

The “Ham and SDR Sandwich”

Innovation and Enforcement Issues for Free and Open-Source Software on Software-Defined Radio Devices

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“Innovative Approaches to
Defining Spectrum Rights “

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The Prominent Disclaimer...

The opinions expressed are those of the author and do not necessarily represent the views of the Federal Communications Commission or the United States Government; The Maureen and Mike Mansfield Foundation; or any Japanese Ministry or the Government of Japan.

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What's the gist of the Ham and SDR Sandwich?

- SDR is an amazing “disruptive” technology much like the internet.
- Free and Open Source Software was a big contributor to that success.
- With the emergence of SDR platforms, FOSS is poised to make great contributions as Moore's Law meets Marconi.
- Crafting the regulatory environment so innovation and prevention of harmful interference both work is a difficult problem.
- My proposal: the motivational and cultural synergies of FOSS suggest FOSS innovation can thrive under the existing Amateur Radio licensing scheme.

Spectrum Reform

- Increasing demand for spectrum
- Exploring options for better:
 - Access,
 - efficiency, and
 - interference resolution
- Strong Focus on New Technology
- Software-Defined Radio, et al, Are Key Consideration

Promise of SDR, et al for New Approaches to Spectrum Use

- SDR can provide a platform for new:
 - Technical approaches
 - *(Listen before talk, ATC, advanced sensing)*
 - Regulatory Approaches
 - *(Ix temp, dynamic coordination, “White Space”)*
 - New Economic Models
 - *(real-time spectrum markets, real-time leasing)*
- SDR can also change how radio's are made...

Promise of SDR, et al for Innovation in Radio Design

- Software can focus on Logical Tasks not on interfacing with Physical Elements
 - How to create the “Software-Defined Engineer”
 - Without neglecting The “Software-Defined Lawyer”
 - Both are important to spectrum reform
- SDR platforms offer new balance of cost and performance considerations for Radio Design
- SDR allows new look at business case
 - Expertise, available technology

HAM Radio Innovation & Experimentation in Radio

- Amateur Radio's Fundamental Charter
- Long History of innovation and cultivation of wireless comm engineers
- Decline in engineering aspect and impact on Amateur's role

Moore's Law and Communications

- Moore's Law Already Met Ma Bell
 - Comm Infrastructure radically changed by software
 - Internet and impact of Software on Wired Comm
- FOSS's Role in Internet and Impact
 - FOSS helped build the Internet
 - FOSS stands poised to make contributions to SDR

The Regulators Juggling Act

The Difficult Balance

Balancing flexibility and protections for harmful interference

- Flexibility

- Promotes new approaches
- Allows new uses
- Reduces burden on new development

- Protections against “Harmful Interference”

- Ensures reliability of spectrum and investment
- Protecting the existing uses

- The How and When of regulating harmful interference

Device-Oriented Approach

- Historical problems with Enforcement
- Expansion of FCC jurisdiction
 - Birth of the Marketing rules
- Shifting Enforcement risk from field to the lab
 - Advance review and compliance with technical rules

Prelude to Device-Oriented Regulatory Approach

- Modern device certification rules responded to Congressional action amending the Communications act to provide the Commission greater authority to address interference problems.
- Late 1960's Congress deliberated on impact of harmful interference emitting from malfunctioning or manipulated devices
- Cited interference caused to air-safety-related emergency communications and other frequencies at a California facility by 58 garage door openers
- Lead to the adoption of amendments in 1968 to section 302 of the Communications Act of 1934, expanding the FCC's authority to address harmful interference concerns from non-compliant devices

Device-Oriented Approach as a “Pre-Check”

- Check for compliance with appropriate technical rules so as not to cause harmful interference.
- A “pre-check” on the harmful interference potential of devices.
- Work together with the technical rules to prohibit the use of equipment which causes interference to radio communications.
- Shift some enforcement risk from the field (costly and difficult to resolve), to the lab (advance review can allay the risk of potential interference occurring in the field)
- Technical or other rules address harmful interference during actual operation, but also enforced via the certification process confirming conformity

