



# WHITE SPACES: READY FOR DEVELOPMENT PERMITS OR OFF-LIMITS?

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The “tragedy of the commons” and the “invisible hand of the marketplace” are two economic concepts that regularly find use in explaining the trajectories of various technologies’ initial developments and evolutions (references 1 and 2). The influence of these concepts is evident in a diversity of issues involving broadcast-frequency spectrum in the United States and elsewhere.

Take, for example, the United States’ 12 ISM (industrial/scientific/medical) bands, with 900 MHz (902 to 928 MHz), 2.4 GHz (2.4 to 2.5 GHz), and 5 GHz (5.725 to 5.875 GHz) the most common variants. The FCC’s (Federal Communications Commission’s) decision to open up the bands for use by low-power transmitters and receivers in a license-free manner has resulted in an unparalleled explosion of adoption, both in the consumer-electronics realm and elsewhere. However, as more consumers who fill their homes with cordless phones, garage-door openers, Wi-Fi networks, microwave ovens, and Bluetooth-based gear are discovering, regulation-free environments are also ripe settings for overuse and subsequent destructive interference (see sidebar “Frequency shifts”).

Or take the FCC’s recently concluded 700-MHz (698- to 806-MHz) spectrum auction (Figure 1). The band formerly corresponded to UHF (ultrahigh-frequency) television channels 52 to 69. Widespread belief was that this spectrum swath was a scarce resource and particularly precious because it could easily travel long distances and through premises’ walls and other barriers. This belief led to the US Treasury’s collecting a mind-boggling total of \$19.592 billion from winning bidders. This fiscal success occurred despite the fact that Block D (10 MHz of cumulative bandwidth between 758 to 763 MHz and 788 to 793 MHz) failed to receive a sufficiently high minimum bid to meet the reserve price and therefore went unsold.

But is spectrum really scarce? The answer to that question depends on how you use the spectrum, say both the White Spaces Coalition and sibling organization the Wireless Innovation Alliance. (*White space* refers to the unused television channels in a region, along with the spectrum-guardband buffer between channels.)

The two groups, encompassing a veritable who’s who of computing and consumer-electronics hardware, software, and services companies, point out that, in any region of the United States, television broadcasters are using only a small percentage of the aggregate VHF (very-high-frequency) plus postauction remaining UHF spectrum at any time. Richard Whitt, Google’s general counsel, recently remarked, “The vast majority of viable spectrum in this country simply goes unused or else is grossly underutilized. Unlike other natural resources, there is no benefit to allowing this spectrum to lie fallow. The airwaves can provide huge economic and social gains if used more efficiently, as seen today with the relatively tiny slices utilized by mobile phones and Wi-Fi services” (Reference 3).

The organizations’ answer to this substantial inefficiency is analogous to the FAA’s (Federal Aviation Administration’s) approach to US airspace, which is a similarly finite resource. As aircraft enter a

**IS WIRELESS SPECTRUM SCARCE OR ABUNDANT? TWO COALITIONS’ FRESH PERSPECTIVES ON A LONG-STANDING ISSUE HAVE PRODUCED PROMISING EARLY RESULTS, BUT OLD-GUARD OPPONENTS ARE RAISING IMPLEMENTATION ROADBLOCKS.**



region's airspace, the FAA assigns them routes, altitudes, and surrounding buffer zones that enable them to evade other aircraft within that region. And, when an aircraft departs a region, its airspace allocation returns to an available-resource pool for subsequent use by others.

The White Spaces proposal for PAN (personal-area-network), LAN (local-area-network), and WAN (wide-area-network) applications is reminiscent of FAA traffic management. It differs in one key area, however: The FAA relies on regional air-traffic control to manage airspace-resource allocation. With White Spaces, no centralized spectrum-governing body exists. Instead, White Spaces technology-based equipment manages itself, dynamically sensing what portions of the spectrum other transmitters are using at any time and, in response, dynamically reconfiguring itself to evade potential interference scenarios.

