Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of	)	
	)	
Additional Spectrum for	)	
Unlicensed Devices	)	**ET Docket No. 02-380**
Below 900 MHz	)	
And in the 3 GHz Band	)	

To: OET

COMMENTS OF

THE NEW AMERICA FOUNDATION
CONSUMERS UNION
CONSUMER FEDERATION OF AMERICA
MEDIA ACCESS PROJECT
CENTER FOR DIGITAL DEMOCRACY
PUBLIC KNOWLEDGE
BENTON FOUNDATION

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Summary

The FCC's recent Spectrum Policy Task Force Report endorses the allocation of more unlicensed spectrum.[1] In this notice of inquiry, all four sitting FCC commissioners echo this endorsement.[2] NAF et. al. wholeheartedly agree. Moreover, this new unlicensed spectrum is most needed in the lower frequencies, such as the broadcast band, with the most desirable propagation characteristics.

Fortunately, new spectrum technology, notably advanced digital receivers, is opening up vast swaths of capacity in the broadcast band. This new capacity offers a great opportunity to allocate unlicensed spectrum in the frequencies where it is most needed.

Specifically, commenters request three types of unlicensed allocations: 1) Pure, 2) Shared, and 3) Opportunistic. Pure unlicensed means a dedicated unlicensed band. Currently, more than 80% of TV channels 52-69 are designated guard band. Commenters request that these be immediately allocated for unlicensed, with the balance allocated after the digital television transition.

Shared unlicensed means a combination of licensed and unlicensed applications in the same frequency band. Currently, the broadcast band is largely exempt from low power underlays and other forms of unlicensed shared use. Commenters request that a low power unlicensed underlay be allocated on all broadcast bands, and that as smart receivers make more unused spectrum usable within these bands, this also be allocated to unlicensed.

Opportunistic unlicensed means use of licensed but unused information carrying capacity. Currently, many broadcasters operate below their maximum power levels, do not broadcast during certain dayparts, and otherwise do not fully use the spectrum allocated to them. Commenters request that with smart radios incorporating simple protocols such as "listen before talk," this unused spectrum can be used by unlicensed devices without harming incumbent licensees.

Lastly, commenters endorse minimum digital television receiver standards, with the caveat that the goal of the receiver standards is to maximize the total information carrying capacity of the broadcast band, not just the portion allocated to incumbent licensees.

[1] Spectrum Policy Task Force Report, Washington, DC: FCC, November 2002

[2] Attached comments of the four then sitting FCC Commissioners in the Notice of Inquiry in the Matter of Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, ET Docket No. 02-380.

Introduction

In recent years, devices using unlicensed spectrum, such as Wi-Fi, have become the center of competition and innovation in the telecommunications sector. This achievement has come despite the fact that unlicensed applications have not been allocated prime space in the radio frequency spectrum. This FCC Notice of Inquiry requests comment on whether unlicensed applications should be allowed into the most desirable part of the radio frequency spectrum—the broadcast band. In particular, we interpret it as requesting comment on whether the new, "empty" spectrum being opened up by new spectrum technology should be allocated for unlicensed use. We believe that the current policy of forcing unlicensed applications into less useful frequency bands, the "spectrum slums," has been a mistake. This NOI represents a historic opportunity to give unlicensed applications the spectrum they need to achieve their full potential. This potential includes providing a low-cost last-mile broadband Internet solution.

Over the last few decades, the rate of innovation in the telecommunications backbone has far exceeded the rate of innovation in the "last-mile." As a result, high prices, slow speeds, and inconvenient wires characterize last mile connections. A single strand of fiber optic cable carries tens of billions of bits/second, but residential Internet connections over phone or cable wires rarely reach even a small fraction of this speed. A major cause of this last mile problem is the government's failure to manage spectrum efficiently. Generally, as the telecommunications network gets closer to the home, wireless becomes the most economical solution. Why spend money to dig up neighborhood streets, private lawns, and household walls when the same information can pass through the air? This is why Africa, China, and most other nations without legacy wired networks are deploying wireless in their last mile.

Generally, also, as wireless applications get closer to the home or are located in less densely populated areas, unlicensed allocation becomes a more efficient allocation regime than licensed. Why pay a third party to provide garage door opener service, TV remote control service, or rural Internet links over empty fields, when it can be done more efficiently via a decentralized and localized system of unlicensed spectrum? This helps explain why unlicensed devices now outnumber licensed ones by a factor of at least 10 to 1 in America and may outnumber them by a factor of more than 100 to 1 in the near future.[3] It also helps explain why, despite the dearth of high quality unlicensed spectrum, most rural wireless Internet Service Providers now use unlicensed spectrum.

The government could help the public save hundreds of billions of dollars of next-generation last-mile telecommunications investment if it made available for unlicensed use some of the broadcast band. This includes the billions of dollars to dig up roads, lawns, and walls for ubiquitous high-speed access, the billions of dollars to wire schools for gigabit broadband when unlicensed spectrum could provide a better service, and the billions of dollars in last-mile subsidies to wire rural areas for even today's slow and

[3] For an overview of the explosion of unlicensed devices in the home and business, see The Explanation to the Citizen's Guide to the Airwaves, Washington, DC: New America Foundation, May 2003.

tethered broadband access. Appendix A lists the many locales now receiving service from unlicensed wireless Internet service providers (WISPs).

I. The Commission should maintain and enforce the current limited scope of the broadcasters' spectrum easement.

Consider a rancher who has secured a contract to graze his cattle on federal land. Oil is discovered on the federal land, and the rancher naturally wants to expand his contract to include oil rights. Should he be allowed to? The law says he doesn't own those rights.

Now consider spectrum. New spectrum technologies make it possible to cram far more services, including unlicensed, into frequencies allocated to local TV broadcasters. Should local TV broadcasters be allowed to appropriate those rights as part of their license to provide TV service? Again, the law says no.

Broadcasters are granted a license to provide a limited set of services over a set of frequencies. They are not granted a license to the entire communications capacity of a set of frequencies, only the part of the frequencies necessary to provide their licensed services. For example, it is illegal for broadcasters to provide mobile telephone service or satellite broadcast TV service with their analog spectrum. By convention and law, their spectrum is primarily restricted to the provision of local, ad-supported ("free") TV programming.

When broadcasters migrate to digital spectrum, however, they will have the opportunity to offer new "ancillary" services. However, the broadcasters do not receive this capability for free. The Telecommunications Act of 1996 mandates that the Commission recover the value of these new uses to the public.

Similarly, as the ability to use existing spectrum for purposes other than broadcasting is authorized by the Commission, that new capacity belongs to the public, not to the broadcaster. There is no "entitlement" to the 6 MHz of spectrum historically required to provide one analog channel. To the contrary, the Commission should limit the broadcaster to the bare minimum necessary to provide the service of a free, over-the-air broadcast channel.

Since broadcasters do not own spectrum, any right not specifically contained in their license belongs to the public.[4] Broadcasters, in other words, are granted an easement by the public to provide a certain set of services. The right to grant an easement belongs to the public, not the broadcasters. Even if it is argued that broadcasters should be allowed to increase the scope of their easement (with or without compensation to the public), this does not give them ownership rights.

As new technology opens up vast amounts of new information carrying capacity in spectrum previously thought to be fully utilized, incumbent licensees naturally want to

[4] Communications Act of 1934, Title III, Section 301.

lay claim to this capacity for themselves. The FCC should resist. A good precedent for this resistance is microwave point-to-point communications. The FCC's clearly stated policy is that if a licensee has a right to use a fixed, directional antenna to transmit a signal to a fixed, directional receiver (for example, to link a mobile cell tower to the telecommunications backbone), it does not also have the right to preclude other cross-cutting point-to-point communications on the same spectrum. The FCC now needs to bring similar clarity to the broadcast band. The politics of the broadcast band may be different, but the underlying technological and public policy logic are identical.[5]

II. The Commission should allocate more unlicensed spectrum in the broadcast band.

NAF, *et al.* detailed the general merits of additional unlicensed spectrum use more fully before the Spectrum Task Force.[6] As explained in detail in previous filings, unlicensed spectrum use promotes innovation in the development of new technologies and new uses of spectrum that benefit the public as a whole. In doing so, the Commission fulfills its responsibilities under Section 303(g) to "encourage the larger and more effective use of radio in the public interest."

More importantly, increasing available unlicensed spectrum use furthers the public's First Amendment interest in the use of the electromagnetic spectrum. As the Commission well knows, licensing constitutes a necessary restriction on the speech of the huge numbers of would-be spectrum users. Because use by everyone would create interference rendering spectrum usable by no one, the Commission may limit who may broadcast and how. *Red Lion Broadcasting, Inc. v. FCC*, 395 U.S. 367, 386-91, 396-401 (1969). But the public retain their "paramount" First Amendment rights in spectrum as both speakers and listeners. *Id.* at 390-91. To the extent new technologies further empower the public as speakers, it serves the interests of the First Amendment.[7]

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[5] This NOI takes as a given that broadcasters should be allowed to continue their present, licensed service: broadcast TV. Thomas Hazlett and others have argued that this is an extremely inefficient use of the broadcast allocation, given that local broadcast TV can be provided just as well via cable TV and the far less valuable satellite TV frequencies. For more information, see Thomas Hazlett, "The U.S. Digital TV Transition: Time to Toss the Negroponte Switch," Working Paper 01-15, Washington, DC: AEI-Brookings Joint Center for Regulatory Studies, November 2001.

[6] For more information on the merits of unlicensed, see NAF et al. FCC comments and reply comments, Kevin Werbach, "Open Spectrum: The New Wireless Paradigm," Washington, DC: New American Foundation, October 2002.

