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A Working Paper on:

6 Deregulating Personal and Amateur Radio

August 1981

By: Alex D. Felker
James A. Brown, Jr.

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Deregulating Personal and Amateur Radio*

Alex D. Felker
James A. Brown, Jr.

Working Paper No. 6

Office of Plans and Policy
Federal Communications Commission
Washington, D.C. 20554

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* The opinions expressed in this paper are the authors'. They do not necessarily reflect the policies or views of the Federal Communications Commission or any other organization or individual.

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Summary

The FCC's category "personal radio" has two main branches: amateur radio and the Personal Radio Services (PRS). The part of the PRS with most licensees is the Citizens Band (CB), but PRS also has two smaller divisions — the General Mobile Radio Service (GMRS) and the Radio Control Service (R/C). Amateur licenses are issued only to individual applicants that pass Morse code and electronics proficiency tests. There are no age requirements. PRS licenses, however, are available to business firms and to almost any person over age 18. And while amateur radio frequencies may not be used for any business-related messages, PRS frequencies have virtually no message content restrictions, so that licensees may discuss almost any business or personal topic. On the other hand, amateurs have extremely broad privileges with regard to frequencies, power, and technologies (in return for their demonstrated technical and operating knowledge), whereas PRS licensees have very restricted operating privileges. The FCC's stated goals for the amateur service include technical progress for the radio art, public service communications, and international goodwill. The goals for the PRS are primarily convenient and low-cost radio communications to serve the personal and business needs of individuals. FCC rules do not recognize purely hobby or recreational communications as goals for either amateur radio or PRS, in spite of the fact that recreational uses are prime motives for many licensees in both branches of personal radio.

This paper's unifying theme is a general call for much greater flexibility than now exists in the regulation of personal radio. The authors believe such flexibility can be an important contributor to the achievement of personal radio's goals. They point to a number of current FCC regulations that may inhibit the achievement of these goals. Specifically, they suggest deregulation or liberalization of the following: (a) restrictions that may inhibit new technologies, like spread spectrum modulation and trunking, in both the PRS and the amateur service; (b) certain restrictions on amateur repeater operations; (c) certain restrictions on amateur third-party messages; (d) mandatory technical standards for PRS equipment; and (e) CB licensing. Moreover, they suggest a type-acceptance criterion for 900-MHz personal radio based solely upon in-band and out-of-band power emission limits. This criterion would permit simultaneous use in the new band of such technologies as (a) conventional voice, (b) computer-to-computer links, (c) electronic mail, and (d) video. They think an improved personal radio service along these lines might allow some users, particularly in non-urban areas, to substitute personal radio for business landmobile, mobile telephones, rural radiotelephones, and/or VHF marine radio. Also, they suggest (a) systematic study of means to strengthen amateur radio's technological orientation, (b) consideration of a code-free VHF amateur license for technically qualified applicants, (c) expanded HF operating privileges for Technician Class amateurs, and (d) allowing some amateur operations on 27- and 900-MHz PRS frequencies. Finally, they recommend that recreational and hobby uses for personal radio have explicit recognition in the rules.

Abbreviations and Acronyms

ACSB - Amplitude Compandored Sideband: A new and largely untried technology for improving the effectiveness of SSB. If successful, it could lead to vast increases in the capacity of frequencies now devoted to landmobile communications.

AM - Amplitude Modulation: The original technology for transmitting voice and music by radio. Used today mainly for CB and standard AM radio broadcasting.

ARS - Amateur Radio Service: A hobby based upon a large group of internationally designated frequencies and numerous operating privileges. Licenses are available only to technically qualified individuals. Successful applicants must pass proficiency tests in electronics technology and Morse code. Amateur radio may not be used for any business or commercial messages.

ASCII - American Standard Code for Information Interchange: One among many codes for transmitting numbers and characters of the alphabet. ASCII was developed originally for computer systems, but is now popular also for straight communications circuits.

ATIS - Automatic Transmitter Identification System: An electronic device, built into a transmitter, that sends out a unique identification signal without action by an operator.

CB - Citizens Band Radio Service: The most popular branch of the Citizens Radio Services (CRS), which allows very low-cost, short-distance HF communications. It is used mostly in automobiles and trucks.

CRS - Citizens Radio Services: Informal terminology adopted in this paper to describe the group comprised of the General Mobile Radio Service (GMRS), Citizens Band (CB), and Radio Control Service (R/C). All are characterized by extremely liberal licensing procedures, which make them open to almost anyone over age 18. See also "PRS," which has the identical meaning.

FM - Frequency Modulation: A technology for transmitting voice and music that usually gives higher sound quality than either AM or SSB. Used not only in FM broadcasting but also in VHF and UHF landmobile equipment by common carriers, business and public safety services, amateurs, and GMRS.

GMRS - General Mobile Radio Service: A UHF radio service open to almost any adult. Unlike CB, it is structured to discourage "partyline" communications, and it has relatively expensive equipment requirements.

HF - High Frequency: That part of the radio spectrum from 3 to 30 MHz.

kHz - Kilohertz: International standard terminology for one thousand cycles per second. Replaces "kilocycles" or "kcs." Used to measure frequency in the radio spectrum.

MF - Medium Frequency: That part of the radio spectrum from 300 kHz to 3 MHz.

MHz - Megahertz: International standard terminology for one million cycles per second. Replaces "megacycles" or "Mcs." Used to measure frequency in the radio spectrum. One MHz equals 1000 kHz.

PRS - Personal Radio Services: Formal FCC terminology for the services regulated under Part 95 of the Rules, namely CB, GMRS, and R/C. Identical to what is called "CRS" in this paper.

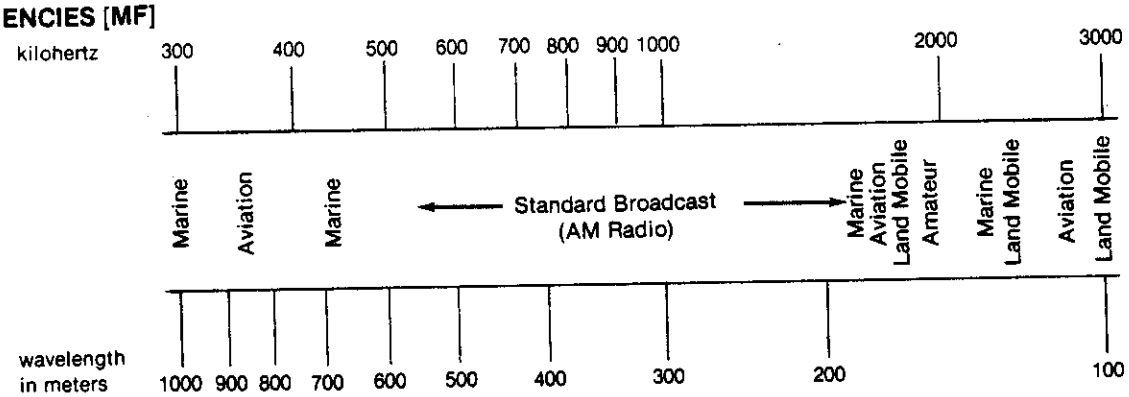
R/C - Radio Control Service: A group of frequencies in both the HF and VHF spectrums that individuals may use for short-range control of remote objects like model airplanes and pocket pagers.

RCC - Radio Common Carrier: A non-wireline firm that provides mobile telephone and/or radio paging services to the general public. These services are also provided by local wireline telephone companies, in competition with RCC's.

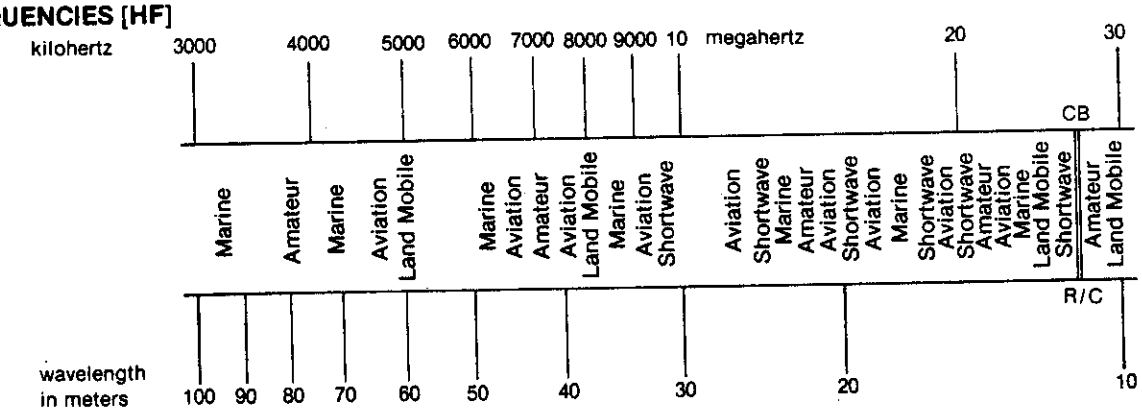
SSB - Single Sideband: A type of modulation used particularly for amateur and commercial voice transmissions in the HF spectrum. Some use also in CB radio. More reliable than AM under some operating conditions. But its sound quality is usually less than that of AM.

SPECTRUM DIAGRAM

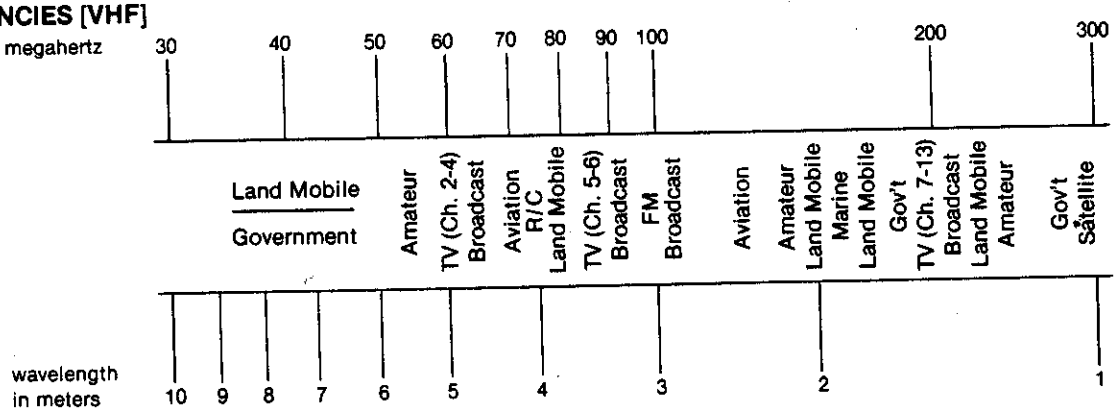
MEDIUM FREQUENCIES [MF]



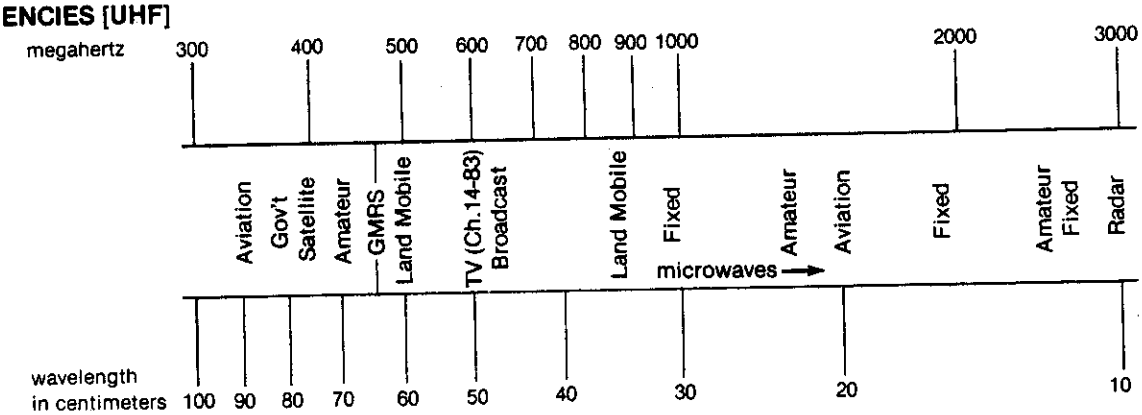
HIGH FREQUENCIES [HF]



VERY HIGH FREQUENCIES [VHF]



ULTRAHIGH FREQUENCIES [UHF]



Preface

We have four main purposes in writing this paper. First, we want to present background information for readers not well acquainted with personal radio. Second, we want to encourage readers to go "back to basics" and think through the relationships between personal radio's goals (implicit and explicit) and its present regulatory regime. We believe many readers will agree that the regulations are in certain instances not consistent with the goals. Third, we want to present specific suggestions on regulatory changes and new technologies that we believe are feasible and may contribute to achieving personal radio's goals. Our third purpose seems timely in view of the Commission's upcoming consideration of a new personal radio service at 900 MHz. Fourth, and perhaps most important, we want to stimulate comments and provoke discussion. In no sense are these suggestions meant as the last word on any subject we discuss.

Until December 1976, the FCC recognized three classes of the "Citizens Radio Service": Class A, Class C, and Class D. (Class B ceased in 1971.) Then the names were changed: Class A became GMRS, Class C became R/C, Class D became CB, and the "Citizens Radio Service" became the "Personal Radio Services" (in the plural). The latter terms remain offically in force. But the Personal Radio Services (PRS) and the Amateur Radio Service today are grouped together organizationally under the "Personal Radio Branch" of the FCC Private Radio Bureau's Rules Division. So sometimes in FCC discussions, the term "personal radio" refers only to the PRS, while other times it refers to the PRS plus the Amateur Radio Service. In a attempt to avoid such confusion, we have used the earlier term "CRS" to refer to GMRS, R/C, and CB; and we use "personal radio" (in lower case letters) to refer to the collectivity of CRS plus amateur radio. This terminology also has the advantages of emphasizing (a) that amateur radio licensing is "personal" rather than "service-oriented" and (b) that amateur radio and CRS perform similar hobby or "recreational" functions for many people. (The text of the paper generally avoids the terms "Personal Radio Services" and "PRS.")

