**Reading List**

**Efficient Interference Management: Rights, Receivers and Regulation**
A Silicon Flatirons Summit on Information Policy
Tuesday, October 18, 2011
University of Colorado School of Law

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(Version 0.63)

This closed-door workshop will convene a small group of experts from government, industry, academia and civil society to explore improving the management of radio interference from legal, economic and engineering perspectives.

The goal of this meeting is to develop proposals for the effective management of adjacent channel interference through well-defined rights and effective institutions, and to explore consensus about changes in the regulatory framework that could achieve this.

This memo offers participants background reading and references.

## Contents



We have suggested priority readings below by an asterisk (thus *); for quick reference, they are:

> FCC TAC , Appendix C, "Case Studies: The Role of Receiver Performance In Promoting Efficient Use of the Spectrum" in *Sharing Working Group, White Paper, Spectrum Efficiency Metrics*, draft, September 2011 (Word Doc)
>
> Pierre de Vries, *Comparison of Receiver Standards v. Protection Limits*, September 2011 (PDF)
>
> Phil Weiser, *The Future of Internet Regulation*, February, 2009, particularly Section IV, "The Transition from Rulemaking to Adjudication at the FCC" (SSRN)
>
> Peter Tenhula, *A Prototype "Taxonomy" for Enforcement of Spectrum Usage Rights*, draft, September 2011, particularly the section "Implications for a New Spectrum Regulatory Framework" (Google Doc)

## Managing Interference due to Receivers

### *Cases*

* FCC Technological Advisory Council, *Sharing Working Group, White Paper, Spectrum Efficiency Metrics*, Draft September 25, 2011 available http://transition.fcc.gov/oet/tac/tacdocs/meeting92711/Spectrum_Efficiency_Metrics_White_Paper_by_TAC_Sharing_Working_Group_25Sep2011.doc

Please see the case studies listed in Appendix C for examples of managing interference due to receivers. For convenience, we repeat the cases and references here:

**WCS/SDARS**: *See* Report and Order and Second Report and Order in WT Docket No. 97-293, IB Docket No. 95-91, and GEN Docket No. 90-357, In the Matter of Amendment of Part 27 of the Commission's Rules to Govern the Operation of Wireless Communications Services in the 2.3 GHz Band and Establishment of Rules and Policies for the Digital Audio Radio Satellite Service in the 2310-2360 MHz Frequency Band at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-10-82A1.doc

**3650-3700 MHz/C-band earth stations**: *See* Memorandum Opinion and Order in ET Docket No. 04-151, WT Docket No. 05-96 and ET Docket 02-380, In the Matter of Wireless Operations in the 3650 – 3700 MHz band, at paras.56-60, http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-07-99A1.doc. See also NTIA Report 94-313Analysis of Electromagnetic Compatibility between Radar Stations and 4 GHz Fixed Satellite Earth Stations discussing solution of satellite receiver overload through use of filtering, http://www.its.bldrdoc.gov/pub/ntia-rpt/94-313/94-313.pdf

**AWS-1/AWS-3**: *See* Notice of Proposed Rule Making in WT Docket No. 07-195 In the Matter of Service Rules for the 2155 – 2175 MHz band, at pars. 61 – 63, http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-07-164A1.doc

**AWS-1/BAS**: *See* Report and Order in WT Docket no.02-153 In the Matter of Service Rules for Advanced Wireless Services in the 1.7 GHz and 2.1 GHz bands at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-03-251A1.doc at paras. 127 - 130.