[7] This does not relieve broadcasters of their public interest obligations. As *Red Lion* observed, the fact that technology continues to advance and render spectrum use more efficient has not resolved the basic dilemma that there are far more would-be users of the spectrum than the current technology can accommodate. *Id.*, 396-99. Moreover, these uses of the spectrum simply do not compare to the power of traditional broadcasting and the privileged place exclusive licensing secured for incumbent broadcasters. As the Court explained:

> Even where there are gaps in spectrum utilization, the fact remains that existing broadcasters have often attained their present position because of their initial government selection in competition with others before new technological advances opened new opportunities for further uses. Long experience in broadcasting, confirmed habits of listeners and viewers, network affiliation, and other advantages in program procurement give existing broadcasters a substantial advantage over new entrants, even where new

Accordingly, the FCC's *Spectrum Policy Task Force Report* and *Unlicensed Devices and Experimental Licenses Working Group Report* endorsed the allocation of more unlicensed spectrum. In addition, the accompanying FCC commissioner comments to this NOI all support additional unlicensed spectrum. The specific question is whether the broadcast band is appropriate for unlicensed services and, if so, how this should be implemented across the 67 channels currently allocated to broadcasting service.

These comments focus on the question of unlicensed operation in the broadcast bands rather than the 3650-3700 MHz band. The 3650-3700 MHz frequencies are located much higher than the TV broadcast bands and hence are much less valuable for unlicensed uses (see the next section on the special propagation characteristics of the broadcast allocation). Furthermore, the amount of spectrum in question is 50 MHz as opposed to the 402 MHz allocated to the local TV broadcasters. However, it should be understood that we strongly support maximal dedicated unlicensed use of this band, as the NOI proposes.

A. Not all spectrum bands are equal: The broadcast bands are vital for unlicensed to reach its full potential

While each similarly sized swath of spectrum has the same information carrying capacity, certain fundamental characteristics affect the value of using spectrum. These characteristics cause the value of spectrum to plummet above 3 GHz.[8]

In particular, there is a huge difference in value between the frequencies allocated to broadcasters and the higher frequencies often mentioned as prospects for more unlicensed spectrum. A 6 MHz swath of spectrum (the size of a single TV channel) at 500 MHz greatly differs from a 6 MHz swath of spectrum at 50 GHz.[9] One major reason is that the spectrum allocated to radio and TV broadcasters is extremely well suited for passing through objects such as buildings, weather, and foliage. (In contrast, spectrum allocated to satellite broadcasters must have a clear path to the receiving dish). Imagine using your car radio or cell phone, for example, if every time you passed a tree or building it went dead. This explains why comparable auctions for spectrum at low frequencies have brought in hundreds of times as much money per megahertz as auctions for spectrum at higher frequencies.

> entry is technologically possible. These advantages are the fruit of a preferred position conferred by the Government. Some present possibility for new entry by competing stations is not enough, in itself, to render unconstitutional the Government's effort to assure that a broadcaster's programming ranges widely enough to serve the public interest.

Id. 401.

[8] J.H. Snider, "The Explanation of the Citizen's Guide to the Airwaves," Washington, DC: New America Foundation, May 2003.

[9] The Spectrum Policy Task Force recommends more unlicensed at frequencies above 50 GHz. For more information see SPTF Report, Washington, DC: FCC, November 2002, p. 38.

Consider a potentially common unlicensed application: wirelessly linking a next-generation (very-high-speed) broadband connection from the street curb into every nook and cranny in the house. Currently, the main Internet links into the home are telephone and cable wires. Now assume, as many do, that a) the ability of wireless to provide ubiquitous, mobile service within the home is highly valued, and b) wireless links offer a considerable cost savings over wired links (it is estimated that 55% of wiring costs are just to get from the curb into the home.). The implication is that wireless is better than wired as a next-generation broadband solution into the home. But if every physical obstacle—such as a wall or person inside a house, or a tree or rain storm outside—slows down or stops a wireless signal from getting from the street curb to the communications device in the home, then the value of unlicensed wireless is seriously diminished.

Similarly, consider unlicensed wireless as a last-mile rural broadband solution. If the signals cannot easily pass through trees, houses, and bad weather—the way broadcast signals can—then the value of unlicensed wireless as a last-mile solution is significantly reduced. Unlicensed wireless Internet Service Providers report that this is a huge barrier to service provision in many rural areas.

B. The Commission must acknowledge these well known differences in spectrum bands and must cease equating all bands as equivalent bands for unlicensed uses

While these differences are well known in business and engineering circles, the FCC's Spectrum Policy Task Force Report inexplicably failed to acknowledge this important consideration in advocating for more unlicensed spectrum.[10] The broadcasters themselves have often obscured this fact when lobbying the FCC and Congress not to auction or otherwise make claims on their spectrum.[11]

Of greatest concern, comments by top FCC officials have indicated that they consider high- and low-frequency unlicensed spectrum as comparable. For example, when several hundred megahertz were recently set aside for unlicensed service in the 5 GHz band, the chief of the FCC's Office of Engineering and Technology reportedly boasted that the amount of unlicensed spectrum would be doubled.[12] He did not mention that the reference point for the doubling was spectrum at a lower frequency; or the fact that at the same time the FCC was boasting about more unlicensed spectrum at the higher frequencies, it was considering reducing unlicensed spectrum at the lower frequencies.

The Commission must stop equating quality with quantity. For unlicensed uses to thrive, innovators must have access to the so-called "beachfront" spectrum currently allocated for broadcasting. This will allow entrepreneurs and rural providers with limited resources to deploy cost effectively, making wireless a real last mile solution.

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[10] *Ibid*.
[11] E.g., "The Hidden Cost of Spectrum Auctions," unpublished white paper distributed to members of Congress, July 1995.
[12] Mary Greczn, "FCC Tees Up Spectrum Rulemaking and UWB Follow-up," *Communications Daily*, February 7, 2003, p. 5.

C. The Commission must acknowledge the gross underutilization of the broadcast band, even with so-called "digital TV"

The broadcast band is famously underutilized. Perhaps no greater issue has preoccupied scholars of broadcast spectrum policy over the last forty years than this underutilization problem.[13] In the memorable phrase of Mark Lewyn: "Television is the wasteland of wasted spectrum."[14] Admittedly, large amounts of underutilized spectrum have come into use over the years. But new technology has chronically outpaced the ability of our spectrum regulatory system to bring this spectrum into efficient use.

Currently, there are 402 MHz allocated for local TV broadcasting. This 402 MHz is scattered between the frequencies of 54 MHz and 806 MHz, and it is divided into 67 channels of 6 MHz each (on your TV set, these are marked channels 2-69; channel 37 is unused). After the digital TV transition, a total of 294 MHz and 49 channels will remain allocated to broadcasting.

Although there are 67 channels, the average American TV market only receives at present slightly more than 7 channels.[15] The remaining channels, close to 90%, are left empty. Most of this empty space was to provide interference protection ("guard bands") to broadcasters. For example, channel 22 can not be simultaneously used in adjacent markets because the two broadcasts would conflict with each other. Nor can channel 23 be used in the same market as channel 22 because at least one guard channel is needed to separate TV stations in the same market. Given these intra-market and inter-market needs for interference protection, each used TV channel has been given multiple unused guard channels to provide TV service.

With higher quality digital TV receivers, many of these guard bands could be used without degrading the quality of existing analog TV service. Thus, using the ATSC digital TV receiver standard, every existing analog TV channel was given a second digital TV channel. This increased the ratio of used to unused TV channels by a factor of 2. Similarly, the ATSC standard allows approximately 10 standard definition digital TV programs to fit in the 6 MHz previously only able to fit 1 standard definition analog TV channel.[16] Overall, then, the information carrying capacity of the local TV broadcast

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[13] For an early example, see Harvey Levin, The Invisible Resource: Use and Regulation of the Radio Spectrum, Baltimore: Johns Hopkins Press, 1971. For a recent example, see Thomas Hazlett, "The U.S. Digital TV Transition: Time to Toss the Negroponte Switch," Working Paper 01-15, Washington, DC: AEI-Brookings Joint Center for Regulatory Studies, November 2001.

[14] Mark Lewyn, "Airwave Wars," Business Week, July 23, 1990.

[15] Thomas Hazlett, "The U.S. Digital TV Transition: Time to Toss the Negroponte Switch." Note that the distribution of these channels had a large variance across the 210 United States TV markets. A large market, such as New York City, might get as many as 20 channels whereas a small market might get only one.

[16] The estimated number of standard definition TV programs per channel has evolved significantly over time and depends on a variety of factors such as the amount of changing detail in a TV image. The ATSC TV standard allows for 19.4 Mbps, so we are assuming an average of 1.94 Mbps for 10 statistically multiplexed standard definition programs. By statistically multiplexed we mean an average bit rate for all 10 programs, not a maximum. For example, if one TV program has an action packed sequence with a lot of

spectrum increases by a factor of about 20 with the introduction of ATSC digital TV receivers. In addition, many broadcasters were allowed to increase their power levels (which expanded their geographic range and potential customer base) as a result of the elimination of guard bands.[17]

Thanks to the wonders of the new digital receivers, the new 6 MHz digital channels, one for each analog channel from channels 2-69, have been fit into the unused guard bands previously allocated to channels 2-51. Moreover, each of the new digital signals can carry ten times as much programming as the old analog signals. Also, thanks to the proposed 7dB receivers (the original receivers had an interference tolerance of 14 dB), the UHF stations have expanded their geographical range. This implies that the underutilization on channels 52-69 is equally huge and could be used immediately.

These channels are already scheduled to be returned to the public for use. The current broadcasters will migrate to digital spectrum.

