Chapter Four

Zoning the Spectrum

Introduction

We know from the previous chapter that the government decided to control the spectrum but to allow private uses of much of it.[1] The next question is what sort of spectrum usage rights the FCC confers on private users. Should the Commission grant licenses requiring particular service and technologies, with no ability on the part of the licensee to transfer, lease, or subdivide its spectrum rights? Should it grant licenses providing the licensee with complete flexibility? Should it allow unlicensed uses, either in addition to or instead of licensed uses? Over time, the Commission's answer has changed. In the early days, the Commission was heavy-handed: through its band plan, the Commission would decide not only exactly what services would be offered at what frequencies, but also how many licensees would be allowed to offer those services. Today, by contrast, the Commission has moved toward allowing spectrum flexibility. In an increasing range of frequencies, the Commission today allows market forces to determine both what services are available and how many service providers will offer them. Meanwhile, the Commission has also allowed for some unlicensed usage, though far less than some unlicensed advocates have sought.

This chapter addresses these issues. We begin in § 4.A. by considering different models of spectrum control, looking at the Commission's own study of the tradeoffs. In § 4.B. we turn to the Commission's implementation of its zoning rules, using as a case study a key order moving toward greater flexibility. Sections 4.C. and 4.D. examine dedicating spectrum for unlicensed uses and allowing unlicensed uses on a more opportunistic basis. Section 4.E. briefly considers dynamic spectrum use, and § 4.F. concludes by discussing spectrum leasing and private commons.

§ 4.A. Models of Spectrum Control

Traditionally, the FCC would identify one or two services as permissible on a swath of frequencies and choose a licensee who would then be allowed to operate one or both services on the relevant frequencies. The Commission would make clear that its licensees were under no circumstances allowed to use their frequencies for unapproved services, even if those other uses would not cause interference problems. Relatedly, although licensees

1. As we noted in Chapter Two, many frequencies are dedicated to government use and managed by the National Telecommunications and Information Administration.

could transfer their licenses to third parties, they could not subdivide their spectrum usage rights and transfer some of them to a third party (say, the right for a third party to engage in a low-power noninterfering use) while keeping the rest. As a matter of engineering, usage rights are readily divisible across frequency, space, and time, but under FCC rules for many years licensees' only option was to transfer all their rights en masse. Thus legal rules limited what science would otherwise have allowed and market forces might otherwise have demanded.

This traditional command-and-control approach has some obvious drawbacks. First, it produces underused, and in some cases unused, spectrum. Spectrum is underused because, even if a service does not utilize its spectrum efficiently (e.g., is relying on antiquated equipment), the licensee cannot do anything with the spectrum if it made better use of it. Because licensees will not benefit from using less spectrum (via, for example, digital compression), they have no incentive under command-and-control regulation to expend any resources to economize on spectrum. Not only does command-and-control regulation not encourage efficient use of spectrum, it actively discourages it. In particular, if a spectrum licensee opts for more effective technology and frees up spectrum as a result, that spectrum might well give the government the opportunity to increase competition by letting someone else use the newly free spectrum to compete against that licensee.

Command-and-control regulation produces unused spectrum, moreover, in cases where there is a single authorized service but that service is not profitable in a given area. That has long been the case, for instance, with UHF (ultra high frequency) television outside of the biggest cities; in many places, UHF television has not been sufficiently attractive to entice any broadcasters, and thus UHF spectrum has been idle in those communities.[2]

Second, allowing only one service on a given swath of spectrum prevents licensees from introducing new services. Innovative services will not have the opportunity to prove their value if they are not allowed on the spectrum in the first place. Flexibility would both give licensees the incentive to optimize their use of spectrum and provide the FCC with new information about how spectrum can be used and how valuable particular services are.

The FCC has recognized the benefits of moving away from command and control toward more flexibility and market forces. The 2010 National Broadband Plan said:

> The current spectrum policy framework sometimes impedes the free flow of spectrum to its most highly valued uses. The federal government, on behalf of the American people and under the auspices of the FCC and NTIA, retains all property rights to spectrum. In several instances, both agencies assign large quantities of spectrum to specific uses, sometimes tied to specific technologies. In some cases, this approach is appropriate to serve particular public interests that flexible use licenses and market-based allocations alone would not otherwise support. However, because mission needs and technologies evolve, there must be a public review process to ensure that decisions about federal and non-federal use that may have worked in the past can be revisited over time. In general, where there is no overriding public interest in maintaining a specific use, flexibility should be the norm.
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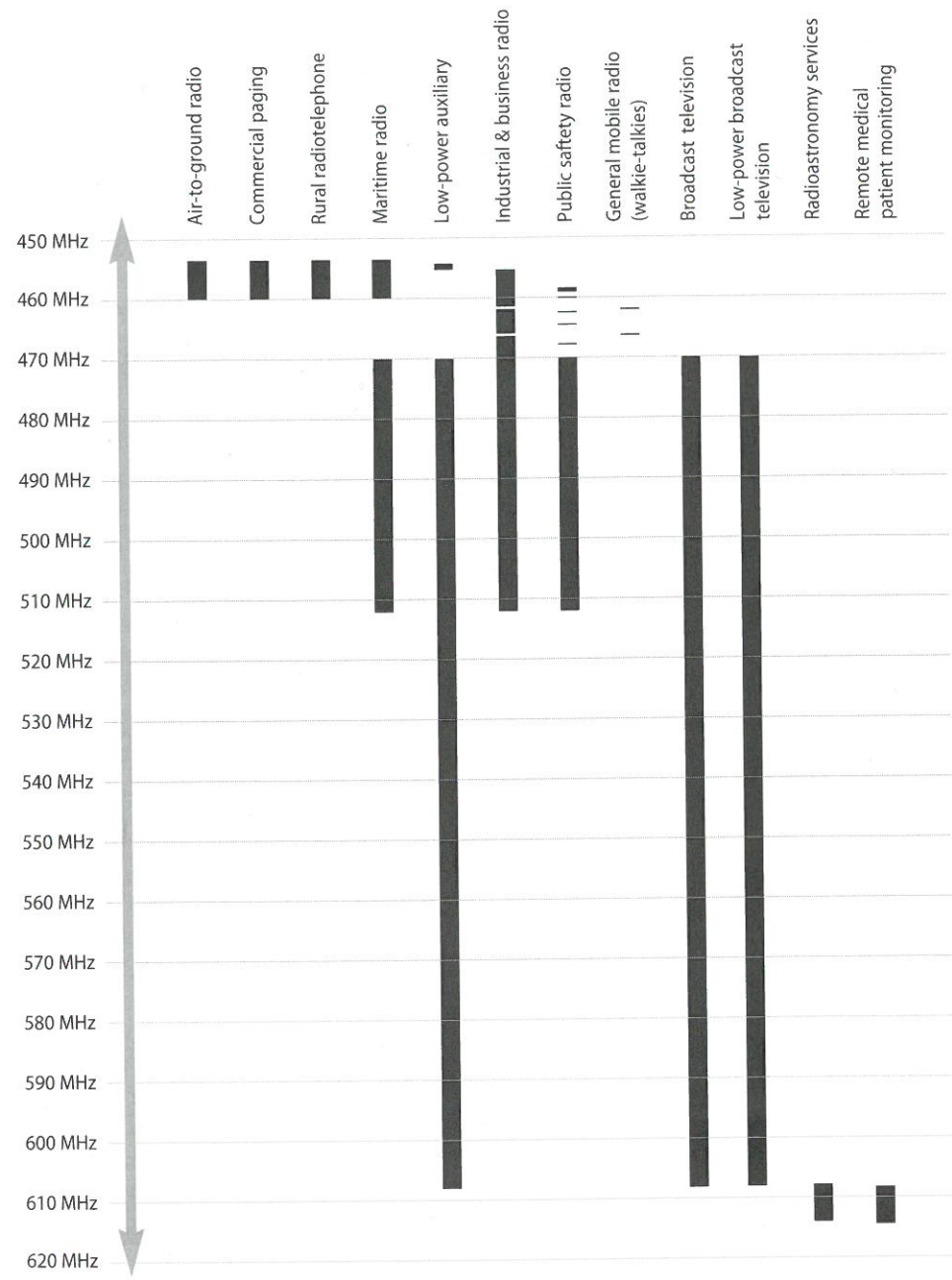
> In the case of commercial spectrum, the failure to revisit historical allocations can leave spectrum handcuffed to particular use cases and outmoded services, and

2. *See* Stuart Minor Benjamin, The Logic of Scarcity: Idle Spectrum as a First Amendment Violation, 52 Duke L.J. 1, 18 (2002).



Spectrum Management. This chart shows the current allocation of a small slice of frequencies in the spectrum—from 454 MHz to 614 MHz. As we noted in Chapter Three, a given frequency will usually be suitable for several competing uses (e.g., land mobile and television broadcasting in the chart above), and a given use can usually be assigned to a variety of places on the spectrum (e.g., television broadcasting occupies many different frequencies, starting at 54 MHz). The FCC's website has a spectrum dashboard with much more detail (http://reboot.fcc.gov/reform/systems/spectrum-dashboard).

less valuable and less transferable to innovators who seek to use it for new services. The market for commercial, licensed spectrum does not always behave like a typical commodities market. Commercially licensed spectrum does not always move efficiently to the use valued most highly by markets and consumers. For example, a megahertz-pop may be worth a penny in one industry context and a dollar in another.[3] Legacy "command and control" rules, high transaction costs and highly fragmented license regimes sometimes preserve outmoded band plans and prevent the aggregation (or disaggregation) of spectrum into more valuable license configurations.

FCC, National Broadband Plan, § 5.1 (2010), *available at* www.broadband.gov/plan/.

The FCC's most sustained discussion of different possible models of spectrum regulation was an FCC task force whose mission was to "[p]rovide specific recommendations to the Commission for ways in which to evolve the current 'command and control' approach to spectrum policy into a more integrated, market-oriented approach that provides greater regulatory certainty while minimizing regulatory intervention" and also protecting against interference. Spectrum Policy Task Force Report, FCC, ET Docket No. 02-135 at 1 (Nov. 2002). That task force issued a report in 2002 that reviewed spectrum policy and recommended significant changes designed to meet these stated goals.

