

# The U.S. experience with non-traditional approaches to spectrum management

## Tragedies of the commons and other myths reconsidered

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### I. Introduction

An intense discussion is currently conducted over the most efficient spectrum policy framework. Since the 1980s, the Federal Communications Commission (FCC) has experimented with somewhat more flexible forms of spectrum management than the classical administrative licensing regime, which relied heavily on government control. In the recent debate, more radical departures from the historical model, including the establishment of spectrum commons (collective property rights) (Buck 2002, Benjamin 2003), the creation of individual property rights (Faulhaber and Farber 2002, Kwerel and Williams 2002), or the introduction of open access models (Noam 1998, Benkler 2002), are considered as alternatives to the traditional model.<sup>1</sup> With a few exceptions outside of the U.S., such as New Zealand or Guatemala, which have privatized spectrum, the latter three regimes are presently only on the drawing board. A significant part of the discussion therefore is at risk to compare the worst properties of the disparaged old regime with the benefits predicted for idealized versions of alternative frameworks. Concrete insights based on experience with alternative approaches is scarce, but could be very valuable in assessing competing claims.

This paper takes advantage of the fact that the FCC has occasionally defined services in ways that deviate from the classical exclusive rights model. For example, in Citizen Band (CB) radio and later in Family Radio Service (FRS) and other locally contained services, the licensing requirement was abandoned altogether. In some bands, such as Personal Communications Services (PCS) and the General Radio Service (GRS), more flexible usage rules were adopted, giving licensees some freedom to determine the actual uses of spectrum. In the 700 MHz Guard Bands, the FCC established band managers who could disaggregate spectrum and lease it to third parties. These experiments are embedded in a framework of administrative licensing but they offer a unique opportunity to evaluate the concrete experience with non-traditional forms of spectrum management

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<sup>1</sup> A full review of the different positions in this discussion would exceed the framework of this paper. Key arguments are surveyed in FCC (2002) and Bauer (2003).

that have properties in common with some of the proposed alternative management schemes. The empirical insights gained from detailed case studies could elevate this discussion above the purely conceptual level at which it is currently conducted.

The paper is organized as follows. The next section develops a framework to assess alternative models of organizing spectrum access and use. It builds on the theory of property rights to describe overall spectrum management regimes as well as specific sets of service-specific rules as bundles of legal rights with corresponding economic rights. Section three of the paper gives a historical overview of the three non-traditional services (CB Radio, Unlicensed PCS, and the 700 MHz Guard Band), which are at the focus of this paper. Based on the framework of section two, section four develops governance profiles for each of the services. Section five relates these profiles to the experience with the services and the last section synthesizes the main insights of the paper. The paper has benefited greatly from information provided by many people in industry and government as well as users of wireless services.

## **II. A conceptual framework**

The rules and regulations governing wireless services evolved over many decades in response to specific problems and opportunities. Their specific substance is influenced by many factors, including the unique features of spectrum, the specific technological basis of a service, and the character of a use (e.g., scientific, commercial, or emergency communication). As technological advances expanded the range of applications, solutions for newer services had to be compatible with earlier policies unless clear net benefits would result from a change of the existing rules and regulations. Since the 1920s, spectrum policy accepted the basic notion that the avoidance of interference was best addressed in a framework of exclusive usage rights. However, different degrees of exclusivity and flexibility of use were established based on the perceived needs of a service or of a band. For example, broadcast bands or cellular telephone bands were designed with a high degree of exclusivity whereas land mobile radio bands foresaw a higher degree of sharing and more limited interference protection. Although all general and service-specific rules are intended to address the problem of interference and to maximize the efficiency of spectrum use, many possible specific approaches exist. They differ with regard to the incentives they create for efficient spectrum use and hence in their suitability to actually achieve the stated goals of spectrum management.

A comparative analysis of different approaches can start from the fact that each specific set of rules defines a bundle of legal rights along the following dimensions: access, use, management, exclusion, and alienation (Ostrom 1990). Rules related to access specify who can have access to spectrum and under what conditions. Provisions governing use define what can be done by those who have access to spectrum. Management rules address who can modify the rules related to access and use. The rules related to exclusion and alienation define the extent to which others can be prohibited from spectrum use and delineate the rights of disposing of the established rights. On each dimension, various ways to define rights (“attributes”) exist, yielding a large number of possible combinations, each constituting a particular constellation. For example, access

to spectrum can be conditioned on the acquisition of a title to spectrum, a lease payment, an administrative license, open subject to certain etiquette rules, or fully free. The right to use could be defined as unlimited use, unlimited use for a certain period, use to transmit a certain quantity of information, or subject to other conditions, such as reliance on a certain technical protocol.

Table 1  
Principal features of alternative spectrum management regimes

	<b>Administrative licensing</b>	<b>Flexible licensing</b>	<b>Individual ownership</b>	<b>Commons (collective ownership)</b>	<b>“Open” access</b>
<b>Access</b>	Contingent upon government license	Typically based on auction	Purchase of spectrum	Purchase or license	Anyone meeting minimal criteria
<b>Use</b>	As determined in license	As determined in license	Any decided by owner	Any decided by members of commons	Any
<b>Management</b>	Government	Government	Owners	Members of commons	None
<b>Exclusion</b>	Anyone without a license	Anyone without a license	Any non-owner	Any non-member	Anyone not meeting minimal criteria
<b>Alienation</b>	Limited transferability based upon government approval	Secondary markets for licenses, with or without government approval	Owner	Members of commons	None

Based on the characteristic combination of these attributes, several prototypes of spectrum management frameworks (“regimes”) can be distinguished (see table 1). Service-specific rules are particular manifestations of the possible attributes of these overall regimes. In the traditional system of administrative licensing, nearly all aspects of spectrum management were controlled by the government. In a regime of flexible licensing, administrative control is replaced with either market based instruments (e.g., auctions to assign spectrum) or more general permission to use spectrum (e.g., use for a set of services rather than a specific one). More radical departures would introduce full property rights in spectrum that significantly expand the discretion of owners to manage spectrum and their rights to alienate it. Commons regimes establish a framework that grants rights to groups of users rather than individual users. The dominant characteristic of open access regimes is that any one who meets certain minimal eligibility criteria is allowed to access and use spectrum.

The rules governing each service constitute a particular bundle of legal rights, drawn from the set of feasible attributes, which in turn has economic consequences and affects

decisions by suppliers and users. For example, a license granting an exclusive right to use spectrum may result in a different investment and innovation strategy than one that grants a right to shared spectrum use. In this sense, the established legal property and disposition rights can be mapped onto corresponding economic incentives and decisions. These have consequences for the static and dynamic efficiency of spectrum use, the level and structure of investment that might be forthcoming, and the adaptability of solutions to changing supply and demand conditions. The relation between legal rights, economic rights, and performance is likely not a one-to-one relation but will be multi-faceted, complicating an analytical examination. The specification of legal rights can influence economic decisions in several ways by:

- delineating the uses of spectrum and thus the kinds of services than can be offered
- affecting the conditions of appropriation of rents for licensees and suppliers
- creating entry barriers to a market
- constraining permissible types of exchanges between users
- affecting the negotiating position of incumbents and potential new entrants
- facilitating or hindering dynamic adjustments among suppliers and users

Some legal rights directly constrain the set of feasible economic choices. Where a licensee is limited to offering a specific service, such as mobile voice, other uses are by definition excluded, thus prohibiting potentially beneficial alternative services such as mobile data. Rights also influence the appropriation of rents from spectrum access and use. Exclusive rights may make it easier for incumbent licensee and first movers to appropriate such rents, whereas more open regimes may weaken their ability to profit from being first in a market. Indirectly, they will also affect the appropriability conditions for suppliers and other upstream stakeholders. Right specification also determines the level of entry barriers. Where exclusive licenses are already assigned, potential market entrants face high entry barriers that can only be overcome if they can acquire a licensee or by lobbying the government to create more licenses. If none of these strategies promises success, entry barriers are insurmountable. Rules governing services also constrain which forms of trades (sale, lease, pooling, etc.) are possible. Moreover, they affect the opportunities for incumbents and potential new entrants to negotiate terms and conditions for the transfer of rights. For example, such a transfer might be conditioned on prior regulatory approval, it might be mediated via a spectrum manager, or it could be negotiated between the interested parties. Lastly, the specific formulation of rights will affect dynamic adjustment processes.

