# SPECTRUM TRAGEDIES

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Avoiding a Tragedy of the Telecommons:
Finding the Right Property Rights Regime for
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*Regulation of radio spectrum can be clarified by recent analysis defining "common interest tragedies." In traditional allocations involving licensed spectrum, regulators impose restrictions on licensees and prohibit transactions to create improvements, leading to airwave under-utilization -- tragedy of the anticommons. With allocations for unlicensed spectrum, regulators have dispersed use rights so widely as to make efficient use impossible – tragedy of the commons. Both forms of market failure trigger anticipations that undercut investment incentives, deterring socially useful services – tragedy of the anticommons, redux. In contrast, targeted liberalization of property rights in wireless telephony appears to avoid costly tragedies. Here, decentralized market incentives succeed in bringing over $100 billion in financial capital to provide services over spectrum shared by more than 160 million subscribers; annual consumer surplus is conservatively estimated to exceed $80 billion. Marginal valuations appear to far exceed the social value of spectrum use under alternative rights regimes. This empirical reality is not well integrated into regulatory decision-making, however, as administrative rulemakings fail to consider the efficiency implications of common interest tragedies, even as stated rationales for spectrum rules reflect such tragedies.*

PRELIMINARY DRAFT. PLEASE DO NOT CITE.

COMMENTS WELCOME.

## I. Introduction

"Tragedy of the commons" has had a long relationship with radio spectrum, but misapplication of the concept has gotten the lion's share of the publicity. That is due to the mindshare boost afforded the "chaos" theory of airwaves in Felix Frankfurter's opinion in *NBC v. United States*,[1] a case brought by a radio network asserting its First Amendment rights against government regulation. The U.S. Supreme Court found that broadcasters were licensees who were privileged to communicate via radio waves, enjoying substantially fewer free speech rights than would a newspaper printing its ideas on paper.[2] The ruling rested upon the finding that prior to government frequency allocation there existed a "cacophony of competing voices"[3] – the audio rendition of tragedy of the commons.

Ronald Coase's 1959 inquiry into how radio waves were allocated by the Federal Communications Commission[4] was targeted at Justice Frankfurter's view of the radio market. Coase showed that the key to orderly development of wireless communications was not spectrum allocation by the Government or licensing of broadcasters under the "public interest" standard, but the issuance of clearly-delineated spectrum rights. Such rights could be distributed by market forces – just as other inputs (e.g., newsprint and ink) in other markets. In fact, the rights associated with broadcasting licenses were routinely traded in secondary markets. Coase saw "government control" of radio spectrum was neither necessary nor sufficient for economic development. What satisfied both conditions was the creation and enforcement of property rights.[5]

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[1] 319 U.S. 190 (1943).

[2] "Freedom of utterance is abridged to many who wish to use the limited facilities of radio. Unlike other modes of expression, it is subject to governmental regulation. Because it cannot be used by all, some who wish to use it must be denied…" *Ibid*., p. 225.

[3] This phrase actually dates to the Supreme Court's 1969 opinion in *Red Lion v. FCC*, 395 US 367, which (extending the *NBC* opinion) upheld government regulation of radio and TV broadcasters under the rubric of the "fairness doctrine." The relevant passage reads: "Before 1927, the allocation of frequencies was left entirely to the private sector, and the result was chaos. It quickly became apparent that broadcast frequencies constituted a scarce resource whose use could be regulated and rationalized only by the Government. Without Government control, the medium would be of little use because of the cacophony of competing voices, none of which could be clearly and predictably heard." Ibid., pp. 375-76 (footnotes omitted).

[4] Ronald H. Coase, *The Federal Communications Commission*, 2 JOURNAL OF LAW & ECONOMICS (1959), 1.

[5] This is not merely a theoretical conjecture. The development of radio broadcasting in the 1920s demonstrated that property rights, when enforced, prevented tragedy of the

This analysis led economists to generally reconsider how markets allocated resources involving spillovers. As articulated the following year,[6] the "Coase Theorem" logically demonstrated that resources would be efficiently allocated if rights to property were well-defined and the cost of trading rights was modest. This moved the default efficiency rule (in economic analysis) from one of administrative resource allocation to decentralized market allocation. This had been the default rule for markets without external costs or benefits; Coase's analysis generalized that result to show how its applicability rested on rights definition and enforcement rather than economic interdependencies. Where rights are clear, costs (or benefits) imposed on 'outside' parties are taken into account by those who produce such costs (benefits), and efficient solutions obtain.

Despite the wealth of economic insight yielded in this laboratory, the "market for radio spectrum" has largely resisted its practical implications. The proposal that wireless licenses were better assigned by competitive bidding than by fiat was implemented in the United States in 1993.[7] Yet, in all but a small number of countries,[8] airwave use rights are still severely truncated. Spectrum is allocated according to "public interest" criteria. As FCC policy analysts Evan Kwerel and John Williams explain:

> In the United States spectrum is currently managed by administrative process. Licenses not only define the amount of spectrum (in frequency, time, and space) but narrowly specify the services licensees may provide and the technologies they may use. For example, a television broadcasting license entitles the licensee to provide only television service. The licensee may not, for example, use its spectrum for cellular telephone service, even if it is technically feasible to do so without interfering with other licensees.[9]

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commons. Thomas W. Hazlett, THE RATIONALITY OF U.S. REGULATION OF THE BROADCAST SPECTRUM, 33 JOURNAL OF LAW & ECONOMICS 133 (April 1990).

[6] Ronald H. Coase, *The Problem of Social Cost*, 3 JOURNAL OF LAW & ECONOMICS (1960), 1.

[7] Countries such as New Zealand and India preceded the U.S. in adopting wireless license auctions. See Crandall 1998; Jain 2001.

[8] Specifically, New Zealand, Australia, Guatemala and El Salvador. See Hazlett 2004; Crandall 1998; Ibarguen 2003.

[9] Evan Kwerel and John Williams, *Moving Toward a Market for Spectrum*, REGULATION (1993, No. 2), p. 53. In the intervening decade, more liberal rules have been adopted for cellular telephone licenses (including licenses issued to personal communications service (PCS) entrants in 1995-96), creating an important – but specifically limited – exception the

Regulators generally determine how particular blocks of spectrum can be used, making rights available to licensees or unlicensed users constrained by allocation rules. These rules go far beyond the delineation of boundaries between users, restricting technologies, power, locations, business models, and services.[10] Hence, "spectrum auctions" are a misnomer[11]; the price system is used to assign operating licenses that restrict the use of radio spectrum to a specific, regulated employment.[12]

The result of this administrative allocation is a panoply of "common interest tragedies."[13] Here the symmetry of "tragedy" is seen: anticipations of inefficient over-use of spectrum (associated with tragedy of the commons) causes financial markets to under-invest in technology and networks (a result associated with tragedy of the commons). This two-sides-of-the-coin analysis extends to non-market failure: in anticipating that open access to spectrum will yield tragedy of the commons, regulators impose regulations (e.g., power limits on transmitting devices) that help police traffic, but in so doing eliminate the opportunity to use spectrum with

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rule. Subsequently, the authors have found that about 7% of the radio spectrum below 3 GHz is available to licensees under flexible use rules. This is the allocation to commercial mobile radio services (CMRS) licenses, which includes cellular, PCS, and specialized mobile radio (SMR). Evan Kwerel and John Williams, *A Proposal for a Rapid Transition to Market Allocation of Spectrum*, Federal Communications Commission, Office of Policy & Plans Working Paper No. 38 (Nov. 2002) ["Kwerel & Williams 2002"].

[10] See Thomas W. Hazlett, *An Essay on Airwave Allocation Policy*, 14 HARVARD JOURNAL OF LAW & TECHNOLOGY (Spring 2001), 335 ["Hazlett 2001"]; Federal Communications Commission, *Spectrum Policy Task Force Report* (Nov. 15, 2002) ["SPTFR 2002"]; Kwerel & Williams 2002.

[11] The error is seen in this recent statement in THE ECONOMIST, which awarded one of its 2003 "Innovation Awards" to Ronald Coase: "In papers published in 1959 and 1960, Dr Coase asked why valuable radio spectrum was going to waste. He suggested that the problem was the lack of **private property rights over spectrum**, which prevented the formation of a market to allocate spectrum efficiently. The answer, he proposed, was to open the allocation of radio spectrum to market forces. His proposal was derided, but radio spectrum is now routinely allocated by auction…" *And the Winners Were…*, THE ECONOMIST (Dec. 4, 2003) (emphasis in original). While the description of Coase's work is accurate, the assertion that "radio spectrum is now routinely allocated by auction" is not.

[12] Some important exceptions exist, both in the United States and internationally. See Hazlett 2001; Kwerel and Williams 2002; FCC 2002; Thomas W. Hazlett, *Property Rights and Wireless License Values*, AEI-Brookings Joint Center for Regulatory Studies Working Paper No. 04-08 (March 2004).

[13] Lee Anne Fennell nicely explains how a fragmentation of common interests drives both tragedy of the commons and tragedy of the anti-commons. See: Ferrell, *Common Interest Tragedies*, 98 NORTHWESTERN U.L.R. (forthcoming 2004; January 2, 2004 draft) ["Fennell 2004"].

alternative systems (e.g., high power networks), resulting in inefficient under-utilization.

This paper explores two families of spectrum tragedies in a preliminary analysis that will hopefully stimulate further research on the law and economics of spectrum allocation regimes. These are summarized as:

* *Licensed spectrum's tragedy of the anticommons.* Unoccupied bands are observed immediately adjacent to spectrum hosting brisk business, implying resource misallocation. Inefficiencies result from the inability of private users to acquire the rights necessary to productively utilize spectrum, and are demonstrably remedied by extending the rights to use spectrum enjoyed by licensees. This ends the rights-fragmentation, and under-use, associated with tragedy of the anticommons. The end of liberalization is an efficient (input) market in radio spectrum.