**TV receivers/whitespace devices**: *See* generally Second Memorandum opinion and Order in ET Docket No. 04-186 and ET Docket No. 02-380 In the Matter of Unlicensed Operation in the TV Broadcast Bands and Additional Spectrum for Unlicensed Devices below 900 MHz and in the 3 GHz Band, http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-10-174A1.doc

**Analog TV receivers/taboos**: *See* http://ieeexplore.ieee.org/Xplore/login.jsp?url=http%3A%2F%2Fieeexplore.ieee.org%2Fiel5%2F5%2F31319%2F01456751.pdf%3Farnumber=1456751&authDecision=-203, and http://ecfsdocs.fcc.gov/filings/1989/02/10/107583.html

**800 MHz Nextel/Public Safety**: *See* Report and Order, Fifth Report and Order, Fourth Memorandum Opinion and Order and Order in WT Docket No. 02-55, ET Docket No. 00-258, In the Matter of Improving Public Safety Communications in the 800 MHz band, http://www.800ta.org/content/fccguidance/FCC_04-168_08.06.04.pdf

*Papers*

* Pierre de Vries, *Comparison of Receiver Standards v. Protection Limits*, available at http://www.silicon-flatirons.org/documents/Roundtables/2011.10.18-1021/ReceiverStandardsvsProtectionLimits.pdf

This document compares and contrasts two regulatory approaches to influencing receiver performance. In one, the regulator/spectrum manager specifies the *interference environment* that the victim system is expected to operate in so that the system engineer can then specify the characteristics of a receiver that can operate successfully in that environment. In the other, the manager specifies minimum *receiver characteristics*, e.g. sensitivity and front-end performance. While the advantages and disadvantages of each approach are well understood in the engineering community, more work is required to deepen understanding and reach consensus in the policy community.

Madelaine Maior, *Receiver Regulation Memorandum*, August 31, 2011, available at http://www.silicon-flatirons.org/documents/Roundtables/2011.10.18-1021/FCCAuthorityMemo.pdf

Explains Title 1 ancillary jurisdiction, which may or may not give the FCC the authority to regulate receivers. Includes discussion of how ancillary jurisdiction could apply to receiver standards, licenses, or protection limits. Presents some challenges to the FCC's authority to regulate receivers through Title 1 ancillary jurisdiction. Ultimately concludes that the best way to ensure FCC authority to regulate receivers is to enact new legislation giving the Commission explicit authority rather than having to rely on Title 1 ancillary jurisdiction.

Pierre de Vries and Kaleb Sieh, *Reception-Oriented Radio Rights: Increasing the Value of Wireless by Explicitly Defining and Delegating Radio Operating Rights* (August 8, 2011). Available at SSRN: http://ssrn.com/abstract=1907813.

"Reception protections" are defined in section 2.3, and compared with receiver protections and interference temperature in sections 2.3.1 and 2.3.2, respectively. The paper proposes a regulatory approach that increases delegation to operators and reduces ambiguity by more clearly defining operating rights and harmful interference, facilitating transactions, and making rights enforcement more efficient by enabling direct enforcement of rights, separating rulemaking from adjudication, and defining remedies up-front.

Pierre de Vries, Receiver protection limits: a better way to manage interference than receiver standards, Deep Freeze 9 blog, June 22, 2011, available at http://deepfreeze9.blogspot.com/2011/06/receiver-protection-limits-better-way.html.

An argument against receiver standards and in favor of protection limits

Lewis Davies and Paul Winter (TTP), *Study of current and future receiver performance*, Report commissioned by Ofcom, January 2010, available at http://stakeholders.ofcom.org.uk/binaries/research/technology-research/receiver.pdf.

> This study examines improving the performance of radio receivers in consumer equipment such as TVs and cellular devices. It focuses on the cost / performance trade-off to make a receiver less susceptible to interference from other frequency bands, based on technologies that can be envisaged over the next ten years. An indication of how this might change over the next twenty years is also given. The executive summary, pp. 3-7, provides a good overview. Chapter 2 provides background on receiver selectivity considerations, and Chapter 3 surveys receiver architectures.

Alakanada Paul et al. (2005). *Interference protection criteria: Phase 1 - compilation from existing sources*, NTIA report 05-432, available at http://www.ntia.doc.gov/osmhome/reports/ntia05-432/IPC_Phase_1_Report.pdf.

> NTIA launched a two-phase study of interference protection criteria (IPC) in 2004. The goal was to compile, explain and validate, modify or supplement the levels of protection from interference that are generally expected and provided for various radio communication systems. NTIA reviewed publications of national, international, public and private organizations to compile established IPC for various radio services operating between 30 MHz and 30 GHz, and presented the results in this Phase 1 report. (The second phase, never completed, was to have reviewed the relevant federal government policies and practices regarding IPC and recommended regulatory and technical refinements.) The level of detail required to specify IPCs is evident in the tables throughout this report.