Discussions of governance frameworks at the level of Table 1 necessarily suppress many of the particulars of implementation and ongoing coordination that have to be addressed when they are applied to real world industries. Regardless of the management regime in place, there are a number of tasks have to be carried out to establish and maintain a functioning wireless system. Spectrum management regimes differ in the ways they organize carrying out these functions. The services in our three cases studies, while having some non-traditional features, are embedded in an overall system of administrative spectrum management. It is therefore not surprising that many of the tasks that might be organized through private ordering are still taken care of by the government in administrative procedures. In the discussion that follows, we will distinguish between

setup functions, which are carried out to make a band usable for a specified service or set of services, and ongoing functions, which pertain to administrative matters that do or may recur and matters that must be addressed on a continuous basis.

In the context of our case studies, it makes sense to distinguish the following (administrative) functions: band provisioning, band allotment and assignment, rules provision, adjustment, coordination, monitoring and enforcement. Sometimes it is necessary to clear a band of incumbent services before it can be utilized for new services. Band provisioning is the process of clearing the band designated for the service under discussion. Band allotment and assignment refer to the process of sorting out the band plan (both in physical and frequency space) and determining who has rights to access the bands. Band provisioning and band allotment and assignment are setup functions. The remaining functions are ongoing. Rule making is the process through which the official FCC rules are established. This process can be supplemented by formal and informal rules developed by spectrum users (“rule provisioning”). Adjustment can be analyzed at these two levels: formal rules (those have legal authority) on band allotment/assignment and usage, and rules established by the entity managing the band regarding the type of uses and applications acceptable. Coordination is the procedures undertaken to protect access to the airwaves from non-cooperative disruptions; this could include both in-band and out-of-band coordination—a distinction will be noted in the following discussion. Monitoring and enforcement refer to the measures adopted to assure spectrum use according to the formal and informal rules of the game.

Given the large number of possible combinations of management regime attributes and the various ways the also numerous ways specific functions may be handled it is more manageable to discuss their implications for specific cases. The remainder of the paper examines the experience with three non-traditional models, CB radio, the unlicensed PCS band, and the guard bands, as specific examples of the design of spectrum rights.

### **III. Historical overviews of three sets of services developed under non-traditional governance regimes**

#### **A. CB Radio**

In the post-war US, two-way radio technologies developed for military uses gradually diffused to the general public as military personnel with training in these technologies were discharged from the army. This was followed by emerging voices advocating common access to the airwaves for small businesses and personal communications to the general public.<sup>2</sup> After some unsuccessful experiments, in 1958 the FCC finally

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<sup>2</sup> Retrocom.com, 27 Megacycle History in the U.S.  
[http://www.retrocom.com/27\\_megacycle\\_history\\_in\\_the\\_u.htm](http://www.retrocom.com/27_megacycle_history_in_the_u.htm), accessed on July 20, 2003.

announced the assignment of the 26.965-27.225MHz band (22 channels) to class D CB radio.<sup>3,4</sup>

Besides its popularity among technology adventurers, by the seventies, CB radio had also gained solid ground with commercial users. In 1974, the Arab oil embargo created a supply shortage of oil in the US and gasoline prices surged as a result. In the same year, President Nixon reduced speed limit on national highways to 55 mph. These events imposed a substantial burden on long-haul truckers. Their fuel bills skyrocketed and the 55 mph speed limit forced them to spend more time on the road per trip. Independent truckers, who were paid by the mile, were especially hard hit. They started to use CB radios to inform each other about the “smokeys” (high way patrol), weight stations, traffic conditions and good fuel deals. Later they even used CB to organize a strike that blocked many major highway intersections (Packer 2002). This brought much publicity to CB radio and average citizens soon embraced the technology as they came to realize they could use such information as well.

By 1975, CB was no longer just a tool for truckers and a hobby for enthusiasts. Family members and friends used CB to contact each other and people gathered on-air, exchanging information on things happening in their communities just like in other social occasions. The media quickly sensed the potential CB had. From the finance pages to the culture section, reports on CB radio could be easily found in major newspapers and magazines, hit movies, TV shows, and dozens of pop songs made CB radio a service that people were highly aware of and interested in. CB had become a cultural phenomenon and could be seen anywhere.

The phenomenon was short-lived however. CB sales rose from 1.8 million units in 1974 to a peak of 11.3 million units in 1976, and fell just as dramatically after that. Only 4.7 units were sold in 1978 and sales bottomed out at 1.4 units in 1980. Annual sales of CB radio have held steady at around 2 million units since the late 1980s, with moderate fluctuations in the late nineties. It was estimated that the actual number of CB users in 1995 was 25 million, but it is not clear exactly how many are regular users as the estimate may include many people who kept an old unit and use it only occasionally. Interference caused by illegally amplified signals has always been and still is a common complaint, but unlike during its peak, channel congestion is not a problem anymore, even in metropolitan areas.

Compared to the past, the current profile of CB users is closer to that before the spike. In addition to some enthusiasts who have stuck with the hobby all this time, a large fraction of current CB users are truckers (or professional drivers), and the rest include people using it for emergency road assistance, recreational uses, convoy coordination, and rural area communications. The rapid growth and dramatic collapse of CB sales has been cited as evidence of a tragedy of spectrum commons, as the general sales profile and oft-repeated stories of excessive use and abuse of the service are consistent with a story

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<sup>3</sup> The earliest attempt was announced in 1945, with the frequency assignment in the 467 MHz band (class A and B). The A and B bands were not massively successful due to overly high costs at higher frequency given the technology of the time. <http://www.cb gazette.com>, accessed on July 20, 2003.

<sup>4</sup> An additional channel was added in 1961.

of a common resource destroyed by over consumption. The complete story, which we return to later, is considerably more complicated.

## **B. Unlicensed PCS**

Starting in the late 1980's, cellular telephone companies and computer makers began to petition the FCC to allocate new spectrum for experiments with a new generation of personal communication services, envisioning integration of complementary applications such as wireless data and wireless telephony in a local area network. Since integrating a broad family of personal communication applications was one of the goals of the PCS proceeding, the FCC consolidated the proposed new services (isochronous applications, such as wireless PBX, and asynchronous applications, such as nomadic data devices)<sup>5</sup> in a consolidated proceeding for Unlicensed PCS services. The unlicensed status reflected a general agreement among service proponents that an unlicensed governance regime with a minimum of regulatory restraints would foster innovation. Two self-governing industry organizations, The Unlicensed PCS Ad Hoc Committee for 2 GHz Microwave Transition and Management (UTAM) and the Wireless Information Networks Forum (WINForum), were formed by manufacturers to deal with critical administrative and technical issues. UTAM proposed a plan for band clearing and frequency coordination while WINForum addressed technical issues related to coordination among users.

