Receivers, Interference, and Regulatory Options: A Silicon Flatirons Roundtable
13 November 2012
Co-sponsored by CTIA and Public Knowledge

Reading List

This closed-door roundtable will convene a small group of experts from government, industry, academia, and civil society to focus on the technical aspects of receiver-oriented regulation, particularly regarding rights definition and enforcement. The goal of the meeting is to deliver an assessment of some options for including a receiver perspective in regulatory action and provide a recommendation to the FCC on potential next steps.

This memo offers participants background reading and references, which have been organized in reverse chronological order. We have marked priority readings with an asterisk (*); for quick reference, they are:

- FCC TAC, *Spectrum Efficiency Metrics* (Sharing Working Group draft White Paper, 2011), available at http://transition.fcc.gov/oet/tac/tacdocs/meeting92711/Spectrum_Efficiency_Metrics_White_Paper_by_TAC_Sharing_Working_Group_25Sep2011.doc. See Appendix C: collection of instances where receiver performance played a significant role in spectrum allocation decisions

- FCC TAC, *Working Group Reports* (Technical Advisory Council Working Group, Sept. 2012), available at http://transition.fcc.gov/bureaus/oet/tac/tacdocs/meeting92412/TAC-9-24-12-Presentations.pdf. See slides 115-127 for the report by the Receivers and Spectrum Working Group

- FCC, *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, Notice of Proposed Rulemaking, Docket No. 12-268, (released Oct. 2, 2012), available at http://www.fcc.gov/document/broadcast-television-spectrum-incentive-auction-nprm. See particularly Section VI. B. 5. a. on guard bands.

Readings

Michael J. Marcus, *Instrument Landing System Receiver Standards: A Case Study of Receiver Regulation and Its Difficulties* (2012), available at http://www.siliconflatirons.com/documents/conferences/2012.11.13 Spectrum/FM ILS_controversy.pdf

- The adjacency of the aviation Instrument Landing System (ILS) to the FM broadcast band results in a possible vulnerability of ILS receiver intermodulation response to new or modified FM transmissions.
- ILS receivers that conform to ICAO immunity standards do not suffer interference. The FCC has not implemented an NPRM to require only ICAO-complaint receivers in US aircraft.

* Federal Communication Commission, *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, Notice of Proposed Rulemaking, Docket No. 12-268, (released Oct. 2, 2012), available at http://www.fcc.gov/document/broadcast-television-spectrum-incentive-auction-nprm.

- The NPRM addresses the many aspects of conducting incentive auctions to free up spectrum for wireless use in the UHF broadcast bands. Relevant areas regarding interference management include Section VI. on reconfiguring the UHF band, particularly Section VI. B. 5. a. on guard bands.

* Federal Communications Commission, Technical Advisory Council, *Working Group Reports to the TAC* (Technical Advisory Council Working Group, Sept. 2012), available at http://transition.fcc.gov/bureaus/oet/tac/tacdocs/meeting92412/TAC-9-24-12-Presentations.pdf.

- Slides 115-127 describe the work of the Receivers and Spectrum Working Group, which recommends clarifying, up-front, who will bear the cost of mitigating harmful interference in specific situations, and encouraging the application of new receiver technology.
- Slides 119-123 recommend the creation of an FCC web portal to serve as a central information source for standards/recommended practices on receiver interference immunity characteristics for different services as a service planning tool
- Slides 124-127 recommends the adoption of interference limits policy

Julius P. Knapp & Mindel De La Torre, *The LightSquared Network: An Investigation of the FCC's Role* (Sept. 21, 2012), available at http://energycommerce.house.gov/sites/republicans.energycommerce.house.gov/files/Hearings/OI/20120921/HHRG-112-IF02-WState-JKnapps-20120921.pdf.

- "The GPS-MSS conflict involves unfiltered or poorly filtered GPS legacy devices bleeding into the spectrum of neighboring users, with the result being receiver overload."
- "Manufacturers and service providers have the relevant information, and they also have the incentive to notify the Commission of potential for receiver overload so as to avoid problems with their services and products."

Pierre de Vries, *Receiver Interference Limits: An Introduction* (Sep. 17, 2012), available at https://skydrive.live.com/view.aspx?resid=AA1CB774A83FAE22!1124&cid=aa1cb774a83fae22&app=Word.

- Four-page introduction to interference limits policy. Proposes bringing receivers into the regulatory picture by using interference limits, a specification of the interference signal levels that receivers need to be able to tolerate before being able to claim harmful interference.
- For more detail, see TPRC paper *Optimizing Receiver Performance Using Interference Limits*, (Sept. 19, 2012), available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2018080; slide deck available at https://skydrive.live.com/view.aspx?cid=AA1CB774A83FAE22&resid=AA1CB774A83FAE22!1899&app=PowerPoint.