* *Unlicensed spectrum's tragedy of the commons.* The allocation of "open access" spectrum is accompanied by non-market coordination, which the government supplies through regulation of wireless devices. This organizational structure works relatively better when satisfying demands for very localized and/or sporadic radio applications. In this setting, rivalry for spectrum space is relatively lax, and blunt instruments (such as power limits on emissions) sufficiently regulate many useful applications. When more extensive spectrum conflicts arise, as in wide area networks, consumers demand more complex spectrum sharing arrangements. Government imposition of coordinating rules in this environment runs a much higher risk of tragedy of the commons (over-use due to too little regulation of access) or tragedy of the anticommons (too restrictive regulation). Anticipation of either failure prompts under-investment in complementary facilities. Current policy characterizes advanced wireless technologies that facilitate spectrum sharing among many networks as motivation for allocating more spectrum to unlicensed; exactly the reverse is true. Government coordination of spectrum use avoids tragedy only when spectrum sharing is very limited.

## II. Licensed Spectrum's Tragedy of the Anticommons

### A. Moscow Streets on a Spectrum Analyzer

Consider a resource misallocation identified by the Federal Communications Commission, one which is strikingly suggestive of the

"tragedy of the anti-commons" offered by Michael Heller.[14] In Heller's seminal paper, the brisk business observed at Moscow's sidewalk kiosks shortly after the fall of Communism, sharply contrasted with the barren look of grand buildings just a few meters away. Block after block of such impressive potential storefronts went vacant, even as demand for floor-space appeared strong. Heller's explanation was that the rights to use the more accommodating office space were effectively blocked because they had been distributed to multiple parties with conflicting interests. Transaction costs, and in particular hold-out problems, made the assembly of valuable rights difficult.

The picture of vigorous economic activity occurring in one spot, against a disquieting absence of economic activity immediately adjacent, struck both Prof. Heller and the FCC as suggestive, but led them to distinct conclusions. Here is how the FCC frames the issue:

> To assess actual spectrum use, the FCC's Enforcement Bureau measured spectrum use below 1 GHz in Atlanta, Chicago, New Orleans, San Diego, and in a Washington, DC suburb during various periods in July 2002. These preliminary measurements indicate that, while some bands are heavily used – such as those bands used by cellular base stations – many other bands are not in use or are used only part of the time. Thus, there may be opportunities for spectrum-based devices to operate in both the temporal white spaces – those resulting from variability in the operations of existing spectrum users over time – and the geographic white spaces – those resulting from the geographic separation of existing spectrum users.[15]

Just as on the Moscow street, the U.S. wireless market sees one band intensely used here, while another is used virtually not at all even as its frequency space is right next door. This stems from the numerous misallocations inherent in the central planning of radio spectrum, what the FCC dubs "command and control,"[16] and what Professors Farber and Faulhaber more colorfully label "Gosplan."[17] Further, it owes to the

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[14] Michael A. Heller, *The Tragedy of the Anticommons: Property in the Transition from Marx to Markets,* 111 HARVARD L.R. (1998), 621.

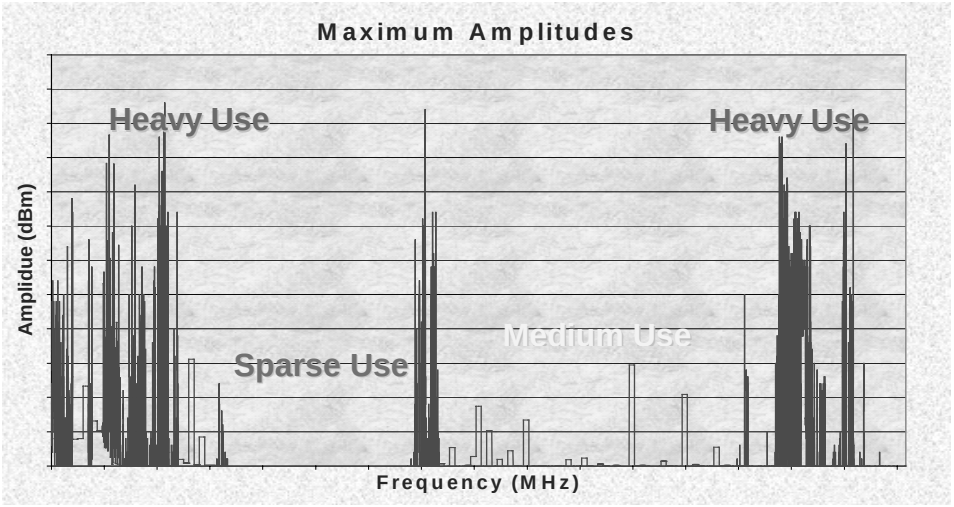
[15] *Ibid.*

[16] SPTFR 2002, p. __.

[17] Gerald R. Faulhaber and David J. Farber, *Spectrum Management: Property Rights, Markets and the Commons*, AEI-Brookings Joint Center for Regulatory Studies Working

inflexibility of the rights issued, such that market transactions are not permitted to divert bandwidth to produce services more valuable than that envisioned by regulators.

FIGURE 1. SPECTRUM USE ACROSS BANDS




Source: FCC, Spectrum Policy Task Force, Technology Advisory Council (TAC) Briefing **(**December 2002).

Hence, the spectral graphic displays a picture similar to that seen by Prof. Heller in Russia. Brisk wireless business here; abandoned bandwidth immediately adjacent. Where the intensity in the "heavy use" bands to bebrought to the "sparse" or "medium" use bands, large social gains could be realized.[18] Idle assets would become productive; new telecommunications services would be obtained and relatively advanced networks constructed. Instead, consumers receive less service at higher prices. What accounts for this suboptimal allocation of resources?

Wireless networks would intensively use the barren frequency spaces if rights were defined such that markets could assign them to productive use. This is gleaned from the above FCC statement itself: the

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Paper 02-12 (Dec. 2002) [Faulhaber & Farber 2002"], http://www.aei.brookings.org/admin/authorpdfs/page.php?id=217, p. 8.

[18] The FCC also produces charts showing the high variability of spectrum use in other dimensions beyond frequency space. These include time, geography, and power. In each case, more opportunistic use of radio waves could produce valuable outputs without disturbing existing communications. The efficiency of such uses depends on the value obtained, the expense incurred to create the new service, and the cost (if any) to other users including those of incumbent service providers.

frequencies allocated to cellular telephone networks – liberally defined (as discussed below) – are seen to host the most intense use.

Due to excessive fragmentation of rights, however, this efficiency is seen rarely outside of the CMRS bands. Two important examples are offered here to illustrate this tragedy of the anticommons.

**B. The Social Value of Liberal Spectrum Property Rights**

The restrictive nature of the property rights attached to wireless licenses in the United States has been notably loosened in one economically important sector: wireless telephony. For licenses issued to cellular, personal communications services (PCS), or specialized mobile radio (SMR) licenses, business operations are substantially left to the discretion of licensees. Operators are free to select technologies, services, and business models, being given freedom to deploy the frequency space allocated their licenses as dictated by profit incentives. This market – summarized as commercial mobile radio services, or CMRS – utilizes about 175 MHz of bandwidth in the 800 MHz, 900 MHz, and 1.9 GHz bands.

I characterize the rights regime in this sector as EAFUS – exclusively-assigned, flexible-use spectrum rights. This corrects this FCC's designation of such rights as "exclusive use." In fact, the radio spectrum assigned to EAFUS (i.e., CMRS) licensees is intensively shared. That sharing is organized by network operators which, with extensive legal rights to control the use of specific frequencies, invest heavily to provide opportunities for consumers to use communications services. This investment can be summarized in both the physical capital – for instance, the creation of 147,719 cellular base stations – and with respect to financial capital – the expenditure of $134 billion in aggregate investment (book value through June 2003).[19] The coordination effort entails much more, however, as the network carrier selects a menu of voice and data offerings, bringing together hundreds of equipment manufacturers and applications providers, while packaging and marketing services for the convenience of users. Currently, over 163 million wireless subscribers use these services, paying about $90 billion annually for over 800 billion minutes of use.[20]

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[19] Cellular Telecommunications & Internet Association, *Annualized Wireless Industry Survey Results* (June 2003).

[20] Merrill Lynch, *Global Wireless Matrix 2Q03: Quarterly Update on Global Wireless Industry Metrics* (2003).

Such intense sharing of radio waves could not take place at the price paid (about 11 cents per minute, on average, in 2003) were EAFUS rights not the regulatory model. The emergence of competition – with six national networks and several regional carriers offering service in 2004 – has had a decided impact, as seen in the sharp price drop of wireless rates following entry by new PCS licensees in the mid 1990s.[21] Consolidation of disparate local licenses, given the extremely atomistic licensing policy of the FCC, also reduced roaming charges and led to the introduction of popular "digital one rate" plans offering consumers buckets of local and long distance minutes at a flat rate.[22] This entry included substantial irreversible investment in network infrastructure, and without exclusive rights to allocate the spectrum these networks were designed to use, these investments in competitive platforms would have been deterred.[23]

The social value of the quasi-property rights regulatory structure in the CMRS bands can be estimated. Using historical price and quantity (minutes of use) data, consumer valuations can be inferred. The price-quantity diagram shown in Figure 2 is not a demand curve, in that the price-quantity pairs are observed over time. During the intervals, many other demand drivers are changing, including the price of handsets, the quality of cellphone calls, and the general popularity of mobile phone use. The assumption employed here is that these non-price demand determinants were generally operating to increase demand during the 1991-2003 period. The curve in Figure 2 then represents a lower bound estimate of demand for wireless minutes at each price; by integrating the area under the curve and above the current price of wireless minutes, a lower bound estimate of consumer surplus is obtained.[24] For 2003, the annual estimate equals approximately $81 billion. The capitalized social value of CMRS

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[21] Thomas W. Hazlett, *Is Federal Preemption Efficient in Cellular Phone Regulation?* 56 FEDERAL COMMUNICATIONS LAW JOURNAL 155 (Dec. 2003), 163-68.