After five years of considering comments from filed responses and hearings, the FCC finalized the rules governing the UPCS band in 1994 in its Fourth Memorandum Opinion and Order. Spectrum from 1910-1920 MHz<sup>6</sup> was assigned to asynchronous devices, while 1920-1930 MHz was assigned to isochronous devices. Because both bands were already occupied in many areas by fixed microwave systems, the operators of these systems had to either suspend operations or relocate their services to different frequency bands before the designated spectrum could be fully utilized by the unlicensed PCS services. Clearing the band required that the operators of the incumbent services be compensated for relocation costs. The FCC appointed UTAM as the frequency coordinator for the band and gave it responsibility for overseeing the band clearing process. All manufacturers of devices utilizing the UPCS band were required to become UTAM members and pay the associated fees, which were used to cover the expenses of clearing the band. Negotiations with incumbents and their relocation both proved to be time consuming.

Band clearing started in 1995. As of 2002, the 1920-1930 MHz isochronous band has been cleared in 98% of the US, and the 1910-1920 MHz asynchronous band had been cleared in 91% of the country. Wireless PBX is the dominant application in the isochronous band. It has been deployed primarily at geographically extensive worksites with highly mobile workers, such as convention centers and hospitals. Although there

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<sup>5</sup> Based on their synchronicity characteristics, the devices are divided into two categories: isochronous devices (used mostly for voice applications, which are sensitive to delay but have a rather steady traffic pattern and are tolerant of errors) and asynchronous devices (used mostly for data applications, which usually have a bursty nature and are sensitive to error but tolerant of delay).

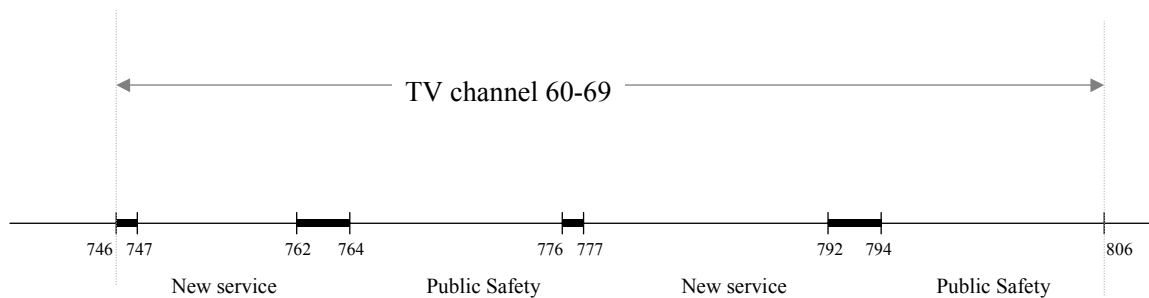
<sup>6</sup> To meet the request for broadband data technology, the FCC later assigned UPCS isochronous devices as co-primary usage with amateur radio in the 2390-2400 MHz band.

are some claims that the band is congested in some areas, the demand for such applications is generally accommodated by the final allocation and rules that promote coordination among users. By and large, this market appears healthy, although the set of diverse and interoperable applications originally envisioned has not developed. On the other hand, the asynchronous band did not develop as hoped. Although the band is largely cleared, no products have been developed and the band lies fallow. The FCC is currently considering reallocating the asynchronous band to either isochronous devices or other new technologies.<sup>7</sup>

### C. 700 MHz Guard Band

The 700 MHz Guard Band service is an innovative regulatory experiment. The Balanced Budget Act of 1997 directed the FCC to reallocate 24 MHz of the 746-806 MHz band (originally licensed exclusively to television stations) to public safety use and 36 MHz to advanced commercial services. In the proceeding “Service Rules for the 746-764 and 776-794 MHz Band, and Revisions to Part 27 of the Commission’s Rules” the FCC established the allocations depicted in Figure 1. To ensure the reliability of public safety networks, the FCC assigned 6 MHz of the 36 MHz commercial band to four guard bands (the thicker spectrum regions in Figure 1) to protect the public safety networks from possible interference from services that might be developed in the commercial bands.

Figure 1  
746-806 MHz band plan



While assigning these bands as buffer areas guarding the public safety bands, the FCC decided to use these bands to experiment with a market-based governance mechanism proposed by many spectrum market advocates who foresaw two potential benefits from this governance arrangement: (1) more efficient utilization of the buffer frequencies while still ensuring sufficient protection to the public safety networks, (2) streamlining the FCC spectrum management process.

<sup>7</sup> FCC Proceeding ET. 00-258. Regarding the 3G Further Notice of Proposed Rule Making (FNPRM), UTAM opposed the idea of reallocating the UPCS band to other services while supporting the cross-over proposal which allows expansion of isochronous devices’ operating band to the 1910-1920 MHz band, as it claims UPCS is facing congestion in certain sites due to increasing demand and new applications that require more bandwidth.

Ever since the FCC started using auctions to allocate spectrum, there has been concern that the auction mechanism would favor large corporations and keep smaller industry users from accessing the airwaves for site-specific services. The band manager idea was introduced in-part to address these concerns. A band manager is a licensee who can act as an aggregator of spectrum demands by partitioning a band and making use rights available to different, and potentially diverse, users. Except for technical restrictions established by the FCC, there are very few restrictions on the types of services that can or cannot be provided in these bands. The band manager is responsible for resolving disputes among users and dealing with possible interference problems.

It was hoped that the flexibility inherent in allowing guard band managers to partition the spectrum and licensed geographic territories among different users would enable the development of services particularly useful to industry users with site-specific communication needs. For example, end users such as railroads or pipelines could contract with a guard band manager to access the same frequency across a long, but narrow service area and contract with multiple guard band managers to achieve the same result across several geographic areas. The guard band managers' role as demand aggregator serves the interests of some smaller entities whose access to the airwaves might otherwise be quite limited. Also, the guard band managers as profit-seeking economic agents will have incentives to maximize the efficiency of use of the spectrum.

The guard bands were auctioned in September 2000. Three firms together acquired 97 out of the 104 available licenses. Among the three big winners, SMR-giant Nextel acquired 42 licenses, all in the B block (the pair of 2 MHz channels, 762-764 MHz and 792-794 MHz). Pegasus, which is a communication service provider owning businesses ranging from TV broadcasting to industrial network services, won 32 A block licenses (the pair of 1 MHz channels, 746-747 MHz and 776-777 MHz) and one B block license. AccessSpectrum, which has close ties to the ITA (Industrial Telecommunications Association, a group of industry users), walked away with 18 A block and 3 B block licenses. The guard band managers started to operate shortly afterwards.

Both Nextel and AccessSpectrum draw on considerable experience with SMR-type services and the FCC and advocates for the guard band manager system anticipated that the guard band would be utilized for similar services. However, as June 2003, there were only six customers with contracts for guard band services, all of which were signed by AccessSpectrum, most for use of spectrum in major cities. These are mostly SMR-type wide area dispatch applications. Nextel and Pegasus have not yet announced any sealed deals, although Pegasus has expressed optimism about signing up some customers in the second half of 2003. Nextel has recently proposed that it be allowed to swap its spectrum for spectrum in another band.<sup>8</sup> Clearly, service deployment in this band has proceeded much more slowly than was anticipated.