## Enforcement

### *Cases*

**HyeCrest/CellularVision**

In January 1991, the Commission granted the application of CellularVision's predecessor-in-interest, HyeCrest Management, Inc., for a license to provide LMDS in the 27.5-28.5 GHz frequency band covering New York City. The application was granted pursuant to waiver of the point-to-point rules in Part 21 in order to allow a fixed cellular point-to-multipoint operation for video distribution (wireless cable). Many other entities subsequently applied for similar waivers. The LMDS rulemaking proceeding was initiated by three petitions for rulemaking concerning the 28 GHz band. The Commission found in the *LMDS Second NPRM* (1994) that the majority of parties supported the Commission's finding of widespread interest in point-to-multipoint uses of the 28 GHz band, but also found significant interest in the band on the part of the satellite industry. It tentatively decided to allow both terrestrial and satellite providers to co-exist in the 28 GHz band, and decided to begin a negotiated

rulemaking procedure to develop technical rules for sharing the band. After more to-and-fro, the *LMDS 2nd Report and Order* was published in 1997.

Peter Tenhula has observed (personal communication, 4 October 2011) that this case is interesting because (1) it involved sharing between unlike services (satellite and terrestrial), with many, disparate interests trying to get access to the same frequency band for different uses; (2) it was unique in using negotiated rulemaking; and (3) it showed how an initial waiver (cf. FleetCall/Nextel/ESMR case) quickly leads to a prolonged rulemaking.

> In the Matter of Rulemaking to Amend Parts 1, 2, 21, and 25 of the Commission's Rules to Redesignate the 27.5-29.5 GHz Frequency Band, to Reallocate the 29.5-30.0 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service [LMDS] and for Fixed Satellite Services, *Second Report and Order* in CC Docket No. 92-297, FCC 97-82 (March 1997) ("*LMDS 2nd Report and Order*"), *available at* http://wireless.fcc.gov/auctions/17/releases/fc970082.pdf.

**5GHz U-NII/TDWR**

In early 2009, the FAA became aware of interference to Terminal Doppler Weather Radars (TDWRs) that operate in the 5600– 5650 MHz band. Investigation by NTIA ITS staff traced it to unlicensed U–NII DFS devices operating in the same frequency band. On July 27, 2010, the Enforcement Bureau and the Office of Engineering and Technology issued a memorandum providing guidance to manufacturers and operators of U-NII devices.

> John E. Carroll, Frank H. Sanders, Robert L. Sole, Geoffrey A. Sanders, NTIA Report TR-11-473, *Case Study: Investigation of Interference into 5 GHz Weather Radars from Unlicensed National Information Infrastructure Devices, Part I*, November 2010, available at http://www.its.bldrdoc.gov/pub/ntia-rpt/11-473/
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> Memorandum from Julius Knapp and P. Michele Ellison, *Elimination of interference to Terminal Doppler Weather Radar (TWDR)*, July 27, 2010, available at http://www.fcc.gov/eb/uniitdwr.pdf.

**DARS Terrestrial Repeater STAs**

In 2001, the FCC granted XM Radio, Inc. special temporary authority to operate Satellite Digital Audio Radio Service (SDARS) complementary terrestrial repeaters in its exclusively licensed satellite frequency band, 2332.5-2345 MHz. WCS licensees raised concerns about the potential for blanketing interference. FCC found that it was in the public interest to grant the STA. There were allegations that the two satellite radio providers were violating the terms of the STA; the Commission eventually acted as part of the Sirius/XM merger.

> *Proceeding*: In the Matter of Establishment of Rules and Policies for the Digital Audio Radio Satellite Service in the 2310-2360 MHz Frequency Band, Report and Order, May 24, 2010, available at http://fjallfoss.fcc.gov/edocs_public/attachmatch/FCC-10-82A1.pdf.
>
> *STA*: In the matter of XM Radio Inc. Application for Special Temporary Authority to Operate Satellite Digital Audio Radio Service Complementary Terrestrial Repeaters,

File No. SAT-STA-20010712-00063, September 17, 2001, available at http://transition.fcc.gov/ib/files/9_17_01/sta_order_sep1701_signed.pdf.