Spectrum Policy Task Force Report

FCC, ET Docket No. 02-135 (Nov. 2002),
available at http://transition.fcc.gov/sptf/files/E&UWGFinalReport.pdf

V. Key Elements of New Spectrum Policy

A. Maximizing Flexibility of Spectrum Use

As a general proposition, flexibility in spectrum regulation is critical to improving access to spectrum. In this context, "flexibility" means granting both licensed users and unlicensed device operators the maximum possible autonomy to determine the highest valued use of their spectrum, subject only to those rules that are necessary to afford reasonable opportunities for access by other spectrum users and to prevent or limit interference among multiple spectrum uses. Flexibility enables spectrum users to make fundamental choices about how they will use spectrum (including whether to use it or transfer their usage rights to others), taking into account market factors such as consumer demand, availability of technology, and competition. By leaving these choices to the spectrum user, this approach tends to lead to efficient and highly-valued spectrum uses. In most instances, a flexible use approach is preferable to the Commission's traditional "command-and-control" approach to spectrum regulation, in which allowable spectrum uses are limited based on regulatory judgments.

The Commission should seek to avoid rules that restrict spectrum use to particular services or applications, so long as the user operates within the technical parameters applicable to the particular band in question. Furthermore, these technical parameters should themselves be limited to those that are necessary to define the user's RF [radio frequency] environment in terms of maximum allowable output and required tolerance of interference.

3. Dollars per megahertz of spectrum, per person reached ($ per megahertz-pop) is the convention used to estimate the market value of spectrum. In the [2007 auction of spectrum that had been devoted to broadcasting], $ per megahertz-pop values ranged from $0.03 in Paducah, Ken., Cape Girardeau, Mo., and Harrisburg-Mt. Vernon, Ill., to $3.86 in Philadelphia. [Footnote relocated. Eds.]

Such flexibility can be implemented under more than one regulatory model for defining spectrum usage rights. As discussed further below, the Task Force advocates expanding the future use of two alternative regulatory models—one based on awarding exclusive spectrum usage rights and the other on creating unlicensed spectrum "commons"—both of which are premised on the concept of flexible use. Under either model, the Commission should give spectrum users maximum possible autonomy in the following areas:

Choice of uses or services that are provided on spectrum. Spectrum users should have the maximum possible flexibility to decide how spectrum will be used, e.g., whether to provide commercial services or to use spectrum for private, internal needs, so long as they comply with the general parameters applicable to the band (including any applicable power limits or interference limits).

Choice of technology that is most appropriate to the spectrum environment. Spectrum users should be allowed to choose the technology that is best-suited to their proposed use or service. They should be allowed [to] adapt their technology to their particular spectrum environment, e.g., to use lower power in spectrum-congested areas and higher power in less-congested (e.g., rural) areas.

Right to transfer, lease, or subdivide spectrum rights. An efficient secondary markets regime should be in place to facilitate the negotiated movement of spectrum rights from one party to another. In more narrowly-defined services (e.g., public safety), spectrum users should have the ability to lease excess capacity for other uses through time sharing of spectrum or other mechanisms.

B. Clear and Exhaustive Definition of Spectrum Rights and Responsibilities

While commenters and workshop participants were vocal about their desire for more flexible rights, they were equally interested in firmness and clarity in the rules they are required to follow. Most commenters and workshop participants also agreed with the proposition that spectrum users' rights and obligations are often not defined with sufficient clarity under the FCC's current rules. An overarching principle eventually emerged: all spectrum users require clear rules governing their interactions with the Commission and other spectrum users. Regardless of how or to whom particular rights are assigned, ensuring that all rights are clearly delineated is important to avoiding disputes, and provides a clear common framework from which spectrum users can negotiate alternative arrangements.

VII. Spectrum Usage Models

A. Comparison of Alternative Spectrum Usage Models

The Task Force examined the Commission's spectrum policies and rules in relation to three general models for assigning spectrum usage rights:

"Command-and-control" model. The traditional process of spectrum management in the United States, currently used for most spectrum within the Commission's jurisdiction, allocates and assigns frequencies to limited categories of spectrum users for specific government-defined uses. Service rules for the band specify eligibility and service restrictions, power limits, build-out requirements, and other rules.

"Exclusive use" model. A licensing model in which a licensee has exclusive and transferable rights to the use of specified spectrum within a defined geographic area, with flexible use rights that are governed primarily by technical rules to protect spectrum users against interference. Under this model, exclusive rights re-

semble property rights in spectrum, but this model does not imply or require creation of "full" private property rights in spectrum.

"Commons" or "open access" model. Allows unlimited numbers of unlicensed users to share frequencies, with usage rights that are governed by technical standards or etiquettes but with no right to protection from interference. Spectrum is available to all users that comply with established technical "etiquettes" or standards that set power limits and other criteria for operation of unlicensed devices to mitigate potential interference.

There is, of course, some overlap among these models as well as variations that combine elements of each. For example, spectrum users that are regulated on a command-and-control basis may have some of the same rights as spectrum users who are subject to the exclusive use model (e.g., exclusive and transferable rights, interference protection). Moreover, spectrum that is subject to the exclusive use or commons model may nonetheless be subject to some degree of command-and-control restriction (e.g., limiting usage based on international allocation restrictions). Nonetheless, the key distinction between the command-and-control approach and the other two models is that the former typically imposes significantly greater usage restrictions on spectrum (and sometimes on the eligibility of spectrum users), thereby restricting flexibility of spectrum use to a far greater degree than either of the other two models.

The Task Force recommends that the Commission base its spectrum policy on a balance of the three basic spectrum rights models outlined above: an exclusive use approach, a commons approach, and (to a more limited degree) a command-and-control approach. It is further recommended that the Commission fundamentally alter the existing balance among these models—which is dominated by legacy command-and-control regulation—by expanding the use of both the exclusive use and commons models throughout the radio spectrum, and limiting the use of the command-and-control model to those instances where there are compelling public policy reasons. Thus, to the extent feasible, the Commission should identify more spectrum for both licensed and unlicensed uses under flexible rules, and should transition existing spectrum that is subject to more restrictive command-and-control regulation to these models to the greatest extent possible.

In proposing to reshape the balance among the three models, the Task Force recognizes that the models themselves are not pure and mutually exclusive approaches to spectrum management, but rather are representative approaches on a broader continuum that may be subject to variation in particular instances. Thus, for any given spectrum band or proposed use, the Commission may find it beneficial to incorporate elements from more than one model. For example, as discussed further below, spectrum that is licensed under an exclusive use approach could also be subject to an "underlay" easement that is available to low-power unlicensed devices using a commons approach. Similarly, services that require some dedication of spectrum on a command-and-control basis (e.g., public safety) may benefit from partial application of the exclusive-use model to enable them to lease spectrum capacity to others when it is not otherwise needed. As a general matter, however, the Task Force believes that there is considerable room to move from the largely ad hoc regulation of particular bands that has evolved historically to a more consistent and comprehensive application of these models across the radio spectrum as a whole. If these models are consistently applied in all Commission spectrum policy decisions, it has the potential to significantly reduce the artificial scarcity of spectrum that currently exists as a result of barriers to access. This approach will have the beneficial effect of reducing the cost of obtaining exclusive spectrum rights in the market and will also help to alleviate congestion of spectrum that is made available on a commons basis, thus mitigating the risk of the "tragedy of the commons"—oversaturation resulting in inefficient use.

B. Application of Exclusive Use and Commons Models

The recommendation to move towards greater reliance on exclusive use and commons models requires that the Commission determine the appropriate balance between these two models. Ultimately, wherever there are competing uses for a resource—that is, wherever there is scarcity—some mechanism must exist for allocating that resource. A mechanism based on markets, such as an exclusive use model, will be most efficient in most cases. However, government may also wish to promote the important efficiency and innovation benefits of a spectrum commons by allocating spectrum bands for shared use, much as it allocates land to public parks.

There are a number of variables that may be relevant to this determination with respect to any particular band, but the Task Force believes that the key factors to be considered are (1) spectrum scarcity, and (2) transaction costs associated with moving spectrum from less efficient to more efficient use. In this context, "spectrum scarcity" means the degree to which particular spectrum is subject to competing demands for use so that the demand exceeds the current supply; and "transaction costs" means the expenditure of time and resources required for a potential spectrum user to obtain the spectrum access rights from one or many parties necessary to its proposed spectrum use.

1. Factors Favoring Exclusive Use Model

The exclusive use model should be applied to most spectrum, particularly in bands where scarcity is relatively high and transaction costs associated with market-based negotiation of access rights are relatively low. The exclusive use model is appropriate because where spectrum is subject to competing demands, and therefore more likely to have a high market value, this approach creates the strongest incentives for parties to put spectrum to its highest valued use. In addition, where rights and responsibilities are clearly defined and effectively enforced, the characteristics of this model—e.g., exclusivity, flexibility, and transferability—generally provide a clear framework for market-based assignment and negotiation of access rights among spectrum users, thereby limiting transaction costs.

These variables suggest that in the lower portion of the radio spectrum, particularly bands below 5 GHz, the Commission should focus primarily, though not exclusively, on using the exclusive use model. The propagation characteristics in this portion of the spectrum (which can support a wide variety of high- and low-power, fixed and mobile uses), combined with the high level of incumbent use (including government as well as nongovernment uses), result in a large number of competing demands for a relatively small amount of available spectrum. These factors tend to weigh in favor of an exclusive use approach with flexible rules because it provides a mechanism for spectrum users to choose among the full range of technically feasible spectrum use options based on market forces. Moreover, the typical transaction costs associated with negotiation of access rights tend to be relatively low in relation to the value of this spectrum.

Even in situations where usable spectrum is scarce but transaction costs are potentially high, the exclusive use model still may be most appropriate, though other variables may also come into play. The presence of high transaction costs means that some transfers of spectrum will not occur, and some valuable uses therefore will not appear in the market. However, wherever scarcity exists, there will be competing claims to the resource, and the exclusive use model is most effective at balancing these competing claims. Moreover, the greater the scarcity, the greater will be the incentive for parties to find ways to overcome

these high transaction costs. In contrast, as discussed below, a commons approach may be less effective in cases of high scarcity, despite its advantages in addressing high transaction costs.

