Radio Spectrum Allocations 101

1. Introduction

The radio spectrum is the range of frequencies used for wireless applications such as broadcast television and radio, cell phones, satellite radio and TV, wireless computer networks, Bluetooth, GPS, police dispatch, and countless other general and specialized applications that we use every day. For the most part, it's difficult for these applications to utilize the same frequencies at the same time. For example, if a local broadcast TV station used the same frequency as your cell phone, your cell phone wouldn't work very well due to interference from the TV station, or your TV picture would be fuzzy due to interference from your cell phone, or perhaps both.

To help avoid such conflicts, the radio spectrum is carved up into different portions, and each portion is allocated to one or more services that, generally speaking, may be able to co-exist with each other. In that sense, the allocation of the radio spectrum is similar to land use zoning: a particular area of a town or city may be zoned for industrial applications, and another area may be zoned for agricultural use, and yet another area may be zoned for residential use. Normally, homes are not built within industrial areas because industrial areas tend to be noisy and potentially more dangerous than most families or residents desire. The two applications – housing and industry – are generally incompatible so they are geographically separated by zoning.

The same concept applies in spectrum allocations where the "zoning" is by frequency rather than geography. Of course, the spectrum is not devoid of all potential conflicts despite the best planning. And even though a particular spectrum band is allocated to services that may be able to co-exist, coordination of frequency use among the allocated services (and even among users within the same service) is still usually required to mitigate interference.

The use of the radio spectrum is at an all-time high due to the explosion in demand for mobile voice, data, and entertainment. As a result, the demand for additions, modifications, and waivers to existing spectrum allocations is also growing. This document explains the basics of radio spectrum allocations. The discussion relies heavily on various laws and regulations, but I do not presume that the reader already has a detailed understanding of regulatory issues affecting radio spectrum allocations, or of the radio spectrum in general for that matter. By the end, however, the reader should have a good working knowledge of various aspects of both. This document predominantly covers radio spectrum allocation issues in the United States and includes discussion of international allocations only to the extent that they influence domestic policy.

2. Regulation of Radio Spectrum in the United States

In the United States, use of the radio spectrum is regulated by two separate entities. Federal government users of the radio spectrum are governed by the rules and regulations promulgated by the National Telecommunications and Information Administration (NTIA),

> "an agency in the U.S. Department of Commerce that serves as the executive branch agency principally responsible for advising the President on telecommunications and information policies. …In addition to representing the Executive Branch in both domestic and international telecommunications and information policy activities, NTIA also manages the Federal use of spectrum…"[1]

NTIA's rules are contained within its *Manual of Regulations & Procedures for Federal Radio Frequency Management*, commonly referred to as the "Redbook" or the "NTIA Manual."[2] Their Table of Frequency Allocations is contained in Section 4.1 of the *Manual*.

[1] http://www.ntia.doc/gov/about.html
[2] http://www.ntia.doc.gov/osmhome/redbook/redbook.html

All other users of the radio spectrum, including private citizens, businesses, and state and local governments, are regulated by rules promulgated by the FCC, an independent Federal government agency:

> "[t]he FCC was established by the Communications Act of 1934[3] and is charged with regulating interstate[4] and international communications by radio, television, wire, satellite, and cable. The FCC's jurisdiction covers the 50 states, the District of Columbia, and U.S. possessions."[5]

The FCC's rules are contained in Title 47 of the U.S. Code of Federal Regulations. The rules are divided into different parts governing general principles and procedures as well as rules governing the use of the spectrum by various categories of users or services. Most rules relevant to radio spectrum allocations are contained within Part 2 of Title 47, entitled "Frequency Allocations and Radio Treaty Matters; General Rules and Regulations." The Table of Frequency Allocations itself is in Section 106 of Part 2, which is usually referenced in the format 47 CFR 2.106. The CFR is updated once per year, with new editions of Title 47 issued in October and complete text of all rule parts usually available in electronic format by December. [6]

The separated regulation of Federal government radio spectrum users and everyone else is apparently unique to the United States, at least among first-world countries. It can contribute to some confusion over allocations, to the extent that the allocation tables published by the FCC and by the NTIA, both of which contain both Federal and non-Federal allocations, do not always agree. The lack of agreement can be due in part to the tables being published at slightly different times. As far as the FCC is concerned, the legal source document for spectrum allocations is the latest edition of the Table as published in the *Federal Register*, which is the U.S. government's "official daily publication for rules, proposed rules, and notices of Federal agencies and organizations…"[7] For convenience, the FCC itself provides an updated Table of Frequency Allocations online every few months[8], but notes that the *Federal Register* version remains the official Table of record.

On a worldwide basis, the International Telecommunication Union (ITU), a specialized agency of the United Nations, also publishes a table of frequency allocations that represents agreement among the 191 member-states of the ITU. The ITU divides the world into three regions (see figure 1), roughly corresponding to Europe/Africa (Region 1), the Americas (Region 2), and Asia/Pacific (Region 3). Allocations may differ somewhat among the different regions. The ITU table is part of the *Radio Regulations*,[9] which is an intergovernmental treaty written and revised by periodic World Radiocommunication Conferences. The U.S. Table of Frequency Allocations is similar to the ITU Region 2 allocation table, but to the extent that any non-compliance with the ITU table does not cause interference to other countries that abide by the ITU plan, each country is free to (and often does) modify the ITU table to suit its own needs.