Particular thanks to Virginia Armstrong, Paul Fox, Phil Gieseler, Ken Gordon, Wendell Harris, Joe Johnson, Mike Marcus, Jim McKinney, Elliott Ours, Peter Pitsch, John Reed, Dave Sumner, Ron Stone, Doug Webbink, and Perry Williams for helpful comments. They do not always agree with us and are, of course, absolved of responsibility for any errors that remain.

A.D.F.
J.A.B.

I. Introduction

Personal radio, as the Federal Communications Commission usually has regulated it, encompasses a large group of stations licensed without regard to the lines of business of the licensees. With a few minor exceptions, this distinction sets personal radio apart from broadcasting, common carriers, and various government, business, aviation, and marine radio services. Furthermore, within personal radio there has been an implicit regulatory distinction between the purely hobby-oriented or "recreational" purposes of amateur radio, where radio communication is basically an end in itself, and the Citizens Radio Services, where radio communications were originally intended by the FCC to convey specific, directed business and personal messages. 1/

We think the only defect in this conceptual framework is that it fails to recognize explicitly the recreational aspects of either amateur radio or the Citizens Radio Services. People desire recreation and hobbies in much the same way they want, say, apples or oranges or any other consumer good. So devoting some portion of the radio spectrum to recreation, much the way some

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1/ In emphasizing the recreational nature of amateur radio, with communications as an end in itself, we do not mean to downplay the importance of technical experimentation, disaster communications, other public service, and international goodwill in amateur radio. But we feel strongly that most amateur licensees invest their time and money in their hobby (often in very considerable amounts) above all because they derive a great pleasure simply from communicating by radio. It is this element that draws amateurs together and has distinguished them from other users of the radio spectrum. It is probably significant that in many other countries (e.g., the Soviet Union, which has the world's third largest amateur radio population after Japan and the USA), amateur radio is known by terms like "radiosport." That is, there is a clear emphasis on the recreational (as opposed to the technical and public service) aspects of amateur radio in perhaps most foreign countries.

public lands are given over to parks, may be a wise national policy. In fact, the FCC has always seemed comfortable with the purely recreational characteristics of amateur radio, even though FCC rules have never formally recognized hobby communications among the service's goals. Moreover, the Commission also has dropped some restrictions against hobby-like communications in the CB service. Regulation of personal radio might proceed more smoothly and more rationally across the board if the rules stated that purely recreational or hobby communications are among the official goals of both amateur and citizens radio. Beyond this point we do not take issue with the FCC's stated goals for personal radio. On the other hand, regulation of both branches sometimes may have blocked goal achievement and in particular may have impeded the use of new technologies, such that the public may get only a part of the possible benefits from personal radio.

The organization of the paper is as follows: First, a general background on personal radio's two main branches (Section II), their goals (Section III), and regulatory characteristics (Section IV). Then personal radio is compared to other services that, from time to time and place to place, are substitutes for personal radio in either its recreational or directed-message aspects (Section V). Such other services include low-power non-licensed devices, VHF recreational marine radio, rural radio telephones, common carriers (i.e., mobile telephone service), and private (business) landmobile radio. Section VI discusses present FCC regulations in terms of their relationships to, and their conflicts with, the goals of personal radio. Next (Section VII) specific suggestions are presented on rules changes and new technologies that could benefit the public in its use of both current and yet-to-be-authorized

personal radio frequencies. Finally a number of important issues related to our recommendations (Section VIII) are discussed and concluding observations are presented (Section IX).

II. What Is Personal Radio?

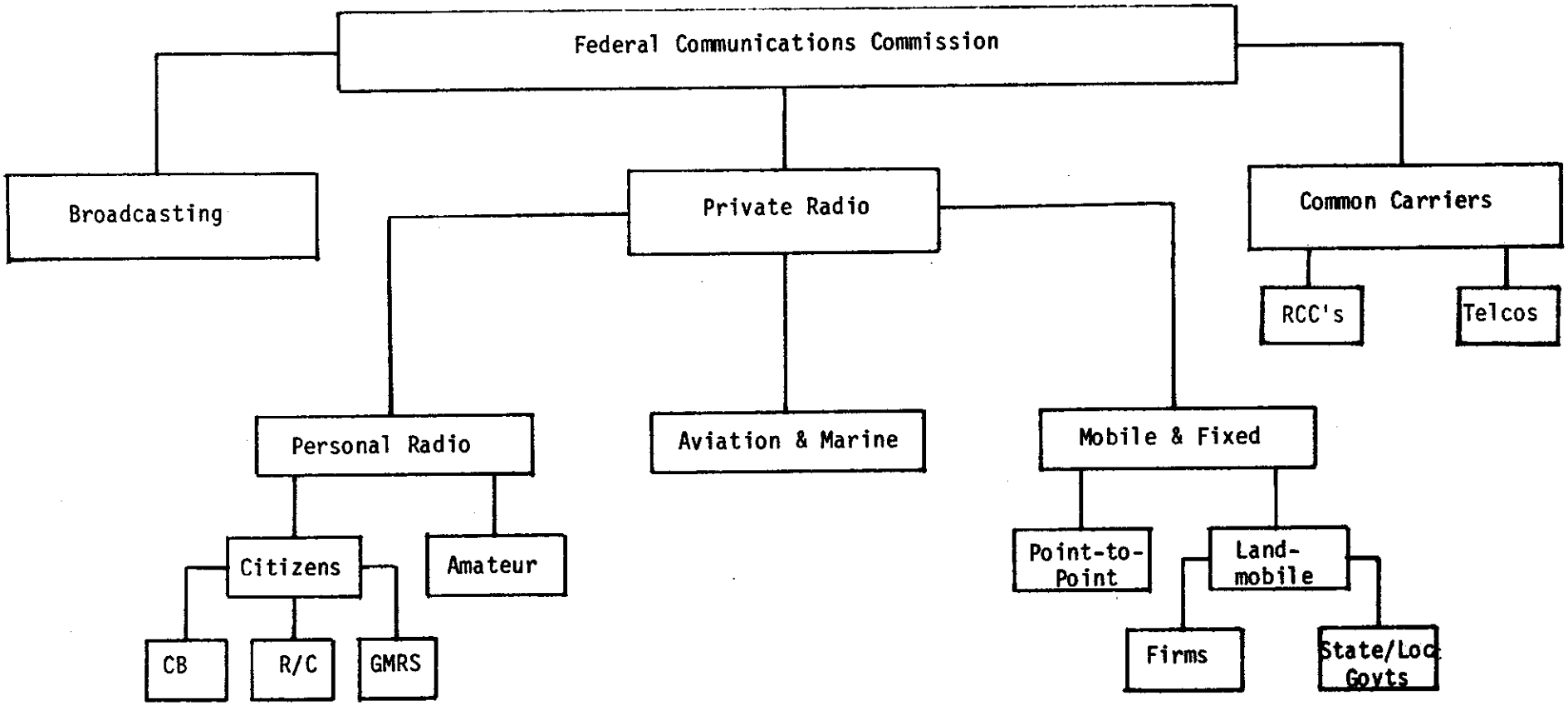
A. Differentiated From Other Private Radio and From Common Carriers

The Federal Communications Commission has established distinct classes of spectrum users, called "services." Licenses to operate radio communications systems are given to individuals or organizations that qualify as members of one or more of the various radio services. Except for personal radio, the services are usually defined by lines of business. And besides the broadcast and common carrier services, which utilize radio transmissions as actual lines of business, the Commission also authorizes radio communications to firms, institutions, and local and state governments for incidental use. These incidental users, plus personal radio, comprise (according to FCC terminology) the "private radio" services. For a summary view of all private services, see Figure 1.

Among the "non-personal" private radio licensees, similar users presumably have similar communications requirements, and therefore they are issued similar authorizations. For example, below 800 MHz all public safety licensees (mostly police and fire) use the same sets of frequencies. Likewise, land transportation firms (like taxicabs and railroads) share other sets of frequencies among themselves, and "industrial communications" users (a

Figure 1

FCC Organizational Structure for Radio Services



category that includes a large variety of firms) utilize yet a third group of frequencies. 2/ In all these services, communications are authorized for business purposes only. For example, a taxi driver's spouse cannot legally have the taxi company's radio dispatcher tell the driver to pick up a dozen eggs on the way home (although such transmissions occur frequently -- and we doubt that any serious harm to the public interest results).

Common carrier radio is different from personal radio and other private services because users are not licensed themselves, but rather pay licensed firms (radio common carriers or local telephone companies) for access to mobile telephone systems. Moreover, common carrier communications carry no legal restrictions on either business or personal content and therefore would be an ideal substitute in many cases for personal radio were it not for the high costs of mobile telephone equipment and the artificial shortages of allocated frequencies. 3/ For a summary comparison of the regulatory distinctions among common carrier mobile radio, private landmobile, and the two branches of personal radio, see Table 1.

2/ For newly assigned landmobile frequencies above 800 MHz, however, users have been assigned to channels without respect to lines of business. This approach has been dubbed "interservice sharing."

3/ We say "artificial" because today's sparse allocation of frequencies to mobile telephone service is the result of FCC policies, which could be reversed, rather than some intrinsic characteristic of the electromagnetic spectrum. In fact, the FCC has recently authorized a large bloc of frequencies for "cellular" radio, which could significantly alienate the shortage of common carrier landmobile channels. Cf. note 57 below and accompanying text.

Table 1
Regulatory Characteristics of Personal Radio
and Some Substitutes

regulatory characteristics / service	business messages	personal messages	economic control by government	eligibility requirements for users	restrictions on telephone interconnection	concurrent state jurisdiction	trunking allowed
common carrier mobile phones	yes	yes	yes	no	no	yes	yes
business landmobile	yes	no	no	yes	yes	no	yes
citizens radio services	yes	yes	no	no	yes	no	no
amateur radio	no	yes	no	yes	yes	no	yes*

* As far as the authors are aware, no amateurs have yet used trunking.

B. Branches of Personal Radio

Personal radio is a combination of frequency assignments for (1) "amateur" use (the Amateur Radio Service) and (2) recreational and utility use by private citizens at large (the Citizens Radio Services). 4/ Amateur radio has a long history. In fact the first regular non-maritime users of the radio spectrum were amateur operators. 5/ But only after World War II did the Commission allocate spectrum for recreational and directed personal communications by private citizens other than "amateurs." The Citizens Radio Services (CRS) were established in 1945. They have changed substantially since then. Some changes were due to new regulatory policies, but the more substantial changes have been driven by technology and socio-economic shifts. Today there are three separate sub-groups within the Citizens Radio Services: (1) The General Mobile Radio Service (GMRS), (2) the Radio Control Service (R/C), and (3) the Citizens Band Radio Service (CB).

4/ The official terminology (in FCC Regulations) for what this paper calls the "Citizens Radio Services" is actually the "Personal Radio Services." On our terminology, see p. viii above. We put the word "amateur" in quotes because its usage today has taken on connotations (thanks to its regulatory history) that set it apart from the standard dictionary definition of "amateur," as opposed to "professional." In fact, a large minority of today's U.S. amateur radio operators are telecommunications professionals. It would not be suprising to find that a higher proportion of CB licensees are actually "amateurs" in the dictionary sense than are the "amateur radio operators." Amateur operations in the regulatory sense are distinguished from "professional" and CB operations in that amateur frequencies may not be used "professionally" or for any business communications. (But "amateurs" themselves may be both "professionals" and CB licensees.)

5/ Marconi himself started using the radio spectrum as an "amateur." Later, of course, he became a "professional," even though he was quoted in the 1930's as saying he still "likes to characterize himself as an amateur." Clinton B. DeSoto, Two Hundred Meters and Down (American Radio Relay League, West Hartford, Conn., 1936), p. 14.

1. The General Mobile Radio Service

GMRS has eight channel pairs in the UHF spectrum and is used primarily for low cost, business-related local communications. These channels are not allocated specifically for business, but in most urban areas they have become excellent substitutes for business landmobile frequencies. In some ways these frequencies are more desirable than the business-only frequencies, because GMRS is not as rigidly regulated as are other private radio services. For example, FCC rules permit business users to discuss non-business personal matters on GMRS frequencies, and they may share facilities with personal users and almost any mixture of licensees from other lines of business.

2. The Radio Control Service

The second sub-group in the CRS is the Radio Control Service (R/C), which is assigned a total of thirteen channels in the HF and VHF portions of the spectrum. The six HF allocations are interspersed with the Citizens Band (CB) channels and although these channels are often occupied with interfering and unauthorized voice communications, they are also utilized by radio control enthusiasts. The R/C channels may be used for controlling remote devices such as model airplanes, garage doors, and pocket pagers. In addition, with some restrictions, the seven VHF channels allocated to the R/C service can be used for licensed personal radio remote control and signalling. 6/

6/ The operation of transmitters for controlling objects remotely is also permitted on amateur frequencies.

3. The Citizens Band

The third sub-group under the CRS is by far the best known -- the Citizens Band Radio Service (CB). CB is assigned forty HF channels at 27 MHz. CB was originally intended for directed personal and business messages, but today it seems to be used by most licensees as a hobby and/or traffic aid. Its popularity has led in certain geographic areas to congestion that probably has encouraged some operators to move illegally to unauthorized adjacent frequencies. 7/

Licensing requirements for all three branches of the CRS are minimal. An applicant must simply complete an application form and return it to the FCC. 8/ Minimum age for CB and GMRS licensees is 18. For R/C, the minimum age is 12 years.

4. The Amateur Radio Service

In contrast to the Citizens Radio Services, where business uses are permitted, Amateur Radio Service rules expressly prohibit all business-type

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7/ Arguments have been made that CB is no longer truly congested, but that only certain channels (e.g., 19) are actually overloaded. Most attempts to measure CB congestion have been inconclusive. In our opinion the band is congested in many urban areas, although new evidences based upon hard data rather than anecdotes might prove otherwise. On the other hand, decisions to adopt the kinds of flexibility recommended below (see Section VII) should depend not so much upon judgments about whether CB today is congested but rather upon judgments about the benefits such flexibility would bring to potential users of personal radio relative to its costs (e.g., costs of interference to other services).