As it turns out, the potential of new digital TV receiver technology to create new spectrum information carrying capacity was barely scratched with the introduction of the first generation ATSC digital TV receiver—a technology that is already more than ten years old.[18] As Intel's Kevin Kahn has testified before the U.S. Senate: "Given the current limitations of television receivers, most of the TV channels in any geographic area are unused. Advanced radio techniques, however, might permit unlicensed use, without any adverse impact on the broadcasters."[19]

The question is: what should we do with all this capacity? In particular, should at least some of it be allocated to unlicensed?

III. The Commission should allocate unlicensed spectrum rights in the underutilized parts of the broadcast band.

As new technologies evolve that make possible more intensive use of spectrum, the amount of underutilized spectrum is exploding. Rather than create a windfall for incumbents, who received their spectrum for free on condition that they serve the public,

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changing detail requiring 3 Mbps, this may be counterbalanced against a talking head sequence with little changing detail requiring 1 Mbps. The use of small 6 MHz channels minimized the efficiency gains from statistical multiplexing, especially for HDTV, where only 2 HDTV programs can fit in a 6 MHz channel.

[17] Broadcasters were originally supposed to return more than 150 MHz after the digital TV transition. Thanks in part to lobbying efforts to maximize broadcaster power levels, this was ultimately reduced to 108 MHz. UHF broadcasters argued it was unfair that VHF broadcasters had higher power levels and that they should be allowed to have higher power levels. Since most TV stations are owned by large TV groups with a mix of both VHF and UHF stations, there was little political opposition to this effort. The higher power levels only came at the expense of the public—the number of channels to be returned after the digital TV transition.

[18] David Weinberger, "The Myth of Interference: Internet architect David Reed explains how bad science created the broadcast industry", Salon, March 13, 2003. http://www.salon.com/tech/feature/2003/03/12/spectrum.

[19] Testimony of Kevin Kahn, Intel Corporation, before the Senate Commerce Committee, "Hearing on the Future of Spectrum Policy and The FCC Spectrum Policy Task Force Report," March 6, 2003, p. 10.

the Commission should return the new information carrying capacity to the public immediately in the form of expanded unlicensed spectrum use.

Commentors further observe that this spectrum is already earmarked for return to the public. However, ***the public need not wait for full digital conversion to enjoy the use of this public resource***. Because the current technology permits non-interfering uses, the public can begin to enjoy use of these spectrum bands immediately.

Commentors propose three ways to allocate this underutilized spectrum to unlicensed:[20]

A. **Pure Unlicensed**—Create a new unlicensed spectrum band dedicated to unlicensed use.
B. **Shared Unlicensed**—Divide spectrum bands into a licensed and unlicensed portion, including an unlicensed underlay.
C. **Opportunistic Unlicensed**—Allow unlicensed devices to make opportunistic use of spectrum temporarily unused for a licensed purpose.

The Commission should employ all of these methods in the broadcast bands. Specifically, shared and opportunistic unlicensed use should be allowed in all TV channels immediately. Pure unlicensed uses should be phased in as the digital television transition progresses. By law, the licenses to broadcast on channels 52-69 are to be returned to the public after the Digital TV transition.

Opportunistic use may be least controversial to implement immediately because it leaves incumbents the right to eliminate those uses at will simply by increasing their own usage.[21] This is, however, only a transition stage to full unlicensed use following migration and improvements in technology.

A. The Commission should allocate *more pure unlicensed bands*

Currently, the dedicated unlicensed bands receive the most intense unlicensed use. These are the bands at 902-928 MHz, 1910-1930 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.[22] The Spectrum Policy Task Force Report, FCC commissioners, major computer industry companies, and members of Congress, have all called for more dedicated unlicensed spectrum. Dedicated unlicensed bands have allowed for higher power levels,

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[20] These three models are derived from the Spectrum Policy Task Force and Unlicensed Working Group report. Some changes have been made. Notably, what the task forced described as opportunistic sharing has been reduced, with the balance shifted under the heading of shared use. FCC Spectrum Policy Task Force, Report of the Unlicensed Devices and Experimental Licenses Working Group, November 15, 2002, pp. 15-16.

[21] However, incumbent license holders strongly oppose opportunistic use because of the widely held view that "possession is nine-tenths of ownership." That is, if a body of users becomes dependent on using the unused spectrum, broadcasters will have a harder time reclaiming it in the future because they will have allowed a potentially potent political force to be created.

[22] Spread spectrum technology is not permitted to operate across the 1910-1930 MHz band, thus significantly reducing its utility. The FCC is expected to convert this band to licensed use. Other dedicated unlicensed bands are available at higher, less valuable frequencies.

less regulatory uncertainty, and faster rollout of last-mile solutions. Proposals for incumbents to share spectrum tend to invite spurious claims of interference and years of costly litigation.[23]

While the full scope of the broadcast channel allocation the Commission dedicates to unlicensed use ultimately depends on the time horizon and the progress of the digital television transition, the public need not wait to receive the benefits of unlicensed use. Many channels could be converted to unlicensed use now without interfering with either current analog transmission or conversion to digital.

The digital conversion calls for broadcasters to relinquish channels 52-69. Broadcasters currently on channels 52-69 will be required to move to unused channels between channels 2-51. Commenters propose two major phases for implementing dedicated unlicensed: the short-term (prior to the return of channels 52-69) and the long-term (after the return). Commenters further divide the long-term into considerations pertaining to channels 52-69 and channels 2-51.

1. Short Term: The Commission should dedicate to unlicensed use "guard bands" on channels 52-69

Table 1 and Figure 1 describe the present utilization of broadcast spectrum between channels 52-69 with respect to a) the average number of channels allocated for use, and 2) the average number of channels for use weighted by population. Regardless of whether channel utilization is weighted by population, only a small fraction of channels are allocated for high power broadcast TV in the 210 Nielsen designated TV markets[24].

Table 1 illustrates the low spectrum utilization rate of the Lower and Upper 700MHz bands and are the data we use to generate Figure 1. The column labeled "By Allocation (%)" shows the percentage of stations operating on a particular channel (across all 210 market areas) and is not affected by the size of the population within those markets. According to Commenters' tabulations, among the 210 markets, 58 have no stations between channels 52-69.

The column labeled "By Population (%)" shows the percentage of viewing households out of the total number of viewing households (from all 210 market areas) that can receive a particular channel. By its nature, this second column weights television coverage depending on the size of the market.

These utilization numbers indicate that there is a roughly 1 in 14 chance of a high-powered station allocated on one of channels 52-69 in your area, and a 1 in 5 chance that the station actually exists based on population coverage. Since a significant fraction of

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[23] For more information, see Thomas Hazlett, "The Wireless Craze: An Essay on Airwave Allocation Policy," *Harvard Journal of Law and Technology*, Spring 2001.

[24] For more information, see: "210 Designated Market Areas", Nielsen Media Research Local Universe Estimates, http://www.nielsenmedia.com/DMAs.html

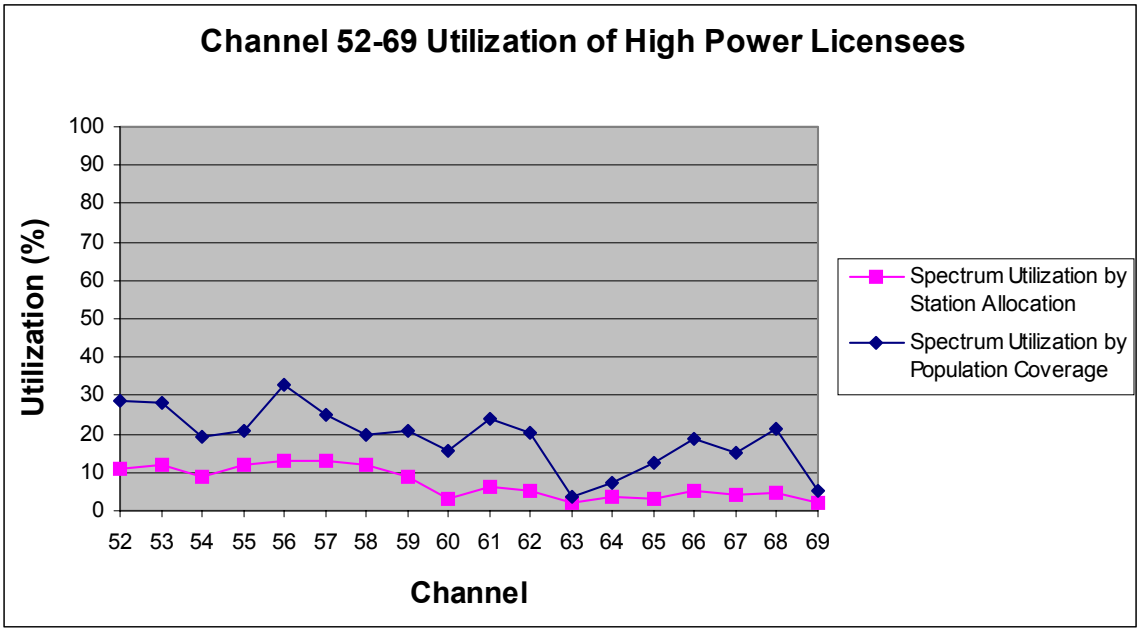
this spectrum lies untapped, a large fraction of the unused channels could be immediately opened to unlicensed use.[25]

Table 1. Spectrum Utilization of High Power TV Stations, Channels 52-69

High Power Station Spectrum Utilization Rate		
Channel	**By Allocation (%)**	**By Viewing Households (%)**
52	10.95	28.73
53	11.90	28.08
54	9.05	19.03
55	11.90	20.60
56	12.86	32.58
57	12.86	24.96
58	11.90	19.99
59	9.05	20.62
60	3.33	15.60
61	6.19	23.96
62	5.24	20.45
63	1.90	3.71
64	3.81	7.52
65	3.33	12.73
66	5.24	18.60
67	4.29	15.31
68	4.76	21.14
69	1.90	5.14
Average	**7.25**	**18.82**

[25] This analysis ignores TV translator stations, Low Power TV stations, Canadian and Mexican TV channels broadcasting over the U.S. border, and other services that have been allowed to use the guard bands. These services are supposed to transition to channels 2-51 along with the high TV power stations. Most of these services are secondary and were given notice that their licenses may not be renewed if high power TV licensees needed their spectrum to complete the digital TV transition.

