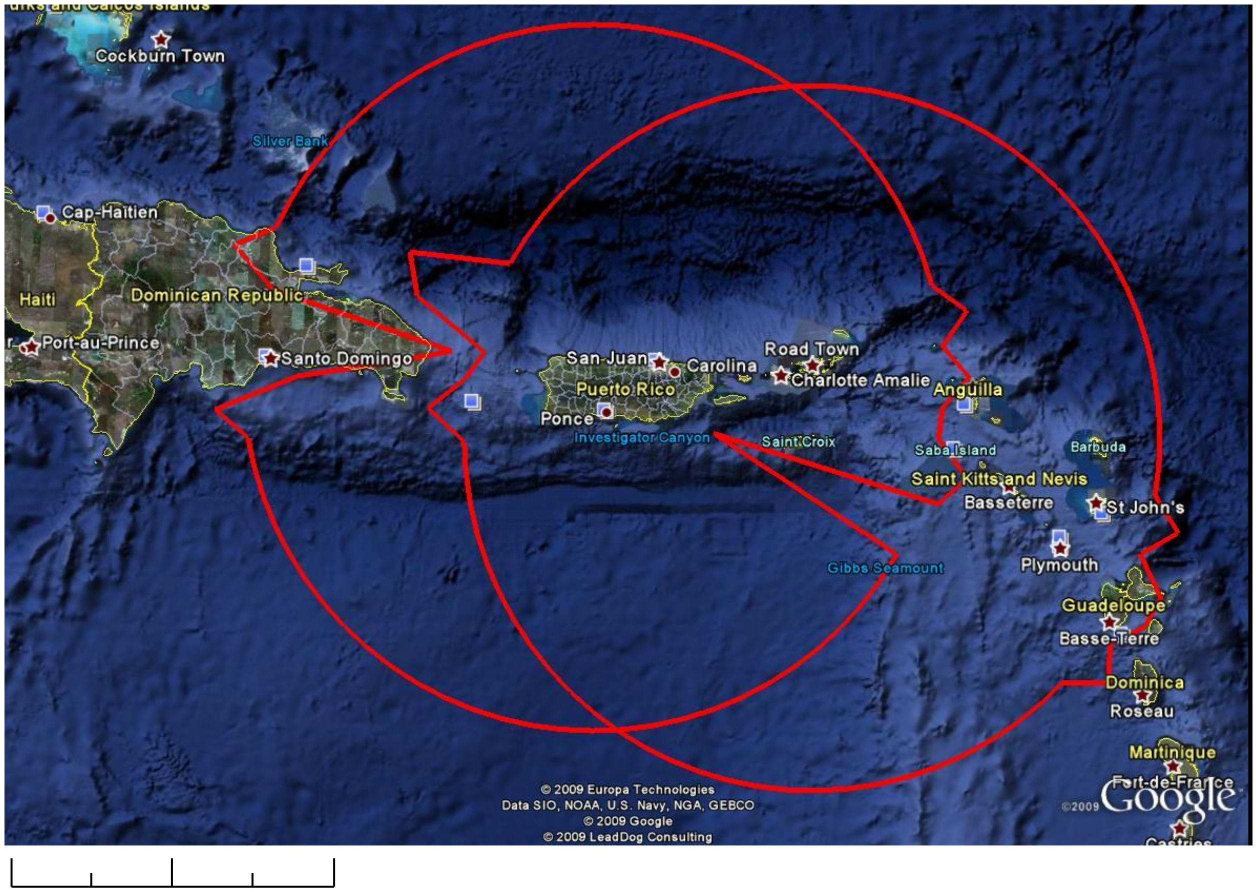

Figure 7.

Arecibo, PR and Saint Croix, VI
1660-1660.5 MHz
Radio Astronomy Spectrum Contours

