

<b>Lesson</b>	<h1>Spectrum Management</h1>
9	
<b>Time Required</b>	<b>Lesson Summary</b>
125 minutes (2.5 – 50 minute class periods)	Students will investigate the local users of the spectrum and learn about additional users who are not in their area. Then students will work in small groups to create a priority list of spectrum users. The lesson will conclude with students comparing and contrasting their priority list to the priorities set by the federal government.
<b>Standards Addressed</b>	
<ul style="list-style-type: none"> <li>○ <b>Next Generation Science Standards (NGSS)</b> <ul style="list-style-type: none"> <li>○ HS-PS4-5 Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy</li> </ul> </li> <li>○ <b>West Virginia Standards</b> <ul style="list-style-type: none"> <li>○ Economics SS.C.23 Examine the opportunity costs in ever-present scarcity for individuals, businesses, and societies to understand how to make choices when facing unlimited wants with limited resources.</li> <li>○ Economics SS.C.27 Describe how households, businesses, and government interact in a free-market economy.</li> </ul> </li> <li>○ <b>New Mexico Standards</b> <ul style="list-style-type: none"> <li>○ Social Studies Content Standard IV: Students understand basic economic principles and use economic reasoning skills to analyze the impact of economic systems (including the market economy) on individuals, families, businesses, communities, and governments.</li> <li>○ Benchmark 4-A Students will analyze the ways individuals, households, businesses, governments and societies make decisions and are influenced by incentives and the availability and use of scarce resources, and that their choices involve costs and varying ways of allocating.</li> <li>○ Performance standard 4 Analyze and evaluate the impact of economic choices on the allocation of scarce resources.</li> </ul> </li> </ul>	

Vocabulary	Objectives
<p>However, if students did not complete lesson 4, these are new words to them.</p> <p>Software-defined radio (SDR), interference, polarization, directionality, gain, coax choke.</p>	<ul style="list-style-type: none"> <li>• Students will determine what types of devices use the spectrum</li> <li>• Students will allocate a limited resource and explain the reasoning behind their decisions</li> <li>• Students will understand how the government allocates the same resource and discuss the similarities and differences</li> </ul>
<b>Materials</b>	
<ul style="list-style-type: none"> <li>• RTL-SDR dongle kit <a href="https://www.amazon.com/gp/product/B00VZ1AWQA/ref=ppx_yo_dt_b_asin_title_o01_s00?ie=UTF8&amp;psc=1">https://www.amazon.com/gp/product/B00VZ1AWQA/ref=ppx_yo_dt_b_asin_title_o01_s00?ie=UTF8&amp;psc=1</a></li> <li>• Download the free technical guide from the website</li> </ul>	
<b>Pre-Requisites</b>	
<p>Students need to know about the electromagnetic spectrum, electromagnetic waves, and how the RTL-SDR dongle works.</p>	
<b>Safety Considerations</b>	
<p>None</p>	
<b>Pacing Notes</b>	
<p>This lesson is planned to last two and a half 50-minute class periods. Below is a suggestion of the activities which can be accommodated in each class period.</p> <p>Day 1 – Explain how the dongle works and scan the spectrum, and students create categories for local and additional spectrum users.</p>	

Day 2 – Students create a priority list of users, students investigate the government's allocation chart, and identify the government's priorities.

Day 3 - Students compare and contrast the two priority schemes.

### Before the Lesson

Make sure you have set up the hardware and software as described in chapters 1 and 2 of the windows-based technical guide.

Print the spectrum management sheet, the how the government makes the rules page (or make it available on your web page), the additional users of the spectrum sheet (or make it available on your webpage, and make the allotment chart available to students on your web page. The chart can be found here <https://www.ntia.doc.gov/page/2011/united-states-frequency-allocation-chart> (last accessed Oct. 9, 2022)

Assessments	Classroom Instructions
<i>Pre-Activity Assessments</i>	<i>Introduction</i>
	<p>While taking attendance, have students brainstorm all the devices that use the electromagnetic spectrum.</p> <p>After you finish administrative duties, ask students to share things from their list and create a list on the board. To save time, ask students to only share things not already written on the board.</p>
<i>Activity Embedded Assessments</i>	<i>Activities</i>
<p>After explaining it to students and showing them a scan.</p>	<p style="text-align: center;"><b>Provide Background Information</b></p> <ol style="list-style-type: none"> <li>I. If you <b>did not</b> use Lesson one: Argumentation and radio waves in your classroom, spend several minutes explaining to students how the RTL-SDR dongle receives radio waves.</li> <li>I. Scanning the spectrum Follow the instructions in the technical guide chapter 2 to scan the spectrum.</li> </ol> <p>Explain to students what you are doing and what they are seeing.</p> <p><b>Say:</b> This antenna receives radio frequency waves that are in the area. Those waves are invisible, but with the help of this dongle and some</p>