Figure 1. Spectrum Utilization of High Power TV Stations, Channels 52-69



Regarding the process by which stations were sorted and selected for tabulation, there were instances in which a station located in proximity to a television market could be disqualified. To be counted into a market, we decided that a station needed to be within 10 miles of the center of the designated market. Stations located outside this limiting radius would be disqualified, since the signal would not be reliably receivable by the entire population of the television market. This rule applied equally to stations of all transmission power levels. Examples of such borderline cases include the decision to include WCVN-TV of Covington, KY in the Cincinnati market area, and the decision to exclude WTTK-DT of Kokomo, IN from the Indianapolis market area.

a. Wireless Microphones Demonstrate the Viability of Unlicensed Uses in the Broadcast Bands

The Commission already permits certain unlicensed uses in the unused guard band frequencies within the 470-806 MHz band (the TV UHF channels).[26] Wireless microphones are widely used in TV production and many other performance venues, including theaters, concerts, football stadiums, and auditoriums. It's not unusual to have a large event where many dozens of wireless microphones are used, each operating on a different frequency. At a professional football game, for example, coaches (e.g., to talk to a quarterback's in-helmet receiver), vendors, security personnel, half-time performers, reporters, referees, and maintenance crew may all use wireless microphones on different unused channels. These wireless microphones can transmit up to 1,000 feet (close to a half mile in diameter), farther than the typical unlicensed Wi-Fi transmitter. Wireless

[26] For more information, see Reply Comments of Shure Incorporated, ET Docket No. 01-75, "Revisions to Broadcast Auxiliary Service Rules in Part 74."

microphone users insist that only low frequency bands—notably the broadcast band—can suit their requirements.[27]

Success of this limited use provides adequate "proof of concept" necessary to justify expanding unlicensed wireless uses within the band. Indeed, the Commission itself recently took further steps to expand the uses in this band. On November 13, 2002, the FCC released a Report and Order granting similar capabilities, but for audio and video, to Wireless Assist Video Devices (WAVD). Usage of these bands for audio/video transmission is restricted to those engaged in the movie and TV production businesses. Users must get permission to use the unused TV channels from the local TV Broadcast Auxiliary Band Coordinator. These coordinators manage use of the approximately 4 gigahertz of high-frequency spectrum that broadcasters currently share for purposes such as electronic newsgathering (reporting live from the field), linking stations to TV transmitter towers, and linking TV stations between cities.

The Commission should continue to open up the spectrum for unlicensed use. However, the Commission should not require users to seek permission for uses. Instead, the Commission should mandate that sufficient intelligence reside in the device to "ask" permission by determining whether spectrum is available.[28]

2. Long Term: The Commission should dedicate all channels 52-69 to unlicensed use

After the digital TV transition is complete, we propose that the entire band be devoted to unlicensed. If congestion proves to be problem, then a system of unlicensed spectrum with congestion pricing, as proposed by Eli Noam, could be created.[29]

The Noam Unlicensed Model argues that spectrum should be unlicensed and available to all without paying a fee as long as congestion does not become a problem. However, if and when congestion becomes a problem, a price mechanism could be used to ration access. This would presumably only involve the subset of unlicensed use employing relatively high power. Low power unlicensed users, even those simultaneously sharing the same spectrum as the high-powered users, would be unaffected (see the discussion below on shared use and underlays).

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[27] *Ibid*.

[28] Although performance is impacted by its use, technology such as Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) allows multiple ethernet users to share the same spectrum in wireless environments. Defined by the IEEE 802.11 standard, CSMA/CA is in essence a listen-before-talk solution to spectrum cacophony. Since such technology already exists and is widely deployed among Wi-Fi equipment, it is the logical facilitator for extending unlicensed technology into the broadcast bands. See: http://www.commsdesign.com/design_corner/OEG20020201S0035. See also: In the matter of Interference Performance Specifications for Radio Receivers, ET Docket No. 03-65, Released March 24, 2003; David Weinberger, "The Myth of Interference: Internet architect David Reed explains how bad science created the broadcast industry," *Salon*, March 13, 2003.

[29] Eli Noam, "Spectrum Auctions: Yesterday's Heresy, Today's Orthodoxy, Tomorrow's Anachronism." *Journal of Law and Economics*, Vol. XLI (October 1998), p. 765.

Noam uses traffic management to explain congestion pricing. The government doesn't sell access to use the roads. But if traffic on highways becomes too great, it can charge higher tolls on some or all lanes to reduce traffic.

The Internet is a prime example of a network technology that has not had to resort to congestion pricing despite huge demand. Consumers pay a fixed fee for use of the Internet regardless of usage. The reasons for this are complex, but we believe a similar regime can and should be applied to spectrum management.

3. Long Term: The Commission should dedicate to unlicensed use "guard bands" on channels 2-51

Thomas Hazlett has estimated that after the digital TV transition the average U.S. TV market will only have 7 channels, with 42 channels still left for other services.[30] Various new technologies could open up many of these bands. For example, the FCC's Spectrum Policy Task Force proposal to allow broadcasters to divide their high power transmitters into many low power transmitters would greatly reduce the need for guard bands in adjacent markets. Similarly, if new smart receivers allowed broadcasters to use spread spectrum technology, the need for guard bands within markets could be completely eliminated. It's hard to imagine how these technologies would ever be implemented unless broadcasters could get a large cut of the guard band spectrum opened up. But we believe that over time substantial guard band spectrum below channel 52 will open up and that as much as possible should be allocated to unlicensed.

B. The Commission should allocate *shared unlicensed* on channels 2-69

There are many potential types of shared use. Robert Matheson, for example, has developed a typology, called "The Electrospace Model," to explain various ways a set of frequencies can be divided and specified in a license.[31] In his model, a licensee need only be given the right to radiate within a licensed electrospace region, which is defined far more narrowly than the current FCC frequency allocation scheme. Commenters here will focus on only one type of potential shared use: a low power underlay.[32]

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[30] For more information, see Thomas Hazlett, "The U.S. Digital TV Transition: Time to Toss the Negroponte Switch." Hazlett observes that the average market has 7 analog stations, 13 on a population-weighted basis. After the DTV transition, when the original analog stations are returned, the same number of channels are supposed to remain because of the 1:1 relationship between analog and digital channels. The situation is more complex than alluded to here, largely because of the large number of low powered TV devices allowed on the "guard" bands. Most of these low power stations are secondary.

[31] For more information, see: Robert Matheson, "The Electrospace Model as a Frequency Management Tool," presented at the 2003 ISART Conference, Boulder, Colorado, March 2003.

[32] Matheson didn't include underlays in his model because he developed his model to specify exclusive use, not shared use. Underlays share the same frequencies in the exact same place. However, Matheson's model is so fine-grained that he demonstrates that today's service rights are by no means comprehensive. For example, today's broadcasters have a right to transmit from a specific location. Matheson's model suggests that this leaves a huge amount of spectrum unused and available for assignment to unlicensed use. For example, assume TV sets had directional antennas; that is, they point in the direction of transmitters. Currently, Direct Broadcast Satellite TV (DBS) dishes and many rooftop TV antennas are directional.

Today, under Part 15 rules, many bands of spectrum have a low power underlay and a high power overlay. For example, garage door openers share the same spectrum used by the United States Defense Department. However, unlike most other bands, the broadcast band has been largely exempt from Part 15 rules.[33] This exemption should end. Moreover, Part 15 type rules can be significantly enhanced, including higher allowed power levels and power levels variable by GPS determined location and other factors.

Consider one important way that unlicensed and licensed services can share the same band. The critical point to understand this example is that electromagnetic signals travel in waves, not particles. When they cross each other's path, they do not destroy each other but temporarily superimpose each other and then pass through each other. The consequence is that a high power wave can pass through a low power wave without any impact except in the immediate vicinity of the low power wave. Figure 2 visually describes this phenomenon in a 2-dimensional wave diagram. The width of the concentric circles corresponds to the power level of the wave, which drops off geometrically with distance from the transmitter.