8/ But the GMRS application form is much more complex than the CB application. And applicants for GMRS licenses must request a specific frequency. As a result, many applicants coordinate their frequency selection with existing users in their area. This coordination is usually performed by the local equipment supplier.

communications. Instead, the service is structured to encourage the technical education of licensees and advancement of the radio art through recreational communications. Amateur practices have been allowed to evolve naturally along with the development of technology, rather than be restricted to specific channels and one or two types of modulation. 9/ At least until World War II, amateurs were a major force in the exploration of HF and higher frequencies -- frequencies that have since provided reliable communications in commercial applications. In those days, equipment building was for many amateurs perhaps as important a part of their hobby as actual communications. (One may argue, however, that much -- perhaps most -- equipment building then was done out of necessity rather than for fun, simply because mass-production of amateur gear had not yet arrived.) Today relatively few amateurs build complete stations, although many construct peripherals and accessories. And some operators continue to explore innovative communications techniques. The rules that exist today, however, do far less than they could to encourage amateur ingenuity (in spite of the fact that the rules still require both Morse code and some electronics knowledge); and in some cases, regulation may positively have discouraged technical progress. 10/

9/ Initial amateur communications were by primitive means (spark gap transmitters). As technology advanced, amateur transmission modes changed. Some of this change was recognized by changes in regulation. Today, amateurs may communicate by voice, still pictures, TV, Morse code, teletype, and other modulation types on many different frequency bands. In contrast, CB is much more restricted. Not only is CB confined to designated "channels," but it also is allowed only to use voice communications (with only two permissible modulation types, AM and SSB).

10/ See Section VI-C below.

III. The Goals of Personal Radio

The FCC originally tried to specify in detail the way various branches of citizens radio would be used. But the actual uses, as distinguished from the FCC's original goals, have evolved over time as a result of socio-economic factors, new technologies, amounts of spectrum assigned, interference, and so forth. So it is important to contrast the Commission's original (and current) formal goals with the services' actual uses. In most cases, the latter have gained at least quasi-legitimacy and thereby take on the characteristics of informal goals.

A. The Citizens Radio Services

The Commission's original rules and practices for both GMRS and CB were intended to allow short-distance, low-cost directed communications (both mobile and point-to-point) for the business or personal activities of individual licensees. Moreover, the rules established these services so that radio would be an aid to other activities rather than an activity in and of itself. Regulations, socioeconomic demands, and technological changes over the past several years have, however, led to a significant difference between the original formal goals and the current actual use of the CRS. The most important actual use today for GMRS appears to be business communications for firms rather than individuals, and the most important actual uses today for CB are non-directed highway communications and hobby-like communications. 11/

11/ There are, of course, some non-business communications in the GMRS; and a few GMRS community repeaters are now even operated similarly to CB. Such operations appear to have increased recently. This trend is unlikely to change the dominant business-related mode of GMRS operations in the foreseeable future.

This history suggests that the FCC (or any goverment agency, for that matter) finds it extremely difficult to predict accurately the future best use of a particular bit of spectrum devoted to a service like personal radio. We suggest below (Sections VII-A and VIII-E, for example) that for this reason, any new personal radio service should have an absolute minimum of governmentally-imposed technical and operational standards.

1. GMRS

GMRS has sixteen channels. Eight are assigned for both base and mobile stations, and another eight are assigned for mobiles only. GMRS now is used almost exclusively by firms rather than individuals, as a substitute for conventional business frequencies. This pattern apparently was not contemplated when the FCC established the service. 12/ Several factors may have deterred recreational and other personal uses and have promoted business use of GMRS. First, compared to 27-MHz (CB) equipment, GMRS equipment is expensive. It is, however, priced competitively with other business land-mobile equipment. Second, GMRS lacks much of the regulatory rigidity of other private radio services. Third, until recently GMRS was less congested than other private radio bands. Thus GMRS could, in many instances, provide businesses with better communications for less cost than could the other private radio services. Another reason most of GMRS is business-related is

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12/ Business use was allowed in the original GMRS (called then the "Citizens Radio Service"), but the Commission's emphasis clearly was on use by individuals (and perhaps small firms) rather than organizations. FCC Docket No. 6651, Report, January 15, 1945, p. 184; also 39 F.C.C. 68 (1945) at p. 146.

that the service cannot provide a significant amount of recreational communications, due to the nature of its frequency assignments: Users normally are licensed for only a single channel. This licensing procedure discourages "partyline" and hobby-like communications among stations, since most persons are licensed to different channels and therefore cannot talk easily to each other. Without a very large demand for GMRS equipment, such as occurred with CB in the early 1970's, prices are unlikely to drop. Yet equipment demand is not likely to increase without a substantial increase in the recreational potential of the service. Doubtless, many potential GMRS users are unaware of the service since it has received almost no publicity. Because the limited number of users, the limited amount of spectrum, and relative cost of equipment are so closely interrelated, the main actual use of GMRS is likely to remain directed communications, although the stated FCC goal of personal communications actually has been replaced by business communications. No significant personal or recreational use is likely to emerge under current regulations.

2. Citizens Band

In CB the formal FCC goals and the actual uses are at even greater variance from one another. Commission rules continue to state the purpose of the service is identical to GMRS. CB's actual uses, however, seem primarily to be hobby-like recreational communications and non-directed highway communications. That is, people use CB heavily because they enjoy talking over radios, or need occasionally to talk to a stranger on the highway, not primarily because they need to send directed messages to business associates

or family members. When the Commission formally separated regulation of CB from the other Citizens Radio Services in 1975, it implicitly acknowledged this difference between formal goals and actual uses. 13/ But the Commission has never given explicit recognition to hobby-like recreational communications in CB.

The FCC promoted recreational and non-directed use of the Citizens Band -- probably without intending to do so -- by assigning it spectrum relatively low in frequency compared to other mobile services. In fact 27-MHz CB initially had the same content and station-to-station communications restrictions as GMRS, and many of them persist in GMRS today. But the lower frequency assignment allowed less expensive equipment and meant less desirable propagation and more interference. 14/ The expense and rigidities that

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13/ Before 1975, Section 95.83 said: "A Citizens radio station shall not be used. . . as a hobby or diversion, i.e., operating the radio station as an activity in and of itself." In 1975, the Commission eliminated channel assignments for CB interstation communications and dropped many prohibitions on the content of communications. These actions were merely an acknowledgment of actual operating practices. At this time, one of the authors was employed by the FCC's Field Bureau and regularly investigated violative CB activity. In the months immediately after the rule change, he noticed a dramatic increase in callsign usage and a general decrease in violative (i.e., still prohibited) activities.

14/ The 27-MHz band is considered undesirable by many users because of its susceptibility to, and lack of regulatory protection from, interference. The interference experienced by users in the band usually takes one of two forms, both of which reduce the reliablity of communications. One type of interference comes from the propagation characteristics of the band. While the band is often only usable for local communications, many times during the year atmospheric conditions may "open" the band up for medium range (500 to 1000 miles) and long distance (up to 3000 miles and more) communications. When the band is open, local communications can be disrupted by distant signals. Second, the 27-MHz band has also been assigned to industrial, scientific, and medical equipment (ISM, see Part 18 of the FCC rules) that uses radio energy for other than communications purposes (e.g., welders, plastic heaters, diathermy machines). Any communications authorized in the 27-MHz band are not guaranteed protection from interference by ISM users. This additional use of the spectrum makes reliable communications even more difficult and the frequency range "undesirable." As one result, the private radio allocations adjacent to CB remained relatively vacant; so as channel congestion became a problem, some CBers simply took it upon themselves to expand their band illegally to unoccupied adjacent frequencies.

deterred recreational communications in the GMRS acted to some extent in reverse for CB. Commercial licensees willing to pay for more reliable communications than possible at 27 MHz opted for assignments in other frequency bands. Personal licensees' desires for recreational communications, technological advancements, and the 1974 gasoline crisis (when CB got national publicity as an aid in locating fuel and avoiding speed traps) reinforced one another and resulted in explosive growth of the CB service. The large number of CBers and their disregard for many regulations led the Commission to re-examine and lift a number of CB restrictions in 1975. Today, CB is growing more slowly than in the mid-70's, and it may even be contracting, but it is still used heavily as a recreational outlet and traffic aid by citizens. 15/

B. The Amateur Service

In contrast to the CB and GMRS services, amateur radio is entirely a hobby or recreational service. No business communications are permitted. More importantly, in return for use of spectrum and many different operating modes, amateurs must have certain technical and operating skills. 16/ This

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15/ During 1976 the Commission averaged over a half-million CB license applications a month. During recent years, licensing and equipment sales have fallen sharply. It is not clear whether this decline represents merely a decrease in the growth rate, or a true fall in usage of CB, or whether licensees simply are not bothering to renew at the end of their licenses' (five-year) terms even though they may continue to use CB actively.

16/ Moreover, amateurs may build and modify their own equipment, which CBers may not legally do. R/C users are permitted, however, limited authority to construct and modify 27 MHz equipment.

distinction can be viewed as a social contract, with international treaty status, between amateur operators (or "hams") and their governments. In this country, FCC rules establish a recreational communications structure for amateur operators with five basic goals: (a) public service communications, especially during emergencies, (b) advancement of the "radio art," (c) improvement of individuals' operating and technical skills, (d) expansion of the national "reservoir" of radio operators and electronics experts, and (e) international goodwill. 17/ These five areas are the formal goals for the amateur service. But what motivates the licensees themselves?

First, many individuals are attracted to amateur radio mainly because they have a hobby interest in the technical side of radio electronics. Indeed, the technical orientation has a long and important history in the amateur service. For example, most of the HF spectrum in commercial use today was first explored by amateurs before World War II. 18/ Some evidence suggests about forty percent of today's amateurs are employed professionally in fields related to electronics or telecommunications. 19/ Also, the

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17/ These goals have been established entirely by tradition and regulations, not by statute. The only statutory requirement for the U.S. amateur service is the definition of "amateur station" in Section 3(q) of the Communications Act of 1934: "A radio station operated by a duly authorized person interested in radio techniques solely with a personal aim and without pecuniary interest." The formal statement of the Commission's goals for the amateur service is in Part 97.1 of the FCC Rules.

18/ On the other hand, the FCC's regulations did not explicitly recognize technical advance as a goal of the amateur service until the 1950's. Most other countries even today do not make such an explicit recognition, although the International Telecommunications Union's definition of amateurs includes the phrase "technical investigator."

19/ E. Walter Terrie, "Amateur Radio in the United States and Canada, 1980," Final Report to the ARRL, Florida State University, Institute for Social Research, September 1980.

required technical examinations, while not fully adequate as measures of technical knowledge, do provide incentives for operators to improve their electronics skills.

Second, many operators find personal satisfaction in donating their recreational time to public service activities through amateur radio. By providing free communications to various civic organizations, or by relaying and delivering messages to third parties throughout the world, amateurs not only provide a worthwhile service to the public but also establish radio networks that are used in emergencies. In fact, the Amateur Radio Service is probably best known to the general public for its activities during natural disasters and other emergencies.

Third, most amateur operators undoubtedly are lured to the hobby simply by the desire to communicate. Using rather modest equipment, amateurs can contact similarly equipped operators in the next state or around the world. As a by-product of their enthusiasm for contacting operators throughout the world, amateurs create international goodwill. Many international amateur projects, like construction of orbital satellites, go beyond simply communicating with other countries and have allowed operators of many nationalities to work together toward concrete common goals. The result can be a certain sense of worldwide fraternity. In short, the hobby is a lot of fun, and it needs perhaps no other justification for most adherents. Unfortunately, this motivation is not recognized explicitly by the FCC rules. This motivation is not only fully legitimate but is perhaps the main reason individuals become amateur licensees. As such, it deserves official recognition.

A recent survey indicates most amateurs agree to the importance of the FCC's formal goals. 20/ Most observers would agree that the service is adequately meeting the public service and international goals. In contrast, many would also agree that the goals of expanding technical skills and manpower and advancing the radio art have fallen on hard times in recent years. Although no quantitative proof is available on this point, relatively few amateurs appear to be deeply involved at the technical frontiers of radio, compared to earlier decades. One reason may be that the advent of modestly priced, high-performance equipment has limited the average amateur's everyday technical involvement to antenna construction and minor transmitter/receiver repair. 21/ On the other hand, amateurs today seem increasingly interested in computers, which can provide expanded communications. 22/ This area is

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20/ Ibid.

21/ The FSU study found less than five percent of amateurs are involved in technically sophisticated areas of radio communication such as satellites, narrow band voice modulation, digital data communications, or microwave experimentation. Ibid. No data appear to be available to prove that hams are less involved technically with radio today than they were before World War II. But the notion of less technical involvement seems almost universal. On the other hand, one should be aware that nostalgia about the "good old days" of amateur innovation is not new. Take for example the 1910 complaint of radio pioneer Lee De Forest: "The art of wireless has now become so complex, the money invested in its development so considerable, and the number of highly trained specialists engaged in careful research so large, that it seems unnatural to expect to-day any valuable contribution to the science from an amateur working independently and with small means. In the early days this was not the case." Hearings Before a Subcommittee of the Committee on Naval Affairs of the House of Representatives on H. J. Resolution 95, 61st Congress, 2nd Session (1910), p. 75. It hardly seems necessary to observe how wrong De Forest seems to have been in the light of subsequent history. He also complained about "manufacturing concerns engaged in turning out great quantities of cheap and inferior wireless apparatus . . . to pander to the newly created amateur market." Ibid. The authors have heard similar comments about today's CB market.

22/ The same survey showed over ten percent of hams are presently active in personal computers. Ibid.

perhaps a "radio frontier," but the regulatory flexibility necessary to explore it may be lacking. Only recently, for example, has the Commission authorized ASCII as a radioteletype code in the amateur bands; and the speeds even now allowed are considered too slow by some operators. 23/ Rigid band allocations, to take another example, have prevented amateurs from exploring extremely wideband modulation techniques. If there is criticism of amateurs for not being technically more advanced, it could be misdirected. Perhaps one should place some responsibility on the regulations, not the licensees. Substantially more regulatory flexibility than the service now has would be desirable. 24/

23/ ASCII is the "American Standard Code for Information Interchange," which is a code developed originally to transmit the alphabet and numbers within and among computers.

