PDHonline Course E411 (1 PDH)

US Frequency Allocation Chart

Instructor: Glenn Baker, P.E.

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5272 Meadow Estates Drive
Fairfax, VA 22030-6658
Phone: 703-988-0088
www.PDHonline.com

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1. Introduction

This course can be taken by anyone with an interest in United States frequency allocations. It will be assumed that anyone taking this course is aware of general communications and technology concepts such as frequency, interference, harmonics, mobile vs. fixed systems, and the concept that multiple systems could share the same spectral allocation.

2. General Information on the US Frequency Allocation Chart

At the advent of radio communications, there were no regulatory organizations and it was up to users to decide appropriate technical and operational standards, if any. The signal generating equipment was rudimentary, sometimes creating interference extending over the entire usable frequency range. Users chose their frequency without needing to coordinate with other stations. The situation prompted the government to start the regulation and enforcement of the radio frequency spectrum. The task has grown from managing a small list of stations, to a complex, ever growing system of services that overlap geographically, politically and technically. These services provide for many different needs of users on land, at sea, in the air and space.

An excellent resource for understanding the spectrum allocations for these services is a chart produced the National Telecommunications and Information Administration (NTIA), under the authority of the U.S. Department of Commerce. A thumbnail view of the chart is shown in Figure 1. The chart represents information contained in the "Table of Frequency Allocations" from the NTIA "Manual of Regulations and Procedures for Federal Radio Frequency Management" (known as the "NTIA Red Book") at the time the chart was created. As part of this course you will need to download the August 2011 version of the U.S. Frequency Allocation Chart in order to zoom in to examine details.

Note that the chart is a synopsis of regulations at the time the chart was created. Revisions of the chart may not coincide with revisions of the "Table of Frequency Allocations", and further, the table may be superseded by changing regulation and international treaties. Reasons for these differences include:

- Changing frequency allocations, temporary and permanent
- Technology upgrades and obsolescence
- Exceptions and details not easily represented in the chart
- Special temporary licensing
- Geographical, power and emission type limitations and restrictions

The spectral allocation information given in the chart is categorized as follows:

- **Radio Service** type, such as broadcasting, mobile, satellite
- **Activity Code** that describes the allocation user as government, non-government or both
- **Allocation Usage** that describes the allocation as primary or secondary