[3] http://www.fcc.gov/Reports/1934new.pdf
[4] The Act was amended in 1982 to give the Commission authority to regulate intrastate communications
[5] http://www.fcc.gov/aboutus.html
[6] A convenient source for FCC rule parts is http://www.nsma.org/CFR.htm
[7] http://www.gpoaccess.gov/fr/
[8] http://www.fcc.gov/oet/spectrum/
[9] http://www.itu.int/pub/R-REG-RR-2008/en (approximately $275 to purchase)

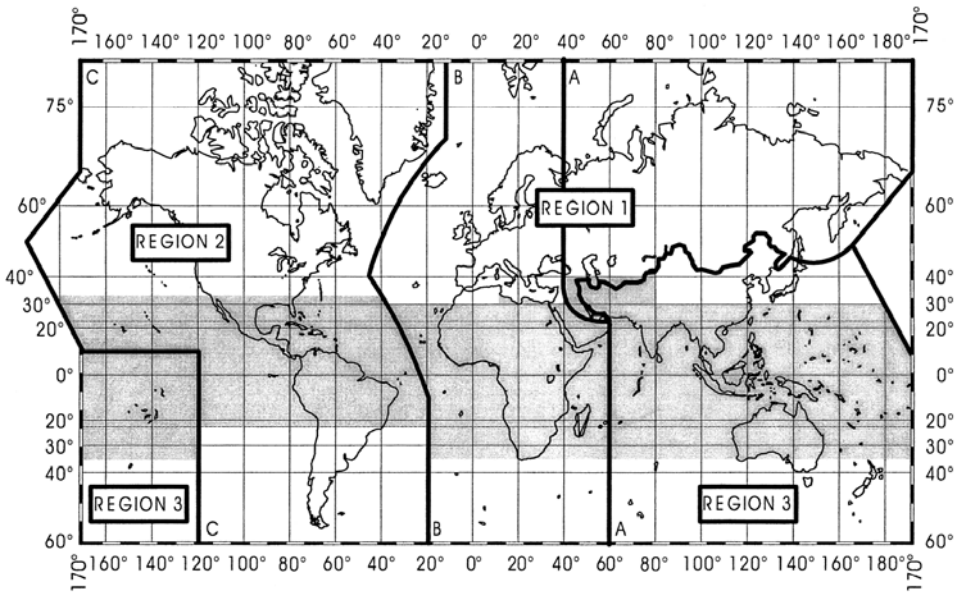


Figure 1: Map identifying Region 1, Region 2, and Region 3, as defined in paragraph 2.104(b), and the Tropical Zone (shaded area), as defined in paragraph 2.104(c)(4).

3. The Radio Spectrum: Definition, Allocated Range, and Band Designators

3.1. Definition of Radio Waves and Range of Allocated Frequencies (9 kHz – 275 GHz)

The FCC, NTIA, and ITU use the following definition of radio:

> *Radio.* A general term applied to the use of radio waves.[10]

Radio waves are subsequently defined:

> *Radio Waves or Hertzian Waves.* Electromagnetic waves of frequencies arbitrarily lower than 3,000 GHz, propagated in space without artificial guide.[11]

According to the FCC, NTIA, and ITU, the radio spectrum therefore encompasses all frequencies below 3,000 GHz, which is an extraordinarily high radio frequency. It easily encompasses all but the most specialized current radio spectrum applications, and all potential (non-specialized) applications for the foreseeable future. Recognizing that normal radio applications have not pushed anywhere near this limit in frequency, the U.S. and ITU tables of frequency allocations presently extend only to 275 GHz. Even at this frequency, uses are generally limited to highly specialized scientific and engineering applications.

Almost all common wireless applications presently utilize spectrum below 100 GHz. The vast majority of applications are at frequencies below 30 GHz. The following table summarizes the approximate frequency bands or range of frequencies used in the U.S. by a few of the most common wireless technologies:

[10] 47 CFR 2.1

[11] Ibid

Application	Frequency or Frequency Range *(~ denotes non-contiguous or approximate)*
AM broadcast	530 kHz – 1.7 MHz
Broadcast television	54 ~ 88, 174 – 216, 470 ~ 698 MHz
FM broadcast	88 – 108 MHz
Cell phones	~750, ~850, ~1700, ~1950, ~2100 MHz
GPS (non-military)	~1.5 GHz
Satellite radio	~2.3 GHz
Wireless computer networks	~2.4 & ~5.8 GHz
Satellite TV	~12 GHz
Fixed point-to-point links	~1 ~ 90 GHz

At the low end of the frequency range, the current allocation tables extend down to 9 kHz. Transmissions near and below this frequency have enormously long wavelengths (near or longer than 33 km), meaning that efficient antennas would have to be physically enormous. Also, very little bandwidth is available at these frequencies. As a result, there is not much interest at frequencies below 9 kHz (or even frequencies near 9 kHz) except for specialized military and scientific systems.