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<sup>8</sup> Nextel Whitepaper to the FCC, "Promoting Public Safety Communications: Realigning the 800 MHz Land Mobile Radio Band to Rectify Commercial Mobile Radio-Public Safety Interference and Allocate Additional Spectrum to Meet Critical Public Safety Needs," November 2001.

## **IV. Governance Profiles**

In this section we look more closely at governance systems (combinations of management regime attributes and mechanisms for handling administrative functions) for the three sets of services. While none of these governance systems is identical to any of the five prototypical systems described in Table 1, each has features in common with one or more of the four non traditional approaches. Thus the historical experiences reviewed in more detail below may be informative as to the role such features may play in other spectrum governance schemes that may be employed in the future, as well as the influence of different administrative mechanisms within these regimes. In addition, a closer examination of the histories of the three sets of services examined here reveals government playing a more complicated role than is typically envisioned when spectrum governance schemes are studied in the abstract. As a matter of US law, industry participants always have the opportunity to petition the government to change rules and allocations. The histories reviewed here make clear that the outcomes of such petitions have influenced the way services have developed in at least two of the bands. This raises questions about how the role of government should be factored into discussions and designs of alternative spectrum governance systems. Another insight that emerges from these studies is that the need to deal with incumbents when clearing a band for new services may influence considerably the manner in which new services develop. Again, this is a factor that must be considered when moving from abstract idealizations of management regimes to their implementation in the real world.

### **A. CB Radio**

#### **1. Management regime features**

As long as users comply with the equipment rules, the CB is basically open for anybody with a CB unit to access. While licensed users were required to pay a fee early on, the fee was set at a nominal level and the requirement that users be licensed was never vigorously enforced.<sup>9</sup> A large fraction of CB users were apparently unlicensed. The licensing requirement was dropped entirely in the early 1980s. With regard to the access dimension of spectrum management regimes, CB would be classified as open, with the minimal criteria required for participation being the equipment specifications mandated by the FCC.

The citizens' band also aligns with the open access model on the exclusion and alienation dimensions of spectrum management. No one with equipment satisfying the FCC's technical requirements is excluded as a user of the band and the right to use the band cannot be bought or sold. Although there are no licenses, CB radio is similar to

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<sup>9</sup> At the beginning only business users were allowed by the FCC, but its licensing policy was in general not restrictive: a \$20 license fee for a term of five years, with up to five units for one station license. Minors could operate CB equipment with the agreement and presence of the license holder. The commercial-use-only rule was never enforced although it prevailed for nearly two decades. Over the years, the FCC constantly lowered the licensing fees and finally dropped the licensing requirement in 1983 due to concerns over administrative costs.

administrative licensing in terms of the use and management aspects of spectrum management. The types of uses permitted in the band are largely determined by the FCC's technical criteria for CB equipment,<sup>10</sup> which also constitute the minimal criteria for access as mentioned above. Rules governing access and use can both be changed at the FCC's discretion.

## **2. Administrative functions**

### **i. Set up functions**

The FCC has followed the traditional command-and-control approach in band provisioning and in allocation and assignment for CB Radio. The frequencies used for CB radio were assigned to the service by the FCC. Before their assignment to CB Radio, the frequencies now devoted to CB communication were used by amateur radio enthusiasts. Apparently because they had little political clout, clearing the CB band of incumbents was not much of an issue. Similarly, the organizational plan for the band, including open access usage rights, was established by the FCC.

### **ii. On-going functions**

The official rules governing CB use are set by the FCC, again to a substantial degree by the technical specifications governing equipment use. However, the FCC has also been active in setting many of the non-technical rules governing use of the band. Rule provisioning has thus been a largely top-down, command-and-control process. A number of the FCC rules also contribute to the coordination function of administration. For example in 1965 the FCC reserved channel 9 for emergency and distress calls, restricted calls to five minutes duration, banned commercials, and required that call letters be announced every five minutes during calls. In 1975, it assigned channel 11 as the official calling channel.<sup>11</sup> However, conventions and etiquettes developed spontaneously by users have also played an important role in CB coordination. For example, channel 19 and sometimes channel 10 are used by vehicles on the move to set up conversations. The arrangement made it easy to find people who might have information being sought, or people with similar interests to talk to, just like today's chat rooms. Different conversational groups naturally congregate on different channels. Another convention among the hard-core CB users is the ten-code system, which uses a number string prefixed with the number 10 (e.g., 10-4) to replace frequently used phrases on the road to make conversations more succinct.

Regarding formal adjustments, the FCC's authority to adjust the band allocation and use rules are given by higher level statutes, and in the past few decades the only major adjustment made to the CB was an expansion from 23 to 40 channels in 1977. The only

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<sup>10</sup> CB equipment must be certified according to Part 95 (technical requirements specific to the CB and Personal Radio services) and Part 15 (technical specifications applicable to all radio receivers) of the FCC rules.

<sup>11</sup> A calling channel is a common channel first called to identify oneself and then find a calling partner or partners before moving to another channel to continue a conversation.

other major adjustments occurred in 1965, when in response to complaints of channel congestion and disruptive activities, the FCC announced modifications to its technical specifications to limit the broadcast distance for CB transmitters. Antenna height was limited to 20 feet above the structure it was mounted on, and broadcast distance to 150 miles. There have also been a number of minor adjustments over the years, such as changing license fees and those related to call duration and statement of call letters (both subsequently rescinded) and designation of special use channels mentioned above.

Monitoring and enforcements responsibilities have been shared by the FCC and users. As will be discussed in more detail in the next section, the FCC has never devoted sufficient resources to enforcement to ensure deter violations of its usage rules or violations of its technical specifications. Violators thus perceive little threat of official punishment. On the other hand, users say that compliance with both formal and informal norms of conduct is the norm. Apparently new users learn the conventions governing use quite rapidly and social sanctions are fairly effective in disciplining those who violate accepted standards of etiquette in most, though not all, cases.

## **B. Unlicensed PCS**

### **1. Management regime features**

Unlicensed PCS was an innovative experiment in introducing self-governance to replace traditional regulatory fiat. While the FCC retains the right to reinsert itself as a more active manager of the band, for the most part responsibilities for managing and administering the band were handed off to UTAM. The use, management and exclusion features of a management regime are similar to those for commons government in that UTAM, which is controlled by industry members, sets the rules governing use of the band, and through such rules and equipment certification requirement to determine who can access the band. However, it is somewhat different in that it is the manufacturers, instead of the actual users, that are governing the band. Because access is not closed, but rather is open to all users willing to buy UTAM certified equipment, the use feature UPCS management regime is somewhat similar to that for the prototypical open access regime.