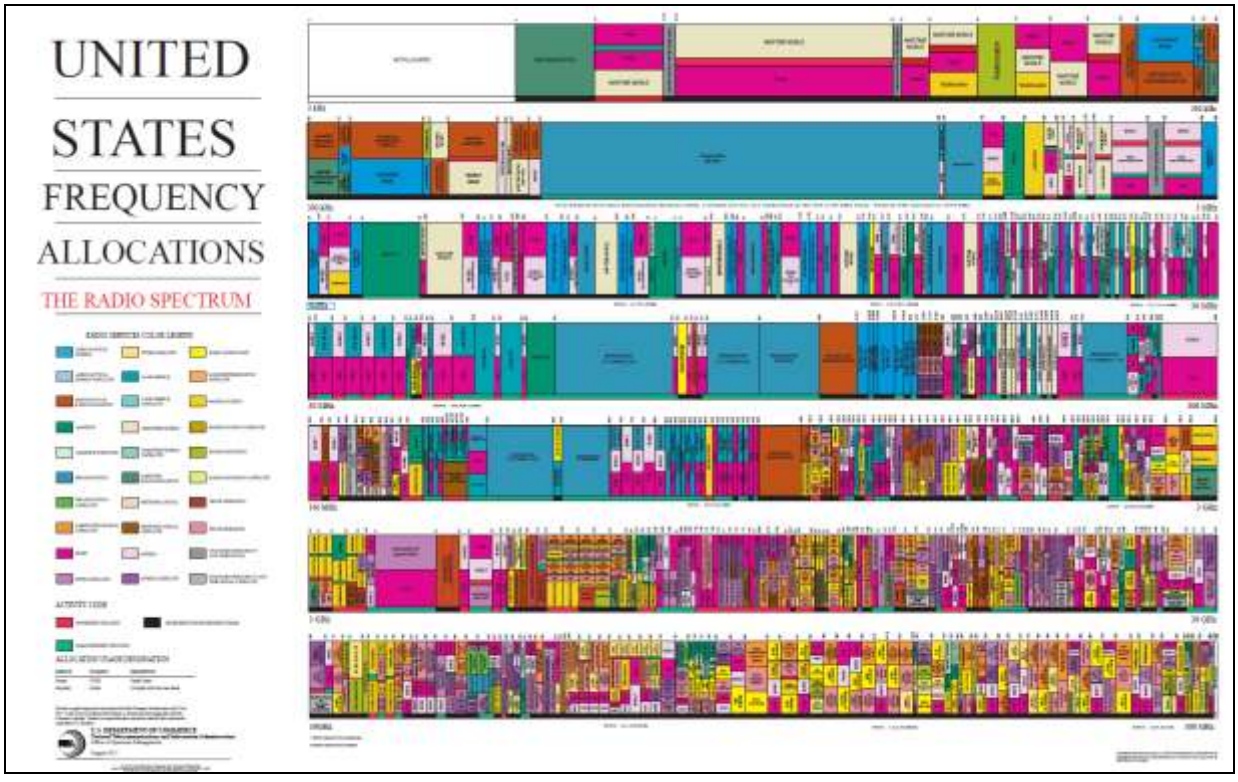

Figure 1. US Frequency Allocation Chart, August 2011*

*from the US Government website: http://www.ntia.doc.gov/page/2011/united-states-frequency-allocation-chart

A full-size printed wall chart is available for purchase from the US government printing office. The NTIA Red Book is available for download here:

http://www.ntia.doc.gov/page/2011/manual-regulations-and-procedures-federal-radio-frequency-management-redbook

3. National Spectrum Management

The overall management of U.S. spectrum allocations is performed by a dual organizational structure shown in Figure 2, where the NTIA manages the Federal Government's use and the FCC manages all other uses. Additional details can be found at the NTIA website http://www.ntia.doc.gov/book-page/who-regulates-spectrum.