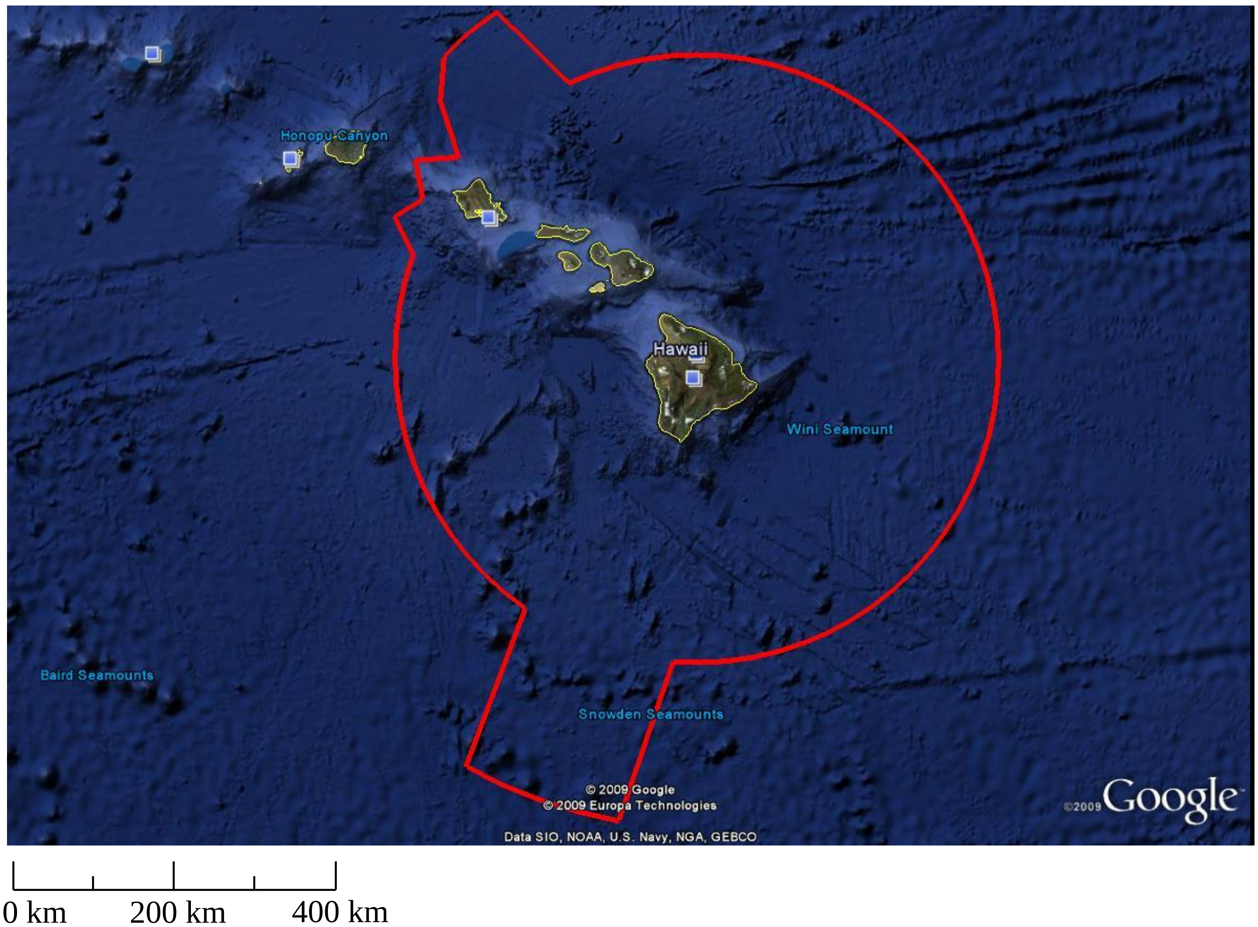

Figure 8.

Mauna Kea, HI
1660-1660.5 MHz
Radio Astronomy Spectrum Contour

1660 – 1660.5 MHz

4b. Mobile-Satellite (Earth-to-space) Service

The mobile-satellite service (MSS) is a radiocommunication service between mobile earth stations and one or more space stations or between space stations, or between mobile earth stations by means of one or more space stations.[9] MSS communication networks are ideal for international applications where rapidly deployable mobile communications is needed. Mobile-satellite communications to and from ships and aircraft can greatly aid their safe operation.[10] The use of ground-based mobile-satellite terminals in times of emergencies to establish immediate communications is now being recognized as necessary.

In the 1660-1660.5 MHz band, the Federal agencies are end users of the London-based International Maritime Satellite Organization (INMARSAT) and the U.S.-based SkyTerra commercial satellites providing mobile-satellite communications. Mobile earth stations operating in this band are used by Federal law enforcement agencies, Federal emergency management teams, the Department of Defense and the Department of Homeland Security. SkyTerra is also authorized to operate mobile earth stations using an Ancillary Terrestrial Component service supporting an integrated satellite and terrestrial communications network. The Federal Aviation Administration operates airborne mobile earth stations in this band for aeronautical safety related communications using the INMARSAT commercial satellites during en-route oceanic flights.

4c. Space Research (Passive) Service

The Federal Government is not using the 1660.5-1668.4 MHz band for space research (passive) operations at this time.

5. Planned Use

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

There are currently no plans to use this band for space research (passive) operations at this time.

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[9]. NTIA Manual §6.1 at 6-10.

[10]. Emissions from airborne MSS stations can be particularly serious sources of interference to the radio astronomy service (*see* ITU *Radio Regulations* at Nos. 4.5, 4.6, 5.376A and Article 29 and US342).