Finally, while these factors weigh in favor of applying the exclusive use model under the above-described circumstances, it should be emphasized that they do not preclude the introduction of unlicensed "underlays" into exclusive use bands. As discussed below, the criteria that favor use of the commons model apply to potential underlay uses of spectrum below the interference temperature threshold, and may apply in some cases to opportunistic uses above the threshold, depending on the nature of the proposed use.

2. Factors Favoring Commons Model

The commons model should be applied to significant portions of the spectrum, particularly in bands where scarcity is low and transaction costs associated with market mechanisms are high. The commons approach makes increased access possible by replacing the negotiation of spectrum access rights among rights holders and prospective users with a commons model governed by user protocols and etiquette. These protocols promote efficiency through spectrum sharing, typically by requiring commons to operate at low power for a short time in limited areas, which allows multiple users to operate on the same spectrum. This approach also promotes technological innovation by providing a spectrum environment in which to develop new technologies. Users do not pay for access to the spectrum, so they will channel their investment exclusively into developing robust technology that can function in this environment and continue to function as the environment grows more congested.

Where both spectrum scarcity and transaction costs are low, the commons model again may be the most appropriate, though this situation is less clear. Under these circumstances, the presence of low transaction costs would add to the efficiency-creating characteristics of the commons. On the other hand, it also is possible that the exclusive use model would provide comparable benefits, as the price will be close to zero if spectrum is abundant. With low transaction costs as well as low price, interested users should have unrestricted access to the spectrum they need.

The variables described above tend to tilt in favor of expanded use of the commons model in higher spectrum bands, particularly above 50 GHz, based on the physical characteristics of the spectrum itself. In these bands, the propagation characteristics of spectrum preclude many of the applications that are possible in lower bands (e.g., mobile service, broadcasting), and instead favor short-distance line-of-sight operation using narrow transmission beams. Thus, these bands are well-suited to accommodate multiple devices operating within a small area without interference. Moreover, administering these uses on an individualized licensed basis would involve very high transaction costs.

The Task Force does not advocate the wholesale conversion of all spectrum to a commons approach as some commenters appear to advocate. Although the commons model is in many ways a highly deregulatory "Darwinian" approach, as its proponents point out, productive use of spectrum commons by unlicensed devices, particularly in lower spectrum bands, typically requires significant regulatory limitations on device transmitter power that preclude many other technically and economically feasible spectrum uses that rely on higher-power signal propagation over longer distances, or that require greater protection from interference. In addition, some commons proponents themselves state that setting aside additional spectrum for use on a commons basis is not essential to the continued success of unlicensed technology because the technological capability exists to prevent congestion from occurring in existing unlicensed bands.

This does not, however, mean that only higher band spectrum should be subject to a commons approach. The record shows that the Commission's dedication of some lower band spectrum to unlicensed uses, e.g., 2.4 GHz, is yielding significant technological and economic benefits in the form of low-power short-distance communications and emerging mesh network technologies that should be further encouraged. The Task Force therefore recommends that the commons model continue to be applied selectively to other lower spectrum bands.

In addition, the commons approach has potential applicability in the creation of underlay rights across the entire range of spectrum for low-power, low-impact devices. To the extent that the Commission establishes "interference temperature" rules for particular bands,[4] the spectrum environment that is created below the temperature threshold has the characteristics that weigh most heavily in favor of the commons approach: low scarcity due to technical restrictions on the power and operating range of devices and high transaction costs associated with negotiating access. Therefore, the commons approach should presumptively be used for operations below the interference temperature threshold. In addition, the commons model may be appropriate for some opportunistic, non-interfering uses of exclusively licensed spectrum above the interference temperature threshold, although this approach raises more significant challenges.

An important caveat must accompany any recommendation for a commons model: although there are indications that technology can go a long way to forestall scarcity concerns, if scarcity eventually does arise in particular spectrum bands in the future, then the commons model may need to evolve to address the problem. Because there is no price mechanism in the commons model to use as a tool for allocating scarce resources among competing users, there is always the risk that free access will eventually lead to interference and over-saturation, i.e., the "tragedy of the commons." These problems can be overcome to some extent through regulatory guidance, requirements such as power and emission limits, and sharing etiquettes. But if actual spectrum scarcity still occurs, rights may need to be redefined and market mechanisms (e.g., band managers) introduced because without them there are insufficient incentives to avoid overuse.

3. Limited Use of Command and Control

The command-and-control model should be applied only in situations where prescribing spectrum use by regulation is necessary to accomplish important public interest objectives or to conform to treaty obligations. With respect to the command-and-control model, as noted above, the Task Force recognizes that continued use of this approach may be required in situations where prescribing spectrum use by regulation is necessary to accomplish compelling public interest objectives. However, such objectives should be carefully defined, and the amount of spectrum subject to a command-and-control regime should be limited to that which ensures that those objectives are achieved. Many spectrum users will claim that they warrant special consideration and thus deserve exemption from any reform of their service allocation rules. It is therefore critical to distinguish between special interest and the public interest, establishing a high bar for any service to clear prior to receiving an exemption.

In general, command-and-control regulation should be reserved only for spectrum uses that provide clear, non-market public interest benefits or that require regulatory pre-

4. [An omitted section of the report explains that "The interference temperature metric would establish maximum permissible levels of interference, thus characterizing the 'worst case' environment in which a receiver would be expected to operate. Different threshold levels could be set for each band, geographic region or service." Eds.]

scription to avoid market failure. For example, radioastronomy may need to have dedicated, protected spectrum bands for the foreseeable future, due to its highly sensitive applications and the fact that its benefits accrue to society as a whole and only over the long run. Public safety and critical infrastructure may also require dedicated spectrum at particular times to ensure priority access for emergency communications. Other areas where limited use of command-and-control may be justified include international/satellite, public safety, and broadcasting.

Subject to these exceptions, the Commission should eschew command-and-control regulation, and legacy command-and-control bands should be transitioned to more flexible rules and uses to the maximum extent possible (whether under the exclusive rights or the commons model).

C. Broadcasting

The Commission has traditionally allocated spectrum specifically for broadcast use, based on statutory public interest considerations and the free over-the-air nature of broadcast service. Many commenters argue that these characteristics distinguish broadcasting from other market-based uses of spectrum, and that the Commission should therefore continue to dedicate some spectrum specifically for broadcast use on a command-and-control basis. Other commenters contend that the continued dedication of spectrum for broadcasting, and particularly for commercial broadcasting, is increasingly anachronistic as the public gains access to alternative sources of programming and information from cable television, satellite services, the Internet, and other outlets.

The Task Force concludes that for the time being, there are valid reasons to continue applying the "command-and-control" model to existing broadcast spectrum. Broadcast service is traditionally not subscriber-based; rather, it provides "universal" news, information, and entertainment services to the general public. As such, broadcasting has consistently been a central focus of Congress and the Communications Act, which regulates broadcast content and behavior by placing certain public interest obligations on broadcast licensees. In addition, localism and diversity of ownership are two important public interest objectives that have been associated with broadcasting to a greater degree than other spectrum uses. Finally, the broadcaster's relative lack of control over receiver equipment affects the rapidity with which technological advances can be introduced into the marketplace and assimilated by consumers—a factor that has complicated the DTV transition.

The transition of broadcast to a digital world, which is already under way, should help to increase the efficiency and flexibility in use of broadcast spectrum. As broadcasters convert to digital, some broadcast spectrum can be recovered for reallocation and reassignment to more flexible uses, as in the case of the 700 MHz band. The Commission has also allowed for some flexible use of broadcast spectrum,[5] and should consider additional ways to allow greater flexibility consistent with broadcasters continuing to meet their core public interest responsibilities. In addition, the Commission can take steps to make "white space" in the broadcast bands available for other uses.

5. Broadcast spectrum can be used for ancillary or supplementary services that do not interfere with the primary broadcast signal, *e.g.*, through use or leasing of the vertical blanking interval to provide telecommunications services. *See* 47 C.F.R. § 73.646. In the digital context, broadcasters may provide ancillary and supplementary services such as subscription television programming, computer software distribution, data transmission, teletext, interactive services, and audio signals so long as such services do not interfere with the required provision of free over-the-air programming. *See* Advanced Television Systems and Their Impact upon the Existing Television Broadcast Service, Fifth Report and Order, 12 FCC Rcd. 12,809 ¶ 29 (1997); *see also* 47 U.S.C. § 336.

Over the longer term, the Commission should periodically reevaluate its broadcast spectrum policies to determine whether they remain necessary to accomplish the public interest objectives they are intended to promote. In particular, such reevaluation should consider the extent to which the public interest benefits provided by dedication of spectrum to broadcasting under a command-and-control regime can be provided through the application of more flexible, market-oriented spectrum policies. It is likely that there will be a continued need to set aside some spectrum for non-market based broadcast uses, such as noncommercial and educational broadcasting. Assuming that technological advances continue to occur and that scarcity of access to spectrum resources decreases, however, it is equally likely that the continued application of command-and-control policies to commercial broadcasting spectrum could be substantially relaxed, or may not be needed at all, to ensure the public availability from multiple sources, including alternative technologies, of the types of information and programming that commercial broadcasters provide.

Notes and Questions

1. How Much Flexibility? At the time this report was written, the FCC had a long history of command-and-control regulation. Yet, here, the report makes it seem almost obvious that flexible approaches are better. Is it possible that the FCC was simply being shortsighted all these years? Is the report slighting the reasons why the FCC has for so many years limited licensees' choice of services?

2. Models of Spectrum Control. The report lists two main alternatives to "command and control": exclusive use and commons. Are there other models that might be worth considering? The report states that exclusive use "does not imply or require creation of 'full' private property rights in spectrum." Should the report have advocated the creation of such property rights? Is the explanation that 47 U.S.C. § 301 prohibits any private party from obtaining such rights, so that the Commission cannot, on its own, grant them? Or is there some other reason to want "exclusive use" that does not encompass full private property rights?

3. Subtle Constraints. The report casts the commons approach as a flexible approach, but then concedes that "productive use of spectrum commons ... typically requires significant regulatory limitations on device transmitter power that preclude many other technically and economically feasible spectrum uses that rely on higher-power signal propagation over longer distances, or that require greater protection from interference." What does this sentence mean? Is the point here that even the seemingly uber-flexible commons necessarily excludes certain uses and users?