### **2. Administrative functions**

#### **i. Setup functions**

As mentioned above, UTAM was charged with managing the process of band clearing. To promote a smooth transition process and prevent interference with microwave incumbents in the UPCS band, UTAM came up with a phased plan<sup>12</sup> of clearing the band

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<sup>12</sup> UTAM made its financial plan based on a study conducted by BIS Strategic Decisions (see The UTAM Plan for Financing and Managing 2GHz Microwave Relocation.) Firms can become voting members by paying either a \$10,000 up-front fee which will be credited against the \$20 per-unit fee for future sales or the per-unit fee plus associated certification costs. This applies to both isochronous and asynchronous devices. At the founding of UTAM, there were 8 voting members and 25 associate members (who only pay a \$500 fee); as of December, 2002, there were 10 voting members and 12 associate members

that only allow coordinated devices to be activated in the presence of incumbents.<sup>13,14</sup> While provisioning was handled entirely by the industry association, allotment and assignment authority was retained by the FCC, although its ultimate decisions largely incorporated industry recommendations. While the FCC allocated the 1910-1930 MHz band to unlicensed PCS, the manufacturers recommended dividing the band. The FCC's allocation and assignment of the 1910-1920 MHz band and the 1920-1930 MHz band to unlicensed data and voice services respectively was actually based on WINForum's suggestion

## ii. On-going functions

Creation of the framework for administering rules provision, adjustment and coordination is best described as a cooperative effort by the FCC and the industry. For rule provisioning (excepting its general rulemaking procedures), the FCC relied heavily on rule drafting efforts from WINForum and UTAM because their members represented a broad range of technology firms whose customers would be the users of this band. WINForum laid the groundwork for building coordination mechanisms into the Unlicensed PCS devices and the FCC adopted many of its suggested technical specifications such as limitations on signal power and building a listen-before-talk etiquette into devices. Through these built-in mechanisms, the devices coordinate amongst themselves and, unlike with CB radio, users are largely freed from managing ongoing coordination tasks. These technical specifications also lessen interference with devices in the adjacent PCS bands.

Monitoring responsibility was delegated to UTAM. The database of installations used to facilitate the band-clearing process<sup>15</sup> helps it monitor market development and

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<sup>13</sup> UTAM's transition plan and approach to prevent UPCS devices from interfering with the incumbents' microwave links started with establishing geographic priorities based on projected revenues and existing incumbents and moving the incumbents in the order set by the priority assessment. During the relocation process, UTAM is responsible to make sure the unlicensed devices do not interfere with the incumbents and all the devices can only be activated in the designated areas where coordination has taken place.

In doing so, UTAM designated larger markets under jurisdictions relatively free of existing microwave systems as Zone 1 areas, others as Zone 2 areas. As the relocation process goes on, Zone 2 areas will gradually be converted to Zone 1 areas. (Smaller markets that do not have incumbents are classified as non-scheduled areas that could be readily converted to Zone 1 areas upon request.)

In Zone 1 areas, deployment is permitted up to a pre-determined and pre-coordinated power limit. In contrast, Zone 2 counties have existing microwave operations either nearby or in the county and therefore UPCS product deployments cannot occur until a site-specific coordination has been completed.

Meanwhile, the deployment information collected during the transition process is used to facilitate coordination among UPCS devices. UTAM members must update the Database Management System (DBMS) maintained by UTAM when products are sold and installed, and they also have access to the database for marketing purposes. The integrity of the database is double-checked by an independent auditor.

<sup>14</sup> During the transition period, all UPCS devices have to meet the power spectral density limitations to reduce out-of-band interference. In addition to these measures, FCC also tried to build safeguard against interference with the incumbents through regulation of device that goes beyond simply specifying maximum power: the devices must be designed in a way that they are not to be activated before being coordinated by UTAM and they must cease transmitting once taken out of the coordinated area.

<sup>15</sup> See note 13.

usage. The FCC retains ultimate enforcement responsibility. Violators of the usage rules are subject to punishment according to FCC rules. Disputes between UTAM and its members are addressed first through negotiation, with resolution through court proceedings as the final resort.<sup>16</sup>

This system of shared governance between the industry and the FCC seems to have worked effectively. The band-clearing process has run smoothly and UTAM has reported a sound financial situation. According to UTAM no disputes among UPCS users or between UPCS users and incumbents have been reported. UTAM has also been successful in its role as a monitor in preventing unauthorized use of the band and early concerns that some members might be able to exploit privileged access to the deployment database to their own advantage appear to have been unfounded.

## **C. 700 MHz Guard Band**

### **1. Management regime features**

As with Citizens Band Radio and UPCS, the management regime for guard band services is a blend of two or more of the five prototypical regimes in Table 1. Access rights are specified on two levels. At the first level, the right to use the bands as guard band managers was assigned through a FCC-administered auction, as with a flexible licensing regime. The few guard band services offered to date have been developed and operated by the guard band managers. However, guard band managers also have the right to make their spectrum available for use by other service providers, which is a secondary level of access. Uses of the guard band spectrum are determined by the guard band managers responding to market demands, subject to technical restrictions designed to limit interference with services in neighboring bands, which is similar to the use rights of individual owners in an individual ownership regime. Management is a shared right. The FCC retains the right to determine who has access, while guard band managers are assigned the right to determine uses. Exclusion is similar to flexible licensing in that only licensed service providers may use the band. Transfer of guard band licenses are subject to approval by the FCC, so alienation rights correspond to those granted under administrative licensing regimes, except that the guard band managers have a limited right of alienation in the form of leases to third parties. At any rate, this type of commercial relationship has not been employed in the guard bands to date.

### **2. Administrative functions**

#### **i. Set up functions**

The FCC has responsibility for clearing the guard bands of incumbent broadcasters. Because there has been very little progress in relocating the television stations utilizing the band to date, efforts to develop commercial services for the guard bands have focused on geographic areas where broadcasters are not broadcasting in the band. For this reason,

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<sup>16</sup> Fourth Memorandum Opinion and Order, FCC GEN Docket No. 90-314, 10 FCC Rad 7955.

provisioning has had little impact on the development of the band to date other than limiting the geographic areas in which the services can develop. The allocation and assignment functions are assigned to the guard band managers.

## ii. On-going functions

Responsibilities for coordination are split between the guard band managers and the FCC. The guard band managers have sole responsibility for coordinating uses within their bands, while the FCC developed three sets of technical specifications to limit interference with users in other bands. First, Guard Band users have to meet strict out-of-band emission criteria<sup>17</sup> so that they do not interfere with the public safety users in adjacent bands; in addition, the FCC requires Guard Band users to follow prescribed frequency coordination procedures.<sup>18</sup> Also, services using cellular-like infrastructures are not allowed in the guard band<sup>19</sup> for concerns that such type of networks can cause interference problems to the public safety users.

There has been very little adjustment to the FCC rules governing guard band services and, compared to the UPCS band, industry members had comparatively little influence on the formal rules established by the FCC. Guard band managers have primary responsibility for monitoring and enforcing compliance with the rules governing the band and for resolving disputes among users. On the other hand, the FCC will hear complaints filed against guard band managers that cannot be resolved as commercial disputes under contract law.<sup>20</sup>

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<sup>17</sup> To ensure that guard band users produce no more harmful interference to the public safety bands than any public safety users, the FCC set an out-of-band emission criteria modeled on public safety standards. Specifically, guard band users must attenuate power below the transmitter power  $P$  by at least  $43+10\log P$  dB for any emission on all frequencies outside the authorized spectrum. In addition, the FCC requires an attenuation below transmitter power for base and fixed stations operating in the 747-762 MHz band and fixed stations operating in the 777-792 MHz band by at least  $76+10\log P$  dB per 6.25 kHz in the 764-776 MHz and 794-806 MHz public safety bands, and an attenuation below the transmitter power for mobile and portable stations operating in the 777-792 MHz by at least  $65+10\log P$  dB per 6.25 kHz in the 764-776 and 794-806 MHz public safety bands.