*Testimony of Commissioner Tate that Sirius Satellite Radio had "failed to comply*—knowingly and repeatedly—with the specifications for its FM modulators and the terms of its Special Temporary Authorizations": Sirius Satellite Radio Inc., Order, 23 FCC Rcd. 12,301, 12,324 (Statement of Commissioner Deborah Taylor Tate), available at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-08-176A1.doc.).

*Consent decrees*: XM Radio, Inc., *Order*, 23 FCC Rcd. 12,325, 12,347 (2008) (with XM); 23 FCC Rcd. at 12,324 (with Sirius), available at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-08-177A1.doc.).

**Puerto Rico WISPS: Islanet vs. Neptuno**

In 2006, Neptuno Media filed applications seeking to make modifications to two of its common carrier fixed point-to-point microwave stations. Islanet, Inc. filed a petition to deny the applications. Islanet argued that because Neptuno had been found previously to be willfully and repeatedly violating section 301 of the Communications Act, it did not have the requisite character to be granted the modifications at issue. The FCC denied Islanet's petition to deny the application on the grounds that there was insufficient evidence to conclude that Neptuno would fail to comply with the Commission's rules in the future.

In 2009, World Data PR Inc. filed applications to register base/fixed stations under its nationwide license at twelve locations in Puerto Rico. Neptuno Networks filed petitions to deny the applications. Neptuno claimed that World Data had been violating the sharing agreement in place in the 3650-3700 MHz band. The parties requested a meeting with the FCC to discuss the problem. The FCC denied the petitions to deny the applications on the grounds that there was insufficient evident to conclude that World Data would fail to comply with the Commission's rules in the future.

For a summary and discussion, see Matthew A Montgomery, *Draft Petition for Notice of Inquiry to solicit public comments about the adequacy of the enforcement procedures used to resolve spectrum interference conflicts*, Samuelson-Glushko Tech Law & Policy Clinic, CU Law School, January 2011, not published, available at http://www.silicon-flatirons.org/documents/Roundtables/2011.10.18-1021/Montgomery.pdf

NAL, File No. EB-06-SJ-022 (Jan. 23, 2007), available at http://www.fcc.gov/eb/FieldNotices/2003/DOC-269874A1.html.
In Re Neptuno Media, Memorandum Opinion and Order ("MO&O"), (Apr 23, 2007) available at, http://fjallfoss.fcc.gov/edocs_public/attachmatch/DA-07-1808A1.pdf.
Neptuno Petition to Deny against World Data (In Re World Data PR, Inc., Memorandum & Opinion Order (MO&O), ¶ 1 (Dec. 29, 2009), http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-09-2626A1.pdf). See also CU Law Comments in ET 10-253.

**Qualcomm/MediaFlo Petition for Declaratory Ruling**

Qualcomm acquired licenses in the lower 700 MHz band. Qualcomm's subsidiary, MediaFLO, planned to operate a nationwide multimedia mobile network to deliver video, audio and data to third-generation mobile phones. Qualcomm sought a declaratory ruling on two issues: (1) that OET-69 is an acceptable basis for demonstrating compliance with section 27 60, and (2) that for purposes of making engineering showings pursuant to section 27 60(b)(I )(iii), predicted interference to not more than two percent of the population served by a TVID TV station is de minimis and therefore acceptable. The FCC held that: "As Qualcomm requests, we declare that . . . (OET-69), with certain modifications, is an acceptable methodology . . . for demonstrating compliance with incumbent broadcaster protection requirements. We decline to establish through declaratory ruling a de minimis exception to the section 2760 interference protection criteria. However, we find it in the public interest to grant a waiver to Qualcomm providing a measured approach towards the requested de minimis interference exception, whereby the percentage of permissible interference incrementally increases each year from the release of this order until the end of the DTY transition."