4. The Exception for Broadcasting. Is the report persuasive in suggesting that command and control may still be appropriate for broadcasting? The report justifies mandatory allocation of spectrum for broadcasting in part based on the fact that control of broadcasting has been a central focus of policymakers, who have imposed public interest obligations. Is that an appropriate consideration? Is it problematic for an agency to use regulation (public interest obligations) to justify further regulation (requiring that spectrum be used for broadcasting)? Note that the final sentence of this section suggests that further developments may render command and control regulation unnecessary. What sort of developments, beyond those that have already occurred, would justify abandonment of command and control? Might the spectrum policy announced in this report have that effect, by opening up spectrum and therefore reducing scarcity problems?

5. Scarcity. One factor emphasized throughout the report is the relative scarcity of the spectrum under consideration. What claim is made about scarcity under a commons ap-

proach? Will scarcity disappear, such that an unlimited number of users can step forward to use the commons without any shortage of supply? If so, how exactly would that work? If not, then what is the claim? That scarcity is less likely to occur? That scarcity can be more equitably addressed? Something else?

§ 4.B. Implementing Flexibility

A major drawback of command and control regulation is the underutilization of spectrum: people might be able to add new services and/or increase the utilization of existing services, but government restrictions prevent that from happening. This concern about the wasting of spectrum is a major impetus for changes in spectrum policies. One response is to reallocate spectrum from one specified use to another, on the theory that the latter will have a higher value. This is a longstanding practice on the part of the FCC, and it does not conflict with the command-and-control model: the Commission replaces one specified service with another.

As the report reflects, the FCC has clearly endorsed spectrum flexibility. How should the Commission transition to greater flexibility? The Commission is not operating on a clean slate—virtually all the spectrum suitable for new, flexible licenses are already licensed. So a big question is how the Commission should deal with existing licensees.

One possibility is for the Commission simply to allow existing licensees to provide the new services.[6] Such an approach has the virtue of simplicity, but it also has some potential drawbacks. It would entail an enormous windfall for most licensees, who either received their licenses gratis (as is the case for broadcasting licenses that have not been sold by the original licensee) or paid relatively small sums for their licenses—prices that were low precisely because the licenses narrowly constrained the services that could be offered. Instead of the government receiving revenues from auctioning licenses, all the value from the newly broadened rights would go to existing licensees. Giving rights to existing licensees also could create significant transaction costs, especially if licenses for the existing service were allotted in small geographic regions (as most were) and new services would be most valuable on a broader geographic basis. Finally, giving new flexible rights to existing licensees could create holdout costs: a licensee whose license was necessary for the creation of a nationwide band in a certain frequency would seek to extract huge sums from the entity that had gathered all the other frequencies in that band.

At the other extreme, a quite different approach also has the virtue of simplicity: the Commission could simply revoke all the existing licenses for a given set of frequencies. Recall that, under 47 U.S.C. § 301 licenses do not confer any property rights on licensees,

6. In the 1980s, for instance, the FCC authorized FM, AM, and television licensees to use part of their spectrum for secondary uses. *See* Amendment of Parts 2 and 73 of the Commission's AM Broadcast Rules Concerning the Use of the AM Carrier, Report and Order, 100 F.C.C. 2d 5 (1984); FM Licensees: Amendment of the Commission's Rules Concerning Use of Subsidiary Communications Authorizations, Final Rule, 48 Fed. Reg. 28,445 (1983); The Use of Subcarrier Frequencies in the Aural Baseband of Television Transmitters, Final Rule, 49 Fed. Reg. 18,100 (1984). These licensees still had to use their spectrum primarily to provide their primary service; but to the extent that there was any spectrum remaining under these licenses, they could also provide nonbroadcast services such as private paging, data transmission, and dispatch services.

and the FCC has the legal authority to revoke licenses and repurpose spectrum. This would likely reduce investment and upset investment-backed expectations, flowing from the abruptness of the revocation. Avoiding abrupt changes allows for greater investment—more expected years of operation should translate into more investment.

In 2010 the FCC's National Broadband Plan proposed a middle ground approach it called "incentive auctions." As the Plan stated,

> Congress should grant the FCC authority to conduct incentive auctions to accelerate productive use of encumbered spectrum.
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> Incentive auctions can provide a practical, market-based way to reassign spectrum, shifting a contentious process to a cooperative one. In an incentive auction, incumbents receive a portion of the proceeds realized by the auction of their spectrum licenses. This sharing of proceeds creates appropriate incentives for incumbents to cooperate with the FCC in reallocating their licensed spectrum to services that the market values more highly. A market-based mechanism—an auction—determines the value of the spectrum; market-based incentives, such as a share of the revenue received, encourage existing licensees to participate, accelerating the repurposing of spectrum and reducing the cost. Incentive auctions can be especially useful where fragmentation of spectrum licenses makes it difficult for private parties to aggregate spectrum in marketable quantities.
>
> Incentive auctions can come in different forms. For example, in a "two-sided" auction, the FCC could act as a third-party auctioneer for the private exchange of spectrum between willing sellers and buyers, similar to a fine art auction. Alternatively, the FCC could offer a revenue-sharing enhancement to the existing spectrum auction system, in which some portion of revenues generated by an auction are shared between the U.S. Treasury and incumbent licensees who agree to relinquish their licenses.

FCC, National Broadband Plan, § 5.3 (2010), *available at* www.broadband.gov/plan/. The FCC has authority under 47 U.S.C. § 309(j) to conduct auctions, but devoting any auction revenues to incumbents requires congressional authorization.

A different possible middle ground is to authorize new services to be provided by new licensees who operate alongside the existing incumbents providing their original service. Note that this leaves the original licensee with no incentive to economize on its use of spectrum. Allowing a new licensee to offer the new service introduces another wrinkle as well: if two or more licensees are licensed to use the same frequency but as part of different services, the Commission will have to articulate and enforce rules that determine which service has priority in the event that there turns out to be interference.

As it happens, the Commission has never simply decided to end a service—it has always given licensees time and some opportunity to recoup their costs. Beyond that, the FCC usually presumes the status quo, putting the burden on a new service to justify changing the existing arrangement. And it often treats as a relevant consideration the preservation of the existing service, even if that service has not proven valuable to users.

This may reflect not only concerns about investment but also a basic rule of political economy: incumbents standing to lose their licenses face a certain loss, and will organize effectively to keep that license; potential entrants lose an opportunity to buy a license, which is less certain (because they may not win the auction) and less beneficial (because they will pay market prices at auction) than keeping the license is for the incumbent. The

result is that incumbents who fear losing their licenses usually lobby more effectively than potential entrants.

An early example of an attempt to move toward flexibility while offering something to incumbents was the Commission's decision to open up spectrum for broadband personal communications services, as reflected in the excerpt below. This proceeding presents an important step in the movement towards greater flexibility and a very important allocation in its own right. But note that the Commission is still deciding how much spectrum to allocate to these new services, exactly which frequencies will be allocated for the new uses, how the transition from the existing services and licensees to the new services and licensees will occur, etc. That is, it is still making many of the decisions that are the hallmark of command-and-control regulation. As you read it, consider what choices the Commission is making, and why it is making them.

Redevelopment of Spectrum to Encourage Innovation in the Use of New Telecommunications Technologies

Notice of Proposed Rulemaking, 7 FCC Rcd. 1542 (1992)

1. By this Notice [of Proposed Rulemaking or NPRM], the Commission proposes to establish new areas of the spectrum to be used for emerging telecommunications technologies. These new frequency bands would be designated from 220 MHz of the spectrum between 1.85 and 2.20 GHz. We further propose to provide a regulatory framework that will enable the existing fixed microwave users in these bands to relocate to other fixed microwave bands or alternative media with minimum disruption to their operations. We believe this can best be accomplished through the use of a flexible negotiations approach that permits financial arrangements between incumbents and new service providers during an extended transition period. We also propose to permit state and local government facilities, including public safety, to continue their current operations on a fully protected basis by exempting such facilities from any mandatory transition period.

NEED FOR EMERGING TECHNOLOGIES BANDS

4. In recent years, technological advancements in digital and signal processing systems have opened possibilities for the development of a broad range of new radio communication services. These technological advances have increased the need for spectrum to foster the growth and development of new services, primarily for mobile applications. However, this has created an environment in which new services are vying with each other and with existing users for relatively small slivers of spectrum that are incapable of supporting full implementation of new service. The Commission currently has pending before it a number of requests for new services and technologies for which sufficient spectrum is unavailable. These requests include: 200 MHz for new personal communications services (PCS); 40 MHz for data PCS; 33 MHz for a generic mobile satellite service; 70 MHz for a digital audio broadcasting service; and 33 MHz for low Earth orbit satellites.

6. We need to develop a plan that includes specific provisions for minimizing impact on existing services. Nevertheless, we believe that establishing these emerging technologies bands is desirable and will again prove advantageous for facilitating the continuing development of new communications technologies and the growth and expansion of existing services.

7. The current lack of available spectrum tends to have a chilling effect on the incentives for manufacturers and financial institutions to develop and fund new communications research. The emerging technologies bands would help provide some of the structure,

in terms of frequency of operation and operating plan, that is needed to facilitate the development of equipment. At the same time, this new concept would provide considerable flexibility with regard to the types of technologies and services that can be authorized.

SPECTRUM ISSUES

9. In the early 1970s [when the Commission foresaw emerging technologies and set aside space for them], spectrum was available in the lower frequency bands that was only lightly used and the licensees on those frequencies could be relocated relatively easily. Today there are substantial operations on virtually all of the lower frequency bands, so that establishment of emerging technologies bands will unavoidably necessitate relocation of significant numbers of existing users. The task, then, is to identify a relatively wide band of frequencies that can be made available with a minimum of impact on existing users and that also can provide suitable operating characteristics for new, primarily mobile, services.

10. The spectrum selected must meet the requirements of a broad range of possible services, including land mobile and satellite. The factors that must be considered include:

Cost of equipment—If the spectrum chosen is in a range for which state of the art equipment is not available, then high costs would delay the introduction of new services.

