Position Papers

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The Need for Well-Defined Yet Non-Exclusive Radio Operating Rights

Michael Calabrese[1]

Introduction

As mobile computing becomes ubiquitous, the resulting exponential growth in demand for wireless data transport will bend current spectrum allocation and commercial business models to the breaking point. Silos of exclusively-licensed and lightly-used spectrum will no longer be tolerable. The imperative of increasingly efficient use of spectrum on both an exclusive and shared basis suggests that we need to redefine access rights to spectrum capacity over the next decade to be:

- **More definite**: Rights to transmit and levels of protection from third-parties (both co-channel and adjacent channel) should be made explicit conditions of new and renewed licenses, and subject to secondary-market transactions.
- **More transparent**: The definition of these access rights and the operating parameters of all deployments on a licensed band should be registered in a publicly-accessible and useable database that can be used to facilitate decentralized coordination and negotiation, as well as opportunistic access to unused spectrum capacity.
- **More intensive**: Since both shared access to underutilized bands and an exponential increase in spectrum re-use will be needed to meet expected consumer data demand, a licensee's affirmative rights must not preclude the use of any remaining capacity by third parties on a non-interfering basis. Radio rights should conform to a 'use it or share it' ethos.

In short, the FCC needs to return to the unfinished challenge defined by its own 2002 Spectrum Policy Task Force (SPTF): To quantify permissible levels of interference on a service-by-band basis. Although Commission staff decided that the "interference temperature" measurements suggested by the SPTF were unworkable, the concept of quantifying the explicit transmit rights and reception protection that a licensee can count on – on a probabilistic and not absolute basis – would better permit private parties to self-manage issues of interference and shared band access. In contrast, the continued resort to a case-by-case, ex post adjudication of interference claims will increasingly cause uncertainty, delay and under-investment.

Outdated Assumptions of Command & Control Interference Protection

Today's spectrum allocations and radio operating rights continue to reflect a dichotomy between the relative availability of spectrum and technology that existed during the first half-century or more of spectrum licensing – but which has nearly reversed itself today. When government licensed broadcast radio in the 1920s and broadcast TV in the 1940s and 1950s, spectrum was plentiful but technology was primitive. Both assignments and rights reflected an industrial policy goal to stimulate the mass-market penetration of very low-cost reception devices (radios, TVs – and later analog cell phones) in a context of relative spectrum abundance. Since there was spectrum enough to allocate guard bands several times larger than the actual channels in use, the cost of receivers could be minimized – and a precedent set that receivers would not be expected to tolerate any degree of interference from other uses.

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The policy of protecting receivers from "harmful interference" became simultaneously absolute (rather than probabilistic or contingent) and vague (since it was defined service-by-service, and only ex post in reaction to complaints). Moreover, the concept of licensing exclusive access to a channel or band presumed that (a) technology and governance rules could not support the shared use of underutilized capacity, except perhaps where there was no protection from interference at all (viz., on designated unlicensed bands); and (b) there were still sufficient allocations and assignments available to meet the public's need for new services and overall communications capacity.

All of these precepts continue to underlie the licensing of radio operating rights – whether to commercial users by the FCC, or to federal users by NTIA – and all are outdated obstacles to an exponential increase in mobile communications capacity.

An Updated Radio Rights Regime

An updated conception of radio operating rights should be based on policy goals that promote pervasive connectivity. It will be far more important to put rules in place that spur innovation and maximize communications capacity than it is to minimize interference per se. Indeed, one of the most oft-quoted passages from Ronald Coase's 1959 article The Federal Communications Commission made this point:

> It is sometimes implied that the aim of regulation in the radio industry should be to minimize interference. But this would be wrong. The aim should be to maximize output.[2]

Meeting society's demand for mobile communications capacity will require a concept of radio operating rights and governance that may seem contradictory by today's standards. We need to simultaneously make spectrum rights more like property (more explicit and certain for the period granted) while also making the overall communications capacity of the spectrum less like property (non-exclusive and open for shared access). That is, we need to provide licensees certainty and flexibility concerning their operating rights – thereby facilitating private negotiations and transactions – while also reserving any unused spectrum capacity to the public itself. Since the public interest in government excluding others from a band (i.e., licensing) lies entirely in the use of the spectrum to communicate, it is the licensee's service – viz., its actual use of the band's capacity – that deserves protection, not its non-use.[3]

In practice, I believe this can be achieved by a combination of definitional and governance changes:

1. Define explicit transmit rights and permissible interference on a band-by-service basis.

For new and renewed licenses, the Commission should make the complete set of transmission rights (e.g., transmit power, out-of-band emissions) explicit. The Commission should also define the level of protection the licensee can expect for its own operations, although this should be defined in probabilistic rather than absolute

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[2] Ronald H. Coase, *The Federal Communications Commission*, 2 Journal of Law & Economics 1 (1959), at 27.

[3] Of course, this follows from both the statutory definition of the FCC's licensing authority, as well as the Commission's fairly recent and explicit rejection of the argument that it does not have the legal right to authorize users of Ultra Wideband devices to emit energy in licensed PCS bands. Rejecting Sprint's claim that its license rights presume exclusive rights to emit on the band, the Commission firmly stated that "spectrum is not, and has never been, exclusive to Sprint or to any other licensee or user." First Report and Order, In Re Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, F.C.C. R. 10505 (2002), at ¶ 271.

terms. These rights, when first defined, would need to be defined service-by-band and as consistent as possible with neighboring adjacent- and co-channel licensees.

2. Combine these rights and the actual deployment parameters of licensees in a public database.

If key policy goals are to maximize useable spectrum capacity and facilitate innovation, then we should want complete transparency into both what licensees have a right to do and what they actually are doing. This enables other licensees to design their systems, to change the use of a band, or to attempt to coordinate and/or negotiate with other users. It also enables other potential users to employ dynamic spectrum access technologies or protocols to make use of unused capacity without causing harmful interference. Depending on the band, this dynamic access could be based on secondary market transactions, or it could be opportunistic and/or unlicensed. Access to any band with a primary user must be conditional; but a centralized, online information registry "enables secondary users to execute more aggressive spectrum access algorithms at acceptably low risk."[4]

The current opaque and uncertain definition of rights for incumbents and potential entrants alike deters both innovation and more intensive and efficient use of the public's spectrum resource. A more definite, transparent and explicitly non-exclusive definition of spectrum use rights on a band-by-band basis will be critical to supplying the capacity for pervasive connectivity.

