DOCKET FILE COPY ORIGINAL

RECEIVED

JUN 1 4 2000

FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
INQUIRY REGARDING SOFTWARE DEFINED RADIOS	)	**ET Docket No. 00-47**
	)	

To: The Commission

COMMENTS OF ARRL, THE NATIONAL ASSOCIATION FOR AMATEUR RADIO
IN RESPONSE TO NOTICE OF INQUIRY

ARRL, THE NATIONAL ASSOCIATION FOR AMATEUR RADIO
225 Main Street
Newington, CT 06111-1494

BOOTH FRERET IMLAY & TEPPER, P.C.
5101 Wisconsin Avenue, NW
Suite 307
Washington, DC 20016-4120
(202) 686-9600

June 13, 2000

No. of Copies rec'd 0+4
List A B C D E

Table of Contents

Summary	i
I. Introduction	1
II. SDRs in the Amateur Service	2
III. Interoperability Issues	5
IV. Spectrum Allocations Issues	7
V. Equipment Authorization Issues	8
VI. Conclusions	11
Exhibit A	

SUMMARY

ARRL, the National Association for Amateur Radio (ARRL), submits its comments in response to the *Notice of Inquiry* (the Notice), FCC 00-103, released March 21, 2000. The Notice seeks comment from the public on various issues related to software-defined radios (SDRs). ARRL is most interested in this proceeding, not only because of the utility of the Amateur Service as a testing ground for different configurations of SDRs, but also because of the potential long-term opportunities for SDRs to effect substantial changes, even conceptual changes, in traditional frequency assignment and spectrum allocations decision making in all services.

The Amateur Service is a fertile testing ground for SDR technology, which is the subject of current experimentation and development of hardware and software. The flexible regulations, shared frequency allocations, and the multiplicity of transmission modes in common use in the Amateur Service constitute the proper environment for the development and deployment of SDR equipment. SDR technology would be especially useful in amateur radio disaster relief and emergency communications. In the future, interoperability between and among amateur stations and public safety agencies and other agencies served traditionally by radio amateurs will be enhanced by SDRs. This technology will allow even greater participation by amateurs in restoration of communications systems following a wide-area emergency or disaster, and in conducting disaster relief efforts on-site in coordination with served agencies.

While SDR technology is likely to enhance spectrum efficiency, regulatory changes at the outset should be relative to the frequency assignment process and those necessary to permit different, flexible transmission modes, so as to accommodate dynamic frequency and bandwidth selection. There are no allocations changes necessary in the future in order to implement SDR technology in given radio services. It is important in the Amateur Service to avoid creating regulatory obstacles antithetical to experimentation and flexibility in conducting amateur operations. Therefore, equipment authorization requirements should not be imposed on SDR hardware or software for use in amateur communications on amateur bands.

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
INQUIRY REGARDING SOFTWARE DEFINED RADIOS	)	ET Docket No. 00-47
	)	

To: The Commission

COMMENTS OF ARRL, THE NATIONAL ASSOCIATION FOR AMATEUR RADIO IN RESPONSE TO NOTICE OF INQUIRY

ARRL, the National Association for Amateur Radio (ARRL), by counsel and pursuant to Section 1.430 of the Commission's Rules (47 C.F.R. §1.430) hereby respectfully submits its comments in response to the *Notice of Inquiry* (the Notice), FCC 00-103, released March 21, 2000. The Notice seeks comment from the public on various issues related to software-defined radios (SDRs). ARRL is most interested in this proceeding, not only because of the utility of the Amateur Service as a testing ground for different configurations of SDRs, but also because of the potential long-term opportunities for SDRs to effect substantial changes, even conceptual changes, in traditional frequency assignment and spectrum allocations decision making in all services. In response to the issues raised in the Notice, ARRL states as follows:

I. Introduction

1. ARRL's understanding of SDRs presently is that they are, in essence, digital computers connected to an antenna, controlled by software. Presently, most software receivers have an analog front end consisting of band-pass filtering, a low-noise RF amplifier to set a low system

noise level, and a local oscillator and mixer to heterodyne the signal to an intermediate frequency where analog-to-digital (A/D) conversion, digital filtering and demodulation takes place. Recently, however, there have been developed some software receivers that perform A/D conversion immediately after the antenna.