Amount of spectrum—There must be enough spectrum available to allow substantial development and economies of scale.

Feasibility of relocation—The existing licensees must be able to relocate with a minimum of cost and disruption of service to consumers.

Non government spectrum—In order to avoid the need for coordination and to speed the process of transition, the new bands should come entirely from spectrum regulated by the FCC.

International developments—It is desirable for the spectrum chosen to be compatible with similar international developments.

11. *Spectrum Study*. With the above considerations in mind, the Commission's staff conducted a study to examine the possibility of creating emerging technologies bands. This study identified the most suitable region of the spectrum, determined the existing users of that spectrum, explored alternatives for relocating those users to higher bands or other media with a minimum disruption of service, and examined the cost of such relocation. The study concluded that 220 MHz in the 1.85–2.20 GHz region could be designated for innovative technologies and services.

12. The study limited the consideration of candidate frequency bands to those in which mobile operations are practicable with current state of the art electronic components and manufacturing capabilities. It found that while experimental mobile use is taking place at higher bands, the state of the art technology for the compact, lightweight, portable electronic components expected to be used in new services generally will limit operations in those services to frequencies under 3 GHz. Thus, the study concluded that frequencies above 3 GHz would not be acceptable. It next found that the spectrum below 1 GHz generally does not appear to offer any possibilities for spectrum availability. Most of this spectrum is used for broadcasting and land mobile services that would be very difficult to relocate. These services have very large numbers of users, particularly in the major urban areas, and there are no bands with similar technical characteristics to which the existing users could be relocated. The remaining frequencies below 1 GHz are narrow, scattered

bands that would not provide sufficient spectrum. [For the above reasons, the study concentrated on the spectrum between 1 and 3 GHz.]

14. The study identified three non Government bands from this spectrum for consideration: 1.85–2.20, 2.45–2.50, and 2.50–2.65 GHz. The study found the 2.45–2.50 GHz band, which is allocated for use by Industrial, Scientific, and Medical (ISM) equipment, less desirable because it has a limited amount of spectrum (50 MHz) and because there is no replacement band that offers the same physical characteristics for the existing ISM operations in that band. The 2.50–2.60 GHz band, which is used for multipoint distribution service (MDS) and instructional television fixed service (ITFS), also was eliminated because there are no other frequency allocations currently available to which existing MDS operations could be relocated.

15. The remaining 1.85–2.20 GHz band is used for fixed private and common carrier microwave services, public land mobile service, broadcast auxiliary operations, and multipoint distribution service. Specifically, the 1.85–1.99, 2.11–2.15, and 2.16–2.20 GHz bands are used for private operational fixed and common carrier microwave operations. The private operational fixed licensees are local governments (including public safety), petroleum producers, utilities, railroads, and other business users such as the manufacturing, banking, and service industries. Systems range from a few links to very large systems that use hundreds of links. They are used as part of communications systems for local government and public safety organizations. These facilities are also used to control electric power, oil and gas pipeline and railroad systems, and to provide routine business voice, data, and video communications. The common carrier licensees are telephone, cellular telephone, and paging providers. Telephone companies use this band to provide telephone service to remote areas, cellular companies to interconnect cell sites with mobile telephone switching offices, and paging companies for control and repeater stations.

16. The 1.99–2.11 GHz band is used for broadcast auxiliary services. The licensees in this service are television broadcasters and cable television operators. Broadcast auxiliary services include studio to transmitter links, inner city relays, and electronic news gathering (ENG) mobile operations. These services are used to transmit video programming from remote sites to the studio and from the studio to the transmitter sites. The 2.15–2.16 GHz band is used for multipoint distribution service (MDS) and its licensees are, for the most part, wireless cable television operators. MDS is used to supply video programming to subscribers over city wide areas and to rural areas where it is not economical to install cable service.

17. The study finds that the private and common carrier fixed microwave operations using this spectrum can be relocated to higher frequency bands that provide for similar type services and can support propagation over similar path lengths. Further, it observes that there are other reasonable alternatives for fixed microwave such as fiber, cable and satellite communications, which can utilize off the shelf equipment to provide these services.

18. The study also concludes that it is not practicable at this time to relocate the broadcast auxiliary and the multipoint distribution services that use spectrum in the 1.85–2.20 GHz range. It finds that currently there is heavy use of the ENG bands and that the forthcoming introduction of broadcast advanced television service may result in more congestion in these bands. Since there currently are a large number of MDS applications before the Commission and the MDS service is a developing industry, the study further finds that it would not be desirable to relocate the MDS channels at 2 GHz.

19. *Proposed Reallocations.* Based on the findings of our staff study, we propose to reallocate 220 MHz of the 1.85 to 2.20 GHz band that is currently used for private and

common carrier fixed microwave services. The specific frequencies proposed to be reallocated are the 1.85–1.99, 2.11–2.15, and 2.16–2.20 GHz bands. We believe that this spectrum will meet the requirements of a significant number of new services and technologies. The private and common carrier fixed microwave services operating in these bands provide important and essential services. Accordingly, we intend to pursue this reallocation in a manner that will minimize disruption of the existing 2 GHz fixed operations.

20. In this regard, we propose to make available all fixed microwave bands above 3 GHz, both the common carrier and the private bands, for recommendation of fixed microwave operations currently licensed in the 1.85–2.20 GHz spectrum.[7]

22. *Transition Plan.* Our proposed transition plan would consist of three basic elements, discussed below.

23. First, we wish to ensure the availability of the existing vacant 2 GHz spectrum for the initial development of new services and to discourage possible speculative fixed service applications for this spectrum. We therefore will continue to grant applications for fixed operations in the proposed new technologies bands; however, applications for new facilities submitted after the adoption date of this Notice will be granted on a secondary basis only, conditioned upon the outcome of this proceeding. [For the meaning of "secondary basis," see ¶ 24.]

24. Second, except for state and local licensees, we propose to allow currently licensed 2 GHz fixed licensees to continue to occupy 2 GHz frequencies on a co-primary basis with new services for a fixed period of time, for example ten or fifteen years. Ten years could generally be expected to provide for a complete amortization of existing 2 GHz equipment. A fifteen year period would extend the relocation period through the useful life of that equipment. At the end of this transition period, these facilities could continue to operate in the band on a secondary basis. This means that if, after the transition period, new services were not able to use the spectrum because of interference from fixed microwave systems, those fixed microwave systems would be required to eliminate the interference, negotiate an arrangement for continued operation with the new service operator, or cease operation. This would allow some fixed microwave systems to continue operations indefinitely, particularly in rural areas where less spectrum may be required for new services.

25. We recognize that state and local government agencies would face special economic and operational considerations in relocating their 2 GHz fixed microwave operations to higher frequencies or alternative media. We are particularly sensitive to the need to avoid

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7. We also will encourage fixed microwave operators to consider other nonradio alternative media to meet their telecommunication needs, particularly fiber optic circuits. In allocating spectrum, one of the primary considerations is whether there is a technological dependence of the service on radio rather than wirelines. Mobile communications necessarily will always require use of radio spectrum, and in the past the Commission provided large amounts of spectrum for fixed microwave because wireline alternatives often were economically prohibitive. However, in the last five years technological advancements in optical communications have resulted in fiber being very competitive with fixed microwave. Further, the capacities of fiber optic circuits greatly exceed those of fixed microwave. For these reasons, many common carrier and private communication requirements, which in the past were met by fixed microwave, are now met with fiber optic circuits. In connection with encouraging migration to other, nonradio alternative media, we ask for comment on whether we should award tax certificates to fixed microwave licensees who receive financial compensation from an entity seeking to use the spectrum for new technology as part of an agreement to surrender their license and use other, nonradio alternative media. Grant of tax certificates in such circumstances would appear to be similar to our recent decision to award tax certificates to AM broadcast licensees receiving financial compensation for surrendering their licenses for cancellation. *See* Review of the Technical Assignment Criteria for the AM Broadcast Service, Report and Order, 6 FCC Rcd. 6273, 6472 (1991).

any disruption of police, fire, and other public safety communications. To address these concerns, we propose to exempt state and local government 2 GHz fixed microwave facilities from any mandatory transition periods. Rather, these facilities would be allowed to continue to operate at 2 GHz on a co-primary basis indefinitely, at the discretion of the state and local government licensees. These agencies would be permitted to negotiate the use of their frequencies with other parties. In this manner, transfer of state and local government operations could be arranged so as to accommodate fully any special economic or operational considerations with regard to the institutions affected.

26. To provide maximum flexibility in the relocation process, we believe it is desirable to permit parties seeking to operate new services to negotiate with the existing users for access to the 2 GHz frequencies and, conversely, to permit incumbents to negotiate with the new service providers for continued use of the spectrum. Therefore, we propose to allow providers of new services assigned spectrum allocated to the new emerging technologies bands to negotiate financial arrangements with existing licensees. This would encourage reaccommodation and underwriting of the costs of transition for the 2 GHz users. In return, the new licensees would receive earlier access to the frequencies used by the existing fixed microwave operators. Such arrangements would allow market forces to achieve a balance between the need to minimize the reaccommodation cost to existing operators and the immediate need for the spectrum to permit provision of these new services. It would also provide incumbents with a way to assure that the new licensees would not interfere with their expanded facilities or current facilities at the end of a mandatory transition period.[8]

Notes and Questions

1. Broadband PCS. The FCC ultimately adopted the reallocation plan laid out in this NPRM. *See* Redevelopment of Spectrum to Encourage Innovation in the Use of New Telecommunications Technologies, First Report and Order and Third Notice of Proposed Rulemaking, 7 FCC Rcd. 6886 (1992). That plan came to be known as the "broadband" PCS plan (as opposed to "narrowband" PCS) because it provided sufficient spectrum for bandwidth-intensive data transmission and thus paved the way for the mobile phones with enhanced capacity that we now take for granted.

2. Valuing PCS. Why did the Commission decide to allocate any spectrum to PCS? That is, how did the FCC know that spectrum would be more valuable if used for PCS than if used for other services? Conversely, why allocate only 220 MHz to PCS? If PCS is so valuable, how did the Commission know that it didn't warrant an even larger chunk of frequency?