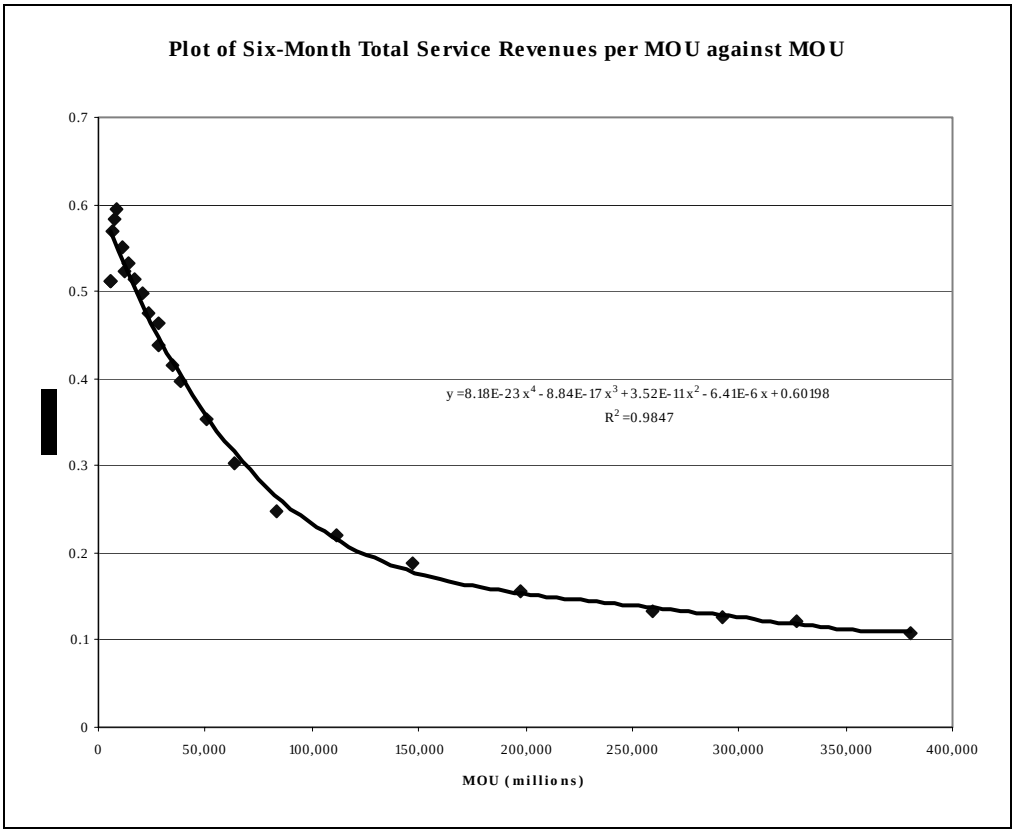
[22] Ibid., 193-99.

[23] Not all regulatory restraints on the use of licensed spectrum diminish anticipated profits. In fact, many license restrictions can be seen as cartel enforcement devices that lessen competition between providers. In this case, anticipated profits rise due to license restrictions. This empirical result has actually been found in the wireless telephone market. Thomas W. Hazlett, *Property Rights and Wireless License Values*, AEI-Brookings Joint Center for Regulatory Studies, Working Paper No. 04-08 (March 2004). Scott Wallsten has recently produced evidence showing that legal restrictions on competition, even when they increase anticipated profits, reduce investment incentives. Wallsten, *Privatizing Monopolies in Developing Countries: The Real Effects of Exclusivity Periods in Telecommunications*, AEI-Brookings Joint Center for Regulatory Studies, Related Paper No. 03-17 (May 2003).

[24] A fourth order equation, included on Figure 2, fits the data as indicated.

bandwidth then likely exceeds $800 billion,[25] a conservative calculation that excludes producers' surplus.

FIGURE 2. MOBILE PHONE PRICES AND MINUTES OF USE (MOU)
JUNE 1991 – NOV. 2003[26]




## C. Excessive Rights Fragmentation in the TV Band

The value of EAFUS rights, and the intense investment and economic activity that occurs there, stands in stark contrast to bands in which rights are regulated under alternative models. I first examine the television band, before turning to the so-called MMDS band.

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[25] This assumes a social discount rate of ten percent, which is high, particularly given the high growth rate of consumers' surplus (which reduces the net discount rate in calculating present value).

[26] Prices are defined as the average revenue per minute of use over the six-month period. Source: Cellular Telecommunications & Internet Association (CTIA), *Semi-Annual Data Survey Results, 1985-2003*; CTIA Nov. 2003 Report, Tables 28, 29, 110.

Some 402 MHz of prime bandwidth – 67 channels @ 6 MHz each -- is allocated to over-the-air television broadcasting in each of 210 TV markets. This frequency space is more than twice the bandwidth allocated to wireless telephone service, and is generally of higher utility to network providers (being lower on the dial).[27]

Of course, TV broadcasting also provides value; the resource allocation question is how much social value would be sacrificed by allowing the alternative (CMRS) use. The key is that the programming produced by TV stations (and their networks) is distributed mostly via cable television and direct broadcast satellite; about ninety percent of homes use multi-channel video program distributions (MVPD) services to receive their television signals. The value of "broadcasting" (as opposed to broadcast content) is then defined, as an upper bound, by the cost of delivering service to the approximately ten million non-subscribing households. According to FCC data, ninety seven percent of U.S. homes are passed by cable; roughly one hundred percent are able to receive the signals of two national satellite TV providers. The incremental cost of an additional subscriber to cable systems (including installation of a digital set-top box), or to satellite TV systems (including installation of an outdoor dish), is under $300. Hence, to provide another ten million homes broadcast TV programs via MVPD distribution would entail aggregate outlays of under $3 billion.[28]

Hence, the social gains available from allowing at least some substantial reallocation of TV band spectrum are enormous – two orders of magnitude or more. The regulators' approach is that reallocation is taking place, on their scheduled "digital TV transition." Officially initiated in 1987, the administrative plan to shift over-the-air viewers to what regulators perceive to be a more efficient broadcasting system has succeeded thus far only in blocking reallocation of TV band airwaves. In fact, alternative uses for the bandwidth was suggested by public safety users and cellular

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[27] Thomas W. Hazlett, *The U.S. Digital TV Transition: Time to Toss the Negroponte Switch*, AEI-Brookings Joint Center for Regulatory Studies Working Paper 01-15 (Nov. 2001).

[28] See discussion in Hazlett 2001b. It should be noted that all cable TV systems retransmit all local TV stations, while satellite operators currently offer (all) local signals in only about the 40 top television markets. If given access to additional spectrum, satellite operators would deliver local signals in all markets. Such, in fact, was the announced policy of a post-merger EchoStar, in its 2002 bid to buy rival satellite operator DirecTV. Even without merger, new entry or additional spectrum made available to incumbents would result in ubiquitous satellite retransmission. Given financial incentives to use existing spectrum allocations more intensively, incumbents could in fact deliver these local signals immediately via more extensive use of directional beams.

technology suppliers who petitioned the FCC in the mid-1980s for permission to access these largely idle airwaves.[29]

TABLE 1. TV DELIVERY SYSTEMS IN U.S.

| *Category* | *Date* | *Number* | *Percent of TV HHs* |
|---|---|---|---|
| TV households | Jan. 2004 | 108,410,160 | 100.0 |
| Basic cable subs | Feb. 2004 | 73,674,240 | 67.96 |
| Other MVPD subs | Dec. 2003 | 24,940,000 | 23.01 |
| Non MVPD HHs (residual) | | 9,795,920 | 9.04 |

Source: National Cable & Telecommunications Association website (visited May 11, 2004), http://www.ncta.com/Docs/PageContent.cfm?pageID=86.
Note: Residual assumes zero overlap between "cable" and "other MVPD" subscribers.

There is now considerable interest in accelerating the TV Band reallocation, as pent-up demand for access to these valuable airwaves intensifies.[30] The primary obstacle to unleashing this bandwidth is often identified as broadcaster protectionism. In common parlance, the assertion is made that *broadcasters will not part with their spectrum.*

Sen. John McCain (R-AZ), chair of the Senate Commerce Committee (with oversight responsibility for the FCC), states it this way:

> The transition to digital television has been a grave disappointment for American consumers and nothing short of a spectrum heist, for an indefinite period of time, by television broadcasters. As USA Today reported on May 1 [2002], "… At the current pace, broadcasters will be able to keep *all of their spectrum*, digital and analog, in perpetuity. That means a substantial chunk will remain

[29] This story is well told in Joel Brinkley, Defining Vision (1997).

[30] "Federal regulators are thinking anew when it comes to the digital-television transition. Feeling heat from Congress -- which is under pressure from the spectrum-hungry wireless-phone industry -- the Federal Communications Commission is trying to map a plan that would set a firm date for the return of broadcasters' analog spectrum. The FCC's Baedeker appears to be the city of Berlin. Last summer, the German capital became the globe's first major city to shut down off-air analog TV in a flash-cut to all-digital broadcasting that came off without any documented displays of civil unrest. According to government and industry sources, FCC chairman Michael Powell and Media Bureau chief Kenneth Ferree, learning from the Berlin example, are mulling a few options and bouncing them off congressional staff on Capitol Hill for a read on their political viability." Ted Hearn, *Powell, Ferree Eye Rigid Digital-TV Transition*, MULTICHANNEL NEWS (MARCH 12, 2004), http://www.multichannel.com/article/CA403381?display=Breaking+News.