The concept is intriguing, but is it achievable in real-life-usage environments? White Spaces backers insist that it is; they point to, for example, similar avoidance techniques in place with 802.11a (through the 802.11h extension) and 802.11n to avoid conflict with 5-GHz-based medical equipment and military- and weather-radar systems. They also offer a number of additional implementation options that will, if necessary, even better avoid conflict, albeit at added cost. Incumbent users of VHF and UHF spectra, notably television broadcasters and developers and users of wireless microphones and medical equipment, are less sanguine about their potential new next-door neighbors. To the extent that they buy into the White Spaces concept at all, they

### AT A GLANCE

▣ The White Spaces Coalition aspires, by intelligently and efficiently using spectra, to shift the supply-versus-demand curve in a low-cost direction without cultivating ISM (industrial/scientific/medical)-band-reminiscent overexploitation.

▣ A map of the VHF (very-high-frequency) and UHF (ultrahigh-frequency) bands may appear to offer plenty of holes for cognitive radios to harness, but the spectrum is actually crowded, albeit, in many cases, by unlicensed, and thereby illegally operating, equipment.

▣ Initial FCC (Federal Communications Commission) testing of White Spaces proof-of-concept prototypes has produced less-than-perfect results that adversaries have extrapolated to a blanket indictment of the technology.

▣ Licensing available VHF and UHF subbands on a region-by-region basis could result in more complete use of available spectra but doesn't play to the low cost, portability, and other advantages that White Spaces promoters tout.

▣ White Spaces backers have recently floated additional implementation concessions to placate opponents. It's unclear what additional costs their inclusion will incur or whether White Spaces technology even needs superset-spectrum-avoidance capabilities.

demand spectrum licensing and other restrictions that White Spaces promoters retort will so restrict price and flexibility as to render the approach dead on

arrival—arguably the ultimate aspiration of detractors.

### INCONSISTENT HISTORY

If you became aware of the White Spaces controversy only through the last few months of heavy media attention, you might be surprised to learn that industry and regulatory debate over the topic is more than a half-decade old (see sidebar "Implementation plans?"). In May 2003, the FCC sponsored an industry workshop on so-called cognitive radio, "a radio that can change its transmitter parameters based on interaction with the environment in which it operates" (Reference 4). Later that year, the FCC published an NPRM (notice of proposed rule-making) on the subject, following it in May 2004 with another notice specific to television-broadcast bands. In that same period, the IEEE began working on its White Spaces-based 802.22 WRAN (wireless-regional-area-network) standard.

The US Senate in February 2006 introduced a bill that proposed opening unused television channels to alternative uses in a license-free manner. A subsequent October 2006 FCC decision opened the White Spaces for use by high-power, fixed-location, professionally installed, and, therefore, expensive transmitters. Such equipment would, for example, provide a competitive broadband-access scheme to incumbent approaches, such as cable, DSL (digital-subscriber line), fiber, and satellite—one with particular appeal in poorly served rural areas.

That FCC ruling also tentatively opened the White Spaces to use by low-power, portable, consumer-activated

## FREQUENCY SHIFTS

At press time in June, the FCC (Federal Communications Commission) was supposedly wrapping up its second wave of White Spaces equipment testing, targeting report publication in October. If all goes well, first equipment availability will coincide with the Feb 17, 2009, NTSC (National Television System Committee) sunset.

I have serious doubts about this schedule and suspect a clearer perspective on where the FCC stands will be available by the time you read this article. As such, monitor the Brian's Brain blog ([www.edn.com/briansbrain](http://www.edn.com/briansbrain)) for timely updates on the topic, along with supplemental materials. Look for "White Spaces" in the

posts' subject lines.

I'll also share through the blog key points from an interview I conducted with Avnera's chief executive officer, Manpreet Khaira. Avnera's wireless-audio-chip sets operate in the 2.4-GHz ISM (industrial/scientific/medical) band, not in the White Spaces-candidate VHF (very-high-frequency) and UHF (ultrahigh-frequency) areas, but they face challenges

from similar crowded-spectrum-interference issues. Khaira explains how the company's products sense and account for the presence of other 2.4-GHz-band transmitters, along with other design trade-offs, such as frequency of sensing, degree of receiver-to-transmitter back-channel communication, antenna design, and 2.4-GHz-band-only versus 2.4- and 5-GHz-band cognizance.