24/ On March 6, 1981, the FCC granted a group of amateurs a "Special Temporary Authority" (STA) to experiment with spread spectrum modulation. In a press release publicizing the event, the Commission urged amateurs interested in experimenting with a variety of innovative techniques (e.g., digital voice and video, packet switching, trunked repeater systems, etc.) to petition the Commission for STA's. FCC News, March 9, 1981. STA's may provide technically valuable information for policy decisions, particularly in areas of great technical uncertainty, because they require systematic reports from the licensees to the FCC. Nevertheless, the STA route may often be an inefficient way to encourage amateur experimentation not only because it is slow, but also because it inherently limits communications using a new technique to whatever small group of licensees are included under a specific STA (or small number of STA's). As a result, an STA may not provide a fair test to a particular new technology, and the final outcome may still unfairly discourage the technology's future use. But the FCC is moving toward greater flexibility in a recent Notice of Inquiry and Rulemaking to permit amateurs to utilize spread spectrum. See, General Docket 81-414, __ F.R. _____(1981).

IV. Regulatory Characteristics

Because the FCC established the citizens and amateur services to meet different communications demands, the two services have radically different regulatory structures. These differing structures were designed with the intent of promoting the expressed goals of each service, while simultaneously limiting interference both within services and to other services. The following section summarizes these structures.

A. The Citizens Radio Services

As noted earlier (Section II), a minimum age is the only significant qualification for a license in the Citizens Radio Services. In fact, aliens are now eligible (except representatives of foreign governments). So in effect the only requirement for a license is simply to apply. One need not even wait for the Commission to act before operating, since applicants may give themselves temporary authorizations.

Licensees are not required to have technical knowledge of communications equipment in any service except the amateur. Therefore, they are not necessarily able to recognize and control the interference to other radio users that their own equipment may generate. So the Commission places various different technical requirements on transmitters it authorizes for specific

radio services. 25/ In this vein, CRS licensees may use only those transmitters "type accepted" by the FCC.

Since the trivial operator requirements and significant equipment restrictions in CRS allow free entry to almost anyone, users may end up paying a penalty in terms of equipment prices and/or channel congestion. In the CB service, for instance, prospective users need only purchase a communications transceiver (combination transmitter and receiver), issue themselves a temporary authorization, plug the equipment in, and attach an antenna to be "on the air." The equipment, however, must meet fairly stringent out-of-band emission limits compared to amateur equipment and may use only two modulation techniques, both for voice and neither of which may be optimum for a particular place or type of message.

B. Amateur Radio

In contrast to the CRS's open entry, the amateur regulatory structure limits entry. While there is no minimum age for a license, operating privileges are granted only upon a demonstration of technical knowlege and Morse code proficiency. There is a five-level hierarchy in operating privileges, each level corresponding to a particular class of license.

25/ These technical requirements may include specifications on output power, frequency stability, frequency coverage (channels), output bandwidth, and modulation technique. These technical requirements, while perhaps necessary to control interference in many instances, also cause not only higher equipment costs than might otherwise exist, but in certain cases may lead to channel congestion due to the lack of flexibility.

Table 2

Amateur Licensing Structure

Class of License	Technical Examination	Morse Code Requirement (words per minute)	Operating Privileges	
			1.8 to 29.7 MHz	Above 50 MHz
Novice	perfunctory	5	very limited	none
Technician	moderate	5	very limited	all
General	moderate	13	limited	all
Advanced	difficult	13	most	all
Extra	difficult	20	all	all

The privileges generally correspond to specific frequencies (and in one case to power levels and modulation techniques) that may be used. The greater the operating privileges, the more difficult the level of technical and Morse proficiency required. For a summary of the amateur license structure, see Table 2. The rationale for this structure is to provide incentives to upgrade licenses and thereby raise the overall technical and operational skill levels of the service. Also, special (i.e., prestigious) call signs are available to

licensees in the higher grades. 26/ After special call signs were made available to higher class licensees, the number of applicants for higher grade licenses increased. Casual data suggest operators may value a special call sign more than increased frequency privileges, but no systematic data or analyses bearing on this question seem to be available. 27/

In addition to more stringent entry requirements, the Amateur Radio Service also has very different technical regulations from the Citizens Radio Services. The amateur service has a very large amount of spectrum compared to the CRS, even though CRS users outnumber amateurs by about forty to one. The FCC licenses equipment as well as operators in the CRS to control interference, but equipment licensing has not been thought necessary in the amateur service since the operators have a degree of technical competence. In addition, either mandatory channelization of amateur frequencies or excessive restrictions on emission types could stifle one of the amateur service's goals -- technical training and experimentation. Consistently, the Commission has avoided imposing on amateurs many technical regulations like those so common in other services. In particular, it has never specified "channels" nor mandated strict transmitter licensing. 28/

26/ Official call signs are the station identification required by Commission regulation in all radio services. CB operators generally identify one another instead by nicknames, or "handles." In the amateur service, however, identification has remained by call sign. Distinctive calls have long been regarded as status symbols among amateurs, and recently the Commission capitalized on the fact by establishing a number of new call sign combinations, each distinctive to a particular class of license. The result seems to have been an increase in the amateurs upgrading their licenses.

27/ Cf. Wayne Green, "Never Say Die," 73 Magazine, October 1980, p. 244.

28/ In an effort to prevent use of high-powered amateur equipment by CBers, however, the Commission now requires type acceptance of certain amateur transmitting gear. And it has imposed modest out-of-band emission constraints on amateur transmitters.

V. Comparisons to "Substitute" Services

The Commission allocates spectrum to a number of communications services that are substitutes for personal radio, and for which personal radio can in turn be substituted. Some can substitute for CRS directed-communications uses. They include common carrier mobile telephones, both private and common carrier paging services, the rural radio telephone service, and business landmobile radio. Other services can provide partial substitutes for personal radio's recreational uses, such as the frequencies authorized for non-licensed, low-power equipment. And still others can provide both directed and recreational communications substitutes, such as the VHF allocations for recreational boating. FCC regulations limit sharply the legal substitutability among radio services. Operators, however, often can shape a particular service to their own requirements in violation of Commission regulations. In these instances the substitution of one service for another, while unauthorized, may in fact be entirely adequate from the user's viewpoint. It is useful to review these substitutes for at least three reasons: First, a comparison helps call into question whether all the regulatory distinctions among services are truly useful. (See also Table 1, above.) Second, it gives clues to services consumers truly want. Third, it indicates areas where spectrum might eventually be freed up if a new, high-quality personal radio service were available at least partially to replace other services.

A. Non-licensed, Low-power Devices

Very low-power transmitting equipment may be used by unlicensed users on a number of frequencies and bands. The power and antenna permitted for a particular low-power device depends on the part of the spectrum used. All

low-power transmitting devices must be certificated. 29/ Many low-power devices for recreation or radio control use frequencies in either the 26.99-to-27.26-MHz band (which also includes some CB channels) or 49.82 to 49.90 MHz. 30/

B. VHF Marine

Marine radiocommunications frequencies are reserved in the medium frequency (MF), the high frequency (HF), and the very high frequency (VHF) ranges. Certain channels are for public correspondence (third party message traffic or telephone calls), while other channels are for calling (establishing communications between stations), emergency traffic, and radio determination (establishing positions by "direction finding" a radio beacon). The rules specifically prohibit use of marine frequencies for superfluous (e.g., "partyline") communications or for communications not directed to specific stations or ships. The rules are intended to provide

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29/ Certification is a Commission equipment licensing program, where technical compliance is determined from manufacturer-submitted measurements. It is less rigorous than "type approval," which requires that equipment be tested in the FCC laboratory.

30/ Up until 1976, the 27-MHz band was the most popular spectrum for recreational low-power devices. Then the Commission, responding to increasing numbers of complaints from CB operators, established the 49-MHz band. This band has since been used primarily by inexpensive "walkie-talkies" and wireless telephones. The 1976 Commission action also instituted a timetable that will in 1983 prohibit the low-power use of the 27-MHz R/C frequencies for any type of voice or continuous wave (CW) modulation. This last action effectively limited the low-power use of 27 MHz to remote control. Since the authorized frequencies in the 27-MHz band for low-powered, remote control transmitters are identical to the frequencies authorized for the R/C service in the 27-MHz band, in many instances this low-powered unlicensed service can provide a perfect substitute for the 27-MHz R/C service, the only difference being that the R/C service is allowed higher power. In a similar manner, the 49-MHz band provides a communications substitute to some 27-MHz CB uses. In particular, inexpensive 49 MHz walkie-talkies are being substituted for more expensive 27-MHz units for very short-distance, portable communications. See 41 F.R. 7398 (1976).

directed communications for ship operations, safety, and relaying of messages (public correspondence).

The HF and MF assignments are primarily for long-distance communications on the open seas. The VHF assignments are primarily for bay, harbor, and river traffic. As a result, recreational boaters overwhelmingly use VHF. The growth in recreational boating in the past decade, coupled with the steady decline in the cost of VHF equipment, has resulted in tremendous growth of VHF marine radio in coastal and river areas. Many boaters also utilize CB radio for marine communications. 31/

The other side of the coin is that many boaters first exposed to VHF communications on the water are now using the band in non-maritime recreational and utility pursuits. According to reports from FCC District Offices located in areas with dense ship populations, it is not uncommon to hear a variety of non-marine communications on the VHF marine channels even though such traffic is prohibited by FCC rules. Anything from taxi dispatch and other business uses to communications between spouses -- one mobile, the other based at their residence -- have been noted by FCC officials on the marine channels. And in addition to this substitution for personal radio, VHF marine channels may lend themselves as unauthorized substitutes for some common carrier services, as documented in many FCC investigative reports. One particular instance with which the authors are familiar involved access to an inland marine operator's radio system by two "pleasure boats" some seventy miles from the water. The "boats" were actually two land-based entertainment businesses that utilized VHF marine channels to connect with the telephone

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31/ One of the authors has frequently had difficulty distinguishing VHF marine communications from the Citizens Band on weekends when the rivers and coastal waterways are crowded with recreational boaters. In fact so many recreational boaters use CB that the Coast Guard now routinely monitors CB channel 9 (the channel reserved for emergency communications).

network. Although the users were violating Commission rules because they were not qualified for marine channels, legitimate users of the channels in the area did not complain of any service degradation or interference. In other words, at least some illegal operators have been able to substitute VHF marine radio for common carrier services (which are often harder to obtain or more expensive) without significantly increasing channel congestion and decreasing other users' communications satisfaction.

C. Rural Radio Telephone Service

In remote locations where the cost of installing and maintaining telephone wire is high, many individuals rely on radio to contact the outside world. Often the radio link is authorized by the FCC in the "Rural Radio Telephone Service," and it is provided by a common carrier. Specific frequencies are set aside by the Commission for such operation. These systems are directly connected to a telephone network, and home operation of the equipment is similar to a standard telephone.

Other isolated communications users -- e.g., domestic and international scientific expeditions, military deployments, and transoceanic yachts -- have used amateur radio for primary communications and to connect with the telephone network. (Since part of the communications link is via amateur radio, however, any communications of a "business" nature are prohibited. In addition, the reliability of such a link is often much lower than for commercial circuits.) In some rural areas, CB provides a substitute for rural radio telephone service. CB is, however, even less reliable technically than amateur links and is forbidden by regulation to connect automatically with the telephone network. This prohibition on "interconnection" probably leads some

users to unauthorized channel use (or other violations), like the case of the two "boat" operators above. 32/

D. Common Carrier Mobile Telephones

Several options are available for telephone communications in an automobile. At one end of the scale are the common carriers. Again, they are authorized specific frequencies, and operation is similar to a standard telephone. Reliability and quality are very high. The mobile telephone is unique among radio services, because it can effectively substitute for most other mobile radio services used in "directed" communications, and because it allows the user virtually unrestricted automatic access to the telephone network. For these reasons, it is extremely popular -- so much so that in many metropolitan areas there are very long waiting lists for a mobile telephone. It is likely that many users who would prefer mobile radiotelephone service often must turn to substitutes.

In much the same way that personal radio can substitute for rural radio telephone service, it can also provide substitutes for mobile radiotelephone service. Amateur radio can substitute through the use of VHF "autopatch" repeaters. Users are required to be licensed amateurs, however, to access such equipment, and all business usage is prohibited on amateur bands. The

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32/ As far as the authors have been able to determine, there is no difference between "connection" and "interconnection," although the FCC generally uses the longer of the two words. Therefore we use the term "interconnection" henceforth in this paper. Marine users are allowed fully automatic telephone interconnection if they communicate via "public coast stations," which are common carriers. Private radio marine channels have more restricted interconnection rules. And automatic interconnection is prohibited altogether in the citizens services. CB stations may be connected manually. GMRS is generally forbidden either manual or automatic interconnect. The only exception to this rule is for those GMRS stations authorized prior to October 16, 1978, and then only until the end of the license term.

Citizens Radio Services can partially replace mobile telephones in specialized areas. In many business-related instances, for example, the GMRS can provide acceptable, although somewhat less reliable, communications. And for large groups of friends with common interests, CB radio can even be superior to common carrier communications if access to the telephone network is not important. But in all these areas, the degree of substitutability is severely limited by FCC regulations, whether by accident or design.

E. Business Landmobile

As mentioned earlier, some personal radio and business radio services are close substitutes. Particularly in metropolitan areas, some businesses use GMRS frequencies rather than the regular landmobile bands because of GMRS's lower congestion and fewer regulations. In less populated areas, CB is routinely used in business applications. CB's primary attractions here are its extremely low licensing and equipment costs when compared to business landmobile.

F. Amateur

Finally, non-amateurs sometimes use VHF amateur bands and equipment illegally for business communications, in a manner similar to the illegal use of VHF marine channels for common carrier service. Discussions between the authors and Field Operations Bureau engineers indicate that this practice is perhaps increasingly common, as business entities risk the costs of apprehension for the benefits of inexpensive but reliable communications on the VHF and UHF amateur bands. These unauthorized users are commonly able to avoid detection by most amateurs (and the FCC) by operating on rarely used

frequencies, with low power equipment. So it appears at least some illegal users find the amateur bands an entirely acceptable substitute for the legal business landmobile service.