3. Finding Frequencies. To find spectrum for PCS, the Commission first studied the physical properties of the technology and determined, within a very wide margin, which areas of the spectrum seemed best suited for PCS transmission and reception. It concluded that some frequencies (those above 3 GHz) were technologically unsuited to PCS and thus those ranges were no longer considered. Next, the Commission identified other ranges

8. Our principal desire is to compensate existing 2 GHz users for the costs of relocation. We recognize, however, that such market-based negotiations could possibly result in windfalls for the incumbent 2 GHz licensees. [Footnote relocated.]

(specifically, frequencies below 1 GHz) and determined that they were already so crowded that they, too, would not be made available for PCS. That left the range between approximately 1 GHz and 3 GHz. The FCC identified services already in that range that, in the Commission's view, should be relocated to make room for PCS, and then announced a transition plan that would move those services out.

But how did the FCC make each of these determinations? Consider each step in isolation. First, the unusable frequencies. The Commission states in ¶ 12 that it limited its consideration of "candidate frequency bands to those in which mobile operations are practicable with current state of the art electronic components and manufacturing capabilities." How confident are you that the Commission can make this sort of technical determination accurately? Besides, even if then-current PCS designs did not work in certain frequency bands, why couldn't the Commission tell PCS innovators to develop variants of the technology that would? The Commission itself reports that "experimental mobile use" was already taking place in these unusable bands. Why not encourage that innovation? In fact, if higher frequencies tend to be particularly uncrowded—something the Commission hints at early in the document—shouldn't the Commission shunt PCS to those higher frequencies, in essence encouraging new technologies to make use of underused spectrum resources?

Now, let's turn to the frequencies below 1 GHz, also discussed in ¶ 12, that were ruled out because they were already in use by broadcasters and land mobile services. How did the Commission know that these services should be left in place whereas services in the 1 GHz to 3 GHz range would ultimately be moved? Did the FCC determine, in each of these instances, that PCS was not a more valuable use for the spectrum at issue? Or was the Commission instead making a prediction about transaction costs? On what basis exactly?

Finally, consider the frequencies between 1 GHz and 3 GHz that the Commission deemed acceptable for PCS. How did the agency determine that PCS was a more valuable use of this spectrum than the private operational fixed services and the common carrier microwave operations that were already there? If PCS is a more valuable use, why did the Commission structure a complicated transition period; won't the more valuable use simply buy out the less valued uses? Indeed, why did the Commission not simply announce that, henceforth, any license (including those already outstanding) for the 1.85–1.99, 2.11–2.15 and 2.16–2.20 GHz bands would be interpreted so as to permit the licensee to offer PCS service, and, further, that those licenses were now freely transferable?

4. A Windfall? How would you respond to footnote 7 if you were an incumbent licensee? What if you were a potential PCS provider? In fact, the FCC modified the transition plan in later orders to mitigate potential windfalls and provider greater structure, via three "negotiation periods." The first, called the "voluntary negotiation period," had no requirement for negotiation or negotiation parameters. That was followed by a "mandatory negotiation period" in which the PCS operator and the microwave operator were required to negotiate in good faith. If those negotiations failed, the "involuntary relocation" period commenced, in which the PCS operator could require the incumbent microwave licensee to relocate if it offered the microwave licensee comparable facilities and paid the cost of relocating (and the FCC capped the relocation costs, to avoid microwave incumbents padding them). The first two periods were longer for public safety licensees (up to five years) than for other licensees (two years). *See* Amendment to the Commission's Rules Regarding a Plan for Sharing the Costs of Microwave Relocation, Second Report and Order, 12 FCC Rcd. 2705 (1997). The Commission also provided an inducement for suc-

cessful negotiations in the form of the tax certificates mentioned in footnote 7 (offering favorable tax treatment). Those certificates were issued only to microwave licensees who reached agreements before the end of the mandatory negotiation period. *See* Clarification of Procedures for Issuance of Tax Certificates Regarding Relocation of Microwave Incumbent Licensees, Public Notice, 13 FCC Rcd. 6661 (1998).

5. Treating Incumbents. Should the FCC have given the incumbents less time to stay in their existing allocations and/or no promise of substitute spectrum? Should it have given them more time? On what should this decision be based?

6. Chickens and Eggs. Allocating spectrum for new technologies seems to raise a classic chicken-and-egg problem. Firms are reluctant to invest research dollars creating new equipment until they are sure that the Commission will license the new service in the designed-for band. The Commission, meanwhile, is reluctant to allocate spectrum to a technology that is unproven both as a technical matter and in terms of its desirability to consumers. How did the Commission address this problem in this spectrum decision?

7. Metrics. How should telecommunications policy respond to the spectrum requirements of new technologies? Can the FCC estimate and compare the likely value of competing uses? Given the large coordination problems that need to be resolved, would it be folly to just leave these issues to the marketplace? Are there intermediate steps? How would you respond if Congress were to put forward legislation conferring perpetual spectrum property rights on current licensees and then permitting those licensees to sell their rights to whomever they chose for use in whatever service the market deemed most valuable?

8. PCS Explosion. The FCC's 2010 National Broadband Plan summarized the impact of the PCS allocation as follows:

> From 1994 to 2000, the FCC auctioned the Personal Communications Service (PCS) spectrum, which made mobile voice communications a mass-market reality and unleashed a tidal wave of innovation and investment. These auctions more than tripled the stock of spectrum for commercial mobile radio services. With spectrum as the catalyst, the mobile industry profoundly changed during this period:
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> - The number of wireless providers increased significantly in most markets.
> - The per-minute price of cell phone service dropped by 50%.
> - The number of mobile subscribers more than tripled.
> - Cumulative investment in the industry more than tripled from $19 billion to over $70 billion.
> - The number of cell sites more than quadrupled, from 18,000 to over 80,000.
> - Industry employment tripled from 54,000 to over 155,000.

FCC, National Broadband Plan § 5.1 (2010), *available at* www.broadband.gov/plan/.

What, if anything, should we learn from these later developments? That is, what does this tell us about how the FCC should act the next time there is a new proposed use of the spectrum? Is it possible to abstract from this experience, and, if so, exactly what should we abstract?

9. Flexible Licenses. The licenses granted to the winners of the PCS auction provided a considerable degree of flexibility. In particular, the FCC specified that the licenses could be used to provide "any mobile communications service" as well as "fixed services" provided in combination with mobile ones—as long as the license is not used to provide a broadcasting service. 47 C.F.R. § 24.3. The Commission has taken similar actions in other frequencies. For instance, in Service Rules for the 746–764 and 776–794 MHz Bands, and Revisions of Part 27 of the Commission's Rules, First Report and Order, 15 FCC Rcd. 476 (2000), the Commission issued an order reallocating spectrum that had been dedicated to broadcasting. Instead of picking a particular service that licensees could offer, the Commission authorized licensees to choose among a wide range of wireless services. Similarly, in Service Rules for Advanced Wireless Services in the 1.7 GHz and 2.1 GHz Bands, Report and Order, 18 FCC Rcd. 25,162 ¶ 13 (2003), the FCC issued an order announcing that "[i]n order to promote innovative services and encourage the flexible and efficient use of the 1710–1755 and 2110–2155 MHz bands, we permit licensees to use this spectrum for any use permitted by the United States Table of Frequency Allocations contained in Part 2 of our rules (i.e., fixed or mobile services)."

It bears mentioning, though, that neither in these nor in any other orders has the FCC given licensees the freedom to choose any service they desired. For instance, in the 2003 order noted immediately above, the FCC stated that the bands could not be used for broadcasting, *id.* ¶ 58, and in the 2000 order noted above it disallowed conventional television service. 15 FCC Rcd. 476 ¶ 15. Why impose any restrictions? The main reason, according to the FCC, was that the danger of interference is too great. The 2000 order explained that

> Establishing regulatory flexibility sufficient to accommodate conventional television broadcasting would impose disproportionate, offsetting burdens on wireless services, constraining their technical effectiveness and, consequently, their economic practicability.
>
> The interference problem arises from the disparity between the two services' characteristic power levels, and between their transmitter tower heights. Any substantial disproportion between the power levels of services sharing a spectrum band creates much greater interference difficulties for the lower power service than when sharing or adjacent band services operate at comparable power levels. The disparity between television transmitter tower heights and those used by typical wireless providers adds to the difficulty by accentuating the power of the more powerful service.

Id. ¶¶ 16–17.

10. Flexibility via Another Route. In ¶ 14 of the NPRM, the FCC chose not to reallocate the spectrum dedicated to instructional television fixed service (ITFS), and therein lies a story. In 1963, the FCC allocated the 2500–2690 MHz band to ITFS, and decided that the licensees would be accredited schools seeking to augment their educational mission.[9] There were two problems, however: in some areas there were no applicants for those frequencies, and those who did apply for this spectrum were given much more spectrum than they wanted to use for their ITFS transmissions.[10] Both problems arose from the fact

9. Amendment of Parts 2 and 4 of the Commission Rules and Regulations to Establish a New Class of Educational Television Service, Report and Order, 39 F.C.C. 846, ¶¶ 15–29 (1963).

10. *See* Amendment of Parts 2, 21, 74 and 94 of the Commission's Rules and Regulations in Regard to Frequency Allocation to the Instructional Television Fixed Service and the Multipoint Distribution Service, Report and Order, 94 F.C.C. 2d 1203, ¶ 25 (1983) (noting the lack of interest in some of the frequencies devoted to ITFS, and the surplus bandwidth for those who did have the licenses).

that the FCC had allocated this bandwidth for ITFS, and nothing else. Instead, the FCC responded to this problem by allowing ITFS licensees to lease "excess capacity" to operators of a service known as multichannel multipoint distribution service (MMDS).[11] Even with both uses, however, the demand was not sufficient to fully occupy the entire range of frequencies allotted for these purposes.[12] Later, the FCC broadened the category of services that can occupy this spectrum (renaming MMDS as Broadband Radio Service).[13] The FCC still does not allow complete choice, but it has broadened the choice available to contain a range of broadband services (though still not any noninterfering service). The result is that wireless broadband companies now provide service on most of this spectrum, but the formal licensees (and recipients of funds from the broadband companies) are the schools with ITFS licenses.