2001 SDR Proceeding's Definition

- Changes to the equipment authorization rules first attempt to define this balance
- defined software defined radio as a
 - transmitter in which the operating parameters of frequency range, modulation type or maximum output power (either radiated or conducted) can be altered by making a change in software that controls the operation of the device without making any changes in the hardware components that affect the radio frequency emissions.
- Definition was permissive allowing manufacturers the choice of declaring a device an SDR
- Most significant among the rules changes created the "Class III change"
 - streamlined procedure for obtaining approval for changes to the software

Cognitive Radio!!

- Expanded scope of the inquiry into SDR and related technologies to explore potential benefits of sophisticated software for improving the spectrum marketplace.
- Notice sought comment on:
 - the capabilities of cognitive radios,
 - permitting higher power by unlicensed devices in rural or other areas of limited spectrum use,
 - enabling the development of secondary markets in spectrum use, including interruptible spectrum leasing,
 - applications of cognitive radio technology to dynamically coordinated spectrum sharing,
 - software defined radio and cognitive radio equipment authorization rule changes.
- 56 parties filing comments and 14 parties filing reply comments, varied highly technical and pure economic or policy nature comments

Cognitive Radio R&O Certification Rule Changes

- New mandatory Definition and “hardening” changes require that:

“software that controls the RF operating parameters is *designed or expected to be modified by a party other than the manufacturer* to comply with the rules for software defined radios, including the requirement to incorporate security features to prevent unauthorized modifications to the software”

- Relaxed “source code” requirement
 - A high level operational description of the software controlling the radio’s RF characteristics
 - Require a description of the software security measures employed to prevent unauthorized modifications

Limited exceptions to Certification

- Statutory and FCC exemptions offer FOSS developers flexibility in developing certain SDR
- Part 97 Amateur Radio Services are subject only to limited Part 2 requirements
- Home-built devices are excluded from equipment authorization requirements.
 - (a) Equipment authorization is not required for devices that are not marketed, are not constructed from a kit, and are built in quantities of five or less for personal use.
 - (b) It is recognized that the individual builder of home-built equipment may not possess the means to perform the measurements for determining compliance with the regulations. In this case, the builder is expected to employ good engineering practices to meet the specified technical standards to the greatest extent practicable. The provisions of Sec. 15.5 apply to this equipment.

Practical problems for Home-Built Exemption

- Development of wireless hardware is not an easy task.
 - Amateur community today, most radios in use are manufactured “shacks” and Johan Costas SSB's adoption Dilemma
- The many projects that are readily available are directed at Amateur licensees in spectrum FOSS developers would not be legally permitted
- Projects not usable in the Commission's Part 15 frequencies
- No “kits” permitted so roll from scratch or naught

Theoretical problems for Home-Built Exemption

- Technical potential of software makes SDR so important to spectrum reform and undue focus on hardware development robs SDR *software* development of its central strength.
- Requiring FOSS developers to first acquire expert hardware wireless engineering fabrication skills before entering the wireless software dev not consistent with policies for encouraging SDR development
- Thus, as a practical matter home-built designs are out of reach of most developers, and as a regulatory matter off-the-shelf or kit development approaches are not permitted without teeing up Commission certification

Other Certification Problems

- Digital Millennium Copyright Act (DMCA), individual software experimentation that circumvents “copyright protection schemes” are subject to strict legal sanctions
- The SDR software hardening scheme would likely involve a protection scheme that by definition is not only designed, but Commission rule *required*, to protect the software of the device
- SDR software modifications raise certain DMCA legal interpretation concerns.

SDR Modification with authorization of grantee

- The rules do not prohibit the modification of the software outright but require a modifying party to assume the regulatory burdens of certifying the modified SDR
- “responsible party” exists to responsible person for initial and subsequent technical compliance of the device.
- Rules allow a grantee to “authorize” modifications to SDR software
- However: “[a]n equipment authorization issued by the Commission may not be assigned, exchanged or in any other way transferred to a second party, except as provided in” Section 2.929 of the rules.