3.2. Band Designators

The allocated radio spectrum has been divided into decades of frequency range, and each decade has its own designation. These ranges are listed below:[12]

Frequency Range	Designation	Abbreviation
3 – 30 kHz	Very Low Frequency	VLF
30 – 300 kHz	Low Frequency	LF
300 – 3,000 kHz	Medium Frequency	MF
3 – 30 MHz	High Frequency	HF
30 – 300 MHz	Very High Frequency	VHF
300 – 3,000 MHz	Ultra High Frequency	UHF
3 – 30 GHz	Super High Frequency	SHF
30 – 300 GHz	Extremely High Frequency	EHF

Within the allocation table, frequencies are supposed to be written in the following units: kHz up to 3,000 kHz; MHz between 3 – 3,000 MHz; and GHz between 3 – 3,000 GHz.[13]

An additional set of frequency band designations is commonly encountered. These letter designations trace their origin to the development of radar systems during World War II, with additional designations added since then. However, there are differing definitions of the band designations, and the designations may even refer to different ranges in different sections of the FCC and NTIA rules, so their use is generally discouraged. Despite the potential for confusion, letter band designations are still commonly encountered, even in modern FCC and NTIA

[12] 47 CFR 2.101(b). Although not officially defined, the following designators are sometimes encountered, and are a natural extension to the list: 300 – 3000 Hz, Ultra Low Frequency (ULF); 30 – 300 Hz, Super Low Frequency (SLF); and 3 – 30 Hz, Extremely Low Frequency (ELF).

[13] 47 CFR 2.101(a)

documents. The following table summarizes the letter band designations as defined by the IEEE:[14]

IEEE Designator	**Range**
L-band	1 – 2 GHz
S-band	2 – 4 GHz
C-band	4 – 8 GHz
X-band	8 – 12 GHz
K_u-band	12 – 18 GHz
K-band	18 – 27 GHz
K_a-band	27 – 40 GHz
V-band	40 – 75 GHz
W-band	75 – 110 GHz

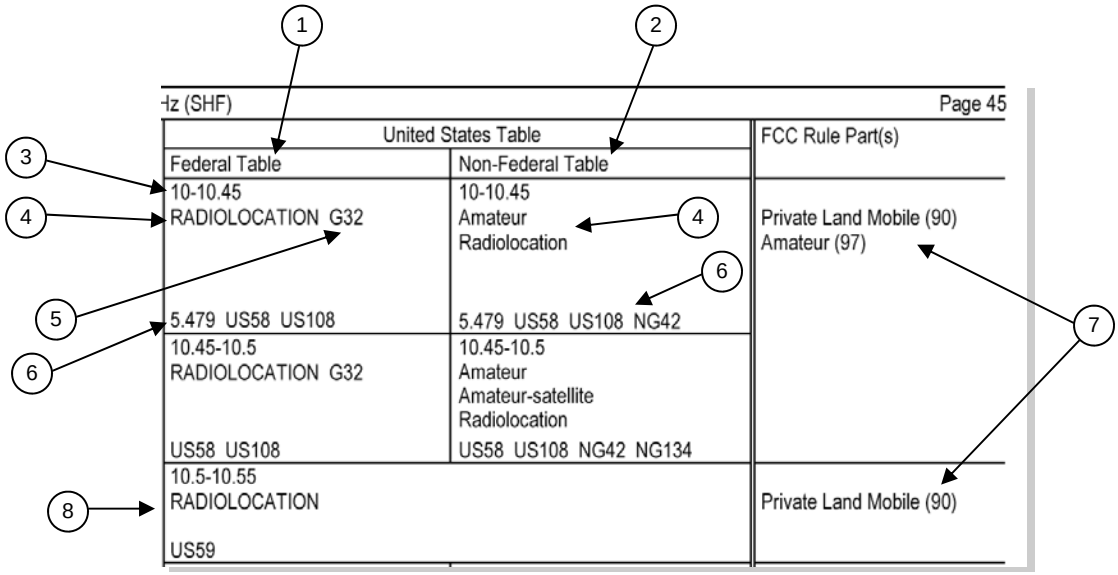
3.3. Sound Waves are not Radio Waves

A common misrepresentation is often encountered in lists of radio frequency bands. A range of frequencies of about 300 Hz – 20 KHz is often included in lists of frequency bands, with the designation "sound frequencies" or "audio frequencies." While this range is in fact an approximate representation of frequencies that humans perceive as sound, sound is a pressure wave that travels in a material substance (gas, liquid, or solid), and is completely unrelated to the electromagnetic waves that constitute radio signals. Sound waves should not be confused with electromagnetic waves and should not be included in a list of radio frequency bands.

[14] IEEE Standard 521-2002, http://www.ieee.org (search the site for "521-2002"), $85 download.