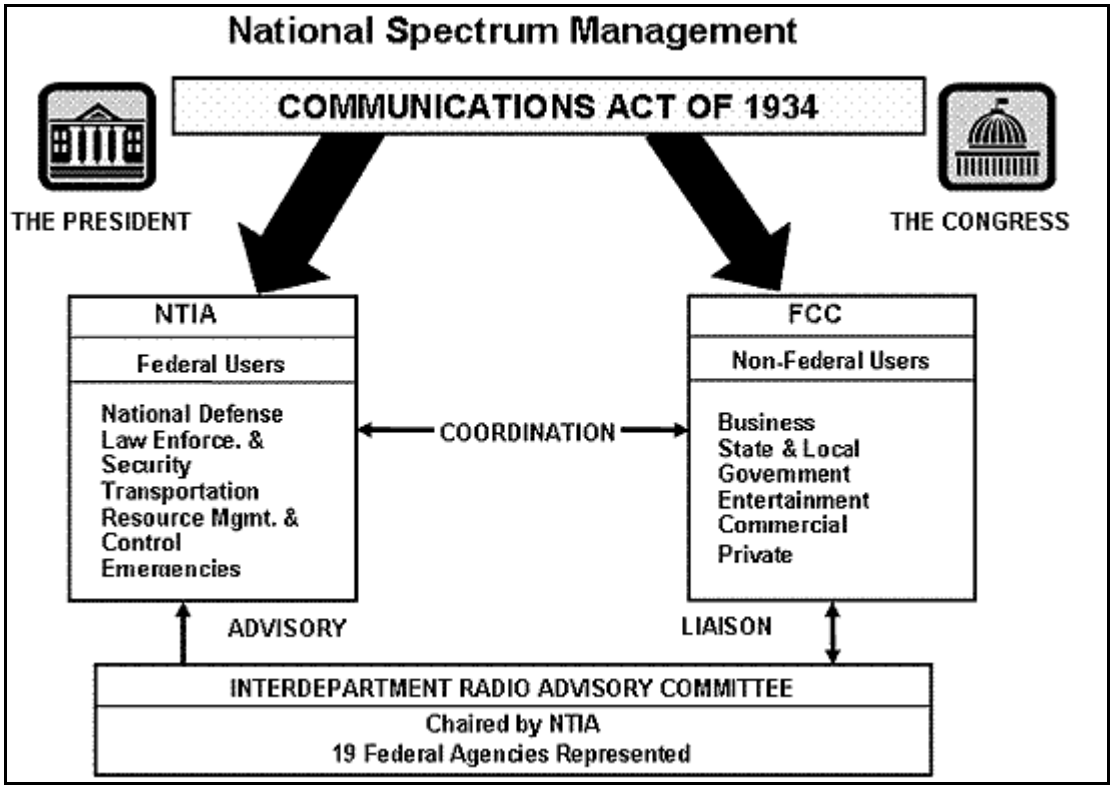

Figure 2. Roles in National Spectrum Management

4. Types of Radio Services

There are many types of **radio services**, for example, aeronautical, maritime, land based, fixed, mobile, navigation, astronomy, and research. The color-coded legend containing the entire list of radio services is reproduced in Figure 3 for convenience, and is found on the left side of the chart. For example, a bright yellow segment on the chart represents the radio service allocation for radio astronomy. To eliminate ambiguity and to assist in situations where the color cannot be distinguished, the allocation segment also contains the typed name of the radio service.

Figure 3. Radio Service Color Legend

5. Types of Activity

The frequency allocation chart indicates the **activity code** for each allocation, as denoted by a colored band below the allocation. The legend for activity code is found on the left side of the chart. There are three types of activity codes:

1. **Government Exclusive** (Red)
2. **Non-Government Exclusive** (Green)
3. **Government/Non-Government Shared** (Black)

The activity code indicates whether the spectrum is allocated for exclusive use by the government or non-government use, or if the spectrum allocation is shared between the two.

6. Types of Allocation

The frequency allocation chart indicates the type of **allocation usage** or **allocation category**, denoted by the case of the text contained in the allocation. The legend for allocation usage designation is found on the left side of the chart. There are two types of allocation usage:

1. **Primary** (All capital letters)
2. **Secondary** (Only first letter capitalized)

The primary allocation grants protection against harmful interference from shared services, whereas the secondary allocation is not granted protection against harmful interference from primary allocations of the authorized spectrum.

Secondary service allocations are on a non-interference basis to the primary service. Per the NTIA Red Book definition, secondary service allocations:

> (a) 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;
> (b) 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;
> (c) 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. Spectrum Allocation Examples

Example #1: A spectrum slice from the chart is reproduced and annotated in Figure 4 as an example. The following characteristics of the spectrum allocation can be determined from examination of the spectrum allocation (for the allocation indicated by arrows):

- Frequency extent of allocation (5.06 – 5.45 MHz)
- Type of Radio Service (Fixed and Mobile)
- Type of Activity Code (Government/Non-Government Shared)
- Designation of Allocation Usage (Both Primary)
- Exceptions (except aeronautical mobile)