VI. How Personal Radio Rules May Hinder Achievement of FCC Goals

Section III compared and contrasted the formal goals of the various personal services with their actual uses. Section IV described the regulatory structure of each service. Section V examined other radio services that could -- if permitted -- provide good substitutes for personal radio (and vice-versa). The following section looks more closely at FCC regulations that may limit not only user satisfaction but also achievement of the FCC's own goals.

A. Overall Commission Goals

The broadest statement of the Commission's goals in regulating the radio spectrum is in Section 303 of the Communications Act, which states that the FCC should "generally encourage the larger and more effective use of radio in the public interest." We believe this general goal encompasses a number of unstated sub-goals, like technical efficiency, economic efficiency, technological progress, consumer sovereignty, competition, and diversity. There probably is no necessary conflict among these sub-goals, so that a good

regulation can harmonize them for the most part. 33/ But the Commission's regulation of personal radio has sometimes worked against such objectives. For example, there has been no provision in the CB rules to allow spectrum-saving techniques: Even though SSB is allowed at 27 MHz, it saves no spectrum under present rules due to the uniform national channelization required by the Commission's rules. Furthermore, data and other non-voice transmissions are not generally allowed in personal radio, with the limited exception of some tone-encoded paging, and CBers using technologies like frequency-hopping (a spread spectrum technique discussed further in Section VIII-A below) have been shut down at least once by the Commission. As a result of these and other rules, the 27-MHz service has become crowded and of dubious utility in large cities, while underused in many towns and rural areas. 34/ The Commission currently has outstanding a Notice of Inquiry on the establishment of a new personal radio service in the 890-960-MHz band, commonly called "900 MHz" (Docket No 79-140). This band is essentially "virgin territory." It presents an opportunity to consider new regulatory approaches for 900-MHz personal radio that could avoid locking up spectrum with technologies that might otherwise be obsolete in a few years. (See VII-A and VIII below.)

33/ For example, the often-perceived conflict between spectrum efficiency (i.e., technical efficiency) and economic efficiency is an artificial condition that arises because our regulatory system does not require licensees' technical decisions to reflect the costs of failing to put their assigned channels to the highest valued use (opportunity costs), nor does it provide them (or allow them to generate) economic signals about the spectrum's opportunity cost. A discussion is beyond the scope of this paper. But see Douglas Webbink, "Frequency Spectrum Deregulation Alternatives," Working Paper No. 2, Office of Plans and Policy, Federal Communications Commission (October 1980), passim and references cited therein.

34/ In some low-density areas, it may be possible that a frequency-hopped 27-MHz system could provide confidential voice communications in competition with rural telephones and/or the rural radio service.

B. CRS Goals

As noted above (Section III-A), the official FCC goal of CB and GMRS is directed, short-distance, low-cost communications for both personal and business uses. Although promulgated to avoid potential congestion, some CB and GMRS regulations hinder achievement of this goal. For example, telephone interconnection in the CB service must be performed by someone at a base station; it may not be automatic. Interconnection is forbidden altogether in GMRS. Such restrictions limit the utility of CB and GMRS as low-cost personal communications and therefore run counter to the main goal of the two services. Proponents of interconnection restrictions say they reduce usage demand, especially for long conversations, and therefore reduce the congestion on these frequencies. This line of argument is perverse, however, because it condemns a technique on the grounds that it improves service. That is, users would view interconnection as a quality improvement for the service, so they want to use the service more. Normally one condemns rules that reduce service quality, not activities that improve it. If quality-improving innovations cause secondary effects like more congestion, it is probably best to look even more diligently for alternatives to deal with the congestion -- more frequencies, new technologies, or eventual ceilings on the number of licenses issued for operation in congested metropolitan areas -- rather than look for conscious means to hold down service quality. (In any event, congestion on CB and GMRS frequencies may now be so high in large urban areas that interconnection might not have a greatly noticeable effect.)

Another example of "anti-quality" bias is the rule on station identification. CB stations are required to "ID" at the end of each transmission even

though, as a practical matter, the rule is virtually unenforceable (and probably ignored by a majority of licensees). This rule alone appears to prevent Commission type-acceptance of frequency-hopping 27-MHz equipment; and the implicit prohibition of digital CB transmissions probably rules out efficient trunking systems. 35/ Existing hardware could probably be adapted quickly and economically to provide hopping or trunking capabilities in 27-MHz equipment, with perhaps significant quality benefits to CB operators in many (relatively non-congested) areas of the country. Absent some of the current rules, market forces might well lead in a few years to commercial equipment with such features. The benefits, measured against the goal of low-cost personal communications, could be substantial.

At a more general level, the Commission's service-oriented spectrum allocation approach is also sometimes at odds with the goal of low-cost personal communications, especially given the possibilities opened by today's technologies. The Commission's basic approach has been to allocate different amounts of spectrum to different services -- private landmobile, common carrier landmobile, personal, broadcasting, private fixed, common carrier fixed, and so forth -- as determined largely by two factors: (a) international treaty obligations and (b) the Commission staff's perception, as influenced by public comment, interest group lobbying, and congressional

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35/ Frequency hopping and trunking are explained below in Section VII-A. The rules do not specifically say digital transmissions are illegal, but they authorize only AM and SSB voice transmissions. In addition to facilitating trunking, the legalization of digital transmission could be linked with an ATIS system (see Section VIII-H below) and perhaps make ID requirements not only enforceble, but also useful in locating illegal interference.

pressures, of various "needs." The problems that arise from treaty obligations are probably manageable at modest cost and need not be of great concern here. But the Commission's attempts to gauge needs frequently create problems in achieving its public interest goals -- not just in personal radio. This traditional system for spectrum allocation has been criticized before, and we need not reproduce all the arguments here. 36/ Among the most troublesome problems is that it offers little flexibility geographically or over time, at least not without complex and slow rulemaking procedures. Technical advances in the recent past have made the distinctions among personal radio, private landmobile, and common carrier landmobile seem increasingly artificial. As noted above in the discussion of substitute services (Section V), spectrum users often ignore these distinctions and the accompanying regulatory inflexibility, and they react with illegal operations that may fill legitimate communications needs. There is probably a very high opportunity cost to the current regulatory inflexibility. This cost may be highest in relatively uncrowded areas of the country, For example, today's off-the-shelf technology might allow people in uncrowded areas to have not only two-way radios in every car, with full automatic interconnect to the telephone system, but also low-cost "walkie-talkies" that for some people might even replace the home telephone. (Cf. Section VII-A, below.) But today's current policy of national uniformity in allocations would probably

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36/ See, for example, Ronald H. Coase, "The Federal Communications Commission," Journal of Law and Economics, II (1959), 1-40; or Harvey J. Levin, The Invisible Resource (John Hopkins Press, 1971), esp. chaps. 2 and 9. The situation today is virtually the same as when these two works were written.

not allow people in Nevada to have such a service if there were potentially serious congestion problems associated with its use in New York. Moreover, a new application of technology along these lines might not fit neatly into any of the current definitions of personal radio, radio common carriers, or fixed services, so that its proponents might not fare well competitively before the FCC in seeking spectrum. We make three tentative conclusions: (1) A system like this might some day offer benefits to consumers on the order of billions of dollars annually, including benefits in terms of user flexibility and wider consumer choice. (2) It ought not make a difference whether a service like this is called "personal radio" or "common carrier," or whether it uses personal radio frequencies, common carrier frequencies, or some mixture of them. And (3) such a system may be quite unlikely, as long as the current service-oriented approach dominates spectrum allocation. 37/

As noted above, recreational uses have never been officially or explicitly recognized by the Commission as goals for CB radio. Yet they have become de facto equal to CB's officially recognized "communications" goal both in the public's (licensees') mind and in the Commission's actual regulatory practices. Realistic policymaking should not ignore it. Among the CB rules that prevent full recreational use of these channels are the prohibitions on (a) communications beyond 250 kilometers, (b) communications with foreign stations, 38/ (c) music and one-way and other broadcast-like transmissions,

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37/ Service-oriented eligibility requirements often prevent spectrum from being put to its most valuable uses across the board, not just in areas like personal and landmobile radio.

38/ The FCC does not currently have clear legal authority to permit widespread international communications in the CRS, due to prohibitions in the existing international regulations (which have treaty status).

(d) remote control, and (e) transmissions longer than five minutes. Although these rules were instituted to reduce spectrum congestion, they are probably not enforceable today. Congestion is now so high on 27-MHz CB that it is hard to imagine their removal would make a noticeable difference. Furthermore, the current mandatory channel plan probably inhibits CB from achieving its full recreational potential and is probably without corresponding benefits in reducing congestion. We doubt that it would be missed.

C. Goals of the Amateur Service

A number of regulations seem inconsistent with the goals of the Amateur Radio Service. They probably no longer serve any useful purposes either because of technological advances or because they were based in the first place on overly pessimistic predictions of troubles that might arise. Although individually these regulations are not serious constraints to goal achievement, collectively their impact may be significant. They are symptomatic of the numerous petty federal regulations so unpopular these days among the American body politic.

As an example of regulations based on overly pessimistic predictions, consider the prohibition on amateurs' handling messages related to the business of any third party (Sec. 97.114c). Originally, amateurs were merely prohibited from receiving compensation (direct or indirect) for handling third-party traffic. The FCC adopted the much more stringent prohibition with the explanation that third-party business-related traffic would lead to unacceptable levels of interference and congestion. In doing so, the

Commission banned not only commercial traffic per se, but also messages related to the regular business of charitable institutions like eye banks and the Red Cross. 39/ This regulation also has been interpreted as preventing even such "business-related" messages as summoning wreckers via amateur radio to the scenes of automobile accidents. This restriction works at cross purposes to the public service goal of amateur radio. It also works to some extent against the goal of international goodwill, as for example when it prohibits carrying certain messages for scientific expeditions, missionaries, and Peace Corps volunteers. 40/ Perhaps worst of all, it is just one more federal regulation without a good deal of meaning. In short, the stringent rules against third-party traffic probably lack any important relationship to congestion in the amateur bands.

Other rules that appear to be counterproductive include (a) the present requirements on station identification, which appear to prevent efficient use of packet-switching and similar digital techniques; (b) restrictions on automatic repeater operations, which limit operations to certain frequencies (there appears to be no particular reason, for example, to keep repeaters completely off all HF bands except 29.5 to 29.7 MHz -- again, the blanket argument about congestion is simply not convincing) and may also inhibit or prevent such novel technologies as packet switching and "electronic mailboxes"

39/ 37 F.R. 21997 (1972).

40/ But see footnote 56 below.

on HF; 41/ (c) other repeater rules that require separate control operators at certain times, whereas sufficient control can probably normally be achieved by the operators actually talking on a repeater; 42/ and (d) implicit restrictions against spread spectrum modulation and similar novel technologies.

Another serious constraint upon amateur radio, especially upon its technological goal, is the implicit statutory requirement that the FCC be able to monitor the content of amateur transmissions. This situation arises from the statutory prohibition on amateur stations' being used for the licensees' financial gain. Furthermore, the vast majority of amateurs surely would not want their bands unguarded against encrypted business traffic. These requirements have led the Commission so far not to authorize most codes (other

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41/ On HF bands except ten meters, repeaters offer few attractions per se. But cross-band repeater operations, with HF equipment accessible by small VHF transceivers, could be quite attractive. Such cross-band operations are implicitly forbidden by current rules. See Sections 97.3(1), definition of "repeater operations," and 97.61(c). Packet switching and certain types of electronic mailboxes would require automatic operations to repeat transmissions. They both use single frequencies for input and output, unlike conventional two-channel repeaters. Packet techniques use extremely high-speed data transmissions to relay bursts ("packets") of data or text. Electronic mailboxes may store data or text for retrieval upon demand by addressees. They might store information in a computer memory as ASCII, Morse code, conventional teletype (Baudot), digitized voice, or some combination; and they could be used for either point-to-point or point-to-multipoint messages (or both).

42/ In any event, we think the liability for all illegal transmissions via repeater should always be on the station originating the illegal transmission, never on the repeater licensee. With this rule, it is hard to see why the FCC should care about separate control operators. (Repeater owners, of course, might want to have separate control circuits and operators, to guard against malicious interference. But the choice should be left up to them, rather than have the FCC impose it upon every repeater operator uniformly.)

than ASCII and Baudot) and some other digital techniques, since they might serve to hide commercial traffic on amateur frequencies. Furthermore, the Commission has for the time being restricted use of ASCII to certain speeds. This restriction also simplifies the Commission's monitoring task. So there is perhaps an inevitable trade-off between enforcement and technological innovation.

VII. Recommendations

A. Permitting New Technologies for CRS

The FCC is now considering the establishment of a new personal radio service at 900 MHz (Docket 79-140). Several new technologies that are feasible at 900 MHz may offer opportunities to create novel types of personal radio communications with (a) good security from malicious interference, (b) reasonable degrees of privacy, and (c) efficient spectrum use. Moreover, such characteristics could give a new service marked utility in all sorts of business applications as well as in strictly personal communications. Therefore the technologies discussed below have the potential to weaken many present distinctions among personal, business, industrial, governmental, and similar categories. Such a weakening might justify a fairly generous spectrum allocation to an improved personal radio service. That is, if prospective business licensees could obtain reliable and private communications services with low-priced "mass market" equipment on 900-MHz personal radio frequencies, they would probably see a correspondingly smaller need for dedicated channels

and other special privileges. Non-interference and privacy would probably be the key determinants of such a new service's utility in business applications. 43/

Good examples of promising technologies for private, interference-free, and reliable 900-MHz personal radio are wideband modulation (i.e., spread spectrum) and trunking. 44/ Current CRS rules preclude these technologies in CB and GMRS. Both may now be ready for commercial applications in personal radio, thanks to the possibilities of low-cost integrated circuitry. There may be no good reason why the two could not co-exist peacefully on any given frequency band and in the same geographic location, along with other technologies like one-channel voice or data and conventional two-channel repeater operations. Therefore serious consideration should be given to a "deregulatory" type-acceptance program for 900-MHz personal radio that would specify only (a) out-of-band emission levels and (b) in-band total emitted energy limits. Of course, the elimination of standards could create at least a few problems. Mandatory standards, such as those the Commission has promulgated for CB in the past, may have benefits as well as costs. For

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43/ It has been suggested that without eligibility requirements (for example, to exclude business firms), an improved personal radio service might be taken over by users that value spectrum most highly, perhaps to the exclusion of the small-scale "personal" users for whom the band was originally established. In the authors' opinion such a development could be good rather than bad, insofar as it might indicate an increase in total spectrum efficiency. Nonetheless the FCC might legitimately wish to make a political decision to "subsidize" small-scale users and treat 900-MHz personal radio something like a national park where businesses could not intrude. This issue clearly merits wider public discussion.