> locked up in broadcasters' hands, instead of being put to more valuable uses, such as for advanced cell phone services. Not only are those needed, the spectrum also could be sold for billions, aiding a deficit-laden U.S. Treasury."[31]

Similarly, former FCC Chairman Kennard objected to the broadcasters' lack of commitment to the FCC's digital transition plan:

> Federal Communications Commission (FCC) Chairman William Kennard last week called television broadcasters "spectrum squatters" that hoard "the most valuable resource of the Information Age." …The broadcasters can operate on both [analog and digital] channels until 2006 or until over-the-air DTV serves 85% of the U.S. market. "Given the way that broadcasters are dragging their feet at the moment, we may not see that level of DTV penetration until 2025," Kennard said.[32]

In fact, tragedy of the anticommons is observed due to precisely the opposite state of affairs: because broadcasters do not enjoy property rights (or the ability to control use), they are unable to either deploy services that are intensely demanded by consumers, or 'cash out' by selling allocated bandwidth to alternative service providers who can do so more efficiently. In fact, the rights to provide a service of little value – TV broadcasting – is held by TV licensees, while rights to provide far more valuable services are held jointly by a large number of policy makers. The rights to provide new services are complementary with the rights held by broadcasters, as the spectrum allocated to the latter can be combined with the former to produce highly valuable output. Yet the bargain is difficult to arrange, not only because of public pressure to avoid "giveaways," but also because broadcasters' financial interests lead them not toward a generic property rights regime, but to a new vector of specialized rights. That bundle may contain some elements of liberalization (e.g., the right to reallocate digital TV spectrum for non-TV services) but will also retain protections favoring broadcasters against competitors (e.g., "must carry" rights granting TV licensees property rights to cable TV spectrum, and entry barriers in broadcast TV markets – still important due to "must carry").

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[31] Office of U.S. Senator John McCain, *McCain Calls for Free TV Time from Broadcasters*, Press Release (June 19, 2002), http://mccain.senate.gov/index.cfm?fuseaction=Newscenter.ViewPressRelease&Content_id=531 (emphasis added).

[32] Bob Brewin, *TV 'Squatters' Jeopardize Time Line for Wireless***,** ComputerWorld (Oct. 16, 2000), http://www.computerworld.com/news/2000/story/0,11280,52478,00.html.

Without a bargain to reallocate radio spectrum, licensees are left with a severely truncated set of rights. This preserves, however, the option value they partly exercise over the use of TV band spectrum.[33] Rather than constructively search out more valuable uses of radio spectrum, broadcasters instead devote their efforts to blocking reallocations that distribute rents in a manner that is disagreeable. They are able to control "their spectrum" by effectively exercising veto power over reallocations. Just as TV incumbents were able to block public safety and cellular interests from "taking" TV band spectrum two decades ago on the promise of providing high-definition television pictures, TV broadcasters can today block productive uses of 402 MHz of prime radio waves by sandbagging the digital TV transition.

The transactions costs of arranging a socially beneficial reallocation are very high. They include decades-long delays during which policy makers attempt to craft a delicate political bargain which induces incumbent TV broadcasters to withhold their veto without extended inducements which are popularly seen as "giveaways." The anticommons tragedy occurs precisely because this stand-off leaves rights distributed in a manner in which the valuable TV band airwaves cannot be used productively. The resulting social loss is enormous, but generates virtually no public commentary.

### C. Excessive Rights Fragmentation in the MMDS Band

Just above the PCS band (1.9 GHz) and the unlicensed ISM band (2.4 GHz) is the MMDS/ITFS band (2.5-2.7 GHz). (The acronyms stand for Multichannel Multipoint Distribution System and Instructional Television Fixed Service.) This band is allocated 190 MHz of spectrum, and is considered valuable for fixed or mobile wireless service – voice or high-speed data. This opinion is validated by noting that radio spectrum Yet rights to use this radio resource are distributed in a manner that has destroyed such valuable opportunities.

Confirmation is provided by evidence from secondary markets. Currently, license values in the CMRS market are visible in two sets of transactions: NextWave licenses, long involved in bankruptcy litigation, are

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[33] How broadcasters have developed such power to control FCC rules is due to a combination of incumbency advantages generic to regulated markets, and special considerations attendant to the fact that broadcasters specialize in the production of "publicity," the key input into legislators' support functions. See: Thomas W. Hazlett, *Assigning Property Rights to Radio Spectrum Users: Why Did FCC License Auctions Take 67 Years?* 41 JOURNAL OF LAW AND ECONOMICS (Oct. 1998), 529.

now being sold to various wireless carriers; Nextel, one of six national wireless networks, has offered a plan to swap certain frequencies so as to obtain contiguous and more useful spectrum rights less subject to interference from adjacent users. License trades with transparent valuation data suggest that carriers are willing to pay about $1.50 to $2.00 per MHz per pop (i.e., per capita) for licenses that can be used under CMRS regulatory rules. For instance, Verizon Wireless just offered to pay the federal government $5 billion for a 10 MHz CMRS license at 1.9 GHz.[34] This equals $1.79/MHz/pop (assuming 280 million population).

In contrast, Nextel just purchased MMDS licenses held by WorldCom (which disposed of the licenses in its bankruptcy proceeding) for $144 million.[35] These licenses covered markets with about 100 million residents, and are allocated 190 MHz. This reduces to a price of about $0.0076/MHz/pop. This valuation differential vividly displays the effect of fragmented use rights. That is because spectrum regulations, which nominally allow MMDS licensees to provide mobile voice or high-speed Internet service (like CMRS licensees), require the assembly of overlapping rights, including those held by FCC regulators. This leads an executive at a wireless equipment manufacturer to observe:

> "The spectrum Nextel got was 1/200 the cost of mobile spectrum. A lot of that has to do with how messy the process of being able to provide services in the spectrum…"[36]

A petition to the FCC in late 2002 requests that a plan to reconfigure the rights issued in the MMDS be instituted.[37] The plan, reached by consensus through negotiations with various license holders in the band, seeks to eliminate various inefficiencies in the assignment of rights. Each stems from the fact that this band was originally allocated to broadcast services, and licenses permit the operation of a one-way transmitter in a

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[34] Glenn Bischoff, *Verizon Wireless pledges minimum $5 billion for 1.9 GHz spectrum Nextel covets,* MOBILE RADIO TECHNOLOGY (April 9, 2004), http://iwce-mrt.com/ar/radio_verizon_wireless_pledges/.

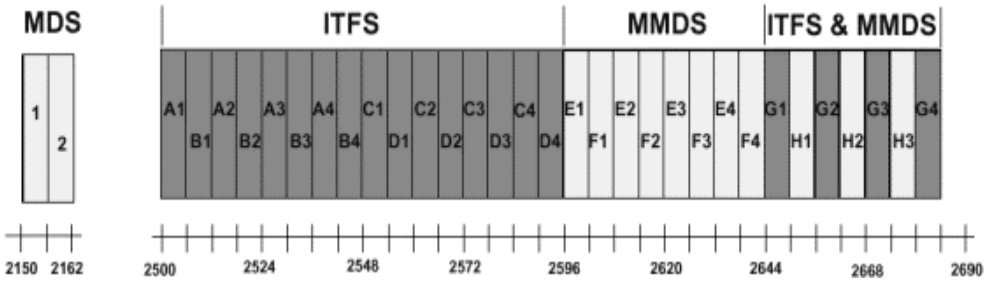
[35] Dan O'Shea, *Big Nextel bid wins Worldcom wireless assets*, TELEPHONYONLINE.COM, (July 1, 2003), http://www.wirelessreview.com/ar/telecom_big_nextel_bid/.

[36] Annie Lindstrom, *Carrying the MDS/ITFS Torch*, SHORECLIFF COMMUNICATIONS MAGAZINE (Sept/Oct 2003), quoting John Hambidge, senior director of marketing at IP Wireless, a fixed wireless broadband technology supplier; http://www.shorecliffcommunications.com/magazine/print_article.asp?vol=40&story=371.

[37] Wireless Communications Association, International, et al., *A Proposal for Revising the MDS and ITFS Regulatory Regime*, White Paper submitted to Mr. Thomas J. Sugrue, Chief, Wireless Telecommunications Bureau, Federal Communications Commission (Oct. 7, 2002) ["WCA 2002"].

fixed location to emit at high power levels. The type of service licensed has never been much demanded, and the MMDS rules were relaxed in 1998 to allow licensees to use the allocated frequencies for two-way broadband, which presumably is (as seen in the rapid growth of digital subscriber lines and cable modems).

FIGURE 3. THE MMDS BAND




The transition to new services under the old spectrum rules creates several transactional difficulties. First, broadband systems want to create cells to re-use spectrum (cell to cell), but the rules mandate that each transmitter be licensed, a lengthy and costly administrative transaction. In essence, subdivision of spectrum space is heavily taxed. Second, transmitter separation rules to limit interference between TV stations are inappropriate for broadband, where receivers are better able to decipher transmissions. Current rules leave large areas where broadband transmitters (either base stations or client radios) could not transmit because such emissions – while inconsequential to other broadband systems – would theoretically disturb microwave broadcast signals – which may not exist but which regulations yet protect. This fragments spectrum rights and imposes very large transactional costs (the expense of acquiring new FCC rules) to reassemble them for productive use.

Third, many channels assigned to instructional broadcasters are "interleaved" with channels assigned to microwave users. See the "ITFS & MMDS" band in Figure 3. This was originally done to limit interference between users, but it now – given some (efficient) spillover between channel usage and rules protecting each licensee from encroachment – "hampers the ability of individual MDS and ITFS licensees to deploy broadband services by giving adjacent channel licensees a 'veto power' over any proposed offering."[38]

[38] WCA 2002, p. 10.

These, and other, regulatory issues would be dealt with in the MMDS consensus plan by repacking the band and allowing licensees greater freedom to determine their own interference rules. Licensees, seeing much improved valuations with more rational utilization in the band (i.e., the data we examined above), wish to eliminate the old apparatus licensing rules in favor of "geographic licensing" and a "spectral mask." These would give licensees flexible use rights within the frequency space already (implicitly) specified. Moreover, the consensus plan would bunch broadcast TV licenses together, leaving broadband operators adjacent to each other. This would reduce spillovers and, hence, transaction costs.