4. Allocation Table Example

Allocation tables are usually designed with one or more columns containing one or more cells of data. Each column corresponds to a particular table (for example, the U.S. Federal government table or the ITU Region 2 table), and each cell corresponds to a particular frequency range within the table (for example, 10 – 10.45 GHz). In the United States, the tables published by the FCC and NTIA each contain not only the FCC and NTIA allocations, but also the allocations for ITU Regions 1, 2, and 3. The following figure is an example entry from the U.S. Table of Frequency Allocations. The left side of the page, which contains the ITU allocations, has been cropped out.



The various components of the table are:

(1) This column contains the allocations made by NTIA to Federal government users of the radio spectrum.

(2) This column contains the allocations made by the FCC that apply to everyone except Federal government users.

(3) The frequency range covered by this cell of the allocation table. In this case, it is 10 – 10.45 GHz. A title at the top of the page, which is partially cropped in this figure, clarifies that the page deals with frequencies in the GHz range, in the Super High Frequency (SHF) band.

(4) The service to which the frequency range is allocated. In this case, the range 10 – 10.45 GHz is allocated to Federal government users in the radiolocation service, and to amateur and radiolocation services for non-Federal users. Services are explained in detail in section 5. If the service name is in all capital letters (such as the "RADIOLOCATION" allocation in the Federal column), then the allocation is primary. If only the first letter of the service name is capitalized (for example "Amateur" and "Radiolocation" allocations in the non-Federal column), then the allocation is on a secondary basis. Primary and secondary allocations are discussed in section 6.

(5) "G32" refers to a footnote to the allocation table. Since it appears directly next to the radiolocation allocation, this footnote applies only to that service, not to all services in the

band. See section 7 for more discussion on footnotes, which are an important component of the allocation table. Footnotes may place significant restrictions on specific services.

(6) At the bottom of the cell are references to footnotes that apply to the entire cell. As discussed in section 7, these footnotes may, among other things, provide for additional allocations that are not shown explicitly in the table cell.

(7) Entries in this column refer to FCC rule parts that apply to non-Federal allocated services. In this example, FCC Part 90 (Private Land Mobile) and Part 97 (Amateur) rules apply to the range 10 – 10.5 GHz. Part 90 also applies to 10.5 – 10.55 GHz.

(8) When the allocations and footnotes are identical for both Federal and non-Federal users, the table cells are joined. However, the specified FCC rule parts, if any, apply only to non-Federal users. Federal users are always governed by the NTIA *Manual*.

5. Allocated Radio Services – Definitions & Examples

Within the U.S. Table of Frequency Allocations proper, spectrum use is broken down into 29 different allocated services for non-Federal applications, and 26 different services for Federal uses. The services are listed in the following table, and their definitions[15] are in the following sections, along with one or more examples of systems operating in each service.[16]

Aeronautical mobile	Fixed-satellite	Radiodetermination-satellite
Aeronautical mobile off-route (OR)	Inter-satellite	Radiolocation
Aeronautical mobile route (R)	Land mobile	Radiolocation-satellite
Aeronautical radionavigation	Maritime mobile	Radionavigation
Amateur*	Maritime radionavigation	Radionavigation-satellite
Amateur-satellite*	Meteorological aids	Space operation
Broadcasting	Meteorological-satellite	Space research
Broadcasting-satellite*	Mobile	Standard frequency and time signal
Earth exploration-satellite	Mobile-satellite	Standard frequency and time signal-satellite
Fixed	Radio astronomy	** Non-Federal Table only*

There are 12 additional services that are defined by the FCC and NTIA, but do not appear in the tables proper (either national or international). These services appear only in footnotes to the Tables, or no longer appear at all:

Aeronautical Mobile-Satellite Off-Route#	Maritime Mobile-Satellite*	Ship Movement#
Aeronautical Mobile-Satellite Route*	Maritime Radionavigation-Satellite#	Special#
Aeronautical Mobile-Satellite*	Non-Voice, Non-Geostationary Mobile-Satellite**	** Appears in footnotes only* *** Appears in U.S. footnotes only* *# Defined, but does not appear anywhere in the Table or footnotes*
Aeronautical Radionavigation-Satellite*	Port Operations**	
Land Mobile-Satellite*	Radiodetermination*	

To further complicate matters, there are "services" that are defined or used in FCC rule parts other than Part 2, but that are not otherwise used in the context of allocations. Some examples include the Personal Communications Service, Specialized Mobile Radio Service, Enhanced Specialized Mobile Radio Service, Special Industrial Radio Service, Manufacturers Radio

[15] Definitions from 47 CFR 2.1 and the NTIA *Manual*

[16] Service examples are not intended to be complete. In most cases, the examples represent an infinitesimal fraction of actual spectrum use by each service.

Service, Railroad Radio Service, Forest Products Service, Experimental Radio Service, Commercial Mobile Radio Service, International Fixed Public Radiocommunication Services, Wireless Communications Service, Cable Television Relay Service, Private Land Mobile Radio Services, Personal Radio Services, and several others. In this document, these services are considered applications of allocated services, not allocated services themselves, since they do not appear in the Tables.

5.1. Aeronautical Fixed Service

Aeronautical Fixed Service: A radiocommunication service between specified fixed points provided primarily for the safety of air navigation and for the regular, efficient and economical operation of air transport.