**Ask:** How does the RTL-SDR dongle receive the radio wave?

**Ask:** How is a picture made from the waves?

While students are working in small groups, walk around.

Observe students; are they all actively engaged in the learning activity?

Approach the ones that are not and have a conversation with them.

**Ask:** What is your

downloaded software, those signals are visualized into the image you see on the screen. This image is referred to as a "waterfall." The peaks occur at frequencies where there is a signal. The stuff between those peaks is referred to as "noise." This "noise" can be caused by many things, including bad reception from the antenna and less powerful signals from things such as microwaves. We will learn more about these less powerful signals during this lesson.

To not overload the system, scan 50Mhz at a time starting a 88 MHz and going up to 1600 MHz. Hint: Make the first scan a little larger, 88-140 MHz, to make the intervals easier to calculate. To increase student participation, have a different student come up and perform each scan using your computer. You can scan parts of the frequency range to cut down on time spent on this activity. As long as each student who wants to scan the spectrum is allowed to try it you may eliminate some of the scannings.

Each time a section is scanned:

**Ask:** Do you recognize any of these broadcasters? (Local radio stations use the frequency in the call sign so students may be able to identify some of the peaks.

After the class has scanned the required frequencies, point out that this section of the spectrum is defined by specific frequencies. Tell students that there is a limited amount of spectrum available for use. Point out that a single broadcaster created every peak that was detected. Therefore, there can only be a certain number of broadcasters before the broadcasts start overlapping and interfering.

## 2. Categorizing the users of the spectrum in the area

Government agencies, public safety, and private businesses use radio frequencies to communicate with members of their organization and sometimes with the general public. These frequencies are a matter of public record and, as such, can be found on the web pages listed on the spectrum management page.

Hand out the Spectrum Management page. Students should work in pairs or groups of three for this activity. Students will first read through the list of broadcasters and place each broadcaster into one of the categories provided in the table.

group doing now?

**Ask:** What would you like to contribute to this task?

Check that students understand they are not assigning frequencies but rather establishing priorities.

**Ask:** What does this percentage represent?

**Ask:** Which category of spectrum user do you think needs the most significant percentage of frequencies?  
Why did you choose that category?

As students are working, walk around and ask questions similar to the following:

**Ask:** Which categories currently have the most significant amount of government allocation?

**Ask:** What similarities have you found between the two

### 3. Identifying additional broadcasters

Say: Now, you will learn about some additional spectrum users. Determine if these users fit into existing categories or if you need to create new ones to accommodate them. You must have a reason for each category.

Instruct students to stop when finished with this activity and wait for you to provide additional information before moving on.

### 4. Creating an allocation system

Explain to students that the government allocates the frequency bands based on rules. Those rules have been created over many years by two government agencies. Tell them the allocation process is much more complicated than determining the importance of each use of the spectrum. This activity is meant to be a model of the process. Like all models, this one has strengths and weaknesses.

Distribute the How the Government Creates the Rules page. Either have students read this silently to themselves or have students take turns reading it out loud.

Explain that they will not be allocating specific frequencies to users because, as mentioned in the handout, that requires a lot of time and input from several people. Instead, they will identify which users should be prioritized by assigning them the most significant percentage of the useable spectrum.

Again, have students stop after completing this activity, so you can provide additional information before they move on.

### 5. Investigating the existing allocation system

Direct students to the government allocation chart. They should estimate the percentage of the spectrum assigned to each of the categories in the table. This will not be an exact value and will probably vary from one group to another. That is okay; the activity's purpose is to understand the users and the amount of



students work together. However, if you have a variety of reading and motivation levels in your class, a group of 3-4 students would be appropriate.

### **Educator Resources**

None

### **Optional Extension Activities**

After student groups have created their allocation system, you could have students present this information to the class. Then students could discuss the choices made, and groups could revisit their allocation percentages.