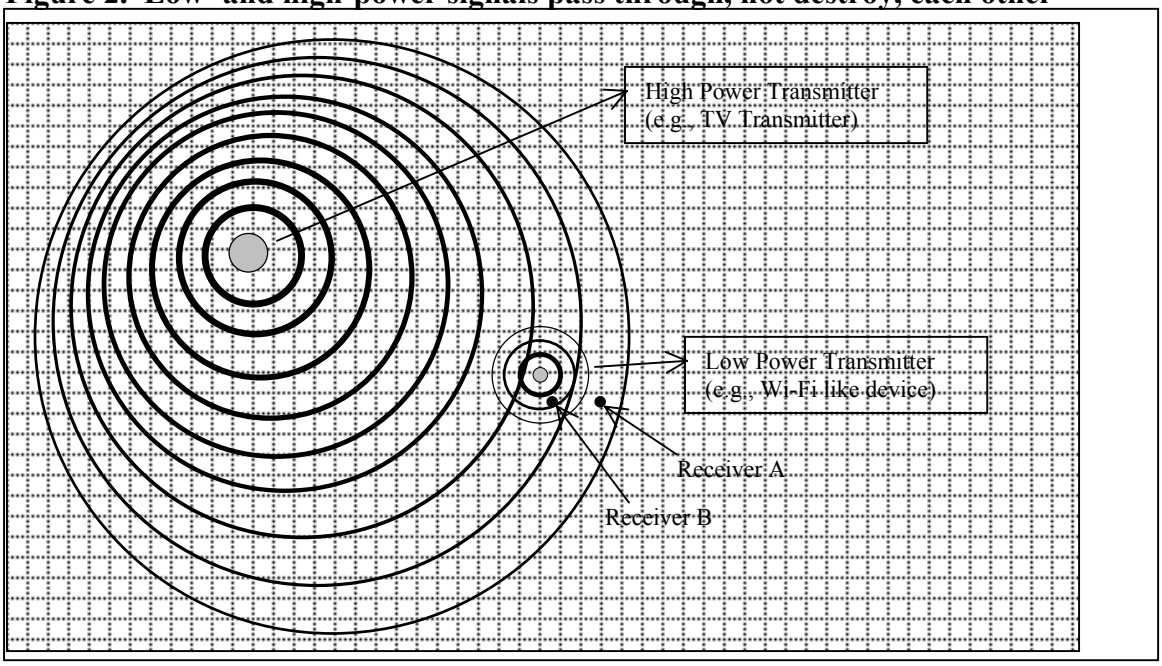
The high power source of waves can be thought of as a TV transmitter, and the low power source of waves a Wi-Fi-like transmitter within the home. The high-power transmitter may suffer interference in the immediate vicinity of the Wi-Fi transmitter, but it is otherwise unaffected. In other words, Receiver A can still receive the high power signal despite the fact that a low-power transmitter using the same spectrum is located directly between it and the high-power transmitter. Only Receiver B cannot receive the high-power signal, which would ultimately be a choice for Receiver B to decide.[34]

Also assume that new digital TV sets had smart receivers, allowing them to distinguish transmissions by angle of reception. Then, if Station A was broadcasting from the South, unlicensed users could broadcast from the North without interfering with the reception of Station A. This is the type of technology that allows Northpoint, a terrestrial service, to reuse the spectrum currently used by DBS. DBS uses a directional antenna (a satellite dish) that points South. A second directional antenna pointing in the opposite direction allows Northpoint to reuse the spectrum based on direction of reception." See: Comments of Northpoint in Multichannel Video Distribution and Data Service (MVDDS) Proceeding, ET Docket No. 98-206**.**

[33] For more information, see: 47 C.F.R. §§ 15.231, 15.241, and 15.242. Medical telemetry is one exemption.

[34] Of course, it is currently illegal to run Wi-Fi and most other types of unlicensed devices in the broadcast band. Hence the phrase "Wi-Fi-like."

Figure 2. Low- and high-power signals pass through, not destroy, each other



This physical description implies that in a given location a receiver cannot receive both a low- and high-power receiver. The homeowner must choose between getting the TV signal or Wi-Fi signal, but cannot get both. However, this assumes receivers are dumb (such as the type of receiver in a TV set), unlike much currently available "smart radio" technology. With smart receivers, it's possible for receivers to distinguish between the high- and low-power signals based on other variables. For example, if the broadcast tower is transmitting from the North and the Wi-Fi node is transmitting a few degrees off to the East, then a receiver with a directional antenna can distinguish between the two signals based on the angle of reception. In this case, Receiver B would still be able to receive the high-power signal. To get a better sense of the power of a smart receiver, consider the human ear. In a crowded room with many conversations going on at once, it can use direction, voice, language, and volume to identify different speakers and choose a conversation to receive.

1. Homeowners, not incumbent licensees, should decide whether to accept interference at the receiver

It may happen that a person using an unlicensed device might experience substantive interference on a broadcast receiver. This decision, like the decision whether to receive any broadcast signal at all, lies squarely with the individual. The Commission must not adopt a paternalistic attitude that over-the-air broadcast signals are "better" for individuals than a home network. To do so raises profound questions regarding the First Amendment rights of would-be speakers through the electromagnetic spectrum.

Of course, the Commission must ensure that an individual's actions do not imperil the reception of his or her neighbor. In doing so, the Commission must be mindful that the relevant standard is one of harmful interference, not "no interference." The Commission

should also bear in mind the tolerance most users already have for limited interference and the incredible variability of interference based on weather and other factors. Indeed, the host of commercially available devices designed to help individuals find a comfortable level of interference, from "rabbit ears" to expensive high-end receivers, demonstrates that a wide range of circumstances and sensitivities exists among individual users. This also provides surety that, if problems do develop over time, the market will find adequate answers.

2. Banning underlays in the electromagnetic spectrum is like banning free speech in the acoustic spectrum.

To better understand the economic and First Amendment logic of the current regulatory ban on low-power unlicensed communication in the broadcast band, consider a football stadium with 100,000 fans. Both the announcer and fans in a football stadium communicate via a small sliver of the acoustic spectrum. The fact that the announcer (the high power transmitter) is allowed to speak in the football stadium doesn't preclude the 100,000 fans (all low power transmitters) from having tens of thousands of conversations at the same time. If the current regulatory regime in the broadcast spectrum was applied to this acoustic spectrum, only the stadium announcer would be allowed to speak. All fans would have to either be quiet or face criminal penalties (see Figure 3).

As radio receivers become more intelligent—that is, better able to discriminate among multiple signals—we believe that the ban on unlicensed underlays is becoming more and more onerous. Just as fans should be able to communicate with their neighbors without the permission of the announcer, we believe citizens should be able to use the spectrum in their homes without the permission of broadcasters.

Figure 3. Acoustic Spectrum Analogy to the FCC Ban on Broadcast Underlays

3. GPS technology provides the means for individuals to maximize their use of spectrum and enhance spectrum efficiency based on geographic location

Commenters endorse the FCC's Spectrum Policy Task Force suggestion that unlicensed power levels be linked to GPS-determined geographic areas.[35] In other words, to the extent possible, underlays should maximize local spectrum usage. In the past, the Commission was constrained to make its decisions based on conservative worst-case assumptions. Individuals in thinly populated areas labored under the same restrictions necessary to guarantee non-interference in the most crowded urban areas. As a result, those who could most benefit from the availability of unlicensed wireless uses have been denied them, despite the absence of any danger of harmful interference to others.

Technology now allows the Commission to abandon this practice and permit maximum efficiency in spectrum use based on the reality of a given location and a given moment. New GPS technology is making this type of dynamic underlay a practical possibility. GPS is a satellite technology that allows ground receivers to know their exact location. Already widely available in consumer devices such as car and boat navigation systems, next generation GPS receivers will be the size of a dime and widely incorporated in mobile telephone sets.

The Commission can therefore create rules that allow ranchers in Montana to establish a mesh network over distances of many miles, allow a home owner in a Maryland suburb to set up a wireless home network that covers the house and yard but does not interfere with the neighbor's wireless telephone, and allow the resident of a New York City efficiency to network her laptop and stereo without interfering with her neighbor's television reception.

4. The Commission should not delay the deployment of new unlicensed uses in order to develop the concept of "Interference Temperature"

As a qualifying note, the Commission should define the underlay threshold in terms of the conventional criterion of low power transmitters. The NOI suggests a new underlay threshold criterion, an interference temperature threshold based on power received at the receiver.

The Commission should decline to adopt the "interference temperature" concept at the present time, although further refinement may make this measure useful. The need to allocate new spectrum for unlicensed uses is urgent. Wi-Fi and other unlicensed uses represent one of the few growth areas in the current information technology market. Current threshold criteria and existing technology provide a sufficient level of certainty to allow the Commission to act now to open needed spectrum to unlicensed uses.

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[35] Spectrum Policy Task Force Report, Washington, DC: Federal Communications Commission. November 2002.

The FCC proposed a centralized regulatory model of interference temperature data, with its interference temperature threshold set based on worst case scenarios. Another approach would be a decentralized use of interference temperature data that would set a threshold based on actual rather than hypothetical worst case conditions. Many advocates of unlicensed prefer this type of intelligent and dynamic interference temperature threshold. Unfortunately, this debate is beyond our technical understanding. There seems no question that the decentralized and intelligent approach would be ideal. But the large number of dumb legacy receivers, including the new digital TV receivers, would seem to render it impractical.

The interference temperature threshold concept has yet to be operationalized and severe doubts exist among even its proponents about whether such implementation will be possible. The Chair of the Spectrum Policy Task Force has estimated it could take five or more years and substantial research before this concept can be implemented, and he is not sure of the outcome. An analogy to this situation is the concept of spectrum efficiency. This concept is used all the time, but the Task Force, despite considerable work, was unable to formalize it as a practical working policy for the FCC.

Other than its lack of precise definition, Commentors have other concerns with the proposed interference threshold underlay test. To develop localized interference temperature measures requires a vast number of radio frequency energy sensors across all frequencies and geographic locations. And even after collecting all this data, the interpretation of the data will be ambiguous because the effect of the interference temperature depends upon the quality of receivers currently or potentially occupying a given band in a given geographic band. This will invite endless band-by-band, location-by-location lobbying and litigation It will, in other words, tend to reinforce the status quo, which is hostile to unlicensed underlays. By comparison, the low power test is simple and can be applied across all bands and geographic areas with only simple adjustments, such as for higher unlicensed power levels in GPS determined rural areas.