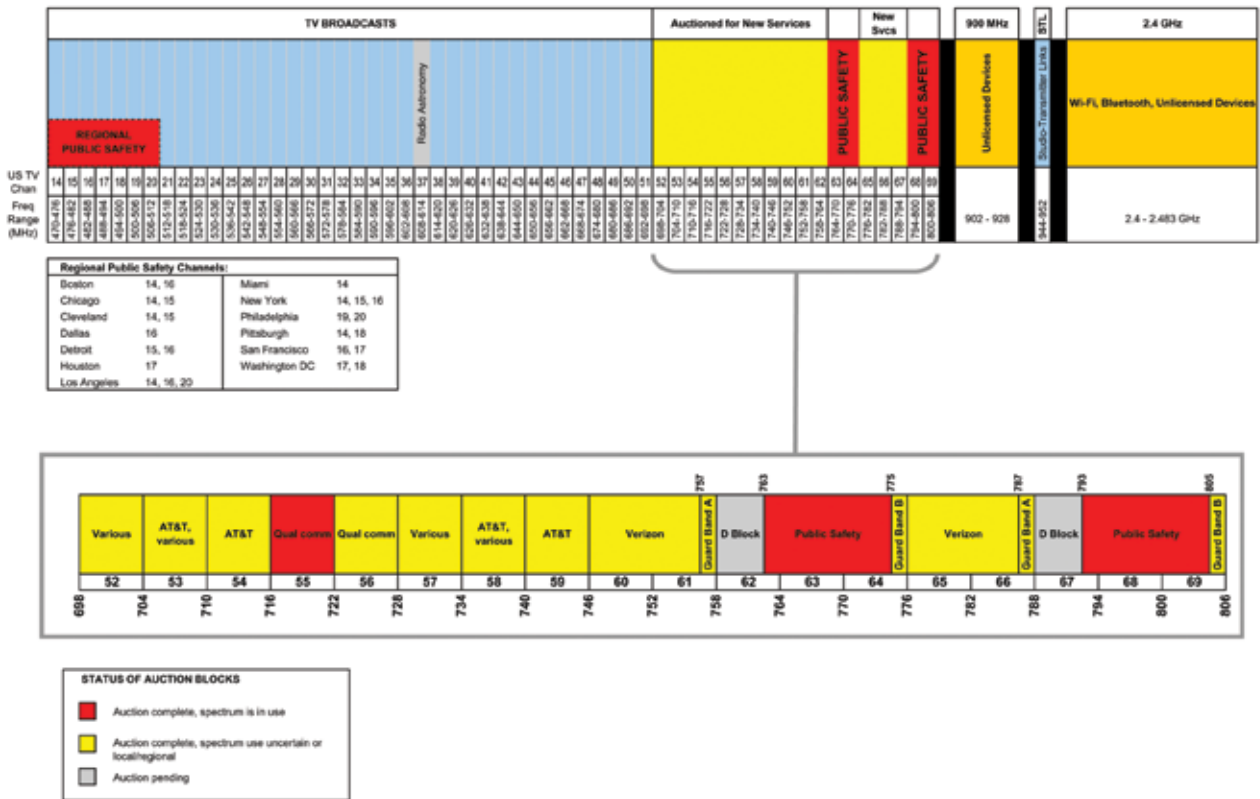


Figure 1 A post-NTSC-sunset spectrum map of UHF and higher-frequency bands showcases White Spaces opportunities along with potential problem areas (courtesy Shure).

equipment, albeit with several key qualifiers. Additional FCC testing and subsequent feature specificity would ensure that such equipment could operate in an interference-free manner, and equipment targeting consumers would be unavailable for purchase until after the Feb 17, 2009, NTSC (National Television System Committee) phase-out date.

The reasons for the delayed first-sale date derive from both technical and logistics causes. At the time, advance preparations for the early-2008 700-MHz-spectrum auction were under way. The FCC was also assisting early-adopter broadcasters with their ATSC (Advanced Television Systems Committee) equipment and service launches. These activities consumed FCC resources. The complete transition to ATSC in early 2009 will also result in a spectrum environment that's friendlier to White Spaces. Redundant NTSC broadcasts will no longer exist, rendering more channels available for alternative uses. Also, the steeper frequency cutoffs defining the edges of each ATSC channel's footprint, in contrast with NTSC predecessors and courtesy of more modern and pre-

cise broadcast equipment, result in additional usable between-channel spectrum (Figure 2).