44/ A brief introduction to spread spectrum communications can be found in P. L. Rinaldo, "Spread Spectrum and the Radio Amateur," QST, Nov. 1980, pp. 15-17. An overview of potential civilian spread spectrum applications is contained in a recent report for the FCC; W. C. Scales, Potential Use of Spread Spectrum in Non-Government Applications (see footnote 46). In addition, the Commission is exploring this area in a Notice of Inquiry in General Docket 81-413, ___ F.R. ___ (1981). An exhaustive technical examination of spread spectrum is R. C. Dixon, Spread Spectrum Systems (John Wiley & Sons, 1976).

example, they have probably made it more difficult for users to operate their equipment on unauthorized frequencies or in other interference-causing ways. Such matters should be carefully weighed as part of any deregulatory program. On balance however, and relative to the current system, the gains to users from a flexible, deregulatory approach like the one recommended here could far outweigh the potential difficulties. In particular the Commission's setting mandatory modulation and channel standards for a 900-MHz personal service might limit user flexibility. Given the speed with which electronics technologies are advancing today, the geographic and socioeconomic diversity of the United States, and the political/bureaucratic problems of federal regulation, a Washington-imposed set of standards would not likely be in the public interest. 45/

45/ It has been argued that government-mandated standards can benefit both consumers and manufacturers by eliminating uncertainties and allowing everyone to have compatible equipment from the beginning, rather than have to wait for the market to settle on superior technologies and standards. Also it has been argued that government-mandated standards can sometimes protect consumers from the danger that a powerful firm might impose its own standards in order to create or maintain a monopoly position. However, neither technical uncertainty nor monopoly is particularly threatening in the 900-MHz context. Initial 900-MHz licensees will probably use conventional channelized FM, with "band plans" established by manufacturers or user groups. So standardization and the attendant economies of scale should be achievable even without an FCC mandate. And although the absence of mandatory standards has occasionally resulted in some conflict among users of different types of modulation in both amateur radio and CB, it seems the "best" modulation schemes by and large have come to dominate bands in both services. Therefore we conclude that neither the mere possibility of user conflict nor the absence of formal user coordination is sufficent justification for FCC-mandated technical standards. By not specifying modulation, the Commission would allow techniques other than FM to be used whenever they become cost-effective to individual users. Moreover, in this type of deregulatory environment, it seems unlikely that the equipment market could be dominated by one firm. There seems to be no significant support in serious legal scholarship or economic research on monopoly for the "monopoly-via-standards" argument. In fact, a market without government-mandated standards is likely on balance to be more competitive than a market with such standards.

1. Frequency Hopping and Other Spread Spectrum Techniques

Frequency hopping is a type of spread spectrum modulation, originally used by the military to increase communications security and resistance to jamming. It involves changing simultaneously, in lock step, the frequencies of both the transmitter and receiver in a radio link. Frequencies can be changed from a few times per second up to several thousand times per second. The information conveyed during any given second is therefore "sliced up," and the slices go out sequentially on different frequencies. The frequency hopping sequence repeats periodically, say once per second or per tenth-second. Such communications can be very secure against casual eavesdropping when the hopping sequence is kept confidential. For example, a frequency band that allowed 50 channels of acceptable bandwidth for a given modulation or data rate would allow users to choose among hundreds of thousands of possible hopping sequences -- making casual eavesdropping impractical. In addition to security against eavesdropping, this technology can offer high levels of protection against the sorts of random and malicious interference commonly found today on 27-MHz CB. But the capacity of such systems is now controversial. Experts' estimates of message through-put range from 0.3 to 5.0 times the capacity of conventional operations occupying exactly the same

spectrum. 46/ Other spread spectrum techniques might also be used. They too would offer the security and "graceful degradation" characteristics of frequency hopping. Because the benefits and costs of spread spectrum relative to conventional narrowband systems are not yet established, any Commission action that precludes the use of this technology at 900 MHz could be a disservice to the public.

2. Decentralized Trunking

A "trunked" radio system is one that gives users automated access to more than one channel, in order to facilitate message flow under congested channel conditions. It may utilize central control equipment, or it may be "decentralized" and use control equipment based on "scanning" devices in mobile units. Trunking offers less protection against interference and eavesdropping than do spread spectrum techniques, but it might be preferable

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46/ The 5.0 efficiency figure was developed in George R. Cooper and Raymond W. Nettleton, "A Spread Spectrum Technique for High Capacity Mobile Communications," IEEE Trans. Veh. Tech., vol. VT-27 (Nov. 1978), pp. 264-275. It applies to cellular systems and may not be valid for conventional systems. One examination of spread spectrum (SS) efficiency estimated spectrum efficiency of SS technology would only be about equal to conventional systems. This assumption used high data rates (32 K-bit/sec.). Even if it is accurate, there still seems to be justification for SS because of its inherent privacy and graceful degradation. See Paul Henry, "Spectrum Efficiency of a Frequency-Hopped-DPSK Spread Spectrum Mobile Radio System," IEEE Trans. Veh. Tech., vol. VT-28 (Nov. 1979), pp. 327-332. The actual efficiency of spread spectrum techniques as compared to conventional FM is a function of a number of different variables, many of which depend on the needs of users. An FH scheme as described here was examined in a recent report for the FCC (W. C. Scales, Potential Use of Spread Spectrum Techniques in Non-Government Applications, the MITRE Corporation Report MTR-80W335, December 1980, available from NTIS, Springfield, VA 22161, as Report No. PB81-165284). Estimates in this report of the maximum equivalent number of users per conventional channel for SS modulation varied between 0.3 and 1.4.

on cost grounds for some users. 47/ ("Might" is emphasized because no firm cost figures are available for either technology at mass-production levels.) Decentralized trunking works as follows: Units are able to scan a specific frequency bloc or certain discrete channels in order to locate a clear spot. (A very small number of channels -- or even one -- might be sufficient for users in rural areas, but New York City users might want to invest in 50- or 100-channel units). When someone at unit A wants to talk to someone at B, the operator of unit A needs only to know (a) the set of channels unit B is scanning and (b) B's access code. Operator A then punches B's channels and code into a memory circuit, and A's scanner locates a clear frequency, locks in, and tells the transmitter to call B. When B's scanner hears its own number, it locks in and sends A an acknowledgement signal. Then A "siezes" the channel and begins to transmit the message. Other units can be designed to stay off the channel until A and B finish their traffic. With proper equipment design, therefore, operators could be totally unaware of, and need

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47/ Conventional centralized trunking requires one or more calling channels, plus central control equipment. Trunking via scanning, or "decentralized" trunking, can be less expensive, since it requires no central control equipment. It also may be more spectrum-efficient, since it requires no calling channels. But its advantage decreases, and may eventually disappear, for large numbers of trunked channels (e.g., more than ten per system). This finding, however, depends on many assumptions about technology, message length, etc., that may not always hold. See, George Sarver and Sam Tropea, "Evaluation of Spectrum Utilization Efficiency of 800 MHz Trunked and Conventional Private Land Mobile Systems," unpublished paper, Office of Science and Technology, Federal Communications Commission, May 30, 1980. Moreover, two users of trunked personal radio who wanted to talk to one another would often not belong to the same "system," in which case decentralized trunking would be essential to them. A disadvantage may be that decentralized trunking cannot "queue" users in direct mobile-to-mobile communications, even though queuing may improve spectrum efficiency by acting as a non-price rationing device.

not interfere with, other transmissions on a shared band. It should be emphasized that trunking, repeater use, and other channelized forms of communications can still evolve orderly in the absence of Commission standards, as evidenced by the history of the amateur service.

3. The Personal Radio "Black Box"

A set of personal radio rules for 900 MHz that specified only out-of-band emission levels and in-band limits on total power emitted (or spectral power-density limits) without regard to bandwidth, channelization, or modulation techniques would allow manufacturers to sell modular "black box" transceivers capable of accepting a variety of baseband signal inputs (voice, video, data) and modulation techniques. Compatible modulation/demodulation units could be sold separately. For example, computer hobbyists wishing to communicate with one another via a radio-based electronic mail system could simply go to a local electronics franchise outlet, buy a black box plus an appropriate digital modulator/demodulator, take the equipment home, and be on the air quickly after only plugging in a home computer and antenna. Other people could buy the same model of black box, plug in a voice modulator/demodulator, and use the identical personal radio band for partyline chitchat and/or directed messages. Still others could use the black boxes plus video equipment for neighborhood television broadcasting. Any of these people could switch their black boxes among several uses merely by plugging in different modulator/demodulator units. This scenario probably can use today's state of the art, not "blue-sky" technology. Commercial applications could develop within a few years, at moderate costs to consumers, if the FCC's rules would

allow them. If this scenario should not develop, even though the rules had been changed, it is hard to imagine what society would have lost in the process.

4. Advantages of These Techniques

A major advantage of either spread spectrum or trunking is that they could be simultaneously compatible with cheap transceivers operating over narrow frequency ranges and with the most sophisticated and expensive multi-mode (data, voice, and picture) equipment. Future equipment may be economically designed so that operators can be unaware of other transmissions in a shared band. Therefore they need not care about other users as long as their equipment could find frequencies adequate for their instant communications needs. Nor should the FCC or they care whether others sharing their bands might be using simplex, repeaters, landline interconnection, encryption, or cellular operations. 48/ By allowing numerous technologies to coexist in a given frequency band, subject only to power-density constraints and out-of-band emission limits, the FCC would allow new technologies to develop naturally under the guidance of marketplace cost and demand signals, rather than be hampered as today by complex, slow, and inefficient bureaucratic decisionmaking.

5. A Proposed Type-Acceptance Criterion

We suggest that the Commission's technical regulations for a new personal radio service specify no more than total in-band and out-of-band power emission limits, rather than follow today's practice of referencing

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48/ For a discussion of cellular radio, see footnote 57, below, and accompanying text.

these limits to transmitter output carrier power. With this scheme, individual users would be free to choose -- and change -- whatever modulation types best fit their communications purposes and environments, without increasing the amount of interfering RF energy in the frequency band. The regulations could require any emission's spectral power (as might be observed on a spectrum analyzer) to be no greater than some constant when integrated over the entire band and over some time period. The comments on the Commission's 900-MHz personal radio NOI (Docket 79-140) suggested transmitter powers as high as 100 watts FM, but they clustered around 25 watts. Therefore we suggest a type-acceptance criterion equivalent to the amount of RF emitted by a 25 watt FM transmitter. 49/ Out-of-band limits could use essentially today's -60dB criterion, so that each out-of-band emission could be no more than 2.5×10^{-5} watts. Such regulations would allow manufacturers and licensees not only the options of choosing spread spectrum and other non-FM or non-voice modulation techniques, but also the option of very high power digital signals of many very short "bursts," interspersed with blank spaces, per second -- as long as the total energy per second fell within the specified limits. Or they

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49/ The total average power of an FM signal is independent of modulation index. See F. G. Stemler, Introduction to Communications (Addison-Wesley, 1977), pp. 283-284. Therefore it makes no difference whether a transmitter uses a 16F3 reference signal at 25 watts or some other F3 bandwidth at 25 watts. The larger the modulation index (i.e., the wider the occupied bandwidth of an FM signal), however, the greater the demodulated signal-to-noise ratio for a given carrier-to-noise ratio. This phenomenon is referred to as the "FM improvement factor." The improvement factor could provide incentives for users to utilize extremely wideband FM which might result in a very inefficient use of a particular band. But there is a potential offset: FM also exhibits a characteristic known as "capture" effect, which results in an FM receiver's "locking in" on the strongest signal in its IF passband. The capture effect would provide users incentives to utilize narrow IF passbands and, consequently, narrow transmitted bandwidths. One area to consider when analyzing the merits of this type-acceptance criterion is how the distribution of in-band energy may affect the response of out-of-band receivers. For instance, signals with very fast rise times that have been band-limited at RF to meet the out-of-band emission limit may still cause interference to out-of-band users whose receiver was not designed to reject signals of this type.

might choose very narrow bandwidths, say for very slow conventional Morse code, with very high carrier power.