SDR Modification with authorization of grantee

“The grantee of an equipment authorization may license or otherwise authorize a second party to manufacture the equipment covered by the grant of the equipment authorization provided: (1) The equipment manufactured by such second party bears the FCC Identifier as is set out in the grant of the equipment authorization. (2) The grantee of the equipment authorization shall continue to be responsible to the Commission for the equipment produced pursuant to such an agreement.”

- Manufacturers may wish to enlist the assistance of the FOSS community for collaborative work where strong relationships with FOSS developers exist use of this rule is likely.
- However, grantees might be reluctant to maintain responsibility for the third-parties software modifications and assume “fees and filling” regulatory burdens on behalf of the third-party.

SDR Modification with authorization of grantee

- Absent collaborative relationship where grantee authorizes and assumes the regulatory burdens for FOSS modifications, FOSS developers would be required to assume the role of “responsible party” and comply with the rules

The “responsible party” and Certification

- Rules permit FOSS developers to independently modify SDR software, but the rules would again pose difficulties for the individual FOSS developer in particular. The first matter is one of economics
 - Application require fees, [\$400] filling fee for some modifications
- The nature of FOSS licenses is specifically designed to address problems of how to share code
- Role of the “responsible party” in certifying and maintaining approval of a device is a burden that FOSS developers may find too much trouble to get involved in wireless innovation.

Pt. 15 and Real-Time Use

- Current market in unlicensed devices excellent illustration of the effectiveness of the above approach of balancing flexibility with reasonable protections against harmful interference
- Balance of the Part 15 rules provides significant regulatory flexibility promoting real-time spectrum access, at the cost of technical flexibility and real-time spectrum efficiency
- Pt. 15 devices are ubiquitous, and widely used in every demographic of the U.S. public

Pt. 15 and Real-Time Use

- WiFi, Bluetooth, etc. technical rules in Part 15
- Rules allow spectrum use without an individual license subject to various conditions
- Use of spectrum under Part 15 rules are subject to the general conditions of operation in Section 15.5.
 - denies any use constituents any vested or recognizable right to continued use of any give frequency.
 - operations do not enjoy protection from harmful interference
 - subject to the condition that it not cause harmful interference and must cease operation when notified it may.

Pt. 15 and Real-Time Use

- Rule that WiFi, Bluetooth and many other unlicensed applications operate under allows two flavors of spectrum protocols that balance allowable power and bandwidth
 - frequency hopping and digitally modulated intentional radiators
- Technical provisions prevent harmful interference and other problems such as
 - spectrum hogging (bandwidth and timing)
 - congestion (timing and channelization)
 - transmissions of a certain breadth, with a certain separation, and certain degree of randomness in selecting operating frequencies
 - minimum 6 dB bandwidth of at least 500 kHz with regard to the output and are also subject to a power spectral density requirement the further defines the acceptable bandwidth power relationship

Pt. 15 and Real-Time Use

- For bulk of consumers this balance is appropriate one
 - Has yielded tremendous benefits and satisfied FCC's obligations under the act to
 - “maintain the control of the United States over all the channels of radio transmission; and to provide for the use of such channels...by persons for limited period of time, under licenses granted by Federal authority...” while at the same time “encourag[ing] the provision of new technologies and services to the public.”
- However, for FOSS software developers significant drawbacks to using the Part 15 framework for wireless software development exist
 - certification
 - Part 15 rules are not well-suited to open-ended real-time engineering experimentations.
 - drafted conservatively with a mass consumer market in mind

Pt. 15 and Real-Time Use

- Development environment of the certification and part 15 rules are not tuned for the independent FOSS entrepreneur.
- This is not a fault of the rules or the Commission but simply a function of the assumptions and balance achieved by the rules.
- Modifying the existing balance of SDR certification or other rules could pose serious risks to the overall balance achieved by the rules
- There exists an alternative...