FCC testing of White Spaces prototype equipment has so far produced mixed results. The first round of analysis encompassed transmission-capable gear from Microsoft (Prototype A) along with a receiver-only unit from Philips (Prototype B) (Figure 3). A July 2007 report deemed the Microsoft hardware unacceptable in performance, revealing, "where a DTV (digital-television) signal was strong enough to be received on the TV, the scanner reported its channel

to be free or available 40 to 75% of the time" (Reference 5).

The Philips receiver fared better; it was "generally able to reliably detect DTV signals at  $-115$  dBm in the single-channel tests and at  $-114$  dBm in the two-channel tests." And the White Spaces Coalition's subsequent analysis of Prototype A prompted a letter to the FCC indicating that the device had a broken spectrum-scanning subsystem and that a backup device that the FCC failed to also evaluate "detected DTV signals at a threshold of  $-114$  dBm in laboratory bench testing with 100% ac-

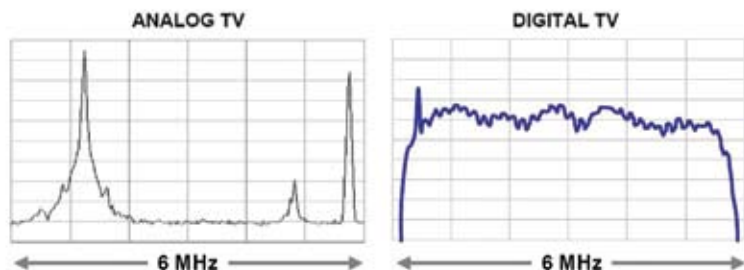


Figure 2 The frequency footprint of an ATSC broadcast channel exhibits steeper cutoff ramps on either side than its NTSC predecessor, thereby leaving more available White Spaces spectrum in the buffer guardband between channels (courtesy Shure).

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curacy, performing exactly as expected” (Reference 6). But related FCC testing of digital-cable-television receivers near White Spaces equipment also produced troubling interference (Reference 7).

The second round of testing began in late January 2008 and consisted of laboratory measurements followed by in-field evaluations. Equipment submissions again came from Microsoft (in partnership with Metric Systems), Philips, Adaptrum, and Motorola. Once again, the unlucky bug bit Microsoft ... twice. An initially functional unit in mid-February began exhibiting power-supply-related issues after more than a week of operation; it would work only when initially booted or after a lengthy intermediary cool-down cycle (Reference 8). Another prototype failed in late March. If White Spaces advocates were hoping to sway the FCC to their side of this controversial issue, they weren’t helping their cause by repeatedly shooting themselves in the foot.

### SELF-SERVING REASONING

White Spaces detractors seized on the equipment failures as a sweeping indictment of the technology’s trustworthiness not to interfere directly with broadcast signals or indirectly through first-adjacent-channel proximity. Accom-

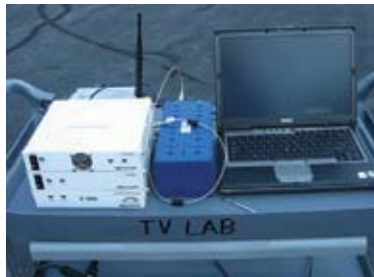


Figure 3 Prototype A was the first of several Microsoft-supplied White Spaces proof-of-concept units to fail during FCC testing.

panying late-2007 advertisements in Washington, DC-area newspapers was a television spot featuring a senior citizen, a television showing an interference-plagued Washington Redskins football game, and a voice-over that ominously intoned, “Digital television means you can watch your favorite shows with a crystal-clear picture. But if some high-tech companies like Microsoft get their way, your picture could freeze and become unwatchable. They want unlicensed electronics devices to operate on channels used for digital TV. Say goodbye to your perfect digital picture!” (Reference 9).