B. Strengthening the Technical Orientation of the Amateur Service

There are a variety of opinions and explanations of why technical experimentation may have declined as an amateur radio activity and why the "ham" fraternity may contribute less to the radio art today than before World War II. FCC regulations may have played a major role, simply by not allowing new technologies (like spread spectrum modulation so far) or by allowing them belatedly (as in the case of ASCII). For example, one cannot rule out the explanation that hams in earlier days built their own equipment, by and large, out of necessity rather than by choice and that this "environmental" motivation for technical proficiency simply is now gone. Perhaps most noteworthy is that no systematic evidence or relatively "hard" data are available about what actually might motivate amateur licensees to experiment more than they now commonly do. There are arguments both pro and con on the FCC's "incentive" licensing structure, but these arguments seem never to have been analyzed professionally against data on applications, licenses issued, or education and technical activities of licensees. 50/ The time may be ripe for

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50/ As mentioned earlier (p. 16, above), limited data suggest that about 40 percent of all amateurs, and over half the Extra Class and Advanced Class licensees, work professionally in telecommunications or electronics-related fields. These data suggest that the technical skills "reservoir" of amateur radio is very large indeed. So the potential probably exists today for much wider experimentation than one now observes. Unfortunately, no time-series data are available to allow a comparison of trends since the 1930's or 40's. But we doubt that the reservoir of technical skills was much higher in the 1930's, relative to the total level of electronics skills throughout the U.S. economy. (The authors have been told informally that membership data of the American Radio Relay League -- which is amateur radio's national association -- indicated about one-half of the members were employed in telecommunications in the 30's and 40's. Unfortunately, such data allow no comparison to the total population of amateurs.)

careful, systematic analysis (perhaps backed by professional survey research) of what truly motivates or might motivate licensees to be more technically oriented. Perhaps the discussion could thereby move from the realm of opinion, to the realm of fact and analysis. A parallel systematic discussion and factually-based analysis about how current regulations can be changed to encourage the flow of new technologies into the amateur service would be useful. Furthermore, a "digital class" or similar amateur license, which could allow technically competent licensees to operate on VHF amateur bands without passing Morse code tests may be desirable. 51/

C. Liberalization or Elimination of CB Licensing

The authors are skeptical about the value of the present CB licensing scheme. The FCC has already undertaken considerable liberalization by allowing applicants to issue themselves temporary licenses. Complete

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51/ The amateur service would probably be enhanced by an influx of computer hobbyists--individuals who have both the knowledge and desire to utilize the amateur bands for technically innovative communications, but who have no requirement to utilize Morse code. The International Telecommunications Union's Radio Regulations, which have treaty status and thus are binding on the United States, require that amateur licensees know Morse code for operation below 30 MHz. Code-free licenses are allowed, however, on VHF and higher. Perhaps two or more code-free license classes above 30 MHz should be allowed, with higher operating privileges allowed to amateurs who demonstrate higher levels of technical proficiency. Whether or not such classes are called "digital" or something else is not important. The Canadian radio authorities have established a code-free, "digital" amateur license class, under which some Canadian amateurs participate in a very sophisticated computer-to-computer trans-Canada radio network. This system relies on an advanced technology called "packet switching" which, to our knowledge, has not been used in U. S. amateur radio. (See, "DOC Creates New Amateur License Class," QST, December 1978, p. 61.)

elimination of licensing would probably require congressional action (see Section 301 of the Communications Act). The Commission might, however, take a number of intermediate steps that could have the dual advantages of (a) reducing administrative costs and (b) lightening the regulatory burden on the citizenry. Among such steps might be one or more of the following: (a) point-of-sale licensing via retailers; (b) "presumptive" licensing, whereby an applicant could rely on a certified mail return receipt to establish that the FCC has acted favorably on a license request without additional documentation; (c) similar "presumptive" renewal; (d) licensing and/or renewal via an affidavit before a local notary-public or other oath-taking official; (e) or simply a "paper" authorization issued by the user to himself similar to the current temporary CB license.

D. Other Recommendations

In addition to the recommendations above, we have several other (and less important) proposals to put the Commission's goals more in line with users' desires: more flexibility for the 27-MHz CB band; coexistence of amateur and citizens services at 900 MHz; an expansion of Technican privileges in the amateur service; full legitimization of hobby communications; and elimination of several amateur rules we consider meaningless or counterproductive. In all cases, these changes would be consistent with a general policy of deregulation, without imposing significant costs upon either the users or the government. The flexibility they introduce would constitute yet another element in an environment that allows greater use of new technologies, without actually requiring them.

1. What to do with 27-MHz CB?

A new personal radio service at 900 MHz would not make the 27-MHz service obsolete, in spite of the current levels of television interference (TVI) the service generates. Even after a 900-MHz service is available, there still may be ample justification for 27-MHz personal radio. There are, of course, intrinsic technical differences between 27 MHz and 900 MHz. These differences result not only in different equipment costs, but also in different opportunities for recreational activities on the two bands. Considerable personal demand for 27 MHz may continue into the foreseeable future. Most commercial users of the 27-MHz band seem already to have vacated it for more desirable frequencies. Probably the only users that especially want this band now are the current occupants, the CBers, plus some amateurs (from whom part of the band was taken over 20 years ago). 52/ Since there do not seem to be any net benefits from re-allocating the 27-MHz band, we recommend consideration be given to expanding its allowed uses. Specifically the FCC might wish to consider (a) elimination of the remaining "hobby" prohibitions, such as those on lengthy transmissions and long distance communications, (b) dropping mandatory channelization, (c) easing technical restrictions to allow innovative modulation schemes, and (d) expansion of the

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52/ 42 F.C.C. 874 (1958).

frequencies allocated to CB. 53/ These steps might result in a mix of users at 27 MHz that does not currently exist. Most users would continue to be CBers, but they could be joined by some hams who might see advantages operating in the CB band -- maybe with higher legal power levels or other privileges not given CB licensees.

2. Coexistence of Amateur and Citizens' Services at 900 MHz

In much the same way that coexistence between amateurs and CBers at 27

53/ The proliferation of CB transmitters after 1973 resulted in a large increase in the annual number of television interference (TVI) complaints to the FCC. Perhaps this situation indicates 27-MHz CB not only should not be expanded, but in fact should eventually be phased out. We do not think the benefits of reducing TVI by abolishing CB are likely to be worth the costs for at least two reasons: First, the number of TVI complaints from CB has levelled in recent years -- possibly an indication tightened type-acceptance limits are having some effect. Second, the enforcement and other administrative costs in re-allocating the 27-MHz band to a service other than personal radio would probably be large. But considerable expert opinion both among FCC staff and on the outside holds that TVI from existing personal radio channels is still too high. The matter of expanded personal radio causes the analysis to be even more complex and controversial: In response to a 1979 Commission directive, the FCC's Private Radio Bureau prepared a Notice of Proposed Rulemaking (NPRM) looking toward expanding the 27-MHz Citizens Band. This NPRM was discussed in an open Commission meeting on July 1, 1980. The Commission failed to adopt the proposed NPRM and directed the staff to prepare a Notice of Inquiry on the subject. Staff opposition to expansion centered on potentially increased interference to television. At present, little data exist either to support or dismiss the hypothesis of increased TVI from CB expansion, although initial FCC analysis indicates the proposed expansion frequencies are potentially an even greater threat to television reception than the existing 40 channels. On the other hand, CB expansion as proposed may not increase actual TVI dramatically. The proposed expansion frequencies are already utilized illegally today by thousands (perhaps tens of thousands) of operators with relatively high power equipment. Interference will not necessarily be made worse by authorizing frequencies that already are heavily utilized, especially if most new users are basically law-abiding operators who will use type-accepted low-power equipment. However, this decision should only be made following an in-depth analysis of the television interference potential.

MHz might be constructive, a mix of these users at 900 MHz could also have certain advantages. There might have to be some distinctions between the two services at 900 MHz since the Communications Act clearly prohibits at least some business communications to amateurs. 54/ Further, because the two groups have different relative abilities to deal with interference, the amateurs might have additional flexibility for higher power and emission limits, and use of "homebrew" equipment. The ability of the non-amateur group to communicate with amateurs might provide incentives for them to become more technically proficient or even to upgrade to amateur status. Moreover, "universal" interest in these frequencies might stimulate amateurs with technical expertise to experiment on the band, in turn developing new technologies and providing increased demand for it. Although such predictions about the prospects for such a shared band may be optomistic, there do not appear to be any significant costs or disadvantages in structuring a service flexible enough merely to allow these or similar developments.

3. Expanded Privileges for Technican Class Amateurs

The first two proposals in this section suggested linking the amateur and citizens' services both at 27 and 900 MHz, partly to provide convenient avenues for CBers to become more proficient technically. The third proposal

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54/ Since the FCC's monitoring requirements (see pp. 38-39 above) will probably rule out encryption by amateurs, their use of the band might not be as "private" as other users, for example. Other distinctions might also be required so as to not violate Section 3(q) of the Communications Act. Personal radio users cannot encrypt under present rules, but there is no statutory bar (as there is implicitly with the amateur service) to their doing so.

looks toward a change in the amateur license structure that could provide greater impetus for lower ranked amateur operators also to upgrade. The idea here is to mix Technician operators with General and higher licensees somewhere in the HF radio telephone bands. Such a link could be useful since both Novice and Technican amateurs are now severely restricted in their HF operating privileges. This situation might motivate at least some of the illegal operators continually noted on the edge of the 27-MHz Citizens Band to become amateurs and to operate legally in the HF bands. In addition, amateur VHF repeater abuse complaints are on the increase, perhaps as a partial result of unfamiliarity by new Technician licensees with the operating habits, procedures, and courtesies of more experienced hams. Allowing Technican Class amateurs to operate in at least part of the ten-meter (28.5-MHz) phone band may be helpful in solving these problems. Such a provision would expose them to a completely different set of procedures from VHF repeaters, where most Technicians now congregate. In addition, the increased operating enjoyment (e.g., worldwide communications) might well entice at least some Technicians to upgrade, in order to enjoy similar activities on other HF bands. 55/ Even those that do not upgrade could be exposed to different operating procedures and courtesies that might carry over to the VHF bands. Moreover, Novice operators would have a stepping stone for further use of their HF equipment, and they might have correspondingly stronger incentives to upgrade to

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55/ One may, of course, plausibly argue the contrary; i.e., phone privileges on ten meters might reduce Technicians' incentives to upgrade. We wonder if anyone can develop objective data on actual licensee attitudes and thereby lift the discussion from the realm of opinion to the realm of fact? And cf. Section VII-B above.

Technician. Finally, some CB operators may find the Commission's thirteen words-per-minute (WPM) Morse code requirement a barrier to entering the amateur service and enjoying HF radiotelephone communications. A lower requirement might entice some technically capable CBers into becoming licensed hams. Although a knowledge of Morse code is desirable for HF amateur operators (to recognize international emergency distress calls, for example), the five WPM Technician's level is probably adequate for such limited HF privileges as proposed here.

There are probably no significant costs to increasing Technicans' privileges in this manner (except perhaps costs of examinations to the FCC if many newcomers should apply for Technician licenses and possible slight increases in television interference). The ten-meter band is relatively vacant even during its most active periods. During its quiet time, when long-distance propagation is not present, the band is virtually unused. With an influx of new stations, quiet-time openings will more likely be noticed by some operators, and the ten-meter allocation will be more actively used in general.

4. Legitimization of Hobby Communications

At several points above we noted that FCC rules have never given explicit recognition to purely hobby-type recreational communications in either amateur or citizens radio, in spite of the fact that many, if not most, licensees use personal radio mainly as a hobby outlet. Such recreational use of the radio spectrum can be a fully legitimate "consumer good" and an appropriate goal for public policy. Some past FCC decisions on personal radio

might have proceeded more quickly and some problems might not have arisen if hobby goals had been clearly recognized in the rules. Future regulation of personal radio might be rationalized and made consistent more easily if the formal goals should recognize more accurately those actual uses that seem to be reflections of legitimate consumer demands.

5. Liberalization of Minor Rules

As noted above (Section VI-C), a number of amateur regulations seem meaningless or even counterproductive. None of these rules by itself imposes a major constraint upon the amateur service's achieving the FCC's goals for ham radio, but collectively these rules and others like them may have a significant negative impact. In any event, they tend unnecessarily to use FCC enforcement resources and contribute to the American citizenry's current distaste for federal regulation. In summary, among the rules we think should be eliminated or greatly liberalized are the following: (a) restrictions on that third-party traffic for which amateurs receive neither direct nor indirect compensation; [56/] (b) restrictions against "automatic control" and repeaters on HF, which appear to prevent not only conventional two-channel repeaters but also such (spectrum-efficient) techniques as HF packet switching and automatic "electronic mailboxes"; (c) requirements for separate control

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56/ International regulations would still oblige the United States to maintain much more stringent regulations against international third-party messages than against domestic traffic, except where the U.S. government might work out bilateral agreements with individual foreign governments for very liberal third-party message rules. See International Telecommunications Union, Radio Regulations, Chapter X, Article 41 (RR 41- 1/2), Geneva, 1975 (revised 1979). These regulations are silent on the content of amateur messages within a single country.

operators on repeaters; (d) identification requirements that hamper the use of advanced technologies; and (e) non-authorization of novel technologies like spread-spectrum modulation.

VIII. Issues About Personal Radio at 900 MHz

A highly confidential, reliable, low-cost new personal radio service at 900 MHz raises some potentially controversial issues. They include (a) the new service's relationship to cellular and other landmobile services, (b) interconnection with the telephone system, (c) appropriate amount of spectrum to use for a new service, (d) licensing and use of repeaters on the new band, (e) whether some frequencies should be set aside for "partyline" and special communications, (f) the merits of government-mandated channel designations and other "standards," (g) congestion, and (h) automatic transmitter identification systems (ATIS). These points are discussed in turn.

A. Relationship to Cellular Systems and Other Novel Technologies

The huge capacities projected by Bell Labs and others for cellular systems could, if achievable at suitably low costs, make most other landmobile services (including the kinds of personal radio systems we have discussed)

obsolete and unnecessary in urban areas. 57/ If valid market tests are possible, then personal, cellular, and other systems should compete freely with one another in the marketplace, with minimal government interference. Valid market tests may not be feasible, however, for any number of reasons. Therefore, an important issue is whether an improved personal radio service may prematurely undercut a more efficient technology like perhaps cellular landmobile (or vice-versa!).

A conflict between cellular systems and an improved personal service at 900 MHz is most likely to develop if the Commission establishes conventional channel and modulation standards for one or both services, because the standards would make it difficult to re-allocate frequencies and equipment in some manner more efficient than the originally mandated configuration. "Healthy" competition between the two services is most likely if technologies and standards are left free to develop under the guidance of market cost and demand signals. In particular there would be advantages to an approach where cellular and personal licensees could share at least some bands, for example

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57/ Cellular landmobile radio systems use many low-power transmitters in a single urban market area on the same frequencies. Each base transmitter on a particular frequency communicates with mobile units only in its own "cell." When a mobile unit crosses a cell border, it begins communicating through a different transmitter. All transmitters in a system are connected to computerized central control units via landline. Such cellular "re-use" of radio frequencies may increase spectrum capacity in a given urban area by a factor of five or more. Cf. The Bell System Technical Journal, vol. 58, no. 1 (Jan. 1979), entire issue devoted to cellular systems. At least one author predicts cellular landmobile radio could evolve into a satellite mobile communications system utilizing spread spectrum and packet switching technologies. See, Ernest R. Freeman, "Cellular Technology: It's Just The Beginning," Telocator, February 1981, p. 35. The FCC has recently issued final rules that authorize cellular radio. 46 F.R. 27655 (May 21, 1981). Fully operational commercial systems are probably at least two or three years away.

via spread spectrum modulation. This approach could allow careful phasing-in and phasing-out of different systems and licensees as customer demands, technologies, and economic conditions evolve over time. As stated above, the Commission probably cannot predict well the best uses of a particular band devoted to personal radio, as witnessed by the history of both CB and GMRS.