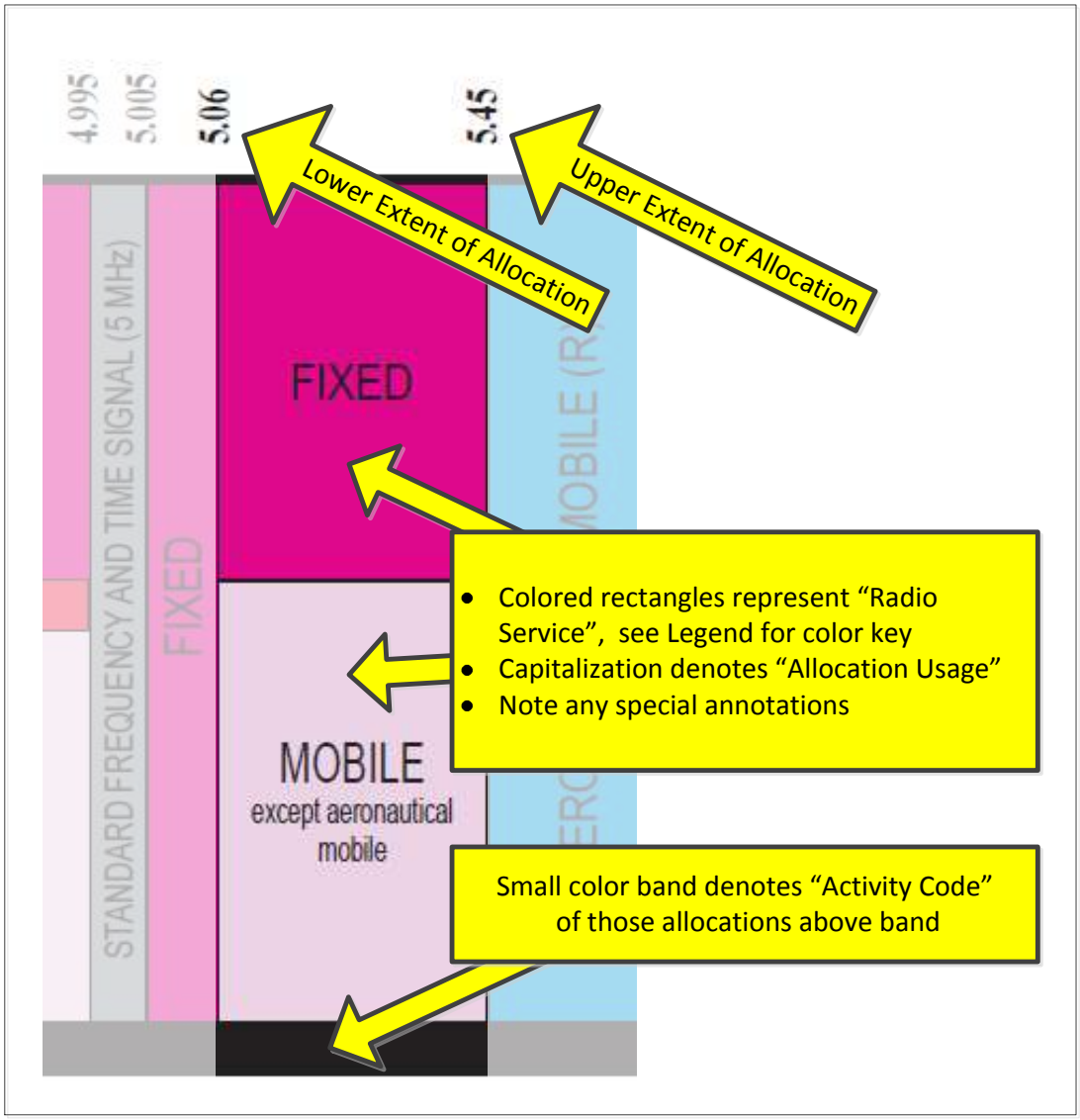

Figure 4. Example Spectrum Slice, 5.06-5.45 MHz

Example #2: A spectrum slice from the chart is reproduced and annotated in Figure 5. Arrows indicate the primary and secondary allocations for three types of activity codes occupying the same frequency allocation. For the spectrum slice highlighted in the figure, there are three allocations, from top to bottom:

1. FIXED: Primary allocation: government exclusive activity
2. Fixed: Secondary allocation: non-government exclusive activity
3. METEOROLOGICAL SATELLITE: shared activity