Peter Tenhula has observed (personal communication, 4 October 2011) that what started out as an adjudication involving one party's particular licenses and a seemingly appropriate application of the OET-69 methodology, ultimately acquired elements of a rulemaking: Commission-level action at an open meeting, ex parte status, heavy lobbying (cf. notes and cites/links to Tenhula's Appendix A (Google Doc) to his "Taxonomy" paper (q. v. below) about how quickly the proceeding was commenced and how long before action was taken by the full Commission).

> In the Matter of Qualcomm Incorporated Petition for Declaratory Ruling, 21 F.C.C.R. 11683, October 13, 2006, available at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-06-155A1.doc.

*Papers*

* Phil Weiser, *The Future of Internet Regulation*, February 16, 2009, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1344757

> Please refer to Section IV, entitled "The Transition from Rulemaking to Adjudication at the FCC," starting in page 47. The paper looks at the problem of how the FCC can oversee Internet connectivity disputes and makes three suggestions about how to best go about approaching such disputes. Weiser suggests that (1) the FCC should act as a "norm entrepreneur", meaning that the regulator should identify areas where cooperation is needed and outline the broad terms that should govern that cooperation, (2) the FCC should use a model of co-regulation that involves a private sector collaborative body operating under its oversight, and (3) the FCC should act with ex post adjudicate authority rather than ex ante rulemaking authority in conjunction with the private sector collaborative body to resolve cooperation failures. Weiser argues that this approach could be widely applicable to all sorts of disputes, not necessarily just Internet connectivity disputes.

* Peter Tenhula, *A Prototype "Taxonomy" for Enforcement of Spectrum Usage Rights*, Draft v. 1.0, September 2011, available at https://docs.google.com/document/d/1OgbVgCi42a91F1hng7x9BYxUfUl9p1vTiMTTWnUc9gw/edit?hl=en_US#.

> Argues that more efficient, transparent, and equitable processes are needed to help parties negotiate with each other. Looks at the problem of enforcement by classifying three different types of disputes: (1) establishment of new rights, (2) modification of existing rights, and (3) enforcing existing rights. Suggests that by taking a systematic approach and evaluating some current case studies, developing better enforcement mechanisms will be easier. Recommendations are given in the section "Implications for a New Spectrum Regulatory Framework"

Matthew A Montgomery, *Draft Petition for Notice of Inquiry to solicit public comments about the adequacy of the enforcement procedures used to resolve spectrum interference conflicts*, Samuelson-Glushko Tech Law & Policy Clinic, CU Law School, January 2011, not published, available at http://www.silicon-flatirons.org/documents/Roundtables/2011.10.18-1021/Montgomery.pdf.

> This draft petition was drafted by Matt Montgomery, now a graduate of CU Law School, while part of the Samuelson-Glushko Tech Law & Policy Clinic (TLPC), working under the supervision of Brad Bernthal. It is still in draft form; please do not distribute without permission of the TLPC.
>
> The draft petition argues that the FCC should reexamine its existing enforcement and dispute resolution mechanisms in order to adapt to an environment where more intensive and dynamic spectrum activity is likely to increase the frequency of spectrum rights disputes. It recommends that the FCC (1) implement an Accelerated Spectral Docket modeled after the Enforcement Bureau's Accelerated Docket for formal complaints against common carriers; and (2) accord precedential authority to orders issued by the Accelerated Spectral Docket.
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> It discusses a number of cases; of particular interest to this meeting, since they are not covered elsewhere, are the Neptuno/Islanet and Neptuno/World Data cases, discussed in Section II. B., pp. 17-24.

United States Government Accountability Office, Report to the Chairman, Subcommittee on Telecommunications and the Internet, Committee on Energy and Commerce, House of Representatives, *FCC Has Made Some Progress in the Management of Its Enforcement Program but Faces Limitations, and Additional Actions Are Needed*, February 2008, available at http://www.gao.gov/new.items/d08125.pdf.

> Concludes that the FCC needs better data management systems in place and more well-defined strategy and specific goals in order to better manage its enforcement activities. Please look at the list of possible FCC actions on page 10, Table 2 on page 21, and the discussion of the problems with equity and transparency on page 27.