[4] John M. Chapin and William H. Lehr, "The Path to Market Success for Dynamic Spectrum Access Technology," *IEEE Communications Magazine*, May 2007. Australia established a centralized online device database along these lines as part of its 1997 adoption of Space-Centric Management as a tool to define a complete set of explicit transmit rights for all new licenses to encourage certainty and industry self-regulation. *See* Michael Whittaker, "Authorising Dynamic Spectrum Access Under Space-Centric Management, Futurespace, February 2009.

The Three Ps: A resulting energy approach to radio operating rights

Pierre de Vries[5] and Kaleb Sieh[6]

The radio revolution is incomplete. The shift from "command and control" radio licensing to a more hands-off regime of flexible-use auctioned licenses and unlicensed operation is well under way, but the vital question of how radio operating rights should be defined, assigned and enforced in order to resolve interference disputes and obtain the maximum benefit from wireless operations remains largely unanswered.

The ambiguous definition of rights is a long-standing problem. For example, the FCC's 2002 Spectrum Policy Task Force noted a widespread sentiment that "the Commission's most difficult, controversial, and unsatisfactorily resolved cases have resulted from situations in which the extent of an incumbent's spectrum rights and interference rights, and its limitation on impacting other bands or users, were not clearly understood by the incumbent, by a new service provider, and even by this Commission."

A review of U.S. interference conflicts stemming from unclear cross-channel rights reveals instances where: two (or more) licensees are both operating within their licenses but unable to operate concurrently (800 MHz); the FCC changes the license rights after auction but before renewal (WCS/SDARS); lack of clarity concerning cross-channel protections leads to protracted proceedings (AWS-3); and a new entrant discovers an unforeseen need to remedy harm to adjacent channel incumbents (AWS-1/BAS). Inter-operator conflict is greatest across boundaries between different service types. The increasing diversity of radio uses and users, as well as the need to pack operations ever closer together, will only serve to amplify the problem.

Current radio operating rights are uncertain due to: the use of the harmful interference criterion; technical parameters that do not define the bounds of allowed operation objectively; the regulator's willingness to alter operating rights at any time during the term of the license; and ineffective delegation to operators of the means and incentives to negotiate bilateral resolutions. This has led to protracted conflicts and unexpected costs, which in turn inhibit innovation and investment.

Our approach is based on three principles: (1) aim regulation at maximizing concurrent operation, not minimizing harmful interference; (2) delegate management of interference to operators; and (3) define, assign and enforce entitlements in a way that facilitates transactions.

We propose that operating rights should be articulated using probabilistic transmission permissions and reception protections (the Three Ps). Since the RF propagation environment changes constantly, parameter values should be defined probabilistically as a percentage of times and locations. Transmission permissions should be based on resulting field strength over a range of locations and frequencies, rather than the radiated power at a transmitter. Reception protections should state the maximum outside electromagnetic energy an operator can expect over a location/frequency profile; protection levels are an undertaking by the regulator to implement these ceilings when making other allocations, but importantly do not form an entitlement against other, existing operators. This formulation of operating rights does not require a definition of harmful

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interference. Quantifying and addressing harmful interference remains a very important topic, but is delegated to operators and, should negotiation fail, adjudicators.

Since the initial entitlement point is unlikely to be optimal, or remain optimal for very long, the regulator should do all it can to facilitate adjustment of rights after the fact. In this process, the number of parties to a negotiation should be limited, both through rights assignments that minimize the number of recipients as much as possible, and by the regulator enabling direct bargaining between the parties. The regulator should stipulate the remedies that attach to an entitlement (i.e. injunctions or damages) when it is issued, and not decide such things *post hoc* in its capacity as an adjudicator. The regulator should clearly separate rulemaking, where it plays an essential role in defining entitlements, from the enforcement/remedy phase where its role, if a court is not available, should be limited to adjudication on the basis of existing rules. Notably, the regulator should refrain, to the extent possible, from rulemaking when acting as an adjudicator.

The full and complete description of every entitlement – including owner, Three P operating parameters, fixed station locations if applicable, and waivers if any – should be recorded in a public registry. And finally, the regulator should refrain from changing the rules, or adding new ones, in the middle of the game. After defining operating rights, parameters, and remedies in a license, the regulator should leave those unchanged until renewal. However, those same rights, parameters and remedies should be allowed to adjust though negotiation between operators.

The fruits of the radio regulation revolution can thus be gained by an objective articulation of the rights in an operating license, and the effective delegation of negotiation and dispute resolution to operators.

Confronting the Problem of Adverse Possession In Spectrum Rights

Harold Feld[7]

Abstract: In property law, a trespasser can acquire a property right in direct contravention to the property right of the actual property owner by occupying the land for some period of years in an "open and notorious" manner. Although spectrum policy has never officially recognized this doctrine, the difficulties of enforcement and the reliance interest created by widespread violation have compelled the FCC and licensees to de facto recognize the doctrine by accommodating widespread infringement. Nor is the solution to the problem amenable to traditional enforcement without significant investment in resources by licensees and the public. This paper proposes two approaches to the problem. The first is to simply embrace adverse possession as a doctrine in spectrum rights management and recognize de jure what the FCC has long recognized in practice. The second is to require technological measures to be embedded in wireless technologies that make spectrum use rights an inherent part of the technology. Both proposals raise significant questions for the long-term viability of a pure property rights regime, and suggest that an emphasis on spectrum use rights may represent a more practical approach than pure property rights.

[7] Legal Director, Public Knowledge

Progress Toward Rational Spectrum Rights: Are We Getting Anywhere?

Ellen P. Goodman[8]

Analysts from legal, economic, and engineering disciplines have supplied plenty of commentary in the past decade on what ails U.S. spectrum management. We have offered a number of competing proposals for how to define the rights of spectrum users to emit signals, the responsibilities of spectrum users to reject noise, how spectrum rights and responsibilities should be recorded, and how conflicts over interference ought to be adjudicated. We have also provided differing views on the proper balance between the prevention of conflicting spectrum uses (frequently called *ex ante* protections) and the resolution of conflicting uses after the fact (*ex post* dispute resolution), as well as varying suggestions for public and private institutional roles.