C. The Commission should allocate *opportunistic unlicensed* on channels 2-69

Spectrum is not a depletable asset. Unlike, say, oil consumption, it does not deplete with time and use. No matter how much spectrum is used at moment A, the same amount of spectrum is available at moment B. Any spectrum not used at moment A is forever lost. If this otherwise unused spectrum can be economically used, a pure loss results when it remains fallow.

The stark reality is that not all licensed broadcast spectrum is in use at a given time. To the extent unlicensed use of this spectrum is possible without materially harming broadcasters, it should be allowed. As discussed above, this furthers the Commission's statutory goals and the goals of the First Amendment.

We believe that there are two important types of unused licensed spectrum. 1) Spectrum on which there are no licensed broadcasts, and 2) Spectrum on which there are no licensed receptions. The NOI only refers to the first type of unused spectrum. No mention is made of the second type, perhaps because its use requires a higher level of technological and institutional sophistication.

No Licensed Broadcasts

Most broadcast spectrum, even channels licensed for use within a particular market, remains unused—even assuming dumb TV receivers. Many broadcasters do not broadcast 24 hours a day. Only a fraction of broadcasters are currently transmitting their digital signals at full power. And the vertical blanking space on broadcasters current analog signals often remains unused. If broadcasters don't use their rights, others, using smart radios, should be able to use that spectrum on a listen-before-talk basis. The listen-before-talk protocol requires an unlicensed device to check for licensed transmissions. If one is detected, then the band is occupied and not available for unlicensed communications at that moment in time.

No Licensed Receptions

Today, only about 10% of Americans get their TV reception via terrestrial broadcast frequencies ("over-the-air").[36] The rest get their TV via satellite or cable. Soon, many may also be able to get television access via Wi-Fi hotspots and 3G mobile telephones.

In some areas, such as rural or mountainous regions, very few people actually receive TV via terrestrial broadcast frequencies. Where such spectrum is not used for licensed receptions, other uses should be allowed. For example, if a community of ranchers in rural Wyoming rely on satellite TV want to use the broadcast frequencies for their own communication purposes, they should be allowed to do so.

Similarly, broadcasters currently have access to far more channels than are ever used in America. The average TV market may have access to more than 7 TV channels, but the average TV home on average has less than one TV on at a given moment. And with the next generation of digital TVs, which require less spectrum to send a program, the ratio of used to unused spectrum will be far lower. In theory, the spectrum not currently being used for reception could be used locally for other purposes. Returning to our hypothetical community of rural Wyoming ranchers, they could enter into a compact to add an attachment to their next generation digital TVs that notifies a central station that a particular TV station is in use. This is the same type of reporting mechanism that mobile phones use so that every channel assigned to mobile phone use can be in simultaneous use. This would allow them to watch broadcast TV over terrestrial spectrum but also make use of spectrum on which no one is currently receiving a program. Spread spectrum technology, widely used in consumer mobile telephones and other devices,

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[36] For more information, see Thomas Hazlett, "The U.S. Digital TV Transition: Time to Toss the Negroponte Switch," Working Paper 01-15, Washington, DC: AEI-Brookings Joint Center for Regulatory Studies, November 2001. There is considerable dispute over this number. The FCC estimates 15%. If all secondary TV sets not attached to pay TV services are included, the number would be considerably higher. Many households have one or more TV sets not connected to their cable or satellite TV services.

makes it easy to spread signals across many temporarily unused channels. Consequently, even if people flip channels quickly, the amount of available spectrum does not diminish.

Commentors acknowledge that there would be many logistical difficulties in implementing such a scheme of opportunistic unlicensed use of spectrum. But most spectrum, such as the close to 4 gigahertz broadcasters share for auxiliary services, is already managed based on access to such comprehensive usage data. Band coordinators gather comprehensive usage data, then allow use on a more-or-less first-come, first-serve basis among a class of users.

In any case, the FCC does not have to solve most of these coordination difficulties to permit such opportunistic spectrum sharing and thus increase the efficiency of spectrum use. Just as the FCC has left the management of the broadcast auxiliary bands to a self-governing system of broadcasters, it can leave the management of the unlicensed spectrum to its local users by mandating the use of technologies that will monitor available spectrum and use it efficiently. Indeed, Wi-Fi, Bluetooth, and other unlicensed networks have already solved at least some of these logistical difficulties. Hundreds of devices can share the same spectrum and dynamically switch frequencies depending on what frequencies other devices are using.

IV. The FCC should set minimal Digital TV Receiver Standards to reduce the amount of polluting interference

Digital TV receiver standards may be desirable to enhance unlicensed usage in the broadcast bands. While true that another FCC NOI specifically addresses the question whether the FCC should impose receiver standards and even raises the question of broadcaster receiver standards,[37] the question of broadcaster receiver standards is equally valid for this NOI.

There is no question that analog TV receivers are "dumb" and, as a result, effectively pollute vast amounts of spectrum with interference.[38] The poor quality of broadcast receivers, as noted earlier, was the prime reason that that the average TV market only provides services on approximately 7 of the 67 available channels.

The advent of digital receivers will alleviate this problem, but does not alleviate the need for the Commission to take action in setting higher standards for the following reasons.

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[37] ET Docket No. 03-65, MM Docket No. 00-39, In the matter of Interference Immunity Performance Specifications for Radio Receivers; Review of the Commission's Rules and Policies Affecting the Conversion to Digital Television, Released: March 24, 2003.

[38] Harmful interference occurs when a desired and undesired signal both arrive at a receiver and conflict, such that the receiver can extract less information from the desired signal. It is important to understand that the level of acceptable interference is overwhelmingly a function of the equipment used, since simultaneous transmissions on the same frequency do not literally cancel each other out. High quality receivers can better discriminate between competing signals, thus mitigating the effects of interference.

First, broadcasters have only been willing to improve receiver standards ***when they have been able to capture the resulting increase in spectrum capacity for themselves***. Where increases in efficiency would benefit rival technologies, broadcasters have resisted increases in receiver efficiency. In 1976, for example, broadcasters opposed a 50-cent per TV enhancement to UHF receivers that would have freed up approximately 100 MHz, likely to be used by competitors.[39] Since pollution is an externality, broadcasters have no incentive to reduce this type of interference when they create a TV receiver standard such as NTSC (the old analog standard) or ATSC (the new and constantly evolving digital TV standard).

Second, broadcasters have been strong advocates of government mandated receiver standards. For example, the FCC recently mandated that every TV manufactured in the U.S. contain an ATSC digital receiver, with a phased in implementation beginning in 2004. Every American, whether or not he watches terrestrial over-the-air broadcast TV, must purchase a TV that has the capacity to receive the ATSC signal. Since the law mandates that the broadcasters need not return their analog TV channels until 85% of American TV sets can receive their new ATSC digital TV signal, this is supposed to speed the return of spectrum for more productive users. The mandate gives broadcasters a windfall because the value of their spectrum is a direct function of how many Americans have equipment that can receive it. Once a large number of Americans have the broadcast digital TV receivers, a positive network externality is created, which gives broadcasters a competitive advantage. The mandate also creates large economies of scale in the production of ATSC TV receivers, which reduces their price for the few consumers who choose to get their TV via terrestrial, over-the-air transmission.[40]

The focus of government receiver standard setting policy should be to reduce receiver pollution of unused spectrum, which would then be allocated for unlicensed use. The current plan to migrate future generation digital television receivers to a 7dB noise factor is one valuable step in this direction, but is only the first step in a continuing drive toward greater spectrum efficiency. More importantly, the spectrum opened up by this improvement should be allocated to unlicensed uses for the benefit of everyone, not used to expand the geographic range of broadcast TV stations to the benefit of incumbents and a limited few.[41]

V. The Commission should create institutional structures to minimize the political abuse of hard-to-understand interference data

The history of spectrum regulation demonstrates that no matter what spectrum allocation policy the FCC adopts, incumbents who perceive they have lost will argue that the

[39] With a $250,000 grant from the FCC, Texas Instruments developed a working model of the receiver. Digital TV receivers are better than these 1976 receivers, but are designed so that broadcasters capture most of the benefit from the improvement.

[40] Since all other consumers also have to pay for the ATSC TV receivers, the overall cost per ATSC TV set actually in use is very likely to be higher than without the mandate.

[41] Improvements in the noise factor allow geographic range to increase without increasing power levels.

allocation regime creates harmful interference. The FCC Spectrum Policy Task Force report notes that current interference standards are highly subjective.[42] For example, they don't clearly distinguish between spectrum incumbents want to grab for themselves as opposed to merely protect. As a result, incumbent licensees frequently seek to exploit concerns about interference to prevent the entrance of rival services.

To help minimize the influence of special interest politics in setting interference standards (i.e., property boundaries), Commenters suggest the following three remedies:

A. The Commission should set consistent unlicensed policies across multiple bands

Unlicensed underlay and opportunistic sharing policies should not be set band by band but across large allocations of spectrum, perhaps even the entire 300 GHz of radio spectrum.

A band-by-band approach for unlicensed uses would merely preserve the legacy of the Commission's previous "command and control" model of allocation. The logic of expanding unlicensed uses – that it serves the statutory goals of the Commission by securing the broadest use of radio to all Americans, promotes innovative uses of the electromagnetic spectrum, facilitates the deployment of advanced telecommunications services, and furthers the interests of the First Amendment – apply equally across all bands.

While incumbents in every band will no doubt have arguments and allies to explain why they are "special" and should exclude unlicensed uses, the Commission should take these arguments with considerable skepticism. As the Commission itself has observed, incumbents have no right to exclusive use. Incumbents have a responsibility to provide a service, and, in exchange, the Commission protects them from harmful interference.[43] The burden must therefore lie with the incumbent to demonstrate that unlicensed uses would create harmful interference, *i.e.* interference that would substantially interfere with the licensee's ability to fulfill its responsibilities, not simply the possibility of some interference to some receivers.