2. The Commission's Notice first asks a series of questions concerning the technical state of the art. For example, the Notice asks what features in a radio are apt to be controlled by software, and what the limitations are in current software-defined radio technology; What capabilities could be incorporated in SDRs that are not currently available; when SDRs could be deployed commercially and for what services; and what the status is of SDRs internationally. The Notice then asks about software interoperability inter- and intra-service; new spectrum sharing opportunities and increased efficiency; and what the equipment approval process should be.

II. SDRs in the Amateur Service

3. From the perspective of the Amateur Service, most recent efforts of individual amateurs have been focused on use of digital signal processing (DSP) boards to perform digital filtering and demodulation, such as for radioteletype and data communications emissions. Manufacturers of amateur equipment have included DSP features in transceivers, with vast improvement in receiver performance, especially in high-frequency bands, in high ambient noise areas. Amateurs have found sound cards to be useful DSP engines because they are both inexpensive and ubiquitous. There is substantial work ongoing by amateurs in the development of DSP which can be run on sound cards. Programs are typically available on numerous web sites for downloading. One practical application of DSP currently is for noise reduction in low-frequency experimentation, where signals are often weak and where ambient noise is very high.

There are several DSP boards in development and use, the cost to amateurs of which is on the order of $100.00. European and American amateur experimenters have cooperated in this developmental work.

4. Amateurs have used software-*controlled* radios for several years now, but real SDR functions other than baseband DSP have not yet been incorporated in commercial and sophisticated home-made amateur communications equipment to date. The software-controlled models are traditional analog designs but typically include DSP and other software-driven features. Of course, the transponder functions of the current generation of Amateur satellites are software controlled as well. The Amateur Service, because of its present shared allocations, is the proper environment in which to develop, test and implement SDR technology, and ARRL, through its technical publication *QEX* (aimed principally at experimentation in Amateur Radio), intends to give a high profile to SDR developments in the Amateur Service.

5. The Amateur Service provides in many cases the first, and often the only, source of communications in disaster relief and wide-area emergencies. Interoperability among amateur stations active in disaster relief has historically not been a problem, due to the Service's shared allocations, the proliferation of amateurs, and the frequency agility and flexibility of modern amateur equipment. However, amateur equipment is typically not interoperable with that of public safety entities and disaster relief agencies. SDR technology provides improved opportunities for enhanced performance of amateur stations in emergency communications and disaster relief relative to served agencies. Amateur SDR equipment could be rapidly reprogrammed to be interoperable with that of served agencies such as the Red Cross, the Salvation Army, local civil defense offices, State OES offices, and public safety agencies, so as

to provide an even more immediate and adaptable source of restored communications for disaster relief coordination than heretofore. There is rarely a shortage of amateur radio operators active in disaster relief; with the advent of SDR technology, amateurs could, and would be prepared in advance to, assist in the restoration of public safety and emergency communication systems by software reprogramming of equipment without delay and use with adaptive ("smart") antennas.[1] Literally, amateur equipment would be brought in to provide almost immediate restoration of emergency communications for any served public service or public safety agency, with requisite expandability and interoperability.

6. The Commission asks what work is being done internationally relative to SDR technology. ARRL, as an individual organization and as a member (and the International Secretariat) of the International Amateur Radio Union (IARU), is an active participant in certain of the ITU Radiocommunication Working Parties, which study certain issues tasked to them by the Radiocommunication Assembly of the ITU. Working Party 8A is the group that addresses land mobile and amateur services issues. At the initiative of the Telecommunications Industry Association (TIA), Working Party 8A was tasked [through the adoption of a Question (8A.SDR)[2] by the May, 2000 Radiocommunication Assembly] with the study of software radios. The ARRL and IARU are likely to submit input papers as contributions to this study, which has just commenced. The Question asks:

---

[1] There is much study ongoing internationally in the area of adaptive antennas, including an ITU-R Radiocommunication Study Group 8 new question on adaptive antennas for mobile radio systems. Adaptive antennas would seem a necessary adjunct to SDRs.