After the failure of the second Micro-

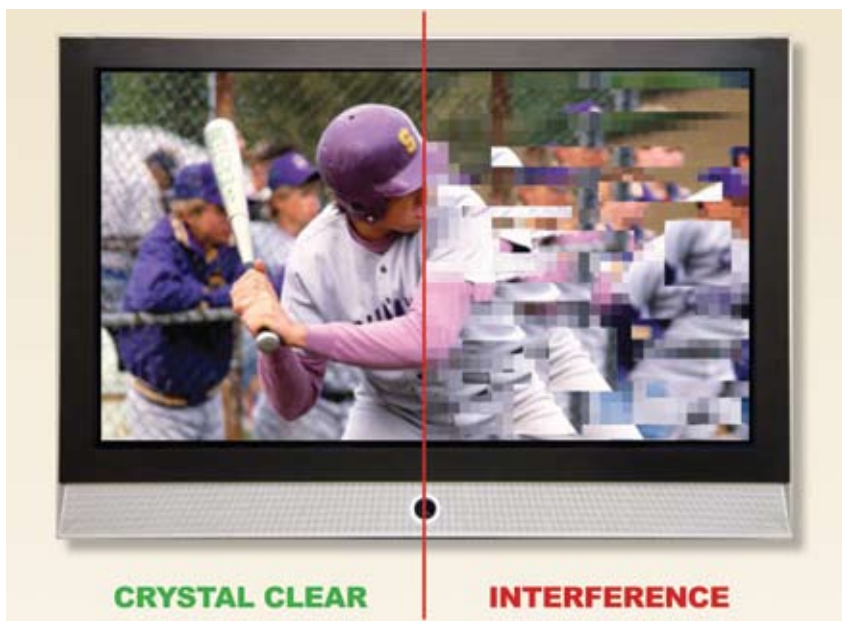


Figure 4 The NAB’s (National Association of Broadcaster’s) FUD (fear/uncertainty/doubt) campaign directly targets technology-ignorant consumers with pessimistic simplifications and ignores the fact that those consumers, not the NAB, own the spectrum from which it’s fighting to bar White Spaces devices.



## IMPLEMENTATION PLANS?

For some of you, this write-up may be your first significant exposure to the White Spaces controversy. Others of you, I suspect, are well-aware of the issues associated with this topic and are closely following developments at the FCC (Federal Communications Commission) and elsewhere. I welcome your posted comments at the version of this article on EDN's Web site ([www.edn.com/080807cs](http://www.edn.com/080807cs)). I'd also like to hear from readers in other countries, whose regulatory bodies may have a different perspective on White Spaces-spectrum equivalents and who may be further along in their implementation processes than their peers in the United States.

soft proof-of-concept prototype in mid-February, NAB (National Association of Broadcasters) Vice President Dennis Wharton proclaimed, "By failing two out of two tests at the FCC, Microsoft and the Wireless Innovation Alliance have demonstrated that unlicensed devices are not ready for prime time. This admission by 'white-space' proponents vindicates beyond doubt the interference concerns expressed by broadcasters, sports leagues, wireless-microphone companies, and theater operators" (Reference 10). In weighing the validity of the NAB's complaints and overall strategy, keep in mind that the spectrum that broadcasters are currently using doesn't actually belong to them; they lease it on a no-cost basis from the US government (Figure 4).

As noted, some camps, including Sprint Nextel, T-Mobile, and the overarching CTIA (Cellular Telecommunications and Internet Association), favor fee-based licensing of available VHF and UHF spectrum in a region as an alternative White Spaces approach. Pragmatically, these players likely see White Spaces-based mobile data, including VOIP (voice-over-Internet Protocol) services, as potential threats to their current and planned future wireless-data programs, such as 3GPP (third-generation-partnership project) LTE (long-term evolution) and WiMax (worldwide interoperability for microwave access). They therefore have a vested interest in increasing the cost, limiting location flexibility, and as much as possible slowing implementation of White Spaces development. Pragmatically, too, as the recently concluded 700-MHz-spectrum auction demonstrates, licensed White Spaces spectra would likely also end up in the possession of a few large telecom operators instead of, as White Spaces advocates wish, cultivating a Wi-Fi-rem-

iniscent ecosystem of equipment, software, and services.