5.2. Aeronautical Mobile Service

Aeronautical Mobile Service: A mobile service between aeronautical stations and aircraft stations, or between aircraft stations, in which survival craft stations may participate; emergency position-indicating radiobeacon stations may also participate in this service on designated distress and emergency frequencies.

Examples of the aeronautical mobile service include voice communications between airline pilots and stations on the ground such as control towers and aviation services companies, or between airline pilots, (typically in the 118 – 136 MHz band); and commercial air-to-ground telephone service (849 – 851 & 894 – 896 MHz band), such as the defunct Verizon Airfone service.

5.3. Aeronautical Mobile Off-Route (OR) Service

Aeronautical Mobile (OR) Service: An aeronautical mobile service intended for communications, including those relating to flight coordination, primarily outside national or international civil air routes.

5.4. Aeronautical Mobile Route (R) Service

Aeronautical Mobile (R) Service: An aeronautical mobile service reserved for communications relating to safety and regularity of flight, primarily along national or international civil air routes.

5.5. Aeronautical Mobile-Satellite Service

Aeronautical Mobile-Satellite Service: A mobile-satellite service in which mobile earth stations are located on board aircraft; survival craft stations and emergency position-indicating radiobeacon stations may also participate in this service.

5.6. Aeronautical Mobile-Satellite Off-Route (OR) Service

Aeronautical Mobile-Satellite (OR) Service: An aeronautical mobile-satellite service intended for communications, including those relating to flight coordination, primarily outside national and international civil air routes.

5.7. Aeronautical Mobile-Satellite Route (R) Service

Aeronautical Mobile-Satellite (R) Service: An aeronautical mobile-satellite service reserved for communications relating to safety and regularity of flight, primarily along national or international civil air routes.

5.8. Aeronautical Radionavigation Service

Aeronautical Radionavigation Service: A radionavigation service intended for the benefit and for the safe operation of aircraft.

Examples of the aeronautical radionavigation service include the instrument landing system (ILS), consisting of a glide slope indicator (typically in the 328.6 – 335.4 MHz band) and a localizer (typically in the 108 – 112 MHz range); marker beacons (74.8 – 75.2 MHz); and distance measuring equipment (DME) (960 – 1215 MHz).

5.9. Aeronautical Radionavigation-Satellite Service

Aeronautical Radionavigation-Satellite Service: A radionavigation-satellite service in which earth stations are located on board aircraft.

5.10. Amateur Service

Amateur Service: A radiocommunication service for the purpose of self-training, intercommunication and technical investigation carried out by amateurs, that is, by duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest.

Examples of amateur service applications include FM voice communications by simplex and repeater links in the 144 – 148 MHz band; single sideband and Morse code communications in various shortwave bands (3500 – 4000 kHz, for example); and digital communications in the 219 – 220 MHz band. The amateur service is only allocated for non-Federal-government use.

5.11. Amateur-Satellite Service

Amateur-Satellite Service: A radiocommunication service using space stations on earth satellites for the same purposes as those of the amateur service.

Examples of the amateur-satellite service include communications through "Orbiting Satellites Carrying Amateur Radio" (OSCAR) satellites and stations aboard other satellites (various bands including 144 – 146, 435 – 438, and 2400 - 2450 MHz); and communications with astronauts aboard the International Space Station (145.8 MHz). The amateur-satellite service is only allocated for non-Federal-government use.

5.12. Broadcasting Service

Broadcasting Service: A radiocommunication service in which the transmissions are intended for direct reception by the general public. This service may include sound transmissions, television transmissions or other types of transmissions.

Examples of the broadcasting service include the AM and FM broadcast bands at 530 – 1700 kHz and 88 – 108 MHz, respectively; and television broadcasting in the 54 – 72, 76 – 88, 174 – 216, 470 – 608, and 614 – 698 MHz bands.

5.13. Broadcasting-Satellite Service

Broadcasting-Satellite Service: A radiocommunication service in which signals transmitted or retransmitted by space stations are intended for direct reception by the general public. In the broadcasting-satellite service, the term "direct reception" shall encompass both individual reception and community reception.

Examples of the broadcasting-satellite service include SIRIUS and XM satellite radio in the 2310 – 2360 MHz band; and DIRECTV satellite television, which uses the 12.2 – 12.7 GHz band, among others. The broadcasting-satellite service is only allocated for non-Federal-government use.

5.14. Earth Exploration-Satellite Service

Earth Exploration-Satellite Service: A radiocommunication service between earth stations and one or more space stations, which may include links between space stations, in which:

• information relating to the characteristics of the Earth and its natural phenomena including data relating to the state of the environment is obtained from active sensors or passive sensors on earth satellites; similar information is collected from active sensors or passive sensors on Earth satellites:

• airborne or earth-based platforms; such information may be distributed to earth stations within the system concerned; platform interrogation may be included. This service may also include feeder links necessary for its operation.

Some examples of the earth exploration-satellite service include the use of active and passive sensors aboard environmental satellites such as LANDSAT, and on satellites in the National Polar-orbiting Operational Environmental Satellite System (NPOESS), which is under construction.