[2] A copy of the draft version of this Question (now adopted) is attached hereto as **Exhibit A**.

A. What are the key technical characteristics?
B. What frequency bands are important to SDRs?
C. What special interference considerations may be required?
D. What are the operational implications?
E. What should be the appropriate ITU definition for SDR?
F. What considerations are necessary for compliance with regulations?

There is also some work being done in connection with SDRs within Working Party 8F, which deals with IMT-2000 and beyond, for third-generation cellular services. ARRL is also aware of work within Working Party 9C, concerning Automatic calling and link establishment (ALE), which utilizes adaptive technology in the Fixed Services.

III. Interoperability Issues

7. Though the Commission inquires whether, and to what extent, SDRs can improve interoperability between equipment and services using differing transmission standards, the ARRL's vision for the future of SDRs essentially moots this question: there need be no differing transmission standards in the future, since SDRs could be programmed to accommodate any transmission standard. Using dynamic frequency selection and smart antennas, SDRs could shift, for example, among narrowband, wideband and spread-spectrum modes, and among frequency bands, depending on the transmission path, noise levels, propagation characteristics, extent of crowding, and other factors. SDRs will be able to overcome these difficulties by shifts in transmission standards. The question concerning "uniformity in standards within or across bands" (Notice, at Paragraph 11) is likewise not necessarily relevant; the precise long-term benefit of SDRs is that uniformity in transmission standards is neither necessary nor desirable: dynamic frequency selection and mode selection offer more efficient use of a given band and greater real-time adaptability than does transmission mode standardization. Bands congested with narrowband signals might, for example, accommodate a spread-spectrum transmission more readily than

would an additional narrowband transmission. Furthermore, interoperability in the emergency alerting context might be facilitated by inclusion in SDRs of an emergency software protocol contained in a ROM, which would, upon entry by the operator of proper coding, transmit an emergency notification, with identification, on a common channel, and retain a record of such transmission, which would be preserved upon return of the SDR to normal operation. The greatest opportunity for SDRs, and the greatest benefit of the interoperability options provided by them, is for their use in emergency communications and disaster relief. Such interoperability is, incidentally, consistent with ITU Resolution GT PLEN-2/5, adopted at WRC-2000, which urges global harmonization of spectrum for advanced solutions for emergency situations, public protection and disaster relief.

8. The Commission asks whether SDRs might facilitate transitions from one technical standard to another, such as the incentives created by the Commission to convert the land mobile services toward narrowband transmissions in the Refarming Proceeding. Now, all commercial services have transitional difficulties because of embedded equipment and architecture, channelized assignments, inflexible regulations, and investment in rigidly designed hardware that requires cost amortization over time. Currently, the only way to firmly commence a transition from one mode to another is to mandate that transition by regulation. In the case of the Part 90 Refarming proceeding, the Commission did so gently, through changes in the equipment authorization process, rather than through mandatory conversion deadlines binding on licensees. The technology was not really a contributor to the narrowband conversion, and the conversion has been, to date, slow, spotty and relatively inefficient.

9. The Amateur Service does not suffer those same limitations, and therefore serves as

a reasonable paradigm for a regulatory structure that might be adapted to other services upon implementation of SDRs. There are relatively few transmission mode regulations in the Amateur Service; there exist shared frequency allocations rather than rigid, channelized operation; there are no equipment authorization regulations (with very few exceptions); and amateurs have some flexibility in their station and system architecture. Transitions from one transmission mode to another, whether triggered gradually by evolution of technology, or more immediately by software definition, can be easily accommodated in the Amateur Service. SDR technology can therefore be expected to permit easy transitions from one technology to another in the Amateur Service, but not perhaps in commercial services under the present regulatory schemes applicable to those services.

10. The Notice asks what particular means could be employed by SDRs to facilitate interoperability. From the Amateur Radio perspective, the most valuable aspects of this technology are dynamic frequency and bandwidth selection. Amateur allocations, though shared, are extremely crowded in many cases, and the means to select less-used frequencies and to adapt the transmission bandwidth to accommodate the available portion of a band would seem to enhance spectrum efficiency. Such could accommodate communications where standardized, fixed bandwidth transmissions might not otherwise be accommodated without interference on the same frequency or on an adjacent frequency.