As simple as this transition is theoretically, it is difficult to achieve in the administrative process. The more than 99% discount applied to MMDS licenses by financial investors attest to bother the inefficiency implied in the allocation of resources and the high degree of difficulty involved in reforming the rights structure.

## III. Unlicensed Spectrum's Dual Tragedies

> The Commission's rules for unlicensed transmitters have been a tremendous success.… The success of our unlicensed device rules… shows that there could be significant benefits to the economy, businesses and the general public in making additional spectrum available for unlicensed transmitters.[39]

Since the issuance of its Spectrum Policy Task Force Report in November 2002, the FCC has moved unlicensed spectrum use to the top of its regulatory agenda. In the intervening months, proposals to allocate more unlicensed spectrum have been advanced by the Commission for the television band[40] and the 3650-3700 MHz band.[41] The Interference Temperature proceeding[42] proposes to allow unlicensed use of low-power underlays in licensed bands, a proposal similar to that advanced in the

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[39] Federal Communications Commission, ET Docket Nos. 04-186 and 02-380.

[40] Ibid.

[41] Federal Communications Commission, *In the Matter of Unlicensed Operation in the Band 3650-3700 MHz: Notice of Proposed Rulemaking*, ET Docket No. 04-151 (released April 23, 2004).

[42] Federal Communications Commission, In the Matter of Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile and Satellite Frequency Bands, ET Docket No. 03-237 (Released November 28, 2003).

cognitive radio notice.[43] In late 2003, an additional 255 MHz of spectrum was allocated for unlicensed use in the 5 GHz band. This follows the 1997 U-NII allocation, under which 300 MHz in the 5 GHz band was allocated for unlicensed use.

TABLE 2. FLEXIBLE-USE LICENSED AND UNLICENSED BANDS (MONETARY VALUES FOR 2003)[44]

| Band | MHz | Type | Services | Service Rev. | Equip. Rev. | Network Capex |
|---|---|---|---|---|---|---|
| 1.9 GHz | 20 | UNL | Voice, data, UPCS (Unlicensed PCS) handsets | ~ 0 | ~ 0 | ~ 0 |
| 900 MHz, 2.4 GHz | 26 83.5 | UNL | Remotes, listening devices, cordless phones, wireless LANs, WiFi, microwave ovens, ISM equipment, local positioning systems, experimental use by schools | $0.03 billion | $3.81 billion | $0.5 billion |
| 5 GHz | 555 MHz | UNL | WiFi, HiperLAN, HiSWAN, amateur radio, field disturbance sensors (such as door openers), aviation radar | ~ 0 | $0.16 billion | $0.02 billion |
| 800 MHz, 1.9 GHz | 189 MHz | LIC | Mobile phones, data | $88 billion | $13 billion | $21 billion |

This relatively frenetic regulatory activity contrasts with a de facto freeze on licensed allocations. The PCS rule making, which officially began in 1990, allocated 120 MHz for licensed use (and 20 MHz for unlicensed use). PCS licenses were assigned in auctions held in 1994-1996. Since that time, there have been no license assignments for CMRS (or EAFUS) licenses in comparable spectrum. Kwerel and Williams, focusing on the bands below 3 GHz as the most valuable airwaves, identify just 170 MHz of CMRS spectrum as being utilized in Nov. 2002 – less than was allocated (but not yet fully licensed) to these services in 1994.[45]

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[43] Federal Communications Commission, *In the Matter of Facilitating Opportunities for Flexible, Efficient, and Reliable Spectrum Use Employing Cognitive Radio Technologies*, ET Docket No. 03-108 (released Dec. 30, 2003).

[44] Source: Thomas W. Hazlett and Matthew L. Spitzer, *Advanced Wireless Services, Spectrum Sharing, and the Economics of an "Interference Temperature,"* White Paper submitted to the Federal Communications Commission, ET Docket No. 03-237 (April 5, 2004).

[45] The shortfall owes to the bankruptcy litigation involving PCS C block licensees.

In steering toward unlicensed allocations, the Commission's logic is simply stated above. Unlicensed devices have proven successful in the marketplace; it is in the public's interest to allocate more frequency for their use. Of course, tragedy of the commons is inevitably an issue in such regulatory decisions, because it entails an open access regime. In this section, I examine the economics of unlicensed spectrum in light of the potential for common interest tragedies to undermine efficient wireless market performance.

## A. Governance v. Exclusion

Scholarship on common ownership systems indicates that property rights need not be exclusively assigned in each instance for an efficient market outcome to obtain. Various rules, customs, or "protocols" can be as effective in rationing the use of scarce resources as the price system could alternatively perform given exclusive rights. The relevant issues involve the efficiency of group decision-making and enforcement, the value of the property, and the cost of using the market to allocate resources.[46]

Useful analysis of the trade-offs between alternative regimes for rationing scarce goods in the "exclusion-governance" dichotomy elucidated by Henry Smith.[47] In this framework, resource use conflicts are dealt with in two distinct ways. On one side of a continuum, access to the resource is exclusionary; dissipation (including tragedy of the commons) is avoided by ownership. At the other end, uses are regulated – governance.

The real world mixes these limiting devices in various proportions. Property identified as a commons is rarely pure open access, instead relying on legal rules or norms (governance) to ration usage. On the other hand, exclusive ownership rights yield market outcomes that often encompass shared access rights; resource rights are either parceled or access is allowed with use restrictions. Choice of rationing instrument focuses on the value of the underlying resource, as well as the cost of measuring resource use.

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[46] Harold Demsetz, *Toward a Theory of Property Rights*, 57 AMERICAN ECONOMIC REVIEW PAPERS & PROCEEDINGS 347 (1967); Elinor Ostrom, Governing the Commons (1990); Ronald H. Coase, *The Nature of the Firm*, Economica (1937); Richard Epstein, *The Allocation of the Commons: Parking on Public Roads*, 31 JOURNAL OF LEGAL STUDIES S515 (June 2002).

[47] Henry E. Smith, *Exclusion Versus Governance: Two Strategies for Delineating Property Rights*, 31 JOURNAL OF LEGAL STUDIES S453 (June 2002).

This framework helps explain the licensed v. unlicensed regulatory choice in radio spectrum. Unlicensed bandwidth is not a "commons"[48] in the sense of common ownership. Rather, usage is regulated by government restrictions levied on equipment. Power levels and protocols and, in some cases, business models[49] are mandated by regulators to avoid tragedy of the commons. The aim is to separate users by limiting emissions, helping to avoid congestion.[50]

Where users are regulated such that interfering with their neighbor's (low powered, localized) use of spectrum space is relatively difficult, wireless demands supplied by the device market may be valuable and over-use may be avoided. That is, users of wireless devices – say, cordless phones, garage door openers, or WiFi systems (cordless PC connections) – may purchase equipment that economically exploits the limited opportunities afforded under unlicensed rules. In fact, spectrum conflicts are largely avoided by governance.

Some argue that competition among equipment vendors will itself produce an efficient outcome in an unlicensed spectrum regime. But bandwidth lacking any exclusivity or governance rules will predictably degenerate into suboptimal deployment whenever scarcity conditions apply. These conditions apply in bands consumers and networks most desire to use. This is why unlicensed bands are regulated via use restrictions.

Such regulation leaves open the possibility of market failure. This occurs when wireless devices are utilized without regard to externalities. EAFUS licensees attempt to use technologies that reduce the bandwidth

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[48] Despite its common designation as such. See, e.g., SPTFR 2002.

[49] For instance, regulators in the United Kingdom prohibited commercial services from being provided using unlicensed bandwidth until quite recently. This was a device to limit spectrum crowding.

[50] It is sometimes asserted that there is no such thing as "traffic" or "congestion" in spectrum, as signals do not physically collide. The assertion is that "interference" is only a problem of inadequate receivers; better technology could, in any particular circumstance decipher a signal even in the presence of interference. The irony is that this argument is typically made in tandem with the argument that spectrum is not a physical thing and that the property concept does not apply to spectrum because property (like "real property") possesses physicality. Kevin Werbach, Radio Revolution (Washington, D.C.: New America Foundation; 2003). But it is actually just the reverse. Property rights are *never* physical. Rather, they are social constructs that give economic agents the ability act in particular ways, while excluding others. Whether signals actually "congest" or "collide" is immaterial, as is the scientific observation that improved technology could overcome communications degradation due to the presence of multiple signals. The salient economic fact is that economic activity of a rights holder is impaired – either through higher costs or lower quality – by the existence of conflicting uses of radio waves.

needed to provide a given communications link, because that creates more capacity for other communications and the value of these additional services is internalized by the network operator. In an unlicensed situation, the radio spectrum user may use advanced (and more costly) systems to conserve spectrum capacity, but those benefits will accrue to others. This is why unlicensed users continually face choices about power limits, protocols, and occasional group activity to restrain over-consumption.[51]

This approach to metering spectrum use works better when users do not demand services best delivered with extensive spectrum sharing. Short-range applications that use relatively little bandwidth – in geographical space – are largely compatible with the use of similar spectrum space in other areas. This prompts equipment vendors to supply customers (or IT departments) with local area networks and other wireless devices that may be highly valued. The coordination of radio spectrum is achieved governance.