5.15. Fixed Service

Fixed Service: A radiocommunication service between specified fixed points.

Examples of the fixed service are the ubiquitous microwave dishes on radio towers, which are capable of transporting large amounts of data along a fixed route. Such data paths are used, for example, to aggregate and transport cellular phone traffic from a cell tower to a central switching facility. The band 5925 – 6425 MHz is often used for this purpose, among many other bands.

5.16. Fixed-Satellite Service

Fixed-Satellite Service: A radiocommunication service between earth stations at given positions when one or more satellites are used; the given position may be a specified fixed point or any fixed point within specified areas; in some cases this service includes satellite-to-satellite links, which may also be operated in the inter-satellite service, the fixed-satellite service may also include feeder links for other space radiocommunication services.

The fixed-satellite service generally encompasses communications between fixed points on the Earth by way of a satellite or satellites, and the uploading or downloading of large volumes of data to or from a satellite, from or to a fixed point on the Earth. It does not imply that the satellites themselves are “fixed” in geostationary orbit, for example, although they can be. An example of the fixed-satellite service is the ubiquitous Very Small Aperture Terminal (VSAT) satellite dishes on top of gas stations and convenience stores that are used to transmit data for credit card validations. Such terminals often transmit in the 14 – 14.5 GHz band and receive in the 11.7 – 12.2 GHz band.

5.17. General Purpose Mobile Service

General Purpose Mobile Service: A mobile service that includes all mobile communications uses including those within the Aeronautical Mobile, Land Mobile, or the Maritime Mobile Services.

5.18. Inter-Satellite Service

Inter-Satellite Service: A radiocommunication service providing links between artificial earth satellites.

Inter-satellite service allocations are often made in bands in which the water and oxygen molecules in the Earth’s atmosphere strongly absorb radio waves. With no such absorption in

space, and isolation between Earth- and space-based signals due to the atmosphere, such bands are ideally suited for inter-satellite communications. The inter-satellite service enables communications between satellites, which in turn may enable relaying of information between points on the ground using fewer ground-to-space-to-ground hops. Frequency bands allocated to the inter-satellite service include various bands near the 23 GHz absorption peak, among others.

5.19. Land Mobile Service

> **Land Mobile Service:** A mobile service between base stations and land mobile stations, or between land mobile stations.

Land mobile allocations are heavily used for dispatch operations, mobile telephone communications, paging, and a large variety of other applications. Examples of land mobile communications include public safety and specialized mobile radio communication systems operating in the 806 – 821 & 854 – 869 MHz bands; cellular telephone systems in the 824 – 849 & 869 – 894 MHz range; paging systems in a variety of bands near 150 MHz, and a multitude of public safety and commercial dispatch operations in the 450 – 460 MHz band.

5.20. Land Mobile-Satellite Sevice

> **Land Mobile-Satellite Service:** A mobile-satellite service in which mobile earth stations are located on land.

5.21. Maritime Mobile Service

> **Maritime Mobile Service:** A mobile service between coast stations and ship stations, or between ship stations, or between associated on-board communication stations; survival craft stations and emergency position-indicating radiobeacon stations may also participate in this service.

Examples of the maritime mobile service include communications between fishing boat operators using various MF and HF bands; and a set of VHF FM frequencies in the 156 – 157 MHz range, including the universal distress and calling frequency (“channel 16”) at 156.8 MHz.

5.22. Maritime Mobile-Satellite Service

> **Maritime Mobile-Satellite Service:** A mobile-satellite service in which mobile earth stations are located on board ships; survival craft stations and emergency position-indicating radiobeacon stations may also participate in this service.

5.23. Maritime Radionavigation Service

> **Maritime Radionavigation Service:** A radionavigation service intended for the benefit and for the safe operation of ships.

Examples of the maritime radionavigation service include ship- and coast-based maritime radars operating in the 2900 – 3100, 5470 – 5570, 5570 – 5650, and 9200 – 9300 MHz bands; and LF navigational beacons operating in the 275 – 335 kHz range.

5.24. Maritime Radionavigation-Satellite Service

> **Maritime Radionavigation-Satellite Service:** A radionavigation-satellite service in which earth stations are located on board ships.

5.25. Meteorological Aids Service

> **Meteorological Aids Service:** A radiocommunication service used for meteorological, including hydrological, observations and exploration.

Most meteorological aids systems are used to produce upper atmosphere measurements. Radiosondes operating under the meteorological aids service are lifted aloft by balloons, sense atmospheric weather conditions such as pressure and temperature, and relay those data back to receiving stations on the ground (or, in the case of hurricane tracking, in airplanes). Many radiosondes operate in the 1668.4 – 1670 MHz band, and are launched as often as twice daily from some locations. Other meteorological aids systems may be installed on ocean buoys, or may be located at fixed ground-based sites to receive data from airborne and ocean-based sensors.

5.26. Meteorological-Satellite Service

Meteorological-Satellite Service: An Earth exploration-satellite service for meteorological purposes.