Notwithstanding difference in the details, it seems that analysts are converging on some important consensus conclusions. These include the following:

- We need much more spectrum made available for mobile broadband
- We need a combination of exclusive rights and shared rights to access spectrum, recognizing that sometimes we will want "easements" or low impact access to spectrum that has otherwise been assigned for exclusive use, sometimes we will want commons spectrum for unlicensed innovation, and sometimes we will want tightly controlled access for specific rights holders
- More intensive use will and should mean more conflicts over spectrum use
- These conflicts should be prevented before the fact by some combination of FCC zoning of compatible uses and industry performance standards
- These conflicts should be addressed after the fact with expedited adjudications and arbitrations, which depend on the creation of the appropriate administrative apparatus (in both private and public institutions)
- Efficient conflict resolution requires that initial entitlements be stated precisely in the license (or license-free allocation) at the outset, and be further articulated in what will be an evolving "common law" allocating responsibilities for mitigating interference
- What the right rule is for allocating responsibilities in any particular spectrum dispute will depend on the kind of services at issue, the relative ability of the parties to address the problem at the receiver or the transmitter, and other public interests (externalities) that may be implicated
- Spectrum use entitlements, both initial and post-dispute, should be made transparent in publically accessible and user-friendly registries

While these conclusions have been gestating, battles have played out over the allocation of spectrum for unlicensed and exclusive use, and over the modification of existing licenses to allow for more intensive (and valued) spectrum use. One cannot say that spectrum management has changed much over the past decade or that we have made a great deal of progress in implementing the conclusions stated above. Spectrum management is still pretty much the same as it always has been: highly conservative, protective of incumbents, without clear entitlements and dispute resolution procedures, lacking in the regularity and transparency that would facilitate secondary markets, and, most especially, bogged down in questions of fairness, windfall, strained readings of the public interest, and competitive advantage.

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That said, this Commission has made several notable recent decisions to free up spectrum for new uses by modifying existing entitlements and mediating between potential spectrum conflicts. These include the order opening up TV band "white spaces" available for unlicensed fixed and mobile wireless usage and the decision removing obstacles to mobile wireless use of spectrum adjacent to satellite radio. There were some innovations on the spectrum management front here and they are worth building on. The most important decision yet to come will probably concern the reallocation of broadcast spectrum for broadband use.

What can we learn from recent experiences? What would it take to accelerate progress?

1. *Things take longer when no one can be held accountable for interference.* One of the complications of unlicensed use, however desirable it may be, is that it's hard to assign responsibility for interference. This difficulty buttresses the already existing tendency towards conservative allocations and is one of the reasons the White Spaces decision took so long. Innovative "zoning," revocable certifications and registrations, and a certain amount of reciprocity for interference prevention ease this problem. Under-explored is the role that interference insurance might play.

2. *Failure or inability to deal with the receiver side of the equation produces sub-optimal entitlements.* Whether or not incumbents should have the obligation to improve receiver performance will depend on many factors, including the type of network deployed and the state and pace of technological innovation. Much more clear is that the FCC should have the authority to mandate receiver performance, or to mandate compliance with industry-set standards.

3. *Harmful interference should be a yield sign, not a stop sign.* The FCC continues to use predicted harmful interference as a gatekeeper to spectrum entry. The concept is in effect BOTH a tool to define rights (new entrant may not cause harmful interference) AND a tool to assign liability (new entrant is responsible for harmful interference it does cause). Instead, the notion of harmful interference should be, among other elements, what gives a spectrum user a "cause of action" to seek redress. Whether the harm is actually redressable, and by what means, should be separate questions.

4. *Confusing efficient spectrum use with distributional issues is recipe for delay.* The public interest in spectrum exploitation and the public (and competitor) interests in preventing licensees from getting windfall benefits are distinct. Whether or not spectrum rights should be expanded, who should get to take advantage of expanded rights, and what they should have to pay for them are all separate issues and should be handled separately, with mechanisms for redistribution of benefits where necessary.

5. *Consideration of values associated with spectrum use other than efficiency is under-developed.* Reallocation of broadcast spectrum in particular will touch on values that are baked into the current allocation, such as universal service, noncommercial set-asides, and distributed access rights. As with distributional issues, these considerations are conceptually separate from efficient spectrum exploitation, but will need to be dealt with.

How should radio operating rights be defined, assigned and enforced in order to obtain the maximum benefit from wireless operations?

Bruce Jacobs[9]

I agree completely with the premise of Pierre's paper about the benefits of clarifying radio operating rights. As someone who has been working on these issues since 1982 and has been advocating and negotiating on behalf of proponents of many of the new services that have been "born" since then, including the Mobile Satellite Service (including its Ancillary Terrestrial Component), Satellite Radio (including terrestrial repeaters), Broadband Radio Service, Broadband over Powerline, and several others unfortunately too obscure to mention, I have seen firsthand the frustration with the delay that characterizes the current regulatory process of defining and redefining rights. Over the years, the process has improved, but for more optimal technology development and capital investment, we should continue to strive for a more predictable jurisprudence that can minimize the delay inherent in relatively ad hoc processes. Engineers need to know what filters must be developed and what power levels they can rely on in a deployment design and business people who are interested in investing or doing deals must be put into a better position to judge their risks.

Ellen's San Diego Law Review article makes the excellent point that we cannot avoid defining such rights regardless of whether the overall regime is one of Command-and-Control, Shared Access, Exclusive Use, or whatever, and regardless of whether the remedy is injunctive relief or damages. In any of these cases, harmful interference needs to be defined, including how it is to be measured.

I do not want to minimize the difficulty of the task. Let's take Pierre's reasonable proposal that rights be established based on field strength spectral density at X% of locations, Y% of the time. How is that energy going to be measured? Ellen's article points out that there is no commonly-agreed way to measure emissions levels in a given geographic area, which is understandable given the complexity. Do you use actual field measurements or a predictive model? If you take measurements, what antenna and receiver do you use? If you use a predictive model, which models is appropriate? What clutter database do you use? What separation distance should be assumed? What height should be used? In a mobile environment, where interference is often fleeting, what probabilistic model should be used? The answers to each of these questions can have an enormous impact on the results and each needs to be addressed in order to establish the certainty that we are looking for.

The FCC has had good reason to prefer a more ad hoc approach, given the dynamic nature of technology and the varying policy implications of each case. For instance, adoption of Pierre's suggested regime would involve an enormous potential reallocation of value depending on the level of protection (i.e. field strength spectral density at X% of locations, Y% of the time) set for the first time for existing licensees. Given the billions of dollars in legacy systems deployed under the current regime, those decisions would be enormously controversial and the potential transition quite costly. Moreover, would the new level be uniform for all services or would it account for differences in real or perceived protection levels? Does spectrum used for satellite services that necessarily deploy more sensitive receivers have the same protection as that used for

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terrestrial fixed services that typically operate with more link margin? How about services like Radio Astronomy? The enormity of the task is obvious.