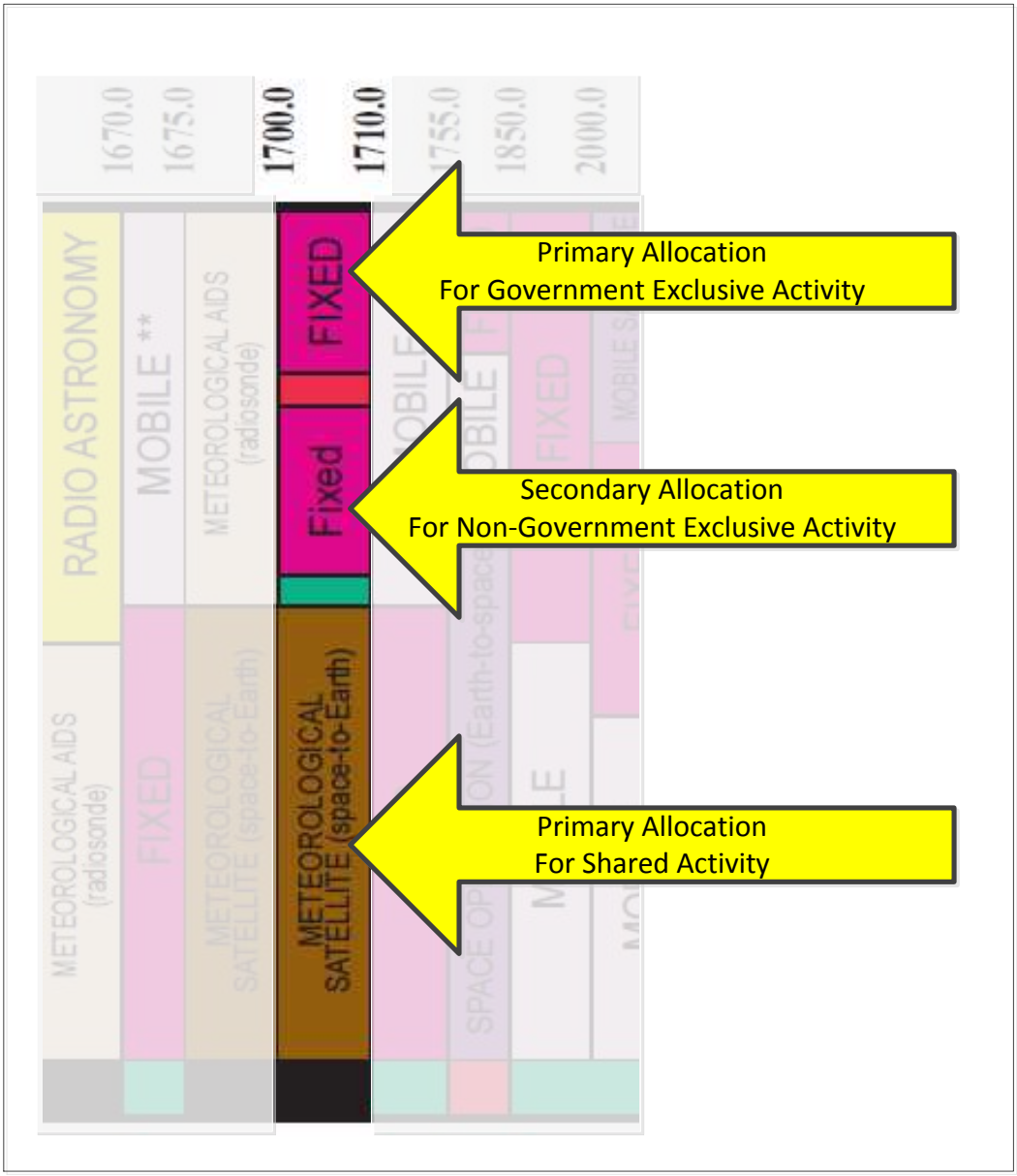

Figure 5. Example Spectrum Slice, Primary versus Secondary

Example #3: A spectrum slice from the chart is reproduced in Figure 6 to illustrate some of the types of special annotations used in the chart. Note that additional limitations may exist, and are detailed in the NTIA Red Book.