IV. Spectrum Allocations Issues

11. It is far too early to suggest any changes in the spectrum allocation process that might prove appropriate later, as SDRs mature. ARRL envisions in the future that SDRs will, within the allocations of each radio service, provide significant opportunities for improved spectrum

efficiencies, for the reasons discussed above. Dynamic frequency selection and transmission mode selection based on monitor-before-transmit protocols will contribute to more efficient use of a given service's its own bands. A commercial licensee which has excess capacity might improve the flexibility and efficiency of use of its frequency assignments by the ability to lease that excess capacity to another user. The allocations process, however, would not be similarly affected. In the Amateur Service, essentially an experimental service and one that is obligated to provide emergency and public service communications where and when needed, there are no allocations changes that are necessitated or occasioned by SDRs at present. The non-commercial character of the Amateur Service should be kept separate from commercial uses, and separate allocations for the Amateur Service will continue to be required.

V. Equipment Authorization Issues

12. A substantial portion of the Notice addresses equipment authorization issues relative to SDRs. This is a matter of some concern to ARRL, inasmuch as amateur equipment (save for commercially manufactured receivers at VHF and above, and certain linear amplifiers) has never been subject to Commission equipment authorization requirements. Traditionally, and to the present, the Amateur Service has been exempted from these requirements. This is because amateur equipment has been either designed and built by amateurs themselves, or commercially manufactured but subject to any of an infinite number of modifications, improvements and adaptations made by the licensees which would otherwise void the equipment authorization grant by the Commission. The Amateur Service, as noted above, is essentially an experimental service, in which equipment, even if commercially manufactured, is incorporated into station architecture in different ways and improved upon by the licensees themselves. Amateur Radio is unique in

this respect among the services administered by the Commission. It is necessary to preserve and protect this flexibility, because to do otherwise would serve as a disincentive to experiment and a disincentive to conduct the technical self-training that is a hallmark of the Amateur Service; and it would make commercially manufactured amateur equipment more expensive and less useful to the licensees, because it could not be substantially modified or adapted for incorporation in other station architecture.

13. Against this background of Commission forbearance relative to regulation of amateur hardware, the advent of SDR technology raises issues as to the necessity of software registration, FCC authorization of the software, and security issues. It is ARRL's position that SDR software should presently be subject only to current Part 2 equipment authorization requirements, and that separate equipment authorization regulations, other than as noted herein, are unnecessary. The present equipment authorization requirements would be applicable to SDRs, and presumably to the combination of hardware and software that comprise an SDR system. Those systems would be tested, presumably, in the configuration and power levels that would constitute the "worst case" relative to SAR and MPE levels, out-of-band emissions, and the typical measurements applicable to grants of certification for intentional radiator devices and transmitters in services other than the Amateur Service. At present, it would appear to ARRL that the present measurements required by Part 2 of the Commission's rules would be sufficient to address the combination of hardware and software incorporated in SDRs. The Commission has recently adopted regulations for Technical Certification Bodies (TCBs) to perform testing and certification of RF equipment. There would appear no need at present to modify these procedures to accommodate the advent of SDRs.

14. It is understood that the software for SDRs could be modified and reprogrammed quickly, from remote sources. The Commission's rules presently regulate what constitutes permissive changes to certificated equipment and what does not, and the present definitions would appear adequate to address post-authorization software changes. It would not seem necessary to regulate the companies that change software, or the means by which software can be downloaded, even if effectuated through direct connection. However, because the software would be used to determine the frequency bands and frequencies on which the SDRs can operate, there is an increased risk that software could be marketed which would cause an SDR to operate in such a manner as to create interference or operate on bands that are allocated to services other than that for which the SDR was authorized in the first place. While licensees which utilize the SDR can be held accountable for such instances, that is not the most expeditious means of conducting enforcement. The manufacturers and purveyors of aftermarket software upgrades and modifications for SDRs should be held accountable for instances of out-of-band operation or interference caused directly by the use of software or software upgrades purchased or distributed from those sources.