B. Automatic Telephone Interconnection

A personal radio service along the lines discussed above would be a natural candidate for fully automated interconnection with the landline telephone system. But it might then take on certain characteristics of common carriers and embroil licensees, regulators, and the courts in a morass of Title II questions. 58/ We are not overly concerned about the courts' and Commission's abilities to cross these bridges when they get to them, but we would encourage others to discuss the issues without waiting for them to arise in a controversial setting. We recommend a permissive interconnect stand. We are particularly interested in seeing the 900-MHz service structured in such a way that, if the users desire and if economic conditions justify, the traditional lines between private radio services and common carrier radio services could blur, and bands could be combined. Perhaps equipment could

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58/ Title II is the part of the Communications Act that sets forth the FCC's powers and responsibilities for regulating common carriers. Title III establishes the regulation of the radio spectrum. Common carriers that use radio come under both Titles II and III. Private radio licensees are regulated only under Title III. Automatic interconnection for personal radio might also raise substantial legal and economic questions as to responsibility for "switches," who must pay for what services, and how billing might be accomplished.

even be type accepted and mass produced for more than one band. This option is most likely to be attractive to manufacturers if the new 900-MHz service is allowed liberal interconnection privileges.

C. How Much Spectrum

Previous discussions of a new UHF personal radio service have assumed only a few megahertz -- say a maximum of four or five -- ever could or should be made available. While it certainly is appropriate to work through the implications of an allocation this size, much larger allocations also deserve serious consideration. Among other things, such allocations might make personal radio frequencies fully adequate substitutes for at least some of the conventional landmobile allocations at 800/900 MHz. They would also allow greater flexibility in use of non-voice and digital communications in personal activities.

D. Repeaters

The mobile-to-mobile range of medium-powered 900-MHz equipment is likely to be no more than three to five miles, without repeaters. This range compares quite well with current 27-MHz CB ranges. But repeaters can easily increase a UHF system's reliable coverage to an entire metropolitan area (e.g., the area within the Washington beltway plus a radius of five or more additional miles). The attraction of repeaters for UHF CB operations may prove irresistable. Major issues might then face the Commission concerning

whether and how such repeaters should be licensed or how they should be regulated and paid for. We believe repeaters should not be restricted in any way other than limits on total power emitted in-band and out-of-band.

E. "Partyline" Channels and Other Designations

There are some good reasons for dedicating certain channels nationally to "partyline" uses, highway communications, repeaters, or emergencies. But there are also negative aspects of channel designation. For one thing, specifying channels tends to specify the modulation used on those channels and may in fact specify the modulation for the entire band. It may not be desirable to freeze technology this way by issuing fiats from Washington, particularly when needs for various channels may differ across geographic regions and when electronics technology is subject to rapid advance. Current Citizens Band users have shown they can select channels for specific uses adequately by themselves. The same freedom might best be left to 900-MHz users -- even for emergency channels. 59/ Similarly, designation of repeater channels could be left to user discretion. 60/ User harmony on repeaters might not develop differently with or without FCC-specified channels. Again, such specification could tend to lock the service into technical standards

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59/ However, various agencies' (e.g., the Department of Transportation) or local governments' (e.g., state highway police) could still recommend specific channels for particular uses like highway emergencies communications much the way they do now for CB.

60/ It might, however, make sense to require some coordination of co-channel repeater users to control interference.

that may not remain efficient as the state of the radio art and user demands evolve over a period of years.

F. Other Government-Mandated Standards

There may be legitimate reasons to impose government-mandated standards for a new personal radio service such as calling protocols, modulation, bandwidth, and the like. However, any advantages of such standards may be outweighed by the rigidities of the current federal regulatory process, especially given today's rapidly advancing electronics technology. 61/ Voluntary government technical standards, however, should not cause any harm.

G. Congestion

An improved personal radio service might only have congestion comparable to what now occurs in conventional landmobile and 27-MHz CB. But another possibility is that the main benefits of an improved personal radio service -- its privacy, versatility, and reliability -- would encourage people to use it much more than they might use an inferior system. So its success might generate much higher congestion levels. Some people might interpret this prediction as an argument against a technically sophisticated personal radio service. Such an argument would be strained. The probable success of an approach ought to be grounds for supporting it rather than opposing it. In fact, the threat of congestion in an improved personal radio service can be an argument for pushing the concept even harder and for giving it even more

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61/ One should note that much of today's regulatory rigidity comes straight from the Administrative Procedure Act (5 U.S.C. 551 et. seq.), not from the FCC itself. Congressional action is required, therefore, to correct at least some of the current problems.

spectrum and technical flexibility than originally contemplated. If such a system became overly congested in a few large cities (New York, Los Angeles, Chicago), it might nonetheless remain highly usable in most of the rest of the country. Moreover, the Commission could retain the option of eventually limiting the number of licenses issued for operation in congested metropolitan areas. In addition, the "graceful degradation" characteristics of spread-spectrum modulation might obsolete some conventional thinking about congestion. 62/ But we urge further study, well-defined and tightly focussed, in this general topic area.

H. Automatic Transmitter Identification

An Automatic Transmitter Identification System (ATIS) could be beneficial to the community of personal radio users at large, as a means of spotting illegal operators and malicious interference creators as well as for identifying stolen equipment and for billing the use of commercial repeaters. A mandatory ATIS may not be desirable. On the other hand, it might be worthwhile to establish some type of voluntary ATIS standard. The

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62/ Conventional thinking about spectrum congestion definitely has undergone some dramatic changes over the years. For example, in 1924, Secretary of Commerce Herbert Hoover (generally considered the "father" of the type of radio regulation that was established for the FCC and its predecessor by the 1927 and 1934 acts) clearly could not imagine widespread amateur radio telephone. And something like CB was even farther from his imagination, as shown by the following statement he made to Congress: "Telephone communication [via radio] . . . is impossible between individuals from the point of view of public interest as there are a very limited number of wave lengths which can be applied for this purpose and the greater usefulness of the available wave bands for broadcasting communications inhibits their use for personal communication." Hearings before the Committee on Merchant Marine and Fisheries, House of Representatives . . . on H.R. 7357, 68th Congress, 1st Session (1924), p. 8. Yet telephony has been the primary mode of amateur communications at least since World War II, and CB and GMRS have always used telephony exclusively.

comments on the FCC's Notice of Inquiry for a new personal radio service generally favored ATIS. A voluntary standard would allow technical flexibility consistent with our other recommendations.

IX. Concluding Observations

One of the major aims of this paper has been to propose a new regulatory approach for personal radio, an approach with the fewest possible restrictions on users, uses, and technologies, in order to allow innovation, technological change, and maximum user choice. Throughout the paper have been references to regulations that may have prevented innovation. Indeed, regulation often seems to have a bias against the new. The belief that regulation may inhibit development of the radio art is hardly novel. It may be traced back at least to 1910 -- a quarter-century before the FCC began operating. 63/ Economists have also noted such bias against technical progress in fields as diverse as

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63/ The United States had no legislation to regulate radio until 1912. The 1906 Berlin Radio Conference had adopted comprehensive regulations that were ratified in treaty form by the major European nations, but the United States did not ratify. During 1910 congressional hearings on wireless, several witnesses claimed regulation might seriously impede technical progress. Mr. Cloyd Marshall of United Wireless Telegraph Company said his firm supported some legislation to overcome America's "wireless anarchy." But "we do not want the parental laws that exist in European governments, because such laws stifle the development of the industry." And Mr. James Hayden, representing the National Electric Signaling Company (founded to support the inventions of R. A. Fessenden, perhaps the most important pioneer of wireless voice transmission), claimed that U. S. adoption of the Berlin treaty "would have prevented most important improvements that have been made in the art." Moreover, "a commission . . . might make a complete system of regulations, and it might do so in a manner that would not interfere with the practice of the art as it is known to-day. But there would be infinite risk of the adoption of some regulation which would prevent most important improvements in future [sic]." Hearings Before a Subcommittee of the Committee on Naval Affairs of the House of Representatives on H. J. Resolution 95, 61st Congress, 2nd Session (1910), pp. 11 and 16-17.

surface transportation 64/ and environmental quality. 65/ One of them explains the matter this way: "Innovative behavior is forward-looking, whereas legal thinking tends to be conservative. To superimpose the continuous, orderly, and evolutionary legal perspective upon what must be a discontinuous and revolutionary process of technological innovation is to limit technological development in the regulated industries." 66/ It may be argued that a certain degree of regulatory bias against "too rapid" technological change is sometimes socially beneficial, because the public will from time to time have legitimate reasons to be wary of the risks inherent in some new technology. 67/ Obviously such a cosmic issue cannot be explored adequately in this short paper. But the "risks" inherent in new technologies for 900-MHz personal radio are probably far too small to warrant anything like the rigid channelization and modulation standards currently imposed on CB and GMRS. Amateur radio's comparative lack of regulatory standards is a far better model to emulate at 900 MHz than are the current CB and GMRS rules --

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64/ E.g., Aaron J. Gellman, "Surface Freight Transportation," in Technological Change in the Regulated Industries, ed. William M. Capron (Brookings Institution, 1971), pp. 166-96.

65/ E.g., Robert W. Crandall, "Environmental Protection Agency," Regulation, Nov./Dec. 1980, pp. 20-21. Cf. Alfred E. Kahn, The Economics of Regulation (John Wiley and Sons, 1971), vol. II, esp. pp. 147-49.

66/ Gellman, op. cit., p. 196.

67/ Cf. Bruce M. Owen and Ronald Braeutigam, The Regulation Game (Ballinger, 1978), esp. pp. 36-42.

and in fact an approach even more liberal than the amateur model may be preferable. 68/

The history and current status of personal radio clearly illustrate regulatory bias against new technology. Take specifically 27-MHz CB. It is common to encounter suggestions around the FCC that CB is not truly congested and moreover that the recent decline in CB license applications means there is no longer a great urgency to the FCC's establishing a new personal radio service at 900 MHz. It may be, however, that congestion is severe in at least some areas and that the fall-off in applications does not necessarily mean a fall-off in the public's demand for CB (since many people may simply be operating without either new or renewed licenses). But a much more important point is at stake. Even if congestion is not severe at 27 MHz, and even if the decline in CB license applications should mean a decline in public requirements for current 27-MHz CB, and even if the public should for the time being manifest little explicit interest in 900-MHz personal radio, one still ought not conclude there is no public "demand" for an improved personal radio service. As mentioned earlier, the FCC's predominant mode of spectrum

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68/ A regulatory model that is perhaps implicit in the FCC's Notice of Inquiry on amplitude-compandored single sideband (ACSB) and other new technologies for landmobile communications is closer to our recommended approach than the amateur model, insofar as it might not impose any restrictions on bandwidth or on modulation type. See Docket 80-440, 45 F.R. 63305 (September 24, 1980). Cf. Morgan O'Brien, "The Big Squeeze: What ACSB Means to the Market," MobileTimes, February 1981, pp. 17-23, for a brief, optimistic discussion of ACSB's potential to revolutionize the entire landmobile market. We generally share the optimism about ACSB. With appropriate regulatory flexibility, ACSB might become technically and economically feasible for 900-MHz personal radio. (Current technical constraints may limit its first commercial applications to VHF, however.)

allocation is to have staff members rely on written comments from the public, plus various lobbying pressures and their own professional judgments, to assess the spectrum "needs" of various radio services. The histories of CB and GMRS appear to show how difficult it is for this allocation methodology to assess the public's true desires and legitimate uses for personal radio frequencies. Not the least of the reasons for the system's drawbacks is that it can overlook or downplay too easily the latent consumer demand for a new technology or service.

For example, if consumers do not know about state-of-the-art communications technologies that might allow highly reliable, confidential, and low-cost personal radio, then they can hardly be expected to besiege the Commission with persuasive written comments favorable to a new service concept. Of course, firms that might profit from sale of equipment for a new service may (and do) petition the FCC for appropriate rules changes. But such lobbying campaigns can be expensive, not to mention highly uncertain in outcome. They often may be distinctly unappealing to firms that cannot afford high-priced legal talent or that do not have strong patent protection. The result, once more, can be a systematic regulatory bias against the new, probably to the detriment of the public. 69/

69/ Historic studies of the innovative process indicate that the sources of new goods and services are highly unpredictable. Sometimes they come from large corporations, sometimes from small firms, sometimes from the lone "madman." Diversity may be the rule, not the exception. See the classic study by John Jewkes, David Sawyers, and Richard Stillerman, The Sources of Invention, 2nd edition (Norton, 1969). A regulatory policy favoring large firms that can afford expensive Washington lobbying and lawyering obviously can cut the public off from otherwise important sources of new products and ideas, such as small firms and individual inventors.

It may be too much to ask that regulation take strong affirmative steps to develop new technologies and other new approaches for personal radio. It is not, however, too much to ask that regulation simply not stand in the way of the new. The tack recommended above for personal radio, which is basically the use of only in-band and out-of-band power emission limits to set the technical parameters of a new service, is a feasible and appropriate way for regulation to "stand aside" and let the natural play of technological and economic factors shape a new personal radio service over a period of years. This approach probably has much greater promise than do current regulatory models to harmonize the goals with the regulation of personal radio. And even if the flexibility we recommend does not lead to the use of important new technologies for personal radio, it is doubtful that any significant harm would be inflicted on the public in the process.

About the Authors

Alex D. Felker is an electronics engineer in the FCC's Office of Plans and Policy. He has previously worked in the Commission's Field Operations Bureau in the Long Beach, California, and Norfolk, Virginia, District Offices, where his activities included CB and amateur radio enforcement and investigation. Earlier he worked in the FCC's Common Carrier Bureau and Emergency Communications Division in Washington. He received the B.S.E.E. from the Virginia Polytechnic Institute and State University in 1972.

James A. Brown, Jr. is an economist in the FCC's Office of Plans and Policy. He has been employed also by the U.S. Agency for International Development, the Institute for Defense Analyses, and Soochow University (Taiwan). He received the B.A. from the University of Mississippi in 1962 and the Ph.D. from Duke University in 1966.

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