Given these challenges, it is not clear to me what is the most realistic way to make either incremental or more radical improvement. I like Pierre's suggestion that the FCC try to establish a protection level for new licensees (along with an approach to measurement), in which case there will not be the same transition costs and potential reallocation of value as there would be for legacy systems. In doing so, the FCC also might attempt to generalize the principles and criteria it uses to set the protection level and measurement approach, to foster a more transparent and predictable set of rights for future proceedings. I would also like to see an effort to compile and sort the existing body of FCC decisions defining harmful interference and how it is measured and to develop a consensus on how to define and measure harmful interference, accepting that there may be a variety of definitions, models and approaches. The FCC's past decisions, although not always as transparent as they might be (at least to us non-engineers), provide a valuable starting point for developing a more predictable jurisprudence and for advancing the process of establishing greater predictability. There may be enough interested parties that have something to gain from developing a set of answers to these questions, in order to provide more predictability to whatever overall regime prevails.

The Spectrum Regulator's Dilemma in a Dynamic World: Limiting Interference without Stifling Innovation

Evan Kwerel and John Williams[10]

We propose that FCC consider revisiting the general policy of providing incumbents protection against any interference resulting from subsequent rule changes. It is well known that limiting spectrum licensees to providing specific services using specific technologies ("command and control") can seriously retard the adoption of new highly valuable technologies, such as cellular telephones. The FCC has recognized this and since the early 1990s has been providing for service and technological flexibility for most newly allocated bands.

What is less well known is that the FCC's sequential approach to accommodating change coupled with its interference protection policy toward incumbent uses can also be detrimental to putting spectrum to its highest value uses. When bands are newly licensed, or when the rules within a band change, the FCC attempts to protect incumbents (those licensed first) against any actual interference resulting from those changes. Protecting incumbents against any actual interference can greatly reduce the potential value of adjacent bands and gives incumbents no incentive to implement efficient mitigation prior to licensing of a new service. Bargaining by licensees of a new service to reduce incumbent protections in adjacent bands is also generally ineffective due to high transaction costs.

To provide licensees better incentives to efficiently mitigate interference in a dynamic world, we propose that the FCC (1) structure all future allocations, flexible or otherwise, on the assumption that such allocations must internally self-protect against potential interference from adjacent bands based on the assumption that those bands, regardless of current use, will be flexibly licensed for dense deployments of base, mobile and fixed transmitters operating at fully functional in-band power levels; (2) gradually apply the same self-protection assumption to all bands as mitigation technology improves and equipment is replaced ; (3) apply a generic out-of-band emission limit to all new allocations, flexible or otherwise, that is low enough to be non-interfering on the assumption that adjacent bands, regardless of current use, will be flexibly licensed for dense deployments of base, mobile and fixed stations; and (4) gradually apply the same generic OOBE limit to all bands and incumbent uses as equipment is replaced.

Managing Interference Efficiently

The goal of efficiently managing interference can be stated as finding the set of rules that minimize the total cost of interference, where:

Total cost of interference = cost of mitigation + cost of interference that occurs despite mitigation.

Mitigation costs include the opportunity cost of guard bands or guard areas, cost of mitigating technology such as filters in transmitters and receivers, loss from constraints on service and technological flexibility, and cost of coordination with other licensees. Interference costs are the value of lost services due to interference that occurs despite mitigation.

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[10] Evan Kwerel is a Senior Economic Advisor at the FCC. John Williams is a consultant at Ambit. The opinions expressed in this paper are those of the authors and do not necessarily represent the views of the FCC or any other members of its staff.

Regulators do not have sufficient information to formally minimize the total cost of interference. But the formula does help structure thinking about least-cost solutions to the interference problem. Among the insights that can be inferred under reasonable assumptions about costs are: (1) there is a tradeoff between mitigation and interference costs, (2) there is a tradeoff between mitigation by transmitters and receivers, (3) the optimal amount of interference is likely to fall over time because technology reduces the costs of certain mitigation measures such as filtering, and the cost of lost wireless services from remaining interference is likely to rise with increasing population and new wireless products, and (4) zero interference is probably never optimal because the cost of eliminating all interference is very high and the cost of tolerating very small amounts of interference is generally low.

Traditional Licenses

The traditional command-and-control approach to spectrum management limits spectrum licensee to providing a specific service, using specific technology, at specific locations. In broadcasting, satellite and other traditional services, the FCC engineers a grid of locations and frequency assignments that packs licensees together with only the minimum necessary amount of spectrum per licensee and the minimum necessary spacing in frequency and geography between licensees needed to prevent unacceptable interference, given technology assumptions. The Commission also specifies the technology such as antenna height and design at the specified site, radio modulation, and maximum power. Any system changes must be approved by the FCC and are closely scrutinized. The system is highly effective at preventing harmful interference for existing uses at the expense of limiting flexibility to put spectrum to more valuable new uses as technology and consumer demands change over time.

Flexible Use Licenses

Flexible use licenses provide licensees the exclusive right of use of specific spectrum within a specific geographic area. Exclusivity is not absolute because limiting externalities (interference) to zero is too costly. Licensees are provided flexible choice of services and technology. Spectrum rights are transferable, divisible and aggregatable. Markets determine spectrum use and users. Interference between licensees can be caused by electrical noise from the out-of-band emissions (OOBEs) from transmitters in adjacent frequency bands and from co-channel signals in adjacent geographic areas. Even in the absence of any out-of-band emissions, receivers may experience blocking by strong signals in adjacent frequency bands.

The FCC establishes one system of interference rules that applies among all the flexible use licensees within a given flexible use band (e.g., cellular to cellular) and another set of rules that applies between new flexible use licensees and incumbents in another service (e.g., 700 MHz to TV, WCS to SDARS).

The basic approach the FCC uses for managing interference among flexible use licensees in the same band is as follows:

- Define a *band plan* of licensable spectrum blocks based on “expected” use assumptions, *e.g.*, cellular architecture, minimum efficient block size, FDD paring. Because FDD is the “expected” duplexing methodology in the U.S., band pairing is provided whenever possible (*i.e.*, each license is given a separate band for base and mobile transmission with a certain amount of spacing between them). If pairing is not possible, then unpaired licenses are created in which both base and mobile are permitted (TDD assumption) or one or the other is permitted for one-way use. The FCC does not provide external guard bands between adjacent FDD licenses, although a large “guard band” is provided

between up/down bands. In contrast, the FCC may provide for external guard bands or additional mitigation by licensees (*e.g*., internal guard bands or synchronization of up/down transmission between adjacent licensees) between adjacent TDD and between adjacent TDD and FDD licenses.