Meteorological-satellite service bands are used to transfer data to and from orbiting weather satellites ("metsats"). An example is the use of 7850 MHz for the National Polar Orbiting Environmental Satellite System (NPOESS) high data rate direct broadcast downlink.

5.27. Mobile Service

Mobile Service: A radiocommunication service between mobile and land stations, or between mobile stations.

Mobile services are often further qualified in the allocation tables, such as "Mobile except aeronautical mobile," and specific mobile services are often given their own service designation, such as the land mobile service. An example of the mobile service proper is pager operations in the 940 – 941 MHz band.

5.28. Mobile-Satellite Service

Mobile-Satellite Service: A radiocommunication service:

- between mobile earth stations and one or more space stations, or between space stations used by this service; or
- between mobile earth stations by means of one or more space stations.

This service may also include feeder links necessary for its operation.

An example of the mobile-satellite service is the Iridium system, which operates within the 1613.8 – 1626.5 MHz mobile-satellite allocation.

5.29. Non-Voice, Non-Geostationary Mobile-Satellite Service

Non-Voice, Non-Geostationary Mobile-Satellite Service: A mobile-satellite service reserved for use by non-geostationary satellites in the provision of non-voice communications which may include satellite links between land earth stations at fixed locations.

5.30. Port Operations Service

Port Operations Service: A maritime mobile service in or near a port, between coast stations and ship stations, or between ship stations, in which messages are restricted to those relating to the operational handling, the movement and the safety of ships and, in emergency, to the safety of persons. Messages which are of a public correspondence nature shall be excluded from this service.

5.31. Radio Astronomy Service

Radio Astronomy Service: A service involving the use of radio astronomy.

Radio astronomy is a passive (non-transmitting) service. One example is the use of the band 1400 – 1427 MHz by the Very Large Array radio telescope in New Mexico. This band is used to observe emissions from the hydrogen atom, the most prevalent constituent of the universe.

5.32. Radiodetermination Service

Radiodetermination Service: A radiocommunication service for the purpose of radiodetermination.

5.33. Radiodetermination-Satellite Service

Radiodetermination-Satellite Service: A radiocommunication service for the purpose of radiodetermination involving the use of one or more space stations. This service may also include feeder links necessary for its own operation.

The radiodetermination-satellite service was envisioned to use satellites to determine the location of commercial assets, such as trucks. The defunct GEOSTAR system was planned to provide such services. The accuracy, availability, and low cost of GPS (which operates under the radionavigation-satellite service) have essentially made radiodetermination-satellite systems obsolete. There are no present examples of this service.

5.34. Radiolocation Service

Radiolocation Service: A radiodetermination service for the purpose of radiolocation.

DoD radars that provide national defense are an application of the radiolocation service. One such system is the PAVE PAWS early warning radars operating in the 420 – 450 MHz band. Industrial uses of the radiolocation service include sensors that utilize low-power radar to measure fluid levels in chemical storage tanks.

5.35. Radionavigation Service

Radionavigation: Radiodetermination used for the purposes of navigation, including obstruction warning.

The LOng RAnge Navigation (LORAN) system, operating in the 90 – 110 kHz band, is an example of the radionavigation service. LORAN considerably pre-dates GPS (which is a ubiquitous radionavigation-satellite service) and is less accurate, but is now considered an important back-up to GPS.

5.36. Radionavigation-Satellite Service

Radionavigation-Satellite Service: A radiodetermination-satellite service used for the purpose of radionavigation. This service may also include feeder links necessary for its operation.

The best-known application of the radionavigation-satellite service is the Global Positioning System (GPS), which operates at 1575.42 MHz (“L1” frequency), among other frequencies.

5.37. Ship Movement Service

Ship Movement Service: A safety service in the maritime mobile service other than a port operations service, between coast stations and ship stations, or between ship stations, in which messages are restricted to those relating to the movement of ships. Messages which are of a public correspondence nature shall be excluded from this service.

5.38. Space Operation Service

> **Space Operation Service:** A radiocommunication service concerned exclusively with the operation of spacecraft, in particular space tracking, space telemetry and space telecommand. These functions will normally be provided within the service in which the space station is operating.

An example of the space operation service is the use of 1801.5 MHz for telemetry, telecommand, and control (TT&C) of the GPS satellite constellation.

5.39. Space Research Service

> **Space Research Service:** A radiocommunication service in which spacecraft or other objects in space are used for scientific or technological research purposes.

NASA's deep space network makes use of space research service bands to receive data from spacecraft throughout the solar system. For example, NASA's New Horizons spacecraft, on its way to Pluto, transmits data at a frequency of approximately 8437 MHz. Voyagers I and II, which were launched in the 1970s and are now beyond the solar wind termination shock, use frequencies of approximately 8415 and 8420 MHz, respectively, for their downlinks.

5.40. Standard Frequency and Time Signal Service

> **Standard Frequency and Time Signal Service:** A radiocommunication service for scientific, technical and other purposes, providing the transmission of specified frequencies, time signals, or both, of stated high precision, intended for general reception.