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§ 4.C. Dedicating Spectrum to Unlicensed Uses

Spectrum flexibility was one prominent theme of the Spectrum Policy Task Force Report. Another was the question of the model of individual usage that might be desirable on any given set of frequencies. The report suggested that in some circumstances a spectrum commons might be preferable to exclusive use. More recently, the 2010 National Broadband Plan recommended the following with respect to unlicensed devices:

> As the FCC seeks to free up additional spectrum for broadband, it should make a sufficient portion available for use exclusively or predominantly by unlicensed devices. This would enable innovators to try new ideas to increase spectrum access and efficiency through unlicensed means, and should enable new unlicensed providers to serve rural and unserved communities. Such an approach would represent a departure from the way the FCC has treated most unlicensed operations in the past. Unlicensed operations are typically overlays to licensed bands, with intensive unlicensed use emerging in some bands (e.g., the 2.4 GHz band) over a long period of time. However, targeting bands for unlicensed use could yield important benefits.

FCC, National Broadband Plan, Recommendation § 5.11 (2010), *available at* www.broadband.gov/plan/.

Both the Spectrum Policy Task Force Report and the National Broadband Plan offer limited support for commons in the lower band spectrum — sometimes called "beachfront property" because it can be used for so many services and thus is the most desirable spectrum. By contrast, some commentators have advocated dedicating large swaths of

11. Amendment of Parts 21 and 74 of the Commission's Rules With Regard to Filing Procedures in the Multipoint Distribution Service and in the Instructional Television Fixed Service, Report and Order, 10 FCC Rcd. 9589, ¶ 1 (1995); Amendment of Parts 2, 21, 74 and 94 of the Commission's Rules, 94 F.C.C. 2d at ¶ 85.

12. *See, e.g.*, Amendment of Parts 1, 21 and 74 to Enable Multipoint Distribution Service and Instructional Television Fixed Service Licensees to Engage in Fixed Two-Way Transmissions, Report and Order on Reconsideration, 14 FCC Rcd. 12,764, ¶ 56 (1999) (stating that "most [ITFS channels] have lain fallow").

13. Amendment of Parts 1, 21, 73, 74 and 101 of the Commission's Rules to Facilitate the Provision of Fixed and Mobile Broadband Access, Educational and Other Advanced Services in the 2150–2162 and 2500–2690 MHz Bands, Report and Order and Further Notice of Proposed Rulemaking, 19 FCC Rcd. 14,165 (2004).

lower band frequencies exclusively to unlicensed uses. One of the most prominent is Yochai Benkler. Below, we excerpt Benkler's most complete articulation of how, in his view, an unlicensed commons should be implemented.

Some Economics of Wireless Communications

Yochai Benkler, 16 Harv. J.L. & Tech. 25 (2002)

In the first half of the 20th century there was roughly universal agreement that "spectrum" was scarce, and that if it was to be used efficiently, it had to be regulated by an expert agency. A little over forty years ago, Coase wrote a seminal critique of this system, explaining why spectrum scarcity was no more reason for regulation than is wheat scarcity. "Scarcity" was the normal condition of all economic goods, and markets, not regulation, were the preferred mode of allocating scarce resources. In the 1960s and 1970s, a number of academic studies of property rights in spectrum elaborated on Coase's work, but these remained largely outside the pale of actual likely policy options. It was only in the 1980s that a chairman of the Federal Communications Commission voiced support for a system of market-based allocation, and only in the 1990s did Congress permit the FCC to use auctions instead of comparative hearings to assign spectrum. But auctions in and of themselves, without flexible use rights, are but a pale shadow of real market-based allocation. Indeed, they might better be understood as a type of fee for government licenses than as a species of market allocation. Since the mid-1980s, and with increasing acceptance into the 1990s, arguments emerged within the FCC in favor of introducing a much more serious implementation of market-based allocation. This would call for the definition and auctioning of perpetual, exclusive property rights akin to those we have in real estate, which could be divided, aggregated, resold, and reallocated in any form their owners chose to use.

Just as this call for more perfect markets in spectrum allocations began to emerge as a real policy option, a very different kind of voice began to be heard on spectrum policy. This position was every bit as radically different from the traditional approach as the perfected property rights approach, but in a radically different way. The argument was that technology had rendered the old dichotomy between government licensing of frequencies and property rights in frequencies obsolete. It was now possible to change our approach, and instead of creating and enforcing a market in property rights in spectrum blocks, we could rely on a market in smart radio equipment that would allow people to communicate without anyone having to control "the spectrum." Just as no one "owns the Internet," but intelligent computers communicate with each other using widely accepted sharing protocols, so too could computationally intensive radios. In the computer hardware and software markets and the Internet communications market, competition in the equipment market, not competition in the infrastructure market (say, between Verizon and AOL Time Warner), was the driving engine of innovation, growth, and welfare. This approach has been called a "spectrum commons" approach, because it regards bandwidth as a common resource that all equipment can call on, subject to sharing protocols, rather than as a controlled resource that is always under the control of someone, be it a property owner, a government agency, or both. It is important to understand, however, that this metaphor has its limitations. Like its predecessor positions on spectrum management, it uses the term "spectrum" as though it describes a discrete resource whose utilization is the object of analysis. In fact, as this Article explains, "spectrum" is not a discrete resource whose optimal utilization is the correct object of policy. The correct object of optimization is wireless network communications capacity. Like trade with India, which is only one parameter of welfare in Britain, bandwidth is only one parameter in determining the

capacity of a wireless network. Focusing solely on it usually distorts the analysis. I will therefore mostly refer in this Article to "open wireless networks" rather than to spectrum commons. Like "the open road" or the "open architecture" of the Internet, it describes a network that treats some resources as open to all equipment to use, leaving it to the equipment manufacturers—cars or computers, respectively, in those open networks—to optimize the functionality they provide using that resource.

Most of the initial responses to this critique were largely similar to the responses that greeted the economists' critique forty years ago—incomprehension, disbelief, and mockery, leading Noam to call the standard economists' view "the new orthodoxy." (*See* Eli Noam, Spectrum Auction: Yesterday's Heresy, Today's Orthodoxy, Tomorrow's Anachronism. Taking the Next Step to Open Spectrum Access, 41 J.L. & Econ. 765, 768 (1998).) But reality has a way of forcing debates. The most immediate debate-forcing fact is the breathtaking growth of the equipment market in high-speed wireless communications devices, in particular the rapidly proliferating 802.11x family of standards (best known for the 802.11b or "Wi-Fi" standard), all of which rely on utilizing frequencies that no one controls. Particularly when compared to the anemic performance of licensed wireless services in delivering high-speed wireless data services, and the poor performance of other sectors of the telecommunications and computer markets, the success of Wi-Fi forces a more serious debate. It now appears that serious conversation between the two radical critiques of the licensing regime is indeed beginning to emerge, most directly joined now in a new paper authored by former chief economist of the FCC, Gerald Faulhaber, and Internet pioneer and former chief technologist of the FCC, Dave Farber. (Gerald Faulhaber & David Farber, Spectrum Management: Property Rights, Markets, and the Commons, *available at* http://rider.wharton.upenn.edu/~faulhabe/.)

What I hope to do in this Article is (a) provide a concise description of the baseline technological developments that have changed the wireless policy debate; (b) explain how these changes provide a critique of a spectrum property rights approach and suggest that open wireless networks will be more efficient at optimizing wireless communications capacity; and (c) outline a transition plan that will allow us to facilitate an experiment in both approaches so as to inform ourselves as we make longer-term and larger-scale policy choices in the coming decade.

To provide the economic analysis, I offer a general, though informal, model for describing the social cost of wireless communications, aggregating the equipment and servicing costs involved, the displacement of communications not cleared, and the institutional and organizational overhead in the form of transaction costs and administrative costs. In comparing these, I suggest that while investment patterns in equipment will likely differ greatly, it is not clear that we can say, a priori, whether equipment costs involved in open wireless networks will be higher or lower than equipment costs involved in spectrum property-based networks. Investment in the former will be widely decentralized, and much of it will be embedded in end-user owned equipment that will capitalize ex ante the cost and value of free communications over the lifetime of the equipment. Investment in the latter will be more centrally capitalized because consumers will not both invest ex ante in capitalization of the value of free communication and pay usage fees ex post. Since the value added by spectrum property is in pricing usage to improve the efficiency of allocation over time, it will need lower ex ante investment levels at the end user terminal and higher investment levels at the core of the network. Which of the two will have higher total costs over the lifetime of the network is not clear.

The most complicated problem is defining the relative advantages and disadvantages of spectrum property-based networks and open wireless networks insofar as they displace some communications in order to clear others. Backing out of contemporary multi-user information theory, I propose a general description of the displacement effect of wireless communications. Then, I suggest reasons to think that open wireless networks will systematically have higher capacity, that is, that each communication cleared through an open network will displace fewer communications in total. This, in turn, leaves the range in which spectrum property-based systems can improve on open wireless systems in terms of efficiency as those cases where the discriminating power of pricing is sufficiently valuable to overcome the fact that open wireless systems have cleared more communications but without regard to the willingness and ability of the displaced communications to pay. As a spectrum property-based network diverges from locally and dynamically efficient pricing, the likelihood that it will improve efficiency declines.

As for overhead, or transaction and administrative costs, I suggest reasons to think that both direct transaction costs associated with negotiating transactions for spectrum and clearing transmission rights, and administrative costs associated with a property-type regime rather than with an administrative framework for recognizing and generalizing privately set equipment standards, will be lower for open wireless networks. In particular, I emphasize how the transaction costs of a property system will systematically prevent efficient pricing, and therefore systematically undermine the one potential advantage of a spectrum property-based system.

My conclusion is that the present state of our technological knowledge, and the relevant empirical experience we have with the precursors of open wireless networks and with pricing in wired networks, lean toward a prediction that open wireless networks will be more efficient in the foreseeable future. This qualitative prediction, however, is not sufficiently robust to permit us to make a decisive policy choice between the two approaches given our present limited practical experience with either. We can, however, quite confidently state the following propositions:

1. Creating and exhaustively auctioning perfect property rights to all spectrum frequencies is an unfounded policy. None of our technical, theoretical, or empirical data provides sufficient basis for believing that an exhaustive system that assigns property rights to all bands of frequencies will be systematically better than a system that largely relies on equipment-embedded communications protocols that are permitted to use bandwidth on a dynamic, unregulated basis.