- For each permissible transmitter class (*e.g*., base, mobile and fixed), specify an *in-band power limit* set high enough for full functionality while avoiding interference from excessive power. Transmitter classes such as satellites, high power broadcasting and radar are generally not permitted in flexible use bands.
- Specify generic *out-of-band emission (OOBE) limit* applicable at the edge of the licensed spectrum block. The same limit is generally applicable to all transmitter classes. It is an absolute limit regardless of in-band power and chosen to be achievable at low cost with available technology. Compliance is determined by measurements at the transmitter output.
- Specify generic *out-of-area field strength (radiated power) limit*. Compliance is determined through calculation using transmitter parameters and a *standard propagation model*. The same limit applies to all transmitter types regardless of power or antenna height. Cumulative field strength is not limited, with the resulting uncertainty addressed by bi-lateral coordination among licensees and unilateral actions to mitigate interference *e.g*., increase the *"desired"* signal strength by strategic placement of base stations with directional antennas along the geographic boundary.

Based on a long tradition in spectrum management that incumbents have the right to absolute protection from interference from new users, interference rules between new flexible use licensees and incumbents in other services are designed to prevent actual interference to incumbents' systems. Power and OOBE limits on the licensees in the flexible use bands are based on an interference model using the incumbent's system parameters and parameters of "expected" use for the flexible licensees. Incumbents are not expected to improve filtering or implement other additional mitigation measures.

The Good, the Bad and the Ugly

The current approach to managing interference among licensees within bands allocated for flexible use has worked well. The rules do not limit actual interference (which depends on the specific characteristics of individual systems, especially receivers) but instead rely on separating licensees by frequency and geography and limiting transmitter externalities (permissible classes and power limits) based on assumptions about expected use. The approach yields large reductions in interference potential at low cost while providing licensees great flexibility in system design and certainty about what they are permitted to do. Within this regime, licensees appear to have managed remaining interference potential efficiently, taking into account the continued improvement of technology and increasing value of spectrum.

The FCC's approach to interference management has not worked so well for spectrum with traditional licenses, and adjacent bands licensed at different times. A unifying theme underlying the difficulties is adaption to change. As discussed above, the traditional method of defining license rules removes nearly all possibility of interference above a defined level as long as nothing changes. The assumption is that even small changes will require FCC approval providing great certainty, but often stifling innovation.

When bands are newly licensed, or when the rules within a band change, the FCC attempts to protect incumbents (those licensed first) against any actual interference resulting from those changes. Protecting incumbents against any actual interference can impose major constraints on the potential value of adjacent

bands and gives incumbents no incentive to implement efficient mitigation prior to licensing of the new service.

These difficulties are illustrated by the case of *WCS* (Wireless Communications Service) and *SDARS* (Satellite Digital Audio Radio Service). SDARS was licensed before WCS giving SDARS incumbent status. When WCS service rules were subsequently established, power limits (especially the out-of-band emission limit) were set at very low levels to protect incumbent SDARS receivers to a no-interference standard. The WCS band was rendered unusable for high valued uses because of the high cost of equipment capable of meeting such an extreme OOBE limit. WCS licenses were auctioned anyway and brought very low prices reflective of these costs. Since they were licensed first, SDARS licensees had no incentive to build receivers that would permit sufficient power in WCS band for WCS to have any value. Building better SDARS receivers would have cost more with all the benefits accruing to WCS. Thirty MHz of WCS spectrum at 2.3 GHz has been virtually idle since it was auctioned in 1997. Private negotiations were not able to resolve the difficulties. Finally, in 2010 the FCC changed the service rules for SDARS, raising the power limits for WCS spectrum not directly adjacent to SDARS.

Policies for a Changing World

The FCC should consider revisiting the general policy of providing incumbents absolute protection against any interference resulting from subsequent rule changes. What are the market failures that would justify such a policy change?

First, when not all rights have been assigned there is nobody to negotiate with. When an adjacent band is not licensed (*e.g.*, WCS band prior to licensing) or not all the rights are assigned (*e.g.*, bands with traditional services such as broadcasting where there is "white space") a new licensee in an adjacent band has no one to negotiate with to design a system that minimizes the total cost of interference. You can't negotiate with future licensees. The direct solution would be to assign all rights. But when most of the spectrum is occupied with traditionally licensed users this is difficult. Kwerel and Williams (2002) address this issue.

Second, even when most rights have been assigned (*e.g.*, WCS after licensing), but many licensees must agree to negotiate a change in the rules, holdout problems, free riding and generally high transactions costs may prevent achievement of a deal that potentially could make all parties better off.

Default assumed emission limits for adjacent bands

To address the problem that not all rights are assigned in adjacent bands at the time of licensing a new band, in all *future* allocations the FCC could require that licensees must self protect against interference exposure from adjacent band(s) *assuming* that those bands would be licensed under the flexible use model with base, mobile and fixed stations at fully functional power levels operating right up to the band edge. This would *internalize* the total spectrum cost of accommodating the new use rather than passing some or most of that cost off to someone else. It would thus provide better incentives to build more robust receivers and avoid disputes about interference. For example, suppose SDARS had been treated this way. They would have had to purchase enough WCS spectrum to create adequate guard bands to protect their highly sensitive receivers, make their receivers better, increase the power in their satellites, or taken other measures. They would have faced the opportunity cost of their system design, resulting in more efficient use of the spectrum.

Dynamic interference rules

To address the problem of high transactions costs in negotiating efficiency enhancing changes in interference rules as mitigation technology improves and spectrum value increases, the FCC should consider establishing dynamic interference rules. Over time, the level of potential interference that incumbents must tolerate might increase. This might include allowing in-band power to rise to fully functional levels where they are now set lower because of protections to incumbents in adjacent bands. This would recognize the increasing value of spectrum (increasing cost of lower-than-functional power levels) and create an incentive for incumbents to upgrade their receivers or adopt other mitigation over time (including internal guard bands) so as to tolerate functionally adequate power levels in adjacent bands. Similarly, the FCC should consider gradually tightening the generic out-of-band power limit to a non-interferring (or nearly so) level. This would eliminate this mode of interference (an externality) in its entirety. To meet this limit licensees would have the incentive to make the lowest cost tradeoffs between better transmitter technology and internal guard bands as the relative costs of those choices changes dynamically over time.

Reference

Kwerel and Williams, 2002. “A Proposal for a Rapid Transition to Market Allocation of Spectrum” Working Paper 38, Office of Plans and Policy, Federal Communications Commission, November, 2002.

Radio Rights and Wireless Technical Innovation

Michael J. Marcus, Sc. D., F-IEEE[11]

For better or worse, wireless technology is one of the most regulated technologies in our modern world. In classic wireless regulation, such as was in place in the US prior to the mid 1970s, almost all innovative technologies needed positive regulatory action before they could be used in operational systems. The ultimate goal of a radio rights regime is to stimulate capital formation for wireless technical innovation while at the same time providing enough certainty for the capital formation of incumbent spectrum users to build out and operate their systems. While these goals are not contradictory at their root, they certainly partially conflict. This conflict explains the difficulty regulators have had in devising such a regime in a way that pleases all parties involved. However, this goal is so important in our information age society and economy that it is vital to move forward towards it no matter how difficult.

