“They used to rob trains in the Old West. Now we rob spectrum.”
Senator John McCain, Chairman, Senate Commerce Committee

The citizen’s guide to the airwaves

A graphic depiction of the uses—and misuses—of the radio frequency spectrum

“The wireless spectrum belongs to the public, and thus should be made to serve the public.”
Senator Ernest Hollings, former Chairman, Senate Commerce Committee

Potential windfall if the spectrum is privatized (   )
Market value of current use (   )

FREQUENCIES

Frequency assignments used by everyday devices

Citizen’s access spectrum (unlicensed, amateur, personal radio)
Obstacles frequencies can overcome (propagation characteristics)

The value of the spectrum if it were thought of as real estate

Notes and definitions

Radio waves are transmitted at different frequencies measured in hertz (Hz). A slice of spectrum contains a band of frequencies. The wider the band, the more information carrying capacity it has. (It has more “bandwidth”).

Sources and further reading are included in the separate report that accompanies this chart.
The electromagnetic spectrum has long wavelengths (low frequency) at one end and short wavelengths (high frequency) at the other end. KiloHertz (1,000 hertz) is written as \( \text{kHz} \), megahertz (1 million hertz) is written as \( \text{MHz} \), and gigahertz (1 billion hertz, or 1,000 megahertz) is written as \( \text{GHz} \).

Wireless bandwidth is generally counted in megahertz.

**Abbreviations:**
- kilohertz (1,000 hertz) is written as \( \text{kHz} \),
- megahertz (1 million hertz) is written as \( \text{MHz} \), and
- gigahertz (1 billion hertz, or 1,000 megahertz) is written as \( \text{GHz} \).

A **wavelength** is the distance between the recurring peaks of a wave. The electromagnetic spectrum has long wavelengths (low frequency) at one end and short wavelengths (high frequency) at the other end. The size of the wavelength influences the ability of a wave to pass through objects. Generally, as a wavelength decreases in size, its value also decreases.

The value of today’s restricted usage rights

The value of completely flexible usage rights (i.e., ownership rights); number based on recent auctions

Today, the government restricts the use of this 6 MHz to broadcasting one TV signal (this example is channel 14). The market values this limited license at $390 million.

If the license allowed the same 6 MHz to be put to its most highly valued use (e.g., cellular telephone service), its market value jumps to $72 billion. The difference ($6.8 billion) is the potential value of spectrum flexibility on channel 14. Note that if all broadcasters were granted flexibility, the greater supply of spectrum would lower this value considerably.

<table>
<thead>
<tr>
<th>Channel 14</th>
<th>Market Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restricted Usage Rights</td>
<td>$390 million</td>
</tr>
<tr>
<td>Completely Flexible Usage Rights</td>
<td>$7.2 billion</td>
</tr>
</tbody>
</table>

The difference ($6.8 billion) is the potential value of spectrum flexibility on channel 14.

The light areas ( ) represent:
1. The windfall an incumbent spectrum licensee could receive if granted flexibility to use it for any purpose or to sell it (i.e., ownership rights).
2. The compensation taxpayers could receive if government charged market rates for use of this public asset.
3. The efficiency loss from not allowing this spectrum to be used for services most highly valued by consumers.

<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>Industry Use</th>
<th>Infringement</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 MHz - 1 GHz</td>
<td>Broadcast TV (channels)</td>
<td>Mobile phones (Narrowband-PCS)</td>
</tr>
</tbody>
</table>

**Permeable zone:** signals, which carry information, can easily traverse through dense objects such as buildings, mountains, forests, and storms.

FIFTH AVENUE, NEW YORK CITY
The radio spectrum (enlarged in the charts above) is the portion of the total electromagnetic spectrum distinguished by its value for communication.

The area under this curve is $4.5 trillion, which should not be interpreted as the total market value of spectrum. The curve shows the marginal value of particular bands based on recent auctions, which only fetched as much as they did because most spectrum cannot be purchased at any price or is mandated for inefficient use.

If government allowed spectrum to be used for any purpose—or allowed the unlicensed sharing of under-utilized bands (see other side)—its supply would increase and market value decrease. The $143 billion estimate for the spectrum’s total value, at right, assumes reforms are instituted to allow flexible use. Without reform, the auction value of prime spectrum will remain artificially high.

The radio spectrum

Visible light
Ultraviolet
X rays
Gamma rays
Microwaves
Infrared

300 GHz
3 kHz

1.5 GHz 1.6 1.7 1.8 1.9 2.0 2.1 2.2 2.3 2.4 2.5 2.6 2.7 2.8 2.9 3.0 3.1 3.2 3.3 3.4 GHz

$143 billion
Mobile phones
(Broadband PCS)

$18 billion
Non-geostationary mobile satellite service (NGSO-MSS)

$2 billion

$42 b.
Electronic news-gathering
(Broadcast TV)

$18 billion
Non-geostationary mobile satellite service (NGSO-MSS)

$30 b.
Satellite radio

$2 billion

$1 b.

$1 b.

2.4 GHz is unlicensed—a “public park” free to a wide variety of consumer devices (300 and growing fast).

Semi-permeable (transition) zone:
The amount of spectrum required for everyday communications

Today, most wireless communication is low fidelity audio. In the future, high fidelity video could require up to 5,000 times as much bandwidth.

In order to emphasize the most valuable parts of the spectrum, this scale gives the lower frequencies disproportionate space.

Using an unadjusted linear scale, the values part of the chart would appear like this:

Higher frequencies are less valuable than lower ones because popular consumer services (broadcasting and cell phones) need to penetrate buildings, and this gets harder as you move up the spectrum.

The spectrum’s worth compared to other things

“[Spectrum is] the most valuable natural resource of the information age.”
William Safire, New York Times

Long line-of-sight zone: signals cannot traverse dense objects but can be sent long distances through the atmosphere.

“The basic problem is that demand for spectrum is outstripping the supply.”
U.S. General Accounting Office Report, September 2002

Note: Spectrum valuations, which are notoriously volatile, are as of December 31, 2001.
The airwaves needed for all the everyday uses shown here amount to less than 2% of the total Radio Spectrum.

“(The spectrum allocation) system is inefficient, unresponsive to consumer demand, and a huge barrier to entry for new technologies anxious to compete in the marketplace.”

Thomas Hazlett, Former Chief Economist, FCC
Spectrum is the most valuable natural resource of the information age.

William Safire, New York Times

The spectrum's worth compared to other things:

- U.S. military budget: $335 billion (est.)
- Port Knox stored in gold: $147 billion
- McDonald's annual sales: $31.2 billion
- Empire State Building: $5 billion
- Temporary assistance for needy families (TANF): $24 billion (est.)
- Medicaid spending: $147 billion annually
- Government: $52.8 billion
- Bill Gates: $52.8 billion
- All the gold stored in Fort Knox: $45.5 billion