B. The Commission should continue its efforts to create an objective measure of interference

A series of FCC reports have argued for the need for an objective measure of interference.[44] Commenters endorse this effort, although—as discussed above with regard to "interference temperature"—the Commission should not delay the deployment of unlicensed uses while developing this metric.

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[42] SPTF Report of the Interference Protection Working Group, Washington, DC: FCC, November 15, 2002.
[43] See: First Report and Order, Revision of Part 15 of the Commission's Rules Regarding Ultra WideBand Transmission Systems, FCC 02-48, ET Docket No. 98-153.
[44] Spectrum Policy Task Force Report, Washington, DC: FCC, November 15, 2003; and report of the Task Force's Unlicensed and Experimental License Work Group, Washington, DC: FCC, November 15, 2003.

VI. The Commission should seek to find a minimally costly "win-win" solution

In the past when new technology has opened up new broadcast spectrum, the Commission has had four options: 1) Do nothing, 2) let a competitor use it, 3) let a non-competitor use it, or 4) give it to broadcasters. In recent years, mandating non-competitor use has become more difficult because of the convergence of information technologies. It's getting increasingly hard to mandate that a bit of information not be used to carry a TV signal or that a TV signal not carry non-TV bits, so distinguishing between options 2 and 3 is now largely impractical. The last few decades have also demonstrated that the only way to put underutilized spectrum to use is to give broadcasters a cut. Members of Congress, often working through their control of the FCC, have clearly demonstrated that they aren't willing to consider anything other than "win-win" solutions.

For example, as early as 1960 engineers argued that broadcasters could cram far more than one signal into a 6 MHz channel. But only when the FCC allowed the broadcasters to capture this additional utilization for themselves was it allowed to go forward. In return, the FCC got a promise that at the end of the digital television transition broadcasters would give back 108 MHz of spectrum. (With the transition to digital FM radio, members of Congress didn't even ask for this much; broadcasters got the increased signals *and* the guard bands).

Can such a win-win solution facilitate giving a fraction of the broadcast band to unlicensed use? Unlicensed spectrum is spectrum the broadcasters could otherwise claim for themselves and charge for. And unlicensed services could also prove a potent competitor to broadcasting. So broadcasters will fiercely oppose it unless Congress and the FCC give them something in return. What this something is we are not prepared to state, but the numerous enhancements the broadcasters are considering for their ATSC digital TV standard is a starting point. Many of these will require changes in the law and a willingness on the part of Congress and the FCC to allow early generation digital television receivers to become obsolete via a sequence of computer industry-like "backwards compatible" enhancements.

Conclusion

Unlicensed spectrum reduces communication barriers to entry, and thus embodies the twin values of free speech and economic competition. These values, in this instance, may be harmful to the economic interests of incumbent spectrum users. But they are central to what America *has* stood for and what we hope the FCC and Congress *will* stand for.

Broadcasters should continue to receive an easement to provide their present level of service, but the scope of that easement should not increase more than practical politics dictate, and the amount of spectrum that broadcasters are allowed to warehouse, pollute, or otherwise cause to be unused should be minimized. As new technology makes it possible to add new information carrying capacity to the spectrum allocated to the

broadcasting industry, this capacity should be set aside for unlicensed use. Shared and Opportunistic Unlicensed should be immediately allowed on all channels 2-69. Pure unlicensed should be phased in on channels 52-69, with unused guard bands opened immediately and the balance turned over at the end of the digital TV transition. The digital TV receiver mandate should be revised to minimize broadcasters' pollution of spectrum to which they do not currently have rights.

Unlicensed spectrum has already unleashed a plethora of highly demanded new applications. If allowed to operate on prime spectrum, it could facilitate many more, including the rapid deployment of mobile, high-speed, low-cost, last-mile Internet service.

Appendix A:
A Selection of States Where Wireless Internet Service Providers (WISPs) Are Using Unlicensed Spectrum[45]

The fixed wireless services indicated here operate on the industry standard unlicensed 2.4 GHz band and the U-NII bands in the 5.3 GHz, 5.7 GHz and/or 5.8 GHz unlicensed frequencies.[46] Our independent interviews with WISP operators indicate that the 2.4 GHz frequency is most commonly used in rural areas and for "last mile" connections from tower to home. The U-NII 5.3 GHz, 5.7 GHz and 5.8 GHz bands are increasingly more common in more "urban" areas and in backhaul transmissions from tower to tower.

NOTE: This table is not intended to be a comprehensive listing of every locality where WISPs are providing fixed wireless services via unlicensed spectrum. Rather, it is a representative sample of the vast number of rural, semi-rural and urban locations where unlicensed, wireless access is available. The states represented in this table are the 10 states with the most markets covered under fixed wireless services, as detailed by *Broadband Wireless Exchange Magazine*, from their National WISP Directory for 2001, <http://www.bbwexchange.com/wisps/>. Additional markets indicated here were also provided by the web sites of the WISPs indicated in the column on the right.

In many instances, these locations are rural "last mile" solutions, where unlicensed wireless is the only option for accessing the Internet at high speeds. In other locations within closer proximity to urban areas, there may be other options for high-speed access. However, even in these more "urban" instances, unlicensed wireless provides an alternative, comparable service and price to consumers.

Please note that the number of markets after each state indicates the total number of markets within that particular state as compiled by *Broadband Wireless Exchange Magazine's* National WISP Directory. This number does not indicate the number of markets included in the "Select Markets" cells.

California – 220 markets	
Select Markets	**WISPs**
1000 Palms, Alameda, Albany, Aliso Viejo, American Canyon, Anaheim, Anaheim Hills, Antioch, Armona, Atherton, Bakersfield, Banning, Beaumont, Belmont, Berkeley, Brea, Browns Valley, Buellton, Buena Park, Cabazon, Camarillo, Campbell, Canyon Lake, Carmel, Carmel Valley, Carpinteria, Castro Valley, Cathedral City, Chatsworth, Cherry Valley, Clovis, Coachella, Coombsville, Corcoran, Corona, Costa Mesa, Cupertino, Cutler, Cypress,Dana Point, Davis, Del Rey, Desert Hot Springs, Dinuba, Dinuba, Discovery Bay, Downey, Dublin, East Palo Alto, Elk Grove, Emeryville, Emeryville, Exeter, Farmersville, Farmersville, Fillmore, Folsom, Foothill Ranch,	Multiple WISPs serving the locations shown

[45] For additional information on WISP use of unlicensed, see: In the Matter of Facilitating the Provision of Spectrum-Based Services to Rural Areas and Promoting Opportunities for Rural Telephone Companies To Provide Spectrum-Based Services, WT Docket No. 02-381. For example, Microsoft urged the Commission to maximize the reach of unlicensed networks by: "1) making a primary spectrum allocation in the lower bands for unlicensed services; and 2) allowing unlicensed devices to use increased power in rural (and other low-interference) areas."

[46] *Broadband Wireless Exchange Magazine* Editor-In-Chief, Robert Hoskins estimated in an email interview with NAF on April 17, 2003 that approximately 90% of WISPs provide services using public spectrum on the 900 MHz, 2.4 GHz and 5 GHz bands.