A radio rights regime must consider the following technical issues:

I/S Protection at Receiver

Fortunately, the issue of how much protection a receiver needs has gotten much simpler in the today's digital age. NTIA's survey study found "(o)ne common feature was that for continuous, long-term interfering signal levels, nearly all established IPC were based on an interference-to-noise power ratio of –6 to –10 dB".[12] So there is relatively little uncertainty for most digital signals about how much protection they need at the receiver.

However, for CDMA systems such as 2G and 3G cellular, I/S translates directly into cell site capacity as the cellular industry repeatedly reminded the FCC during the UWB[13] and Interference Temperature[14] rulemakings. This is because of the nature of CDMA where the receiver sees multiple signals overlapping in frequency and sorts them out by processing gain.

I/S Field Strength at the Antenna vice I/S Power at the Receiver

In the past, mobile antennas were omnidirectional and other antennas had fixed patterns. In such a scenario, one could reasonably consider the worst case transfer of I/S field strength ratio at the antenna to I/S power ratio at the receiver to be the same. However, MIMO antenna technology is now well established in the commercial world and will be even more important in the future. MIMO and other adaptive antenna technologies can readily change the I/S ratio at the receiver by preferentially passing the desired signal and not the interference. Thus for system that either use or can be reasonably be expected to use such technology any radio rights regime will have to consider how much to budget for I/S reduction attributable to the antenna system.

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12 NTIA Report 05-432, p. ii

13 ET Docket 98-153

14 ET Docket No. 03-237

Propagation Models

Assuming one know what I/S ratio at the receiver antenna would be acceptable, how would one translate that into acceptable geometries and transmitter power for the new entrant? This involves projecting geometry and power with both scenarios and propagation models.

Propagation would be simple if all radio waves behaved like light in a vacuum with monotonic predictable decrease in field strength with path length increases. It doesn't always. Thus agreeing on a propagation model is a major issue. This was shown in the TV White Space proceeding[15] where the broadcast interests kept insisting on the R-6602 model[16] that is the basis for the FCC's Grade B contours. The "66" part of "R-6602" comes from 1966 – the year the model was first published prior to the computer age.

So realistic radio rights will depend on realistic propagation modeling – something that segments of the wireless community would like to avoid if traditional models give them a better position.

MCL vice Stochastic Modeling

The issue of "minimum coupling loss"/MCL is also key in any radio rights formulation. In the AWS-3 proceeding, incumbent licensees argued that protection from proposed AWS-3 band TDD emitters to incumbent lower adjacent band FDD downlink mobile receivers must be based on MCL – the worst case scenario. In stochastic modeling, geometries are considered along with their probabilities yielding a probability estimate for interference. Generally incumbents prefer MCL analysis as it precludes *any* probability of interference independent of any public interest factors. New entrants, on the other hand, would like to show that interference is minimal and does not meet with the "seriously degrades, obstructs, or repeatedly interrupts" part of the harmful interference definition.

At present FCC does not have a clear policy on when MCL or stochastic models should be used. This policy absence was a definite factor in the prolongation of the AWS-3 deliberations.

It appears that NTIA insists on MCL for all "safety services" although it is unclear if NTIA considers *all* federal government spectrum use to be a safety service or not.

Minimum Protection Distance

A close relative of the MCL issue is the question of minimum protection distance. Or how physically close a new entrant might be in space to an incumbent's receiver. Since propagated radio signals' strength is often proportional to $1/d^n$ where d is distance from transmitter to receiver and $2<n<4$, simple math shows that as $d \prod 0$ the received power become infinite! In the real world there are either minimal physically possible distances or minimum distances beneath which a user is causing interference to only himself.

In the Commission's landmark 1979 decision on regulations of unintentional emissions from PCs and other "digital devices" stated that "we are assuming that the home computing device is at least 10 meters from the

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[15] ET Docket 04-186

[16] J. Damelin, W. Daniel, H. Fine and G. Waldom Development of VHF and UHF Propagation Curves for TV and FM Broadcasting, FCC, Office of Chief Engineer, Research Div., Report No. R-6602, September 1966 http://www.fcc.gov/oet/info/documents/reports/R-6602.pdf

receiver. The separation distance is a basic parameter in computing tolerable levels of signal that may be radiated by a computer." And then picked an emission level that would not cause interference to TV receivers at 10m distance even though industry recommended a 30m minimum protection distance.[17] In the UWB case, FCC limits were based on an assumption of 2m minimum separation distance between portable UWB transmitters and GPS receivers[18] and 1.8m away from PCS receivers.[19]

Acceptable Interference Statistics

What does the harmful interference definition mean with respect to interference that "seriously degrades, obstructs, or repeatedly interrupts"? This has rarely come up in FCC deliberations, but was a key issue in the MVDDS/Northpoint proceeding. DBS satellite systems have natural outages that result from excessive desired path lost during heavy rain. For typical home antennas in the Washington DC area, this comes to about 120 minutes/year. The DBS operators argued that *any* increase in outages over this naturally occurring level would be harmful interference. The Commission ultimately decided that *de minimis* increases would not be harmful and based it technical rules on an objective of increasing rain related outages by no more than 10%[20] over the naturally occurring outages - actually the naturally occurring outages predicted by a standard ITU-R model.[21]

While the Commission tried hard to limit this outage increase precedent to only the MVDDS issue at hand, this is a key point in radio rights. Is interference caused by any new entrant that is *de minimis* with naturally occurring outages in space or time really "harmful"? While most incumbents want to believe that they have perfect coverage within their nominal service area, in most cases they don't due to factors such as multipath propagation, terrain shielding, technical limits of real receivers.

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[17] *Report and Order*, Docket 20780, (Sept. 18, 1979), 79 F.C.C.2d 28, at para. 53

[18] *UWB R&O* at para. 107

[19] *ibid.*, at para. 162

[20] Memorandum Opinion and Order and 2nd Report and Order, Docket 98-206, April 11, 2002 at p. 29

[21] In reality, heavy rain statistics vary greatly from year to year. Also the ITU-R model only has data for a grid points about 60 miles apart and uses linear interpolation between data points. As a result actual rain rates and the resulting satellite outages during a given year at a given place may vary widely from the predicted data and the real impact of a 10% increase would be impossible to differentiate over the base case.