<sup>18</sup> Guard band managers must notify FCC-recognized public safety frequency coordinators (Association of Public-Safety Communication Officials, Inc—APCO; International municipal signal Association—IMSA; Forestry Conservation Communications Association—FCCA and American Association of State Highway and Transportation Officials—AASHTO) in the 700 MHz public safety band and adjacent-area guard band managers of the technical parameters of any site constructed in both new stations and station modifications.

<sup>19</sup> The major reasons for forbidding cellular-like networks are technical difficulties and uncertainties, as a cellular-like infrastructure contains high density of possible interference sources that makes coordination with the public safety networks a lot more complicated. This problem is exemplified by the CMRS-public safety interference problem in the 800 MHz band, which is described in more detail in footnote 23.

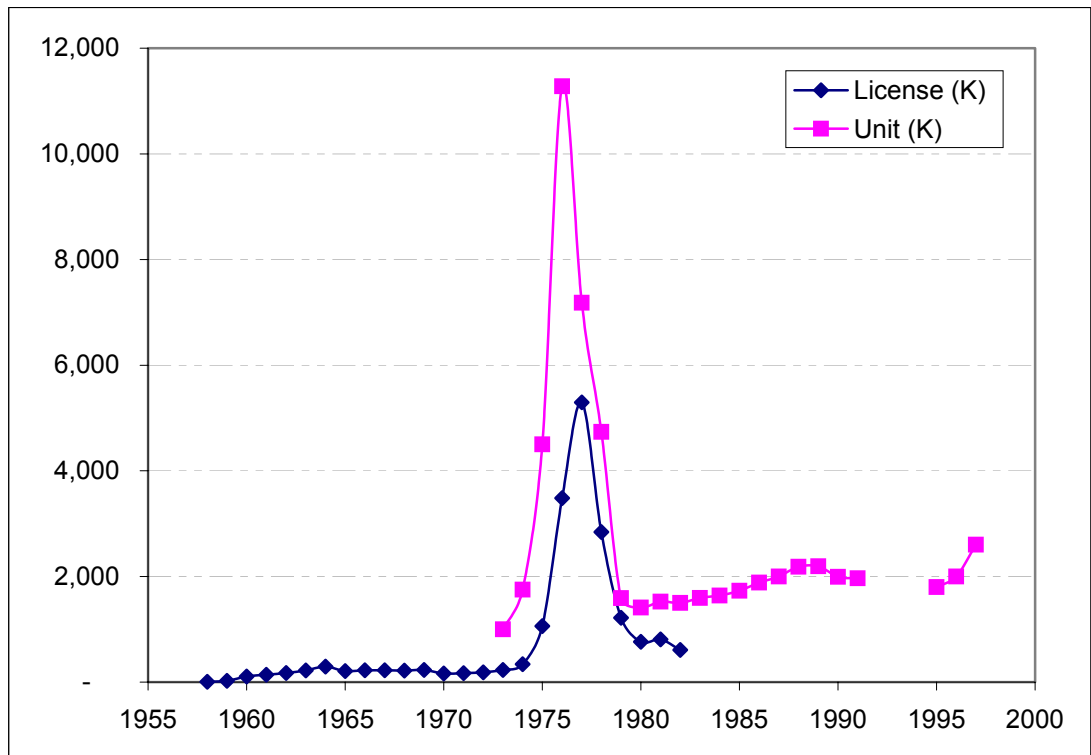
<sup>20</sup> Second Report and Order, WT Docket No. 99-168.

**V. The influence of governance institutions and choices on the economic histories of the three sets of services**

**A. CB Radio**

By far the best known event in the economic history of Citizens Band Radio is the crash in CB unit sales from their high point in 1976 until the market in CB units stabilized at a dramatically lower level in 1979. Probably less remembered now was the collapse in stock prices for CB manufacturers and a spate of bankruptcies among manufactures, distributors and retailers triggered by the collapse in sales. Parallel to the recent experience with the dotcom boom and bust are hard to miss. As was discussed earlier, the CB management regime has a number of features in common with the prototype open access regime. As the resource accessed is common to all users, this episode in the history of CB has frequently been cited an example of a tragedy that occurred in a spectrum commons. Upon closer inspection, this interpretation is seen to be most likely in error, and questionable at best.

Figure 2  
Number of CB Radio licenses and sales



Note: Sales in 1977 included 23 channel units that were illegally sold

Source: Dealerscope Merchandising, Cobra Electronic, FCC, Goldenber et.al. (2002).

Historical data for sales of CB equipment is spotty, however, such data as we were able to find plus the figures from a limited time series on the number of CB licenses given out each year are presented in Figure 2. The FCC is the source of the figures for number of licenses. This series, which begins with the establishment of the current citizens band in 1958 ends in the early 1980s when the FCC dropped its barely enforced requirement that CB equipment be licensed. For the ten years from 1973 through 1982 the licensing figures can be compared to the numbers of units sold reported by industry sources. The two series move largely in parallel, with units always exceed licenses, and by a substantial multiple through most of this period. While the ratio of units sold to licenses is not constant, the same trends are clearly evident in both series, with the movement in licenses lagging that in sales by about a year. Units sold began their dramatic rise in 1974, licenses in 1975. Sales peaked in 1976 and licenses in 1977. The trend is similar on the downside of the peak, where declines are just as dramatic as were the increases during the boom. It is easy to read into this event a greedy rush by many to exploit a common resource followed by a mass exodus from the band as the quality of service was degraded by over crowding and abuse of norms of fair use.

Interference complaints to the FCC did increase during the upswing in sales, from 30,000 in 1974 and 31,000 in 1975 to 100,000 in 1976.<sup>21</sup> At first blush this would seem to support the tragedy-of-the-commons interpretation of events. However, the ratios of complaints to sales and complaints to licenses declined substantially, from 0.017 and 0.088 respectively in 1974 to 0.008 and 0.029 in 1976. While it would be more informative to work with changes in the number of units in use, the drops in these ratios are so large that it would be hard to argue that the increase in complaints reflects a decline in the quality of service experienced by the typical user.

This is not to say that interference was not a problem. Interference has always been a nuisance with CB radio, long before and after the spike in 1976. Our interviews with users and industry members, however, suggest that for the most part, interference is at worst a minor nuisance, and is not a major impediment to use of the band. FCC rules and conventions developed informally by CB users appear to have been quite effective as coordination devices. As FCC resources devoted to monitoring and enforcement were never sufficient to be effective, much of the credit for successful coordination in the CB band must be attributed to cooperation among users. Misbehavior seems to be confined to a fairly small subset of CB users, and it is argued by some knowledgeable industry insiders that much interference frequently attributed to bad behavior is in fact a consequence of ionospheric propagation of CB signals that may result in interference over distances that far exceed the official broadcast limits of certified CB equipment.

If one considers the sales and licenses series in their entireties, the spike and collapse in both sales and new licenses during that occupied four years in the mid-1970s could easily be seen as a rather dramatic interruption in series that was relatively steady from the late 50s to the early 70s that shifted to a somewhat higher path with modest growth

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<sup>21</sup> These figures are based on press reports at the time, which cited official FCC statistics. However, we have not been able to find the referenced FCC records. For this reason, we are unable to report complaints for the immediately following years.

beginning in the mid to late 1970s. Other consumer products, from hoola hoops to pet rocks have exhibited similar sales patterns, and our earlier brief examination of the history of consumers' use and temporary fascination with CB suggests that the boom and bust episode had strong elements of a consumer fad. Supply chain responses to rapidly increasing demand contributed to the financial chaos that followed the bust. Less well-known is that the inflationary tendencies already present in the consumer market were probably amplified by the FCC's policies for implementing a decision to increase the citizens band from 23 to 40 channels. The crash that followed was thus also larger than it otherwise would have been.