15. Frequency blocking would appear to be facilitated by SDRs, and Commission rules could limit the configuration of software intended for certain services so as to preclude the use of the SDR in bands outside those allocated for the intended service. ARRL suggests that, by rule, software intended for services other than the Amateur Service should be configured so as to block amateur allocations. As to privacy considerations, this is not a problem in the Amateur Services, as all amateur communications are subject to monitoring. Anti-tampering or other security requirements are antithetical to the Amateur Service, because they significantly inhibit

experimentation with software and hardware. No such restrictions should be applicable to SDRs for amateur use. Authentication codes to be displayed on LCD displays in the hardware may have some justification in other services, but software experimentation in the Amateur Service would be inhibited by such a requirement, and it would appear unnecessary in the Amateur Service.

VI. Conclusions

16. The Amateur Service is a fertile testing ground for SDR technology, which is the subject of current experimentation and development of hardware and software. The flexible regulations, shared frequency allocations, and the multiplicity of transmission modes in common use in the Amateur Service constitute the proper environment for the development and deployment of SDR equipment. SDR technology would be especially useful in amateur radio disaster relief and emergency communications. In the future, interoperability between and among amateur stations and public safety agencies and other agencies served traditionally by radio amateurs will be enhanced by SDRs. This technology will allow even greater participation by amateurs in restoration of communications systems following a wide-area emergency or disaster, and in conducting disaster relief efforts on-site in coordination with served agencies.

17. While SDR technology is likely to enhance spectrum efficiency, regulatory changes at the outset should be relative to the frequency assignment process and those necessary to permit different, flexible transmission modes, so as to accommodate dynamic frequency and bandwidth selection. There are no allocations changes necessary in the future in order to implement SDR technology in given radio services. It is important in the Amateur Service to avoid creating regulatory obstacles antithetical to experimentation and flexibility in conducting amateur

operations. Therefore, equipment authorization requirements should not be imposed on SDR hardware or software for use in amateur communications on amateur bands.

Therefore, the foregoing considered, ARRL respectfully urges the Commission to focus attention on the Amateur Service as an "incubator" for development of SDR technology and initial implementation, and for its use as a regulatory model for implementation of SDR technology in other services in other bands. ARRL also suggests that any proposed rules for SDR technology be consistent with these comments.

Respectfully submitted,

ARRL, THE NATIONAL ASSOCIATION FOR AMATEUR RADIO

225 Main Street
Newington, CT 06111-1494

By: _____
Christopher D. Imlay
Its General Counsel

BOOTH FRERET IMLAY & TEPPER, P.C.
5101 Wisconsin Avenue, NW
Suite 307
Washington, DC 20016-4120
(202) 686-9600

June 13, 2000

EXHIBIT A

ANNEX 11

Source: Document 8A/TEMP/99

Chairman, Radiocommunication Study Group 8

DRAFT NEW QUESTION ITU-R[8A.SDR]*

SOFTWARE DEFINED RADIOS

The ITU Radiocommunication Assembly,

considering

a) that considerable research and development has been done on Software Defined Radio (SDR) design;

b) that SDRs may offer design and operational versatility and flexibility in mobile radio systems;

c) that SDRs may facilitate spectrum efficiencies in complex mobile radio configurations;

d) that SDRs offer intersystem interoperability in disaster and emergency situations;

e) that SDRs may facilitate the regional and global harmonization of wireless communications;

f) that SDRs may provide for improve manufacturing economies of scale;

g) that SDR design can provide users with more operational features;

h) that Recommendations on SDR design would be complementary to other ITU-R Recommendations on mobile telecommunications,

decides that the following Question should be studied

1 What are the key technical characteristics that are associated with the design and application of SDR?

2 What frequency band considerations are important to the application of SDR?

3 What special interference considerations may be required in SDR applications?

4 What are the operational implications of SDR to mobile radio systems?

5 What should the appropriate ITU definition for SDR be?

6 What technical considerations are necessary to insure conformance with ITU Recommendations and Radio Regulations?

* This Question should be brought to the attention of Radiocommunication Study Groups 1 and 9.

further decides

1 that the results of the above studies should be included in one or more Recommendations and in a handbook;

2 that the above studies should be completed by the year 2003.