In fact, property rights to real property make a very real contribution. Because over-use of spectrum is often avoided by the rational separation of devices by residents or businesses, parties that can allocate local bandwidth by using conflicting devices at different times or by selecting different unlicensed frequencies (say, 900 MHz for the cordless phone, 2.4 GHz for the WiFi system). This is exclusive rights structure is found to efficiently coordinate local usage:

> Contrary to claims that the success of the FCC.s unlicensed regime in general and WLANs in particular, are the result and proof of a

[51] A recent conference held at George Washington University, provided unlicensed WiFi connectivity for conference participants, distributing the following plea: Note that this is a 10 meg point that will be shared by many people, so please use it in moderation and avoid huge downloads or other bandwidth-hogging activity. Also note that you may run into some interference with the campus networks and the general wireless haze in the DC area." Program, Fourth Annual Future of Music Policy Summit (May 2-3, 2004), Washington, D.C. A recent newspaper article relayed a story about "one Florida suburb where so many signals jammed each other that residents formed an 'ad hoc neighborhood spectrum allocation committee' of WiFi users." Mike Musgrove, *Here, There, WiFi Anywhere Wireless Web's Spread Is Crossing Our Signals*, WASHINGTON POST (April 25, 2004), p. F1. When hotspots become over-crowded, access slows or stops, the product of insufficient network coordination. This has been known to happen at trade shows run by tech experts. "Wireless snafus at TechEd in Barcelona and CeBIT in Hanover have been well-documented. Both incidents had the same simple cause: An expert network installer failed to produce a working network because there were too many wireless units." Nick Hunn, *News - CeBIT over-does the WiFi - it falls over!* NEWSWIRELESS.NET (March 14, 2003), http://www.newswireless.net/articles/030314-crash.html.

> successful "commons," it is local property owners exercising their de facto rights that have prevented a "Tragedy of the Commons."[52]

WiFi hotspots can be built and maintained at a nationwide chain – say, Starbucks – to create a large number of valuable wireless services. Access is "open" in the sense that unlicensed spectrum is used by the PCs connecting to access points. But access is closed in two important respects. First, each Starbucks effectively controls "its" airspace, such that rival hotspots do not create conflicts. This result does not always obtain; conflicts with nearby hotspots, or other unlicensed traffic, occur.[53] Yet in the standard case it does, which has been sufficient to encourage the creation of over 4,500 hotspots nationwide.[54]

But the policy mechanism that allows property owners to secure a place for effective use of local airwaves comes at a steep price: government spectrum coordination via regulation. Those rules, particularly in the form of power limits, make investment in wireless networks exceedingly difficult and expensive for many applications. T Mobile, to extend the example, maintains approximately 20,000 base stations for its national PCS network. This infrastructure utilizes an average of approximately 25 MHz of radio spectrum – much less than the 2.4 GHz band reserves for WiFi use – and serves over 13 million subscribers. In 2003, T Mobile (owned by Deutsche Telekom) invested some $1.7 billion in capital. In contrast, the T Mobile hotspot investment, and the economic activity created, are trivial.[55]

The economics are simple: given the ability to use higher power levels, and the advantage of licensed (exclusively-assigned) spectrum rights, capital markets sink risky investments to provide valuable

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[52] Mike Chartier, *Local Spectrum Sovereignty: An Inflection Point in Allocation*, U.S. Department of Commerce, PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM ON ADVANCED RADIO TECHNOLOGIES, NTIA SP Special Publication 04-409 (March 2-4, 2004) ["Chartier 2004"].

[53] Sometimes competing WiFi access points will 'steal' hotspot customers; other times they will simply provide unwanted interference. Scott Rafer, *Uncommon Markets*: *T-Mobile's elusive Starbucks exclusive*, TECHNOLOGYREPORTS.NET (January 19, 2003), http://technologyreports.net/wirelessreport/?articleID=1452.

[54] "T-Mobile operates the largest carrier-owned wireless broadband network in the country with more than 4,500 convenient locations that offer the T-Mobile HotSpot service such as Starbucks, Borders Books and Music, Kinko's, select airline clubs and lounges, and some of the nation's busiest airports." Press Release, *On Campus with T-Mobile Hotspot*, Yahoo!Finance (April 16, 2004), http://biz.yahoo.com/bw/040416/165172_1.html.

[55] "In the U.S., In-Stat estimates that [this year] Wi-Fi providers will take in about $28 million – roughly as much as Verizon Wireless Inc., the nation's largest cellphone company, generates in 12 hours." Scott Thurm, *Chill Hits Wi-Fi 'Hot Spots,'* WALL STREET JOURNAL (March 18, 2004).

opportunities to customers. The value derived from short range unlicensed use may constitute efficient use of the spectrum space it occupies, but – if so – the limits that make that productive use possible deter it from offering efficient use in wider applications. That is where the exclusively-assigned rights held by wireless telephone operators are crucial from the consumer's perspective. Under an unlicensed regime, tragedy of the commons would be anticipated if government use controls were set too lightly, and tragedy of the anticommons (under-use) would be anticipated if too restrictive. Importantly, even if set optimally for localized use, the rules do not allow for the creation of wide area networks even when consumers are willing to pay the cost (including the opportunity cost of spectrum) to provide.

Hence, observed "success" of unlicensed bands in local use does not imply that additional spectrum would be efficiently allocated for more unlicensed use, or that such a regulatory model should be used to encourage broadband networks. Just as cordless phones are handy to use, but serve as complements rather than substitutes to the local exchange carrier's telephone service, WiFi systems have been productively deployed in enterprises, campuses, homes, and small businesses as convenient, mobile links to DSL, cable modem, or T1 connections. Even these short-range applications can encounter spectrum coordination difficulty, which is why universities and corporations typically maintain proprietary WiFi access and reserve the right to remove unapproved WiFi access points.[56]

**B. Using the Market to Coordinate Spectrum Use**

When providing wide area network services, more severe congestion problems develop with unlicensed spectrum. Even with sharp power limits, wireless operators can send signals several miles, depending on the nature of the signal sent and the quality of the antenna and receiving equipment. Many rural wireless ISPs (WISPs) offer service – over 1,500 by one count.[57]

First note that unlicensed WiFi use is particularly popular in two applications: (1) home or business networks; (2) rural broadband networks. These spaces feature fewer spectrum conflicts; with less scarcity applications work better via unlicensed. Alternatively, conflicts are more of a problem when using unlicensed airwaves to serve wide area services to metropolitan customers. In densely populated areas, the provision of

[56] See Chartier 2004 for the WiFi 'exclusivity' policies published by Carnegie Mellon University and Intel.

[57] These are said to serve 600,000 subscribers. NAF CITE.

wireless service is much more likely to need coordination to be worth the investment by carriers and their subscribers.

Secondly, the simple market reality is that the blunt instrument of power limits breaks down when operators turn their attention to overcoming those power limits to send signals a considerable distance. When airwave use crosses over the real property of many disparate parties, coordination becomes important and negotiations become difficult. This introduces the standard tragedy of the commons, as seen in the experience of WISPs using unlicensed spectrum. In petitions filed with the Federal Communications Commission, such operators complain that interference with other unlicensed users seriously degrades their service. One writes:

> I own and operate a WISP (Wireless Internet Service Provider) in rural Southern Illinois. I provide services over the network I have built there that exceed the quality and varied uses seen in any other broadband based networks… This is not just coffee shop WiFi we are discussing… This type of highly engrained use of this technology in small towns and metro areas is not unique to Mt. Vernon, IL. These services are part of the infrastructure of our communities now on a worldwide scale. The aggressive adoption of these bands has come with little protections to WISPs and their high profile customers and is in danger of creating a disastrous implosion if nothing is done to remedy the impending interference hazards on the horizon. WISPs have no rights to the spectrum they use… I want to suggest a policy to help solve these issues and provide unlicensed use of this band simultaneously. I propose a new policy called the WISP Homestead Policy… Homestead status would be given to WISPs who register with the FCC and provide documentation proving active use… There would be no enforcement of license rights unless a homestead operator proves they have a claim to spectrum and that they are receiving interference from other sources.[58]

[58] John Scrivner, Mt. Vernon. Net, Inc., *WISP Homestead Policy Proposal For WISP Use of the ITFS Band*, Comment filed with Federal Communications Commission, WT 03-66 **(**March 19, 2004).

This view is echoed, if not copied verbatim, in numerous other F.C.C. filings by those attempting to use unlicensed frequencies for "last mile" broadband. Here are Comments from Jeff Phillips of Rural Ramp:

> I would like to encourage the FCC to reallocate some spectrum for exclusive use of internet service providers or other deployers of outdoor fixed wireless broadband data networks.
>
> Currently numerous companies, mine included, are working to deploy high-speed internet service in areas it does not yet exist by using off the shelf wi-fi equipment because licenses and licensed equipment is much to[o] expensive in many rural markets. A problem that we run into is that the 2.4 GHz and other ISM bands are jammed with all sorts of off the shelf consumer products, like cordless phones, security cameras, etc. Many of our customers would like to have their own home Wi-Fi Lan, and we have to ensure that their signals do not interfere with the one they are using on their roof to connect to our network. It is quite a bit of a pain to deal with at times.
>
> I feel that the vast majority of wireless ISPs are more than willing to cooperate with each other to ensure that their network deployments do not cause signal inte[r]ference with each other…
>
> What we need is a small chunk of spectrum that any ISP or other outdoor network deployer can freely use without worry of interference by completely irrelevant devices. I would suggest charging a very minimal (say $100/year) registration fee for ISPs to identify themselves and the general area or community that they intend to use the spectrum in. This way when one goes to deploy a fixed wireless data network, we would not worry about interference from everybody and their brother and could get a very simple list of other organizations using the spectrum in our area, so that we can contact them and work out arrangements to ensure that our signals do not cause problems with each others networks.
>
> I would strongly discourage the FCC from allowing consumer products to use these frequencies, as they already

> have several different ISM bands to use (900 Mhz, 2.4 GHz, etc.)[59]

Other comments from WISPs are displayed in Table 3.[60] One might ask: why can equipment vendors compete to provide systems that relieve congestion experienced by unlicensed users? They do offer solutions, but they are geared towards letting the buyer communicate more effectively rather than economizing on spectrum space that could be used by others. This is what creates the reported conflicts. And such conflicts will increase when the applications involve substantial sharing of radio spectrum.