As it rapidly grew in popularity in the mid 1970's, CB Radio experienced a short period of dramatic supply shortage. Manufacturers were unable to keep up with orders and responded by supplying distributors with only fractions of orders placed. Distributors responded by ordering multiples of their actual needs. The supply shortage and high prices also brought many new manufacturers, including major radio equipment companies, into the business and supply finally caught up with demand in 1976. As the strong demand and ostensible potential growth led to optimism for the future of the industry, CB manufacturers' stocks soared. When manufacturers started to catch up with orders placed, they shifted rapidly from a state of shortage to excess supply and prices began to fall. The fall in prices was exacerbated by FCC policies for managing the transition to a 40 channel band.

In response to CB radio's growing popularity, the industry lobbied the FCC to open more channels. In summer 1976, the FCC announced it was expanding CB channels from 23 to 40, effective January 1, 1977. However, the expansion came with a transition policy that prematurely forced the upgrade of the products: sales of 23-channel products would be banned after January 1, 1977, while 40-channel products could not be sold before that. The short notice gave the channels only five months to clear all the 23-channel products. The announcement created tremendous market chaos. Their panic to move their inventory of old products drove dealers and retailers to dump them at fire-sale prices that were as low as 20% of their pre-crash levels. The dramatically lower prices further stimulated sales, making the subsequent drop off in sales appear more dramatic than it otherwise would have been.

## **B. UPCS**

The isochronous UPCS band has been a moderate success: the interests in investment are obvious, and no cases of interference or disputes have been reported. As to the failure in the asynchronous band, a review of the rule-making process and numerous interviews with industry experts point to four possible factors: narrow bandwidth, high band-clearing costs, incompatibility with incumbents' operations, and the unanticipated appeal of the ISM band for developers of similar technologies and services.

Simply put, the bandwidth assigned to asynchronous UPCS was not enough for the technology and applications envisioned, and this is a combined result of regulatory error (the FCC allocating too little bandwidth) and possibly a coordination failure on the part of the advocates of different applications participating in the self-governing process (further dividing the already limited bandwidth and assigning the parts to different uses).

During the PCS authorization proceeding, the demand and commercial potential of wideband PCS services grabbed most of the attention and these services were consequently treated most favorably in the spectrum awards. In its Memorandum Opinion and Order issued on June, 13, 1994, the FCC slashed the spectrum allocated to unlicensed devices from the 40 MHz awarded in its Second Report and Order<sup>22</sup> (1890-1930 MHz) to 20 MHz (1910-1930 MHz), after moving the entire Broadband PCS spectrum to the lower 2GHz band (as requested by telephone companies due to concerns over equipment availability and relocation costs).

This dramatic reduction in bandwidth, coupled with an earlier decision to part ways by the isochronous and asynchronous camps, left only 10 MHz for each camp. The decision to split rather than share the band occurred as the two camps' visions for band utilization diverged. The asynchronous camp (data companies) wanted to deploy wideband technologies, but the most of the isochronous camp (voice companies) preferred narrow channelization schemes that accommodated their need for low bandwidth, non-bursty connections. Another point of contention is whether the devices could be coordinated and how to share the coordination cost.<sup>23</sup> The two sides finally decided to rule out the possibility of overlaying frequency assignments and divided up the band in halves. The division of the band reduced the spectrum available for asynchronous devices to 10 MHz only. Even though the FCC assigned another 10 MHz (2390-2400 MHz, shared with Ham radio) to asynchronous devices in a later decision, the total falls far short of the 40 MHz originally request by Apple and other asynchronous device manufacturers before sharing with synchronous services was even envisioned.

Another problem came from the cost of clearing existing microwave incumbents.<sup>24</sup> Although the 1910-1930 MHz band assigned to unlicensed PCS was relatively lightly loaded with incumbent microwave links, the estimated cost of clearing the band was 67 million dollars and the actual clearing has taken more than seven years. The band-clearing plan requires manufacturers to share the cost by paying an equipment certification fee of \$20 per device. For products like wireless PBX, which is an investment in infrastructure by firms and has an average unit price of over \$1,000, this cost was not a major issue; however, for nomadic data devices such as PDA's, that amount of premium does make a difference.

The rule that no nomadic devices could be deployed before the band-clearing process was completed also contributed to the failure of asynchronous services in the UPCS band.

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<sup>22</sup> Second Report and Order, FCC GEN Docket No. 90-314, 8 FCC Rcd 7700 (1993).

<sup>23</sup> For the dominant isochronous application, wireless PBX, all devices would be used in a closed site and connected through a base station, which helps frequency coordination during the band-clearing process. But since nomadic devices do not connect to base stations, it would be impossible to accurately keep track of their locations and radiation levels, and coordination is not possible with such devices. Thus the final rule requires nomadic devices must not be sold before the band-clearing process is complete. The nomadic device makers also worried that, since the cost of coordinating the isochronous devices would be partially coming from the administrative funds, which is contributed equally by the isochronous and asynchronous device makers, the asynchronous device makers would be forced to implicitly subsidize the coordination of the isochronous devices.

<sup>24</sup> There were 383 microwave incumbents operating in that band when the rule went into effect. Those were wide area campus microwave networks used by utility, petroleum companies, etc.

This requirement responded to a concern that it would not be possible to provide reasonable assurance that nomadic asynchronous devices would not interfere with the communications of the industrial microwave users that were incumbent to the band. Thus, while isochronous services were able to start up immediately, asynchronous services had to wait for the band clearing process to run its course in each market.<sup>25</sup>

The narrow bandwidth and high costs of the UPCS band made the possible interference problem in the ISM band seem less of a problem. Apple initially believed that the unlicensed 2.4000-2.4835 GHz ISM band was not suitable for wireless data networking because of lack of protection.<sup>26</sup> But some startups such as Aironet started to build data networking gear for that band in the early 1990's and pushed for standards. They started to ship 2.4 GHz products in 1992. More and more tech companies, including chip and equipment makers, joined this movement to develop the ISM band. In 1995, Intersil (then Harris) started to develop chips for 802.11b and soon began mass production and prices dropped rapidly.

In June 1997, IEEE released the 802.11 standard and sales of 802.11b products took off. The global nature of this band, system-wide economies and mass-production made equipment prices drop even lower and attracted more vendors. By 1998, it was clear that UPCS was off the radar screen for most manufacturers of asynchronous devices. Eventually, even Apple's Airport wireless technology turned to the 802.11 standard.

In addition to the reasons discussed above, some technologists also argue the FCC's decision to include a detailed etiquette also contribute to the failure in the asynchronous band. They contend that the Listen-Before-Talk etiquette is not efficient and making it part of the final rules limits technological innovation. Given the development in the isochronous band, this might not necessarily encumber technological development, although it is likely that the short term certainty and protection provided by the etiquette may entail some sacrifice of long term flexibility and efficiency.