Defining Radio Rights – Theory and Practice

Charla M. Rath[22]

For years, academics and other researchers have been struggling with the question of how to define radio operating rights. As demand for spectrum grows, and as this conference demonstrates, many are seeking to develop a more robust theoretical framework for defining, assigning and enforcing such rights. It is equally important, however, to investigate current practice with respect to interference rights and consider how licensees resolve interference scenarios in today's marketplace. A framework cannot rely solely on analysis of the intractable large-scale issues such as the competing interference claims often contained in de novo spectrum allocation proceedings, but should explore how licensees, with the flexibility to do so, trade rights and resolve innumerable local interference issues.

To that end, what is it like to provide an itinerant, dynamic consumer service that operates 24/7, reaches 289 million Americans and depends on a difficult to manage resource that is federally regulated? Verizon Wireless has nearly 100 million customers, more than 1500 mobile licenses (not to mention thousands more microwave licenses), tens of thousands of cell sites transmitting on several frequencies and tens of thousands of miles of RF borders and boundaries. In order to constantly improve our service to the customer, and because interference is a costly drag on our network's capabilities, we must deal with issues of rights and interference on a daily basis. It is critical to our business that we're able to negotiate and resolve quickly most, if not all, rights and interference issues without seeking intervention or assistance of the Federal Communications Commission.

There has been some discussion in the literature as to the usefulness of applying the lessons learned about these kinds of negotiations to the larger question of defining interference rights.[1] It is not practical within the limited scope of this short paper to consider the details of wireless carriers' rights and experience with interference management. Two areas illustrate, however, why any discussion of radio operating rights can benefit from a better understanding of licensees' market based approach to rights and interference management**:** where the individual licensee has clear, enforceable rights and is permitted to negotiate extensions of these rights and where the class of licensees has enforceable rights, but needs additional regulatory clarity in order to resolve interference issues.

Clear, Enforceable, Negotiable Rights - FCC Rules Allow for Private Agreements. Unlike most radio services, the rules governing mobile wireless carriers permit private rights negotiations. Under the Commission's PCS rules (and AWS and 700 MHz rules) parties can agree to a higher field strength than is outlined in the rules.[2] Commission rules also permit cellular licensees to negotiate service area boundary extensions agreements with neighboring licensees.[3] Wireless carriers' thousands of licenses and thousands of miles of adjacent and co-channel boundaries create a laboratory for evaluating whether this successful approach to interference 'rights' negotiations is pertinent to a larger radio operating rights framework.

Under current rules, licensees negotiate to extend rights into each others' licensed spectrum on a daily basis. These are not massive, one-time negotiations between companies, but involve hundreds of individual negotiations between companies' engineers who are tasked with the day-to-day operations of the network.

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And, although mobile wireless licensees are, for the most part, "stable and 'repeat players'"[4], this does not mean interests are always aligned or that licensees always get what they want or need. Indeed, not all negotiations are symmetrical or mutual – in our case, we attempt reciprocity when we seek to extend RF borders, but these negotiations can be difficult and carriers (including Verizon Wireless) don't always achieve their goals. That said, because the rights of both licensees are clear, there is no benefit to seeking regulatory redress. Instead we manage the process in the market and look to other ways to gain the rights to spectrum we need to operate – typically through spectrum purchase or lease.

Unauthorized Operator-to-Licensee Interference – Need for Additional Enforcement Assistance. Licensees also deal with thousands of instances of interference from unauthorized operations each year. Again, licensees' efforts to resolve these issues are very much local and generally do not involve the FCC. If we can locate the source of harmful interference, we can often work with the owner of the property or transmitter to address the problem. However, some cases may require FCC intervention, such as in 2006 when a signal booster installed in a Manhattan office building interfered with about 200 Verizon Wireless cell sites in New York and New Jersey.[5] Although most instances of booster interference are smaller in scale, they still can be difficult to resolve – the source may be nearly impossible to identify if installed in a moving vehicle or boat. Interference from these and other sources costs carriers thousands of hours to investigate and, where possible, to resolve. In the case of boosters licensees are not seeking individual relief, but are asking the Commission to confirm licensee rights and take a strong stance on the marketing of these devices, so that licensees can address these interference issues more forcefully in the marketplace.[6]

Final Thought. Getting the right theoretical framework to define radio operating rights is important, but the exercise must be informed by the experience licensees have gained resolving interference issues in an increasingly complex and market-oriented RF environment.

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[1] See, e.g., Philip J. Weiser & Dale Hatfield, Spectrum Policy Reform and the Next Frontier of Property Rights, 15 GEO.MASON L. REV. 549, (2008) ("Weiser and Hatfield – Spectrum Policy Reform"); Thomas W. Hazlett, A Law & Economics Approach to Spectrum Property Rights: A Response to Weiser and Hatfield, 15 Geo. Mason L. Rev. 975 (2008).Philip J. Weiser & Dale N. Hatfield, Property Rights in Spectrum: A Reply to Hazlett, 15 Geo. Mason L. Rev. 1025 (2008). Thomas W. Hazlett, A Rejoinder to Weiser and Hatfield on Spectrum Rights, 15 Geo. Mason L. Rev. 1031 (2008).

[2] 47 C.F.R. § 24.236. The Commission's Part 27 rules, which cover both AWS 1 and 700 MHz spectrum licenses, also permit these kinds of field strength agreements. 47 C.F.R. § 27.55(a).

[3] 47 C.F.R. § 22.912. Unlike PCS, new cellular agreements that extend the boundaries of a cellular licensees coverage are considered a major modification to the license and thus must be approved by the FCC. Moreover, these agreements are more cumbersome than the PCS field strength agreements in that they often need to be renegotiated when the licensee changes technology.

[4] *Weiser and Hatfield – Spectrum Policy Reform* at 289.

[5] Radio signal boosters, repeaters or amplifiers that are marketed and used without a wireless carrier's authorization are a growing and serious cause of harmful interference to wireless networks.

[6] *See* Comments and Reply Comments of CTIA in *Wireless Telecommunications Bureau Seeks Comment on Petitions Regarding the Use of Signal Boosters and Other Signal Amplifications Techniques Used with Wireless Services*, WT Docket No. 10-4; DA 10-14 (released January 6, 2010); *See also* Comments and Reply Comments of Verizon Wireless. Specifically, Verizon Wireless has asked that the Commission (l) confirm that signal boosters cannot be operated without a license or licensee approval, and (2) declare that signal boosters cannot be sold to entities not authorized to operate them. Verizon Wireless Comments at 8

Economic Principles for *Ex Ante* Rules for Radio

Gregory Rosston[23] and Scott Wallsten[24]

In September, 2009, Silicon Flatirons hosted a conference featuring a number of recent case studies of radio regulation and interference. The studies highlighted substantial disputes about rights and responsibilities of radio operation in various bands despite apparently detailed *ex ante* rules by the Federal Communications Commission regarding interference.[25] In each case the parties disagreed about whether the transmitter or the receiver "caused" the interference and if so, whether that party was operating within its rights as defined by the FCC.