Something similar to Ronald Coase's "nature of the firm" analysis is relevant here.[61] For some wireless applications, users find that they can effectively integrate into the spectrum coordination function (called "self-provisioning, sometimes). They can buy the help they need embedded in the equipment they purchase, possibly aided by an enterprise-level "tech support" department. In other wireless endeavors, however, users find it efficient to purchase spectrum coordination services from an agent who organizes thousands or millions of subscribers into a network. This not only reduces conflicts given an existing communications infrastructure, it offers secure airspace in which the spectrum coordinator can arrange substantial irreversible investments. The enormous capital sunk in wireless networks operated on exclusive-assigned spectrum offers consumers services that are not economically viable under the governance model.

TABLE 3. COMMENTS BY UNLICENSED WISPS IN F.C.C. DOCKET NO. 03-66

| | |
|---|---|
| Reliable Internet Services (3.19.04) | I recently heard that the FCC was looking at adding more spectrum to the 2.4 band. This would be great for us as we could use it, with all of the 2.4 phones, home users having wireless networks, and other wireless isp's it is hard to find channels that are not crowded. I am in |

[59] Jeff Phillips, Rural Ramp, Comment filed with the Federal Communications Commission, WT 03-66 (March 22, 2004).

[60] Many wireless experts have concluded that some form of exclusive rights will be needed to police "unlicensed" spectrum use. "What is almost certainly going to have to happen is a congestion charge. We'll have to evolve social mores to say who will provide the access point for an area, and what rights the rest of us have. We'll have agreements about turning off clients that aren't being used. We'll have a shift from private wireless transport to public infrastructures. Guy Kewney, *Breaking Wi-Fi Gridlock*, EWEEK (September 10, 2003), http://www.eweek.com/article2/0,4149,1364568,00.asp. Mike Chartier, of Intel, writes that he "advocates the establishment of local spectrum sovereignty, where the right to use some frequencies, and freedom from interference in using them, is attached to the property where they are used." Chartier 2004, p. 29.

[61] Ronald H. Coase, *The Nature of the Firm*, ECONOMICA (1937).

| | |
|---|---|
| | full support of this type of move. |
| John Buwa, Michiana Wireless (3.22.04) | We are a small privately owned wireless internet service provider and would like to see more unlicensed spectrum in the MMDS/ITFS band that is available for our use. Something that is reserved for our industry would be nice to where a consumer could not knock our service out by something they can by at the store be it a access point or phone or camera or whatever rf device they use. |
| Accel Net, Inc. (3.22.04) | We also would be in favor of adding some teeth to the ISM rules to keep operators from causing frivolous interference on sites that are being used for mission critical applications. We also need to get the amateur users off of this band as well. |
| T Stelle (3.22.04) | I would simply like to voice my desire to see more unlicensed spectrum in the MMDS/ITFS band. We (and other WISPS) are utilizing this resource to provide needed services to underserved areas as well as highly populated ones. Having this extra spectrum space will allow competition to thrive by allowing more space in which competitors can operate without interference. |
| K Sullivan (3.19.04) | We are currently using 5800, 2400 and 900 MHZ to distribute high speed internet access to the rural community that we are located in. The addition of the 2.5 Ghz band, or a portion of it, would greatly help us provide reliable access, as well as let us expand existing tower sites to a larger customer base. |

## C. Allocation Tragedies

The command and control allocation of licensed radio spectrum, as seen in the TV and MMDS bands, has led to severe inefficiencies. This central planning approach – "Gosplan" – has few defenders. Even the FCC, which continues to practice it, argues against it at an analytical level.[62] The truncation of rights issued to economic agents reliably results in spectrum being utilized to produce far less valuable output than what would obtain in a market with more extensive, and more flexible, spectrum use rights. This resembles tragedy of the anticommons in its under-utilization result, but it is a tragedy of the commons that keeps the necessary use rights from being defined and distribute to economic agents. The spectrum allocation reforms constitute public goods, and they are under-supplied because the gains from productive investments promoting them are largely appropriated by free riders.[63]

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[62] SPTFR 2002.

[63] Interestingly, initiation of license auctions lessens dynamic incentives for spectrum liberalization. Rent seeking to gain new spectrum allocations is taxed when new rights are allocated by the regulatory agency via competitive bidding.

Unlicensed allocations can also trigger observable multi-dimensional tragedies. Open access can, as elsewhere, lead to over-use when demand is insufficiently rationed by use regulations. Conversely, regulations themselves impose inefficiencies. In fact, the blunt instruments available to regulators – most generally, power limits – raise costs for many applications, even when higher power levels would not impose costs on other (licensed or unlicensed) users. Regulatory standards, however, are difficult to customize and, given administrative inertia, difficult to update. These rigidities are especially important when technology is dynamic.

In some cases, as with very localized wireless services, the blunt instruments available to ration unlicensed spectrum access work well enough so that users can purchase radios that provide valuable services. This is seen in popular use of the 900 MHz and 2.4 GHz unlicensed bands. Yet wide area networks have been able to use such bands only in limited situations (such as low-demand rural areas) due to the costs imposed by use regulations, on the one hand, and congestion, on the other. The unsuitability of the regulatory model then imposes tragedy of the anticommons by discouraging investment in such bands. New network infrastructure will not likely be built, even when demand is sufficient to justify the cost of a network, due to the insecurity of airwave rights. Because new interference would render sunk capital largely worthless, wireless communications systems are simply not constructed.

The importance of licensed spectrum, with protection from interlopers, is seen in the evolution even of the WiFi standard itself. The emerging WiMAX broadband standard aims to serve metropolitan area networks by sending signals as far as thirty miles from a transmitter. WiFi hotspots, in contrast, have a radius of under 100 feet in most practical deployments.[64] It is noteworthy, then, that WiMAX is being advanced as a licensed service precisely because its supporters – most notably, Intel – believe that radio interference would limit its usefulness.[65]

Unlicensed spectrum allocations cannot escape tragedy at the most fundamental level of technology choice. When the government sets aside given bandwidth for unlicensed users, access rights are distributed so widely as to make negotiation among interested parties prohibitively expensive. This becomes an issue when technologies become available that

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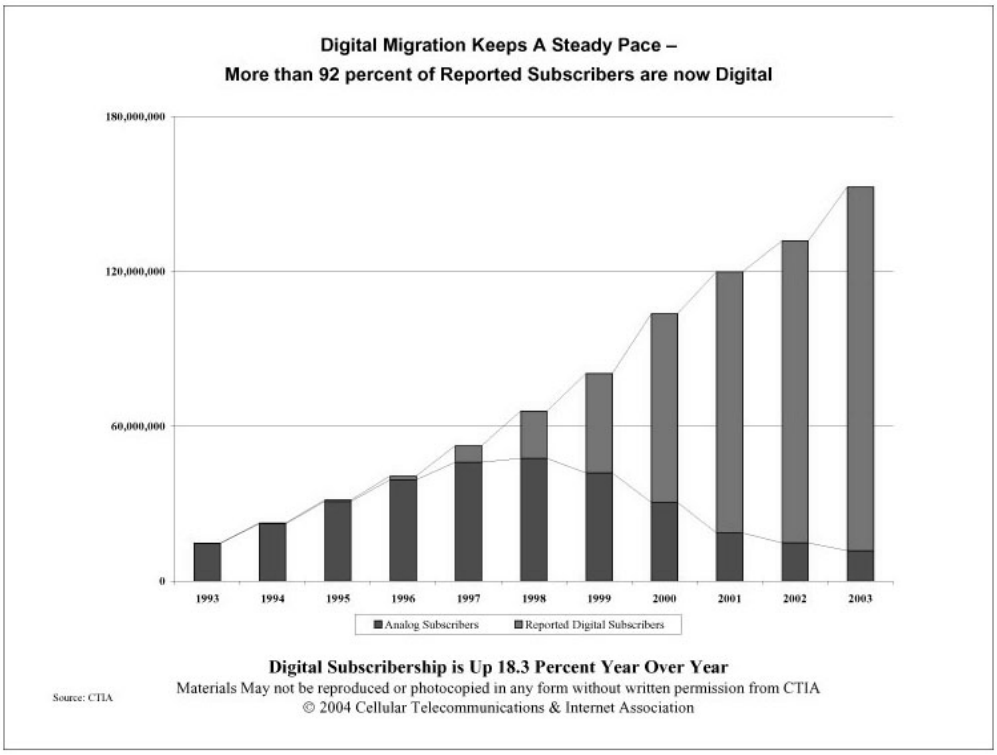
[64] Jeff Belk, *Adventures in the Public Hotspot Wi-Fi World*, http://reiter.weblogger.com/2003/05/27 (May 27, 2003); Jeff Belk, *Adventures in the Public Hotspot Wi-Fi World, Part II*, http://wifinetnews.com/archives/001767.html (June 12, 2003).

[65] Peter Pitsch, XXX (2004).

are efficient to deploy but require group action. In cellular, a transition from analog to digital networks in the 1990s was achieved seamlessly because operators, internalizing the gains from more efficient (digital) spectrum use, invested in new architecture and widely distributed new phones. These carriers were also careful to manage the transition, having flexible rights to gradually shift spectrum capacity from analog carriage. Millions of users have been migrated to entirely new networks, without organization difficulty, due to the rights structure of EAFUS. See Figure 4.

FIGURE 4. THE DIGITAL CELLULAR PHONE TRANSITION




In contrast, the digital TV transition is entering its third decade. Instead of spectrum holders changing out technologies to increase the value of services offered, government mandates direct TV stations and TV buyers how the transition will proceed. The political outcome is that interest parties are not much interested, and key players – e.g. broadcast stations – find that they can extract rents by non-cooperation (hold-up). Similarly, in unlicensed bands, users cannot be organized to abandon old systems and upgrade to seize new opportunities, given the extreme decentralization of rights. The inability of existing unlicensed bands to accommodate new technologies is, in fact, the FCC's stated argument for allocating new spectrum blocks for unlicensed use.