### **C. 700 MHz Guard Band**

Industry experts agree that the most important reason for the slow start of the guard band service is the slow process of clearing the band of incumbent users (TV broadcasters). Lack of equipment may also be an important factor hindering the development of services in this band. Additional factors include competition from existing SMR services, and Nextel's proposal that it be allowed to swap its guard band frequencies for frequencies in another band, the current users of which would then utilize Nextel's guard band frequencies.

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<sup>25</sup> The failure of the asynchronous band is reflected in changes in the member makeup of UTAM. In the early days of UPCS, companies such as HP and Sony had been involved in UTAM but all dropped out eventually. Apple Computer, the major early proponent of the UPCS data services, never joined UTAM. Currently nearly all UTAM members are conventional telephony equipment makers.

<sup>26</sup> In its first petition to the FCC, Apple asked the Commission to set aside 40 MHz spectrum in the lower 2GHz band for unlicensed wideband data communications; they claimed that the 2.4 GHz ISM band was not a suitable environment for such applications because of high possibility of unexpected interference caused by all the other devices operating in the same band. Apple petition to the FCC, Jan. 28, 1991.

In the DTV Sixth Report and Order, the FCC stated that all analog TV and DTV operations in the 746-806 MHz band would be fully protected during the DTV transition period. Guard band managers are thus required to provide co-channel and adjacent channel protection to TV signals. This co-channel protection requirement has proven sufficiently stringent as to preclude the development of guard band services in areas with television stations broadcasting in the band. Therefore, due to the much slower-than-expected television station clearing process, the 700 MHz guard bands are still encumbered with TV signals in major markets and this greatly limits the areas where guard band services can be rolled out.

For a new market largely addressing site-specific needs, service providers, manufacturers and users have to work closely to address technical, legal and financial issues that may vary substantially from case to case. Guard band managers have to coordinate and contract with dealers and equipment manufacturers for designs that can fulfill the unique needs of each customer. The need to identify needs specific to each user prolongs the product development cycle and slows service rollout. It also leads to limited production runs which may preclude realization of significant economies of scale, as might the fact that the overall market for guard band equipment is still relatively small, partly because deployment has been substantially delayed by the slow pace of band clearing as mentioned above, and perhaps in part because demand is suppressed by competition from SMR services that address some of the same needs as the guard band services.

So far, the only two vendors providing equipment for these bands are Microwave Data Systems and Motorola, and Motorola's involvement in this band is closely tied to its involvement in the adjacent public safety bands, a traditional Motorola stronghold. Although the 700 MHz Guard Band is a new business opportunity, the technical interdependence between it and the 700 MHz public safety band played a very important role in Motorola's decision to participate in the Guard Band business.

The last issue is the uncertainties created by Nextel's strategic decision to propose spectrum rebanding in the 800 MHz public safety and the adjacent bands<sup>27</sup>. According to

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<sup>27</sup> Since Nextel introduced the iDEN technology, which has a cellular-like infrastructure with high-density, low-site base stations, numerous reports of interference with public safety networks have been filed, and in most cases Nextel sites are identified as at least part of the source of interference. This is a problem brought about by unexpected technology advancement rather than lack of compliance to the rules; simply put, Nextel introduced a cellular-like network built with the new "interference-limited" design paradigm, which strains the ability of the public safety network built on the "noise-limited" paradigm. However, Nextel bought the 700 MHz block B guard bands in the auctions in 2000 and subsequently submitted a proposal to the FCC, asking the FCC to move all the public safety networks to two contiguous 10 MHz bands in the 800 MHz range as a solution to the interference problem. This will require the business/industry users, among other users, to relocate to other bands, and Nextel offers to give out their 700 MHz block B guard bands and other bands Nextel holds in the 800 and 900 MHz band to business/industry users displaced by the public safety networks from the 800 MHz band. In return, Nextel asks for 10 MHz in the 2.1 GHz band for exchange of their giving up those lower bands. The 2.1 GHz is ideal for PCS type of services; thus Nextel's bidding of the guard bands and the following proposal inevitably induces a lot of conspiracy theories. Industry analysts point out that Nextel's strategy of taking advantage of the high standards and general concerns over the reliability public safety services might pay off since it has gain the backing of the major public safety organizations. The FCC is expected to make a decision on this later this year.

Nextel's proposal, it would give its B blocks in the 700 MHz guard band to business/industry users in the 800 MHz band that would be displaced by the proposal. Because a rulemaking process is pending, Nextel has put its guard band business on hold and is waiting to see whether the FCC will adopt its proposal. This in itself may have slowed down the development in the 700 MHz guard bands, and a possible side-effect is that it may also affect manufacturers' incentive to invest in R&D for the Guard Bands since the size of the market will be halved if the Nextel proposal is adopted.

## **VI. Conclusions**

These experiments with three very different non traditional spectrum management schemes provide two examples of apparent, though perhaps modest, success, and two examples of services that have not developed as hoped, at least one of which would be classified as a failure. From the successes we learn that wireless services can be effectively provided with governance systems that differ substantially from the more traditional administrative licensing approach.

CB Radio, while commonly cited as an example of a failure of a commons, on closer examination appears to be a service where minimal government oversight and heavy reliance on informal coordination among users has preserved the essential character of a service deemed valuable by its users, even though access is essentially open, even if restricted to traditional CB services. This restriction of the band to a set of homogeneous devices used for a fairly simple service may help explain the failure of a true tragedy to materialize. Limited demand for CB services may preclude serious over crowding. Nevertheless, coordination among users does significantly contribute to the quality of service, and by most accounts voluntary user coordination has been effective.

Isochronous services in the UPCS band provide a second example of success with an alternative management scheme, but in this case one with many of the critical attributes of commons governance. Of particular note is granting use rights to a users' organization (UTAM), along with responsibility for many (although not all) of the administrative functions of governance, including monitoring and enforcement.

On the other hand, under the same governance scheme, the asynchronous UPCS band failed to develop entirely. However, many of the factors offered in explanation of this failure are exogenous to the governance structure in place. To the extent that delays due to the slow pace of band clearing are to blame, they imply that a requirement that incumbents' services be protected as long as they occupy a band has different implications for different services. Band clearing proceeded nearly as fast in the asynchronous band as it did in the isochronous band.

One lesson learned from the experiment with band managers for the 700 MHz guard bands is that firms will bid for the right to subdivide larger blocks of spectrum so that they may used to develop somewhat specialized services for numerous and potentially diverse users. Only one of the three major guard band managers has developed a customer base to date, however, and this is small. Again, there are complicating factors that make it difficult to attribute the slow start to problems with the governance regime. Of particular note is that development of guard band services may have been slowed by

the decision of the largest band manager to explore the possibility of trading its guard band frequencies for frequencies in another band with the services currently using those frequencies. Because the right to petition the government to change rules of this type is constitutionally protected, it is hard to see how the uncertainties associated with the threat that this type of strategy will be successfully employed can be eliminated.

While we are able to speak to the successes and failures of these alternative specifications of rights, our analysis cannot provide an assessment of the overall efficiency of the models, as this would require an estimation of the opportunity cost of spectrum use. Our findings also cast a shadow of doubt over the proponents of rapid spectrum privatization by illustrating how complex the specification of rights for spectrum is. Most of the present debate assumes that such rights would evolve from repeated interactions among the stakeholders, mediated by public policy and the courts. However, the transaction costs of such a process can be very high. Additional research as to how spectrum property rights could be defined and the potential transaction costs associated with alternative specifications would therefore be needed urgently.

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