SDR Dev on Amateur

- Important distinctions for amateur licensees and their devices make extremely attractive for many FOSS developers
- Twenty-seven small frequency bands throughout the spectrum are allocated to this service internationally
- Some 1,300 digital, analog, pulse, and spread-spectrum emission types may be transmitted
- Design, construction, modification, and repair of amateur's personal stations is encouraged, reflected by the fact that the FCC equipment authorization program does not generally apply to amateur station transmitters.

SDR Dev on Amateur

- Relative to Pt. 15, Amateur licensees have access to a liberal certification system and real-time spectrum experimentation environment.
- Real-time spectrum use and technical modifications
- Sections 97.305 and 97.305 provide broad directives for authorized emission types and standards,
- for example compare Pt. 15 technical rules with 97 def. that “[a] data emission using an unspecified digital code . . . also may be transmitted” with an authorized bandwidth 100 kHz subject to the caveat that “[n]o amateur station transmission shall occupy more bandwidth than necessary for the information rate and emission type being transmitted, in accordance with good amateur practice.”

Obtaining Amateur License

- Obtaining a license grant requires passing an examination administered by a team of volunteer examiners (VEs) for the desired class of license.
- Three classes of license, each authorizing privileges corresponding to the qualifications required from most liberal to restrictive: Amateur Extra Class, General Class, and Technician Class.

Shortcoming and Caveats

- Amateur is great for experimentation and development
- However there are restrictions on communications
 - Non-commercial basis
 - “regular basis” “reasonably be furnished alternatively through other radio services”
 - Music, no streamy HAM

Your SDR and Ham Sandwich is ready...

- Already a vibrant development community that offers newcomers to wireless software development a valuable center for technical software and hardware assistance. These projects demonstrate that synergies between the Amateur and FOSS communities already exist and are yielding important technical contributions.

Current Ham Development

- FlexRadio System SDR--Gerald Youngblood
 - PowerSDR, the device's freely distributable software meeting the GNU General Public License FOSS definition.
- DttSP, signal processing software used in the PowerSDR, is made available under a FOSS license by the DttS Microwave Society
- AMSAT, the Radio Amateur Satellite Corporation now develops and deploys all of its satellites using SDR based transponders.
- The ARRL's High-Speed Digital Networks and Multimedia (HSMM) and SDR working groups developing an Orthogonal Frequency Division Multiplexing (OFDM) based SDR modem, leverages turbo trellis coding to be largely "fading immune."

Current Ham Development

- On the FOSS development side
- GNURadio project releases a variety of transmit and receiver-side software and is heading the development of a modular SDR hardware platform called the Universal Software Radio Peripheral

Current Ham Development

- American Radio Relay League, Inc., portal of information on SDR development and active amateur work in the area via their Technical Information Service.
 - Links to the many important articles on SDR
- Dr. Michael Marcus in his article “Linux, Software Radio and the Radio Amateur” first discussing the possible synergies
- Serial articles by Leif † sbrink and Gerald Youngblood, focus on technical development of both hardware and software aspects of SDR under the Amateur regime (available at ARRL's TIS)

Conclusion

- FOSS SDR can contribute much to the development and innovation poised to revolutionize how spectrum is used
- FOSS development under an amateur licensing model can flourish under the liberal regulatory framework for technical experimentation.
- The broad influx of new engineering insights and talent will also benefit amateur radio invigorating it with new engineering talent and renewed focus on engineering innovation relevant for the modern communications world.
- Individual FOSS developers will acquire valuable new skills likewise providing a new pool of talent for the commercial, academic and government spectrum engineering communities.

Future Issues

- Petitions for Reconsideration of Cognitive Radio R&O
 - Looking at
 - Amateur Certification
 - Software Source and
 - Security
- Implementing FCC rules as “policies” and efforts toward higher-order cognitive radio processing
- Interference resolution and Dynamic Coordination

Thank You!

ご清聴、どうも有り難う
ございました！