But each time a block of frequencies is set aside for unlicensed, the opportunity cost of alternative use in invested. Those costs can be substantial, given the extremely high social value of additional EAFUS spectrum (see discussion above). Again, tragedy of the commons enters. Because unlicensed users have highly fragmented property rights, no market valuations are discernible. In evaluating which bands to allocate for licensed, which for unlicensed, markets can reveal consumer demands only for the latter. Without such information, regulators cannot evaluate the relevant economic trade-offs.

No matter the error made in an unlicensed allocation, rights are dispersed and cannot be reassembled short of a new regulatory mandate. Conversely, EAFUS rights are responsive to consumer demands, in that the exclusive rights vested in a responsible economic party allows low-cost coordination to accommodate new industry structure. Included in the opportunity set are low-power services of the type commonly provided, on a shared basis, in unlicensed bands. EAFUS avoids the common interest tragedies that plague both licensed and unlicensed allocations made under command and control.

## IV. Policy Implications

Common interest tragedies occur in both licensed and unlicensed radio spectrum allocations. They stem from fragmentation of rights such that the efficient level of coordination between spectrum users is deterred. The anticipation of such a result will, ex ante, cause investors to limit their commitments, providing less network infrastructure than in an optimally structured rights regime. And, due to the public good aspect of regulatory reform, more efficient rights structures are under-supplied, leaving the "market failure" uncorrected. Hence, multi-sided common interest tragedies as suggested by Lee Anne Ferrell.

Alternatively, market failure is avoided in the intensely utilized radio spectrum coordinated via liberal property rights. With exclusively-assigned, flexible-use spectrum (EAFUS) allocations, operators create substantial national networks, deploy advanced technologies, compete to drive down costs, and coordinate extremely complex spectrum sharing arrangements. Marketplace evidence indicates that the CMRS band, with the most liberally use rights in place, produces annual consumer surplus exceeding $80 billion, and further evidence suggests that additional EAFUS

bands have very high social value both absolutely and relative to alternative incremental uses of radio spectrum.

U.S. regulators, however, have allocated no EAFUS rights since PCS licenses were authorized in 1994. In the interim, 555 MHz (in the 5 GHz band) has been set aside for unlicensed use in two separate rule makings (in 1997 and 2003), and several proceedings are now in process to make additional spectrum available for unlicensed use. In some of these, the Commission expresses an explicit preference for unlicensed over licensed allocations.[66] In others, the effect would be to transfer spectrum currently used by licensees to unlicensed use.[67] In every case, the allocation for unlicensed use precludes competitive market reallocation – based on investor anticipation of the services and technologies that will most profitably satisfy consumer demands – of rights that are distributed so widely as to be labeled a "commons."

These decisions substitute regulations for market forces. Spectrum resources that could be utilized in one way are instead used in a mutually incompatible way, as determined by administrative edict. The cost of the alternative use is incurred by consumers – externalities decisionmakers impose on others. Consumers may not be well served, but they are dispersed, information is costly, organization is difficult, and free rider problems ubiquitous – reform is stymied by tragedy of the commons.

Hence, regulators have considerable latitude to express their regulatory preferences. While they do not have reliable information as to the magnitude of the unlicensed allocation values (no bidders for spectrum), market evidence does shed light on the high opportunity cost. This is found in the estimated magnitudes of consumer surplus associated with incremental EAFUS allocations. Yet, FCC rule makings do not attempt to

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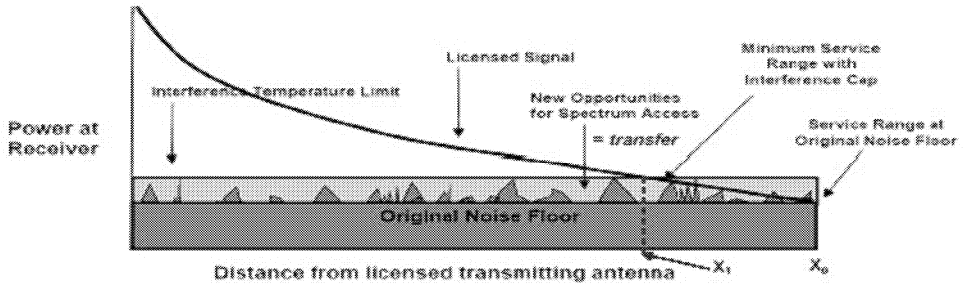
[66] In its proposed rule making in 3650-3700 MHz, the Commission considers allocating 50 MHz of nationwide spectrum – virtually all of which has been left idle in a band allocated for satellite downlinks that occur only on the East and West coastlines -- for new uses. It proposes to allow unlicensed use according to sharing rules it will draft, rejecting requests to allow licensed uses, on the grounds that the latter would interfere with the former. "[W]e believe that even a moderate presence of potentially ubiquitous terrestrial services under a licensed allocation could hamper or preclude the operation of unlicensed devices in large geographic areas – including, especially, rural America where the need is greatest. Therefore, our initial proposal to allow unlicensed operation" precludes licensed use. The Commission went on to request input on the matter. Federal Communications Commission, *In the Matter of Unlicensed Operation in the Band 3650-3700 MHz: Notice of Proposed Rulemaking*, ET Docket No. 04-151 (released April 23, 2004), par. 21.

[67] This is the proposal in the Interference Temperature proceeding, discussed just below.

quantify the opportunity cost incurred when regulators divert inputs (i.e., spectrum) from satisfying the revealed preferences of consumers.

Understanding the nature of common interest tragedies can contribute to policy analysis just here. Take the ongoing Interference Temperature proceeding.[68] Within a licensed band, signals are transmitted from an antenna intended to reach receivers. When signal strength is only as strong as the noise floor, distinguishing the intended signal from other emissions is difficult. Traditionally, most wireless systems have been engineered such that coverage ends where signal strength equals that of the underlying noise floor. In Figure 5, this is labeled "Service Range at Original Noise Floor."

FIGURE 5. FCC'S INTERFERENCE TEMPERATURE PROPOSAL




The Commission also observes interfering emissions above that caused by standard background noise. These often emanate from communications traffic, both in-band and out-of-band, causing spikes above the "noise floor" at certain times, places, and frequencies. Because they occur only intermittently, they do not often eliminate reception of low power signals. But because they can seriously degrade service, licensed systems were historically engineered to rely solely upon higher power levels.

The FCC concludes that there exists a well-defined space between the noise floor and the licensed signal floor. This space, defined in a given

[68] Federal Communications Commission, *In the Matter of Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile and Satellite Frequency Bands*, ET Docket No. 03-237 (Released November 28, 2003).

band in a given geographical market by the power of the signal at the receiver, is labeled *Transfer*. The *Transfer* bandwidth would be taken from the licensed spectrum allocation and reallocated for use by unlicensed devices. The Commission argues that this gives licensees security against encroachment (i.e., interference from a rising noise floor), and allows unlicensed users valuable new opportunities. In essence, regulators arrange – or, rather, impose -- gains from trade.

What is not considered, however, is the alternative allowing competitive markets to optimize use of this spectrum space. Were the gains as clear as the Commission theorizes, market transactors would not need to be coerced into realizing positive sum exchanges – except in the presence of transactional difficulties like common interest tragedies. But the evidence available overwhelmingly suggest that spectrum use is used intensely and that sharing among millions of disparate, potentially conflicting, users is efficiently coordinated by what Coase calls "the price system."

The irony is that the EAFUS rights enjoyed by CMRS licensees have already produced intense utilization of precisely the space defined by the proposed *Transfer*. One example directly relevant to the wireless networks operated by Verizon and Sprint: the CDMA chip used in handsets adjusts power levels some *800 times per second*, continuously searching to emit just the minimum level of radiation to keep a communications link connected. This dynamic power optimization not only prolongs battery life for mobile radios, it conserves valuable bandwidth so that more capacity is left for other uses. These gains are internalized by wireless network operators, which invest billions of dollars to deploy the advanced technologies that produce such sophisticated sharing opportunities.

By seeking to transfer spectrum rights from licensees, the FCC understands that it must substitute its rules for those of private coordinating agents. But it does not conduct an analysis of the transactional asymmetries between the alternative rights assignments. If it did, it would discover that common interest tragedies are of primary concern. In transferring rights to a "commons," the transactional efficiencies of a well-defined property rights structure are sacrificed. That EAFUS markets overcome highly complex coordination problems to divvy spectrum use rights among tens of millions of competing users is relevant information. Conversely, so are the observed and implicit common interest tragedies associated with unlicensed spectrum allocations.

Indeed, the argument for allocating more spectrum for unlicensed services is driven – according to FCC arguments – by coordination failures

such as those spoken to by unlicensed WISPs (cited above). Because unlicensed wide area networks (WANs) conflict with existing local wireless applications (such as WiFi) as well as with each other, the FCC concludes that such WAN applications should be given access to more spectrum. Regulators, moreover, conclude that the low power limits placed on unlicensed bands has inhibited the financial viability of wireless WANs, and should be allowed to use higher power levels; this is used as further justification for additional spectrum allocations (given that higher power usage would raise costs of existing users elsewhere). Both rationales are motivated by observing the high cost of coordinating unlicensed spectrum use. Users cannot be efficiently organized to limit congestion, when economic optimization requires complex trade-offs between deployment of alternative technologies, funding of new technologies, access pricing structures, protocols, or other organizational devices. Transactions costs are seen to typically be prohibitive (tragedy of the commons) beyond local area usage. Blunt regulatory instruments are then used to control congestion, but impose high costs of their own, driven by extreme fragmentation of public rights and responsibilities.

Common interest tragedies sprinkled throughout spectrum markets allocated by fiat make it highly unlikely that efficient outcomes will be seen, particularly when opportunity costs are properly accounted for. An alternative legal framework, conversely, allows standard competitive market forces to allocate spectrum such that efficiency is highly likely. We have observed these results, and common interest tragedies do not appear to obtain where property rights are liberally defined.