In each case, the FCC had set rules on factors such as transmission power in order to control emissions, but circumstances changed so that those rules no longer prevented "harmful interference." Unable to reach mutually beneficial agreements given changing supply and demand conditions under the existing rules, some of the parties came to the FCC to resolve the dispute, in part, by amending its rules (possibly to the benefit of some parties relative to others).

These case studies highlight the importance of a regulatory framework that facilitates efficient transactions between licensees and minimizes transactions costs to achieve efficient solutions. Such a regulatory framework would start with clear rules and allow parties to negotiate efficiency-enhancing changes to those rules.

Well-Defined Rights and/or Rules

The FCC must ensure that licensees and other spectrum users know the rules and that those rules be clearly defined. Spectrum users are more likely to invest if they understand their and others' rights well enough to be reasonably sure their long-lived investments will continue to work without harmful interference from other users, and that their transmissions will not be shut down because they interfere with other users' transmissions.

For example, the FCC should clearly spell out rules regarding emissions into a band on the basis of emitted power, protection from emitted power or other well-defined technical metrics, yet also allow—and probably encourage—parties to work out solutions to violations of these standards, or to adapt the standards to other levels or even other metrics on their own.

Focusing on emissions into other bands—the actual cause of harm to adjacent licensees—rather than on transmission power—which is but one potential cause of harm—should create more, though by no means perfect, certainty and align incentives with minimizing the transaction costs of adapting behavior.

For example, consider a licensee with the right to emit a certain level of radiation into an adjacent band. If those emissions interfere with an adjacent licensee's transmissions several solutions that do not involve the FCC become possible that are not possible, or at least not likely today. The licensee could continue to operate

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24 Vice President for Research and Senior Fellow, Technology Policy Institute.

25 The bands in the case studies included 800 MHz, AWS-BAS, AWS-3 and WCS/DARS.

in the same way while the adjacent licensee installs receiver filters to ensure its transmissions still work. Alternatively, if the receiver technology is expensive relative to emitting less from the transmitter, the adjacent licensee could negotiate with the transmitter to change its technology. Today, such an outcome is not likely because of the reliance on the FCC to change its rules in favor of one party or another, and the difficulty in coming to complete agreements when the FCC stands in the background.

This simple example illustrates some the potential inefficiencies due to bargaining and diffusion of rights. The well-known Coase Theorem implies that if transaction costs are zero the two parties will agree to an efficient solution for solving the interference problem. In our example, the transmitter would simply agree to pay to replace the receiver since that is mutually beneficial. The real world, however, is rife with transactions costs. For example, suppose the example involved a large number of parties with receivers. Some might hold out on the agreement, preventing the neat solution. In fact, in the relocation of microwave incumbents from the PCS band, many incumbents apparently asked for substantial premiums to their actual costs of moving.

With these types of licenses and flexibility, licensees that desire to make trades with neighbors can adapt or make trades to allow for different standards that then become part of their new operating rights. For example, if a new 5G technology had different operating characteristics that roll off more to adjacent bands, existing cellular and PCS licensees could negotiate a solution—even one that involved rule changes—without a rule-making by the FCC. However, to facilitate these transactions, the rules need to be set and the FCC must credibly commit not to change its rules in response to political or other pressure. Setting a firm stance might be difficult in the face of pressure from groups like public safety who might argue that they cannot afford to get to pay others to move to the efficient solution and there may be other reasons that it would be difficult for a public agency to commit, but when firms make long-lived investments, they tend to get more court protection against *ex post* rule changes.

Well-defined rules are important for licensed and unlicensed bands as well as for device-type acceptance. Unlicensed bands may, however, require stricter rules because trades of the sort described above could be prohibitively costly. That is, the ability to make trades is not as important for unlicensed bands as it will be more difficult or impossible to organize such a complete change in rights with a diffuse and amorphous group of rights holders.

Because trading of rights and adaptation is more difficult with unlicensed bands, setting up a rational and clear set of rules in advance is more important for unlicensed bands than for licensed bands.

Application to the case studies

One key problem with the historic method of command and control radio regulation based on transmitter power has been its inability to deal with technological change. Technological change is crucial for increasing the standard of living as it allows more productive use of scarce resources. However, changing technology can cause conflict with rules written for then-current or only foreseen technology.

The dispute between Nextel and the public safety community over the 800 MHz transmissions exemplifies how the current system is ill-equipped to deal with technological change. The initial 800 MHz private radio rules were written when the FCC expected that spectrum to be used for “high-tower, high-power” sites. Based on this expectation, the FCC set maximum power limits for transmission, and allocated channels in an interleaved pattern. (At the same time, adjacent spectrum was allocated in large blocks to the two cellular providers).

Nextel (then FleetCall) realized that the spectrum allocated to "private radio" was nearly identical in its physical properties to the spectrum allocated to the two cellular providers and began to acquire licenses. After substantial work Nextel convinced the FCC to change the private radio rules so that Nextel could function as a CMRS provider and use "low-tower, low-power" cellular architecture. The low power sites obviously did not exceed the power limits of the high power high tower sites, but they did interfere with the public safety receivers operating on adjacent (and interleaved) channels.

The rules for 800 MHz transmission could have minimized interference between CMRS providers and public safety providers by requiring Nextel to continue to only use high-tower, high-power sites. But that would have disallowed the technological advances of cellular architecture and digital transmission and prevented much more efficient use of the spectrum.

The FCC could also have allowed the new technology but only if the CMRS licensees negotiated with the public safety entities for the right to operate their systems in a new manner. By clearly defining the rights upfront, but allowing for changes to the rights upon agreement, the flexibility could have led to a mutually agreeable situation.

Finally, and perhaps best, would have been to define initially the rights of 800 MHz licensees differently. Rather than designating technology or transmission power, the rights could have explicitly established a maximum level of emissions into adjacent channels. The emission rate would have been known to both the private radio licensees (and Nextel when it bought those rights) and the public safety entities when they began to construct their adjacent systems and acquire their radios. If Nextel had then decided to use a technology that increased emissions into the adjacent channels, it would have realized that it would have to negotiate with the public safety agencies if its new transmission method did not comply with the emission limits. If Nextel's new technology did comply with the emissions rules, then the public safety agencies would either have to adapt their receivers or negotiate with Nextel. In both cases, the efficient reducer of interference would be selected by negotiation between the parties. Of course, this in part depends on the ability to strike a deal with one or a small number of parties on each side – transactions cost increase with the number of parties needed to reach agreement.