2. Creating such a property system will burden the development of computationally intensive, user equipment-based approaches to wireless communications, potentially locking us into a lower development trajectory for wireless communications systems. This is particularly so for the dominant position that advocates creating perfect property rights in spectrum blocks, but is true even with modified systems, such as the Faulhaber-Farber proposal to include an easement for noninterfering transmissions or the Noam proposal of dynamic market clearance on the basis of spot-market transactions and forward contracts.

3. It is theoretically possible that pricing will sometimes improve the performance of wireless communications networks. The geographically local nature of wireless communications network capacity, the high variability in the pattern of human communications, and the experience of wired networks suggest, however, that if pricing will prove to be useful at all:

3a. It will be useful only occasionally, at peak utilization moments, and the cost-benefit analysis of setting up a system to provide for pricing must consider the value of occasional allocation efficiency versus the cost of the drag on communications capacity at all other times.

3b. It will be more useful if there are no property rights to specific bands, but rather all bandwidth will be available for dynamic contracting through an exchange system on the Noam model.

3c. At most, the possibility of implementing pricing models suggests the creation of some spectrum for a real-time exchange alongside a commons. It does not support the proposal of a Big Bang auction of perfect property rights in all usable frequencies.

As a policy recommendation, it is too early to adopt a Big Bang approach to spectrum policy—either in favor of property or in favor of a commons. From a purely economic perspective, it would be sensible for current policy to experiment with both. What follows is a proposal that offers a series of steps that could embody such an experiment.

1. Increase and improve the design of the available spaces of free utilization of spectrum by intelligent wireless devices, so as to allow equipment manufacturers to make a credible investment in devices that rely on commons-based strategies:

1a. Dedicating space below the 2 GHz range that would be modeled on one of two models: (a) FCC equipment certification, with streamlined FCC certification processes, or (b) Privatization to a public trust that serves as a nongovernmental standards clearance organization.

1b. Improving the U-NII Band regulations for the 5 GHz range by designing the regulatory framework solely on the basis of the needs of open wireless networking, rather than, as now, primarily in consideration of protecting incumbent services. This would require: (a) clearing those bands from incumbent services, and (b) shifting that band to one of the models suggested for the 2 GHz range.

1c. Permitting "underlay" and "interweaving" in all bands by implementing a general privilege to transmit wireless communications as long as the transmission does not interfere with incumbent licensed devices. "Underlay" relates to what is most commonly discussed today in the name of one implementation—ultrawideband—communications perceived as "below the noise floor" by the incumbent licensed devices, given their desired signal-to-interference ratios. "Interweaving" relates to the capability of "software defined" or "agile" radios to sense and transmit in frequencies only for so long as no one is using them, and to shift frequencies as soon as their licensed user wishes to use them.

1d. Opening higher frequency bands currently dedicated to amateur experimentation to permit unregulated commercial experimentation and use alongside the amateur uses. This will allow a market test of the plausible hypothesis that complete lack of regulation would enable manufacturers to develop networks, and would lead them to adopt cooperative strategies.

2. Increase the flexibility of current spectrum licensees to experiment with market-based allocation of their spectrum. This would include adoption of the modified property right proposed by Faulhaber and Farber for some incumbent licensees and implementation of a scaled-down auction of spectrum rights with structurally similar characteristics to the proposed Big Bang auction.

3. Subject both property rights sold and commons declared to a preset public redesignation option, exercisable no fewer than, say, ten years after the auction or public dedication, to allow Congress to redesignate the spectrum from open to proprietary, or vice versa, depending on the experience garnered.

3a. Congress could, from time to time, extend the ten-year period, if it believes that the experiment is not yet decisively concluded, so as to preserve a long investment horizon for the firms that rely on either the proprietary or the open resource set.

3b. The exercise date of the option would reflect the discount rate used by spectrum buyers for the property system and by equipment manufacturers for the commons, and would be set so as to minimize the effect of the redesignation right on present valuation of investments in buying spectrum or designing equipment for ownerless networks.

Notes and Questions

1. Dedicated Spectrum versus Underlay Rights. Benkler lists a number of possible forms of spectrum rights. Most notably, he refers to dedicated spectrum as well as underlay rights. The latter is what Faulhaber and Farber propose as an easement creating an underlay commons, and what the Spectrum Policy Task Force Report conceptualizes as an underlay commons below an interference temperature. This is not inconsistent with having property rights in spectrum.[14] Dedicating spectrum to a commons, however, is inconsistent with property rights. The whole point is that no one would have the right to exclude; the sole use of the spectrum would be as a commons. Benkler's disagreement with Faulhaber and Farber is that he advocates such a devotion of spectrum to commons, and his article focuses on that proposal.

2. Open Access? One can imagine a regime of truly open access to the spectrum, a regime in which anyone could transmit over a given set of frequencies however she sees fit. The concern about such freedom is interference: any given user has an interest in ensuring that her message gets through, even if that means increasing power and/or the number of messages sent (to create redundancy) such that others' messages cannot be heard. Recognizing this danger, the FCC has never allowed truly open access. For unlicensed uses, the FCC sets out the protocols that acceptable devices must use and then certifies equipment that meets that standard.

Benkler does not deny that interference can occur with truly open access. Rather, in the remainder of the paper he argues that new network designs can eliminate the dangers posed by interference, with the result that a commons is an efficient—indeed, possibly the most efficient—option. Specifically, he envisions abundant networks comprising devices that operate at low-power, send computationally complex transmissions, and not only send the owner's messages but also repeat others' messages, so that each additional user also represented additional capacity. Benkler's proposal would have the FCC or a private entity certify that user devices meet these standards. The envisioned networks will thus have some controls. In order to avoid the interference that would arise from truly open access, some entity—whether public or private—will determine what sort of devices can operate.

3. Policing the Spectrum Commons. Advocates of a "spectrum commons" approach sometimes downplay the considerable challenges of ensuring that users of unlicensed spectrum cooperate with one another. In the worst of all worlds, users of unlicensed spectrum will interfere with one another and continually adjust their equipment to overpower one

14. As one of us put it, "This is purely a question of how the rights in the license are constructed and construed. If a license to broadcast television were construed as giving the licensee complete control over a given range of frequencies, then any potential user would have to obtain the existing licensee's agreement before it could offer a new service. If, on the other hand, a license to broadcast were construed as conferring only the right to broadcast on that range of frequencies without interference, and as not including a broader property right in that range of frequencies, then a potential new user would not have to gain the agreement of the licensee." Stuart Minor Benjamin, The Logic of Scarcity: Idle Spectrum as a First Amendment Violation, 52 Duke L.J. 1, 85 n.259 (2002).

another. To avoid such a "tragedy of the commons" scenario, government regulation, market forces, or self-regulatory efforts need to facilitate cooperation (say, by enforcing a limit on power levels or enforcing the use of cooperative protocols that require users to "listen before talking"). Some combination of such efforts may well be critical to enabling unlicensed spectrum to achieve the hopes that policymakers have for it. *See* Philip J. Weiser & Dale N. Hatfield, Policing the Spectrum Commons, 74 Fordham L. Rev. 663 (2005).

4. Why Won't a Private Entity Create These Networks? Just as the FCC could design transmission standards and certify devices, so too could an owner of spectrum in fee simple. If the envisioned abundant networks are so capacious, why wouldn't private owners with full property rights create them? Benkler responds to this question in another paper, arguing that the transaction costs of privately creating these networks are high, because the FCC usually allocates spectrum in small slices (e.g., six megahertz for each broadcaster), but an abundant network might occupy 50 or 100 megahertz. *See* Yochai Benkler, Overcoming Agoraphobia: Building the Commons of the Digitally Networked Environment, 11 Harv. J.L. & Tech. 287, 364–65 (1998). A response, of course, would be to have the FCC start licensing spectrum in larger chunks and thus eliminate these costs.

A very different argument is that owners won't create these networks even if the spectrum is allotted in big swaths, because abundant networks will be less remunerative for the owners. But why would that be? Owners would have lots of pricing options—for example, per message, per minute, per month, and/or bundled in the price of the user device. Is the problem that owners would not be able to capture the value of these networks? The question, though, is a comparative one—whether it is more difficult to capture the value of these networks than of other kinds of wireless services—and it is not at all clear that capturing the value of the envisioned networks is any more difficult. Finally, maybe the problem is that these abundant networks will not be as remunerative because people will simply pay more money for other services. But if that is so, isn't the entire case for those networks undermined?

5. Should We Prefer Government-Created Networks? Assuming that private owners would create these networks, that still does not mean that private ownership is preferable. What are the tradeoffs? To oversimplify dramatically, the main advantage of private ownership is flexibility. The profit motive gives private owners a greater incentive to choose the best system and to make changes as new possibilities arise. And private companies' decisions are not subject to the exhaustive procedures that are imposed on government actors. The main disadvantage of private ownership is the danger of monopoly. But can't the danger of monopoly be minimized by the FCC auctioning off enough spectrum to support five or ten of these envisioned networks (just the sort of "big bang" that Faulhaber and Farber advocate)? More generally, are there other ways the government could avoid monopolization (spectrum caps; requiring that bidders act only as band managers; mandating interoperability)?

Does the foregoing miss the real advantage of government-created networks, namely that the government would let users access the spectrum free of charge? But why is that desirable? Everyone who creates a network (whether cellular telephony, broadcast television, or car dealerships) wants the government to contribute, free of charge, some otherwise expensive element of that network. Why subsidize these networks? Is it because government control will in fact be more responsive to users' desires than private control will be? Does that position understate the government's incentives and/or the possibility that the market will provide citizens with the networks that they want?

6. Uncertainty. One obvious difference between the government creating these abundant networks and leaving it to the private market is that the latter option does not guarantee that they will be created. But is that a bug or a feature? These networks may not develop as hoped,

either because they do not work as planned, or they do work but people do not flock to them. Is it better for the risk of failure to fall on private owners rather than on taxpayers?

7. Further Reading. Many of the issues raised here are covered in greater detail in Stuart Minor Benjamin, Spectrum Abundance and the Choice Between Private and Public Control, 78 N.Y.U. L. Rev. 2007 (2003).