Radio-astronomy- and medical-telemetry-industry participants aren't strong White Spaces backers, either; the FCC in 1963 reserved UHF Channel 37 for radio astronomy and in 1974 formally banned television-broadcaster use. White Spaces promoters have signaled their willingness to avoid using channels 36 to 38 to avoid potential destructive interference with such equipment. Shure publicly leads the other large, vocal anti-White Spaces alliance, the Microphone Interests Coalition. The members' complaints border on hypocrisy; although the law requires owners and operators of FCC Part 74 devices, such as wireless microphones, to obtain licenses, few do. "We-were-here-first" arguments lose much of their punch when, as it turns out, "we were here first, illegally" more accurately describes the situation.

But with respect to wireless microphones, White Spaces advocates are also guilty of oversimplification. They point to the prevalence of unlicensed VHF and UHF microphones, all generally working in a problem-free manner, as a proof of concept of the spectrum approach that White Spaces technology is attempting to also adopt. This pitch is at first glance persuasive, but further inspection reveals several notable holes.

[+](#) See the "White Spaces" posts at [www.edn.com/briansbrain](http://www.edn.com/briansbrain) for supplemental information on this article's topics.

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First, wireless microphones aren't spectrum-diverse; they transmit and receive on a fixed frequency. Therefore, unless you use them in multiple widespread regions with different spectrum-occupancy characteristics, they'll either always work or never work. And, as Shure's manager of educational and technical communications, Chris Lyons, pointed out during his April NAB-conference presentation, wireless-microphone transmitters' output is several orders of magnitude weaker than local-television-broadcast signals (Reference 11). A VHF- or UHF-based municipal-broadband-service network, conversely, would have broadcast-power characteristics closer to those of a local-television affiliate.

### ADDITIONAL CONCESSIONS

In attempting to appease the technology's detractors, White Spaces Coalition and Wireless Innovation Alliance members acting on their own and together have in recent months offered a number of additional implementation proposals, most notably in a Google presentation to the FCC in late March—ironically, one week after the conclusion of the 700-MHz-spectrum auction. Although these ideas would increase the cost and diminish the bandwidth robustness of White Spaces devices, the alternative scenario of no White Spaces devices is less palatable. Conversely, though, if spectrum-detection and -avoidance techniques by themselves prove to be sufficiently robust, White Spaces-technology implementers will likely discard the additional steps that follow in favor of minimizing the equipment's bill-of-materials costs.

As noted, Channel 37 conflicts with radio-astronomy and hospital-telemetry gear. However, avoidance of this channel plus a one-channel buffer on either side isn't a panacea; official FCC assignment of WMTS (wireless-medical-telemetry service) in the 608- to 614-MHz band to medical instrumentation didn't happen until 1998, and some hospitals are likely still using older equipment that employs other broadcast frequencies. Also up for potential channel-avoidance consideration are UHF channels 14 to 20, which find use for regional public-safety broadcasts.

Supplementing the broadcast-audio signals from wireless-microphone transmitters, beacons broadcasting on as-yet-undetermined frequencies would more

definitively direct White Spaces equipment to avoid using relevant portions of VHF and UHF spectra. Cost estimates for beacons vary widely, from tens to hundreds of dollars. White Spaces promoters' quotes lie predictably at the low end of the range; detractors' forecasts, at the high end. Detractors also argue that they shouldn't need to pay anything to ensure White Spaces technology's coexistence with their products.

White Spaces devices might even incorporate GPS (global-positioning-system) receivers, enabling them to discern their exact location at any time, along with dynamic access to a database of nearby VHF and UHF transmitters. Using this data, they could avoid the frequencies that those transmitters are using. And, when they lack access to the database, they don't transmit until they again assess that they can safely do so.

Google's interest in the White Spaces concept is understandable, given that the company's continued fiscal success hinges on users' convenient and low-cost or free access to its services, and that Google isn't yet an ISP (Internet-service provider) and therefore relies on ISP partners as intermediaries. White Spaces technology, coupled with the company's past success in getting the FCC to add open-access requirements to 700-MHz-spectrum licenses, which Google initially bid on but lost to Verizon, conceptually would make Google less vulnerable to the whims of such service-provider middlemen. However, whereas a GPS receiver might exist in an Android-operating-system-based mobile phone, for example, adding it to a device that doesn't otherwise need geolocation capabilities might prove too costly.**EDN**

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