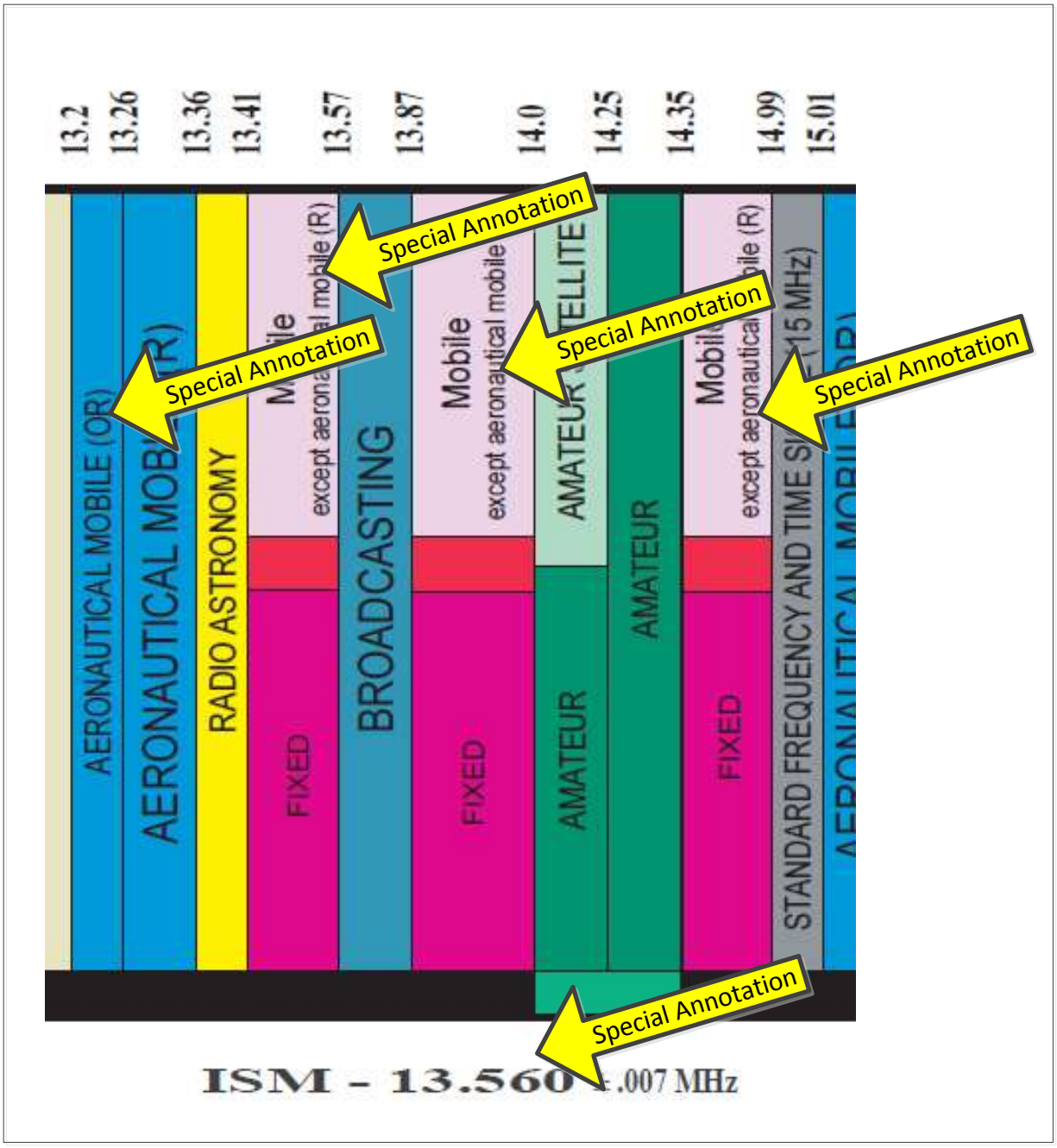

Figure 6. Spectrum Slice, Special Annotation Examples

8. Practical Usage

In addition to using the chart for radio system planning purposes, it can be an aid during investigation of sources of interference. Sources of interference include:

Shared Service Interference: Even though a radio service is authorized for a specific allocation of spectrum, it may interfere with other services assigned to share the frequency allocation. Possible causes include not adhering to frequency channel assignment, geographical location or authorized power limit. Also, a transmitter may be exceeding the authorized spectral mask that specifies the signal bandwidth and spectral shape, causing adjacent channel interference. This type of interference is also known as co-channel interference. The chart indicates directly what services could be producing the interference.

Harmonically Related Interference:
Due to non-linearity in physical systems, radio frequency transmitters produce harmonics of their fundamental operating frequency. Regulations define limits for these harmonic emissions, but defective components, installation or miss-adjustment may cause excessive harmonic output and subsequent interference to other services. A typical problem is excessive third-harmonic emissions, where the transmitter is producing an interfering signal on a frequency three times the assigned frequency. The user of the transmitter is often unaware of the interference as it is usually to a user of a different radio service. The chart can be used to determine what radio service could be producing the interference by examining allocations that are harmonically related. For third-harmonic interference, the radio service at 1/3 the frequency of the interfered service would be a likely source to investigate.

Intermodulation Interference:
Spurious emissions can be generated that are algebraic combinations of either signals contained within the transmitter, a mixture of an external signal received by the antenna combining with the transmitter signal or of a strong local signal mixing within the receiver. Typical problems involve multiple radio services co-located on an antenna tower. By knowing which radio services are co-located, an analysis can be performed to determine the likely problem of co-site interference.

Broadband Interference:
This type of interference spans a wider bandwidth than a normal transmitted signal and may have no readily recognizable modulation characteristics that could be used to aid in the determination of the source. Additionally, the generated

interference may not be related to the radio service's allocation. This type of interference can be isolated with field strength measurements that can then be correlated to radio services or devices in the area of highest field strength.

Spurious and Unlicensed Emissions:
Spurious emissions can be emitted from devices that should not radiate a signal outside their physical enclosure, such as microwave ovens and computers. Physical relocation of the devices or turning the device off can establish the source of interference. The chart can be used as a starting point, e.g., the consumer microwave oven frequency of 2.45 GHz is in the Industrial, Scientific and Medical allocation that is also used in some cordless telephones and Wi-Fi systems. Other sources of interference are from unlicensed transmitters such as low-power broadcasting, wireless microphones and infant monitors, remote controls and hand-held transceivers.

9. Summary

The U.S. Frequency Allocation Chart is a useful reference for understanding radio frequency allocations and the relationships between allocations. The government agencies with authority to allocate radio frequency spectrum (NTIA and FCC) have a complex and dynamic task of assigning the allocations. The source of the underlying data contained in the chart has been provided, as well as examples of details that may not be expressed in the chart. Examples of how to read the chart and use it in practical situations have been provided.