Ellen P. Goodman, *Spectrum Rights in the Telecosm to Come*, San Diego Law Review, Vol. 41, No. 269. (2004), available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=484922.

Goodman explores the legal structures and rules that will be necessary to relieve decision makers of the public interest balancing the FCC undertakes today in distributing spectrum entitlements. She concludes that a nuisance-like common law, as applied to spectrum, will require its own public interest standard, and that the development of liability standards and nuisance remedies will be difficult and costly. She argues that the costs and indeterminacy of dispute resolution could be reduced with the development of a hybrid approach that combines the strengths of regulation and the common law. Such an approach might involve defining categorical nuisances in spectrum and establishing presumptions as to the appropriate entitlements in different kinds of interference disputes.

Section IV. C. 2 surveys a series of FCC cases, categorizing the remedies using the Calabresi & Melamed "four rule" taxonomy.

## Recap: Conclusions from Previous Meetings

### 2009 Meeting

Event web page: http://www.silicon-flatirons.org/events.php?id=761

Pierre de Vries, *Radio Regulation Summit: Defining Inter-channel Operating Rules A report on a Silicon Flatirons Summit on Information Policy, held 8/9 September 2009*, available at http://www.silicon-flatirons.org/documents/misc/OOBSummit/Inter-channelSummitReportv1.0.1.pdf (Report on the 2009 meeting)

There was consensus that increasing service diversity, flexible license rights, and the shift to mobile and ad hoc operation had brought the industry to an inflection point where past methods of governance were no longer adequate. Attendees felt that properly defined rules and rights could shift some of the coordination burden from regulators to the market.

The participants agreed that interference problems were rooted in boundary conflicts between different technical architectures and/or commercial interests. However, there was no agreement on whether the problems exemplified in the case studies were due to poorly defined rules or some other cause, e.g. poor governance or commercial self-interest.

The role of receiver performance in interference was a recurring theme. There was broad support for taking receivers into account more explicitly when drafting rules, for example by regulating resulting signal levels rather than in terms of the customary rules on individual transmitters. However, there was debate about implementation, particularly the difficulties of using models rather than measurement to determine interference.

**2010 Conference**

Event web page: http://www.silicon-flatirons.org/events.php?id=862

Matthew Montgomery, *The Unfinished Radio Revolution: New Approaches to Handling Wireless Interference*, available at http://www.silicon-flatirons.org/documents/conferences/2010.11.12-862/TheUnfinishedRadioRevolution.pdf

> Rapporteur's report on the conference. The participants identified a wide variety of challenges facing the FCC and proposed a variety of intriguing solutions. Although there was no grand consensus, four overarching themes emerged from the discussion: (1) radio rights must be defined clearly, predictably, and objectively; (2) there is a wide range of views regarding the need to define harmful interference; (3) private dispute resolution and negotiation should be broadly enabled by the FCC, especially with an eye towards facilitating market transactions; and (4) the FCC should articulate specific policies to address institutional constraints and reforms, such as dealing transparently with decisions about the equitable distribution of rights.

Kaleb A. Sieh, *Perspectives on Radio Operating Rights*, available at http://www.silicon-flatirons.org/documents/conferences/2010.11.12-862/PerspectivesonRadioOperatingRights.pdf

> Rapporteur's report on the discussion at a luncheon meeting following the conference.

J. Pierre de Vries and Kaleb A. Sieh, *The Unfinished Radio Revolution: Eight Perspectives On Wireless Interference*, 9 J. on Telecomm. and High Tech. L. 501, available at http://jthtl.org/content/articles/V9I2/JTHTLv9i2_DeVries.PDF

> Papers presented at the 2010 conference. The event set out to address the key unanswered question: How should radio operating rights be defined, assigned, and enforced in order to obtain the maximum benefit from wireless operations? The papers are summarized on pp. 501-504. The first outlines current consensus and lessons learned so far; the next five papers make proposals for improving rights definitions; and the last two delve into practical considerations for day-to-day regulation.