The transmission of standard time and frequency signals by radio station WWV (Fort Collins, Colorado) on 2.5, 5, 10, 15, and 20 MHz is an example of this service. Consumer clocks that set themselves automatically by tuning into the 60 kHz signal from radio station WWVB (also in Fort Collins) are another application of the standard frequency and time signal service.

5.41. Standard Frequency and Time Signal-Satellite Service

> **Standard Frequency and Time Signal-Satellite Service:** A radiocommunication service using space stations on earth satellites for the same purpose as those of the standard frequency and time signal service. This service may also include feeder links necessary for its operation.

In the United States, there are presently no assignments to the standard frequency and time signal-satellite service. GPS (a radionavigation-satellite service) is presently able to transfer highly accurate time to virtually any location on the Earth, making obsolete the need for this application within the standard frequency and time signal-satellite service at the present time.

5.42. Special Service

> **Special Service:** A radiocommunication service, not otherwise defined in this Section, carried on exclusively for specific needs of general utility, and not open to public correspondence.

6. Allocation Status

Each service generally has either primary or secondary status in each band in which the service is allocated. In the United States, the spectrum rights of secondary services with respect to primary services are defined in the CFR and the NTIA *Manual*:[17]

[17] 47 CFR 2.105(c)(2)

Stations of a secondary service:

(i) Shall not cause harmful interference to stations of primary services to which frequencies are already assigned or to which frequencies may be assigned at a later date;

(ii) Cannot claim protection from harmful interference from stations of a primary service to which frequencies are already assigned or may be assigned at a later date; and

(iii) Can claim protection, however, from harmful interference from stations of the same or other secondary service(s) to which frequencies may be assigned at a later date.

7. Footnotes to the Allocation Tables

Footnotes are an important component of the allocation table. Footnotes can modify considerably the information that appears in a given cell. Such modifications may include significant restrictions on particular allocated services, or allocations to additional services that do not appear explicitly in the table. Generally speaking, an understanding of the allocations in a particular band cannot be definitively determined without reference to any applicable footnotes. The various types of footnotes are explained in the CFR:[18]

The following symbols are used to designate footnotes in the United States Table:

(i) Any footnote consisting of ''5.'' followed by one or more digits, *e.g.*, 5.53, denotes an international footnote. Where an international footnote is applicable, without modification, to both Federal and non-Federal operations, the Commission places the footnote in both the Federal Table and the non-Federal Table (columns 4 and 5) and the international footnote is binding on both Federal users and non-Federal licensees. If, however, an international footnote pertains to a service allocated only for Federal or non-Federal use, the international footnote will be placed only in the affected Table. For example, footnote 5.142 pertains only to the amateur service, and thus, footnote 5.142 is shown only in the non-Federal Table.

(ii) Any footnote consisting of the letters ''US'' followed by one or more digits, *e.g.*, US7, denotes a stipulation affecting both Federal and non-Federal operations. United States footnotes appear in both the Federal Table and the non-Federal Table.

(iii) Any footnote consisting of the letters ''NG'' followed by one or more digits, *e.g.*, NG2, denotes a stipulation applicable only to non-Federal operations. Non-Federal footnotes appear solely in the non-Federal Table (column 5).

(iv) Any footnote consisting of the letter ''G'' following by one or more digits, *e.g.*, G2, denotes a stipulation applicable only to Federal operations. Federal footnotes appear solely in the Federal Table (column 4).

Some international footnotes can create allocations that are not explicitly listed in the table for the ITU region in which the country is located. For example, international footnote 5.334 creates a primary allocation to the aeronautical radionavigation service:

5.334 *Additional Allocation:* In Canada and the United States, the band 1350-1370 MHz is also allocated to the aeronautical radionavigation service on a primary basis.

Even though the U.S. maintains its own allocation tables, the existence of such notes in the ITU table may convey some level of protection for the listed service in case of interference with another country along a common border.

Some international footnotes may also change the allocation status of a particular service in a particular band. For example, 5.78 elevates the radionavigation service to primary in the 415-435 kHz band:

[18] 47 CFR 2.105(d)(5)

> **5.78** *Different category of service:* In Cuba, the United States of America and Mexico, the allocation of the band 415-435 kHz to the aeronautical radionavigation service is on a primary basis.

Other footnotes, either international or U.S., may restrict certain allocated services. For example:

> **G32** Except for weather radars on meteorological satellites in the band 9975-10025 MHz and for Federal survey operations (see footnote US108), Federal radiolocation in the band 10-10.5 GHz is limited to the military services.

Yet other footnotes may change the relative rights between two services:

> **NG42** In the band 10-10.5 GHz, non-Federal stations in the radiolocation service shall not cause harmful interference to the amateur service.

8. Summary

Radio spectrum allocations in the U.S. are the result of rules and regulations promulgated by the NTIA (for Federal government users) and the FCC (for all others). The ITU develops spectrum allocations on a worldwide basis, which may or may not be adopted by an individual country. Allocations usually provide for orderly use of the radio spectrum and a general expectation of the RF environment that may be encountered in a particular band. Each band between 9 kHz and 275 GHz is allocated to one or more of the 26 defined radio services. Footnotes to the allocation table add important information to what's presented in the table itself.