Fountain Valley, Fowler, Fremont, Fresno, Ft. Bragg, Fullerton, Garden Grove, Goleta, Goshen, Grass Valley, Hayward, Hemet, Hollywood, Huntington Beach, Indian Wells, Indio, Irvine, Ivanhoe, Kerman, Kingsburg, La Habra, La Mirada, La Quinta, Laguna Beach, Laguna Hills, Laguna Niguel, Laguna Woods, Lake Elsinore, Lake Forest, Larkspur, Leemore, Lindcove, Live Oak, Livermore, Lompoc, Los Alamitos, Los Altos, Los Angeles, Los Gatos, Los Olivos, Manteca, Marin, Marysville, Meca, Menlo Park, Milpitas, Mill Valley, Mission Viejo, Modesto, Monterrey, Montecito, Moorpark, Morgan Hill, Morongo Reservation., Mountain View, Murrieta, Napa, Nevada City, New Port Beach, Northridge, North Sacramento, Norwalk, Novato, Oakland, Ojai Valley, Olivehearst, Ontario, Orange County, Orange Cove, Orosi, Oxnard, Palm Springs, Palo Alto, Parlier, Penn Valley, Petaluma, Piedmont, Placentia, Pleasanton, Porterville, Rancho Cordova, Rancho Mirage, Redding, Redwood City, Reedley, Richmond, Riverside, Roseville, Rossmore, Sacramento, Salinas, San Bernardino, San Carlos, San Diego, San Francisco, San Jacinto, San Jose, San Lorenzo, San Luis Obispo, San Mateo, San Pablo, San Rafael, Sanger, Santa Ana, Santa Barbara, Santa Clara, Santa Cruz, Santa Fe Springs, Santa Maria, Santa Paula, Santa Rosa, Santa Ynez Valley, Sarasota, Saratoga, Sausalito, Seal Beach, Seaside, Selma, Semi Valley, Silicon Valley, Simi Valley, Solvang, Somis, Sonoma, Stanford, Stanton, Stockton, St. Helena, Strathmore, Sunnyvale, Temecula, TerraBella, Thermal, Tiburon, Tracy, Traver, Tulare, Tustin, Ukiah, Union City, VAFB, Ventura County, Vero Beach, Villa Park, Visalia, Watsonville, Westminster, Whittier, Wildomar, Wilton, Woodlake, Woodville, Yorba Linda, Yountville, Yuba	
Illinois - 207 markets	
Select Markets	**WISPs**
Atwood, Ballou, Bement, Broadlands, Buckley, Chenoa, Cisco, Clifton, Coal City, Colfax, Crescent City, Dewey, Dwight, Elliott, Elwood, Fairbury, Fischer, Fisher, Forrest, Fulls, Galesville, Gibson City, Gifford, Grand Ridge, Grant Park, Herscher, Ivesdale, Ladd, LaPlace, Lexington, Loda, Ludlow, Manhattan, Maroa, Marseilles, Mazon, Minooka, Momence, Monee, Monticello, Morris, Odell, Onarga, Ottawa, Paxton, Philo, Pontiac, Ransom, Ritchie, Sadorus, Saunemin, Savoy, Saybrook, Seymour, Shorewood, Sidney, Sloan, St. Joseph, Thomasboro, Tolono, Tonica, Tyler	Prairie iNet
Athens, Atlanta, Auburn , Barnes, Blue Mound, Brighton, Bunker Hill, Burtonview, Carlinville, Clinton, Curran, Delavan, El Paso, Emden, Eureka, Fillmore, Franklin, Gillespie, Girard, Goodfield, Greenfield, Green Valley, Gridley, Hopedale, Heyworth, Hudson, Irving, Kincaid, LeRoy, Lincoln, Mason City, McLean, Minier, Monmouth, Morrisonville, Mt. Pulaski, New Berlin, Niantic, Nokomis, Palmyra, Pawnee, Pleasant Plains, Raymond, Roanoke, Sharpsburg, Shipman, Stanford, Stoningto, Towanda, Tremont, Virden, Wapella, Warrensburg, Waverly, Witt	DTN SpeedNet
Iowa – 88 markets	
Select Markets	**WISPs**
Adel, Alden, Alleman, Altoona, Avon, Beaman, Bondurant, Cambridge, Clarion, Clive, Colfax, Conrad, Dallas Center, Dike, Dysart, Eagle Grove, Ellsworth, Farnhamville, Fort Dodge, Gilbert, Gladbrook, Granger, Grimes, Grundy Center, Hubbard, Hudson, Indianola, Iowa Falls, Jesup, Johnston, Knoxville, Lake City, LaPorte City, Madrid, Maxwell, Melbourne, Minburn, Mitchellville, Nevada, New Hartford, Ogden, Panora, Parkersburg, Perry, Prairie City, Reinbeck, Rippey, Rockwell City, Roland, Sac City, Slater, Story City, Urbandale, Vinton, Waukee, Webster City, West Des Moines, Williams Winterset	Prairie iNet
Camanche, Carroll, Cedar Falls, Cedar Rapids, Clinton, Decorah, Glidden, Hiawatha, Indianola, Marion, Marshalltown, Newton, Pella, Sioux City, Waterloo, Waverly	Dynamic Broadband
Texas – 141 markets	
Select Markets	**WISPs**
Flatonia, Stratfort, Dumas, Stinnett, Pampa, White Deer, Amarillo, Vega, Camarillo, Clarendon, Canyon, Tulia, Dimmitt, Friona, Farwell, Plainview, Floydada	AMA Online
Abernathy, Anson, Anton, Bridgeport, Brownfield, Buffalo Springs Lake, Burkburnett, Chillicothe, Crosbyton, Dalhart, Dumas, Goodlet, Hale Center, Hamlin, Hartley, Haskell, Henrietta, Holliday, Idalou, Iowa Park, Knox City, Krum, Lakeside City, Levelland, Littlefield, Munday, Nocona, Petersburg, Plainview, Post, Quanah, Ralls, Red Springs, Runaway Bay, Sanger, Seymour, Shallowater, Slaton, Stamford, Vernon, Wolfforth	DTN SpeedNet
Minnesota - 140 markets	
Select Markets	**WISPs**
Webster Farm, Wilder, Wilmar, Wilmont, Windom, Winthrop, Worthington, Thorpe, Traverse, Stewart, Storden, Sumter, St, George, St, James, Spicer, Spafford, Slayton, Sioux Valley, Searles, Schultz Farm, Rushmore, Round Lake, Remmers Farm, Reading, Lake Wilson, Lakefield, LaSalle, LeSueur, Lismore, Mankato, Mt, Lake, New Auburn, New London, New Ulm, Nicollet, Norseland, Olivia, Henderson, Hector, Heron Lake, Howard Lake, Hutchison, Iona, Jackson, Jeffers, Jessenland, Kandiyohi, Kasota, Kinbrae, Klossner, Kurth Farm, Lafayette, Lafayette, Lake Crystal, Lake Jennie, Lake Lillian, Lake Shetek, Danube, Darwin, Dassel, Dundee, Eagle Lake, Ellsworth, Fulda, Gaylord, Gibbon, Glencoe, Hadley, Hamburg, Hanska, Haugen Farm, Alpha, Arlington,	XtraTyme Technologies, Inc.

Atwater, Avoca, Bell Plaine, Bergen, Bernadotte, Biegelow, Bingham Lake, Bird Island, Biscay, Blakely, Bloomkest, Brewster, Brownton,,Buffalo Lake, Butterfield, Cedar Mills, Chandler, Cleveland, Cokato, Comfrey, Corvuso, Cosmos, Courtland, Currie,	
Estherville Area, Luverne Area, Mankato Area, St. James Area, Fairmont Area, Le Center Area, Minnesota Lake Area, Mason City Area, Charles City Area, Clear Lake Area, Northfield Area, Faribault Area, Owatonna Area, Albert Lea Area, Austin Area, Red Wing Area, Lake City Area, Rochester Area, Plainview Area	Midwest Wireless
Florida – 82 markets	
Select Markets	**WISPs**
Apalachicola, Bayonet Point, Blountstown, Boca Raton, Bonifay, Bonita Springs, Bradenton, Bradenton, Brandon, Cape Coral, Chattahoochee, Chipley, Clearwater, Clearwater, Crestview, Dade County, DeFuniak Springs, Destin, ElfersEstero, Gainesville, Gilchrist County, Ft. Lauderdale, Ft. Myers, Ft. Walton Beach, Heathrow, Holiday, Hudson, Indian River, Jacksonville, Jay, Key Largo, Lakeland, Largo, Lehigh Acres, Longwood, Madison, Marco Island, Marianna, Martin County, Melbourne, Miami, Naples, New Port, Richey, Niceville, Orlando, Palm Harbor, Palmetto, Panama City, Pensacola, Perry, Pinellas Park, Port St. Joe, Port Richey, San Carlos Park, Sarasota, Seagrove Beach, Springhill, St. Augustine, St. Lucie, St. Petersburg, Sun City, Tallahassee, Tampa, Tampa Bay, Trinity, Venice, Vero Beach, West Palm Beach, West Palm Beach, Zephyrhills	Multiple WISPs serving the locations shown
Indiana – 77 markets	
Select Markets	**WISPs**
Ade, Bringhurst, Brook, Brookston, Cambria, Cutler, Delphi, Demotte, Flora, Fowler, Francesville, Frankfort, Goodland, Kentland, Kersey, Kouts, Lafayette, Logansport, Medaryville, Monticello, Pleasant Ridge, Rensselaer, Remington, Reynolds, Roselawn, Rossville, Winamac, Wolcott	Fairnet, LLC
Colorado – 72 markets	
Select Markets	**WISPs**
Broomfield, Castle Rock, Cherry Creek, Englewood, Founders Village, Glendale Lafayette, Littleton, Morrison, Northglenn, Parker, Roxborough Village, Roxborough Park, South East Denver, South West Aurora, Thornton, Westminster, West Lakewood	MHO Networks
Utah – 70 markets	
Select Markets	**WISPs**
Jordan, JosephKanab, Kaysville, LaVerkin, Layton, Lindon, Logan, Manti, Midvale, Monroe, Mount Pleasant, Murray, Nephi, Oasis, Ogden, Orem, Park City, Petersboro, Pleasant Grove, Providence, Provo, Redmond, Richfield, Richmond, Riverside, Roy, Salina, Salt Lake City, Sandy, Santa Clara, St. George, Saratoga Springs, Sigurd, Smithfield, South Jordan, Sutherland, Syracuse, Trenton, West Valley, West Valley, Wheeton, White Horse	Multiple WISPs serving the locations shown
Arizona – 67 markets	
Select Markets	**WISPs**
Alpine, American Fork, Anabella, Aurora, Benson, Bloomingtion Hill, Bountiful, Cache Valley, Cedar Hills, Centerville, Clearfield, Clinton, Delta, Draper, Elsinore, Ephram Davis, Delta, Deseret, Farmington, Fredonia, Fruit Heights, Gunnison, Highland, Hinkley, Hooper, Hurricane, Ivins, Ahwatukee, Anthem, Apache Junction, Black Canyon, Black Mountain, Bullhead City, Bullhead City, Camp Verde, Carefree, Casa Grande, Cave Creek, Central, Chandler, Coolidge, Cottonwood, Cave Creek, Chino, Cottonwood, Desert Hills, Flagstaff, Glendale, Gilbert, Guadalupe, Higley, Holbrook, Lake Havasu, Lake Pleasant, Laughlin, Lechee, Mesa, New River, Nogales, North Phoenix, Page, Paradise Valley, Phoenix, Prescott Valley, Queen Creek, Safford, Scottsdale, SedonaShow Low, Sierra Vista, Snowflake, Shumway, Taylor, Tempe, Thatcher, Tucson, Tucson, Village of Oak Creek, Wickenburg, Winslow	Multiple WISPs serving the locations shown