Tom Hazlett & Sarah Oh, *Exactitude in Defining Rights: Radio Spectrum and the "Harmful Interference" Conundrum,"* (Aug. 14, 2012), Berkeley Tech. L. J., pre-print George Mason Law & Economics Research Paper No. 12-55, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2135098.

- Argues that poorly assigned use rights, not poor rights definitions, are not the root cause of interference problems.
- "The relevant comparison is not between approximate use rights and a theoretically ideal set of precise, fully-specified spectrum use rights covering all dimensions over which frequencies may be usefully deployed (including those yet to be discovered), but between continuing administrative control and decentralized choices made by profit-seeking operators possessing incomplete spectrum rights."
- "When regulators succeed in delegating flexible use rights to a responsible economic agent, specifically an organization constrained by profit maximization, the problems associated with "ill-defined rights" dissipate."

President's Council of Advisors on Science and Technology, *Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth*, (July 2012), available at http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf.

- "The Secretary of Commerce working through National Telecommunications and Information, in cooperation with the Federal Communications Commission, should establish methodologies for spectrum management that consider both transmitter and receiver characteristics to enable flexible sharing of spectrum," (*See* Recommendation 3.1 available on pg xii).
- See Section 3.2 "The Need for Receiver Regulation," particularly section "Receiver Classes" on p. 36 that introduces decoupled receivers
- See Appendix D "Better Sharing Through Receiver Regulation" for a primer on receiver interference (Section D.2), and Table D.2 in Section D.4 that proposes different levels of regulatory intervention depending on receiver management classes and band use.

Peter A. Tenhula, *Enforcement of Spectrum Usage rights: Fair and Expedient Resolution of 'Interference' Disputes,'* (Mar. 31, 2012), Telecommunications Policy Research Conference, available at http://ecfsdocs.fcc.gov/filings/1989/02/10/107583.html.

- Tenhula develops a taxonomy to evaluate the resolution of harmful interference disputes. He proposes that identifying case studies in each of three main categories of conflicts and evaluating those cases will "foster development of a more consistent, data-driven analytical approach to evaluating the procedural options (or lack thereof) for resolving all types of spectrum access or interference disputes..." Three main categories of disputes to be evaluated are: (1) Establishment of new rights, (2) Modification of existing rights, and (3) Enforcing existing rights.
- Argues that enforcement, not rights definition, is the most important tool in addressing interference problems: "Notwithstanding the continuous clamor to clearly define SURs, especially those related to harmful interference, among disparate, neighboring and competing spectrum users, enforcement of those rights is equally, if not more, important."

Federal Communications Commission, *Work Group Questions Presented at 3-28-12 TAC Meeting* (Technical Advisory Council Receivers and Spectrum Working Group, 2012), Summary available at http://transition.fcc.gov/bureaus/oet/tac/tacdocs/meeting32812/Meeting-Minutes-Presentations-3-28-12.pdf.

- This TAC Working Group document represents a broad range of opinions on a variety of receiver performance issues.

- *See also,* meeting presentation available at http://transition.fcc.gov/bureaus/oet/tac/tacdocs/meeting32812/Technological-Advisory-Council-2012-3-28.pdf.

Jeffrey J. Carlisle, LightSquared Inc., *Comments in Opposition of LightSquared Inc.*, IB Docket No. 11-109, DA 12-214, File No. SAT-MOD-20101118-00239 (Mar. 16, 2012), available at http://apps.fcc.gov/ecfs/document/view?id=7021901726.

- Any concerns about the incompatibility of a limited number of GPS receivers with LightSquared's long-planned ATC operations does not constitute legally cognizable "harmful interference."

Paul G. Scolese, Coalition to Save Our GPS, *Comments of the Coalition to Save Our GPS*, IB Docket No. 11-109, File No. SAT-MOD-20101118-00239, ET Docket No. 10-142 (Mar. 16, 2012), available at http://apps.fcc.gov/ecfs/document/view?id=7021901511.

- LightSquared will cause harmful interference to GPS and there is no immediate way forward.

Department of Commerce, National Telecommunications and Information Administration, *Findings regarding the impacts of the proposed LightSquared deployment of terrestrial operations on Global Positioning System services*, (Feb. 14, 2012), available at http://www.ntia.doc.gov/fcc-filing/2012/ntia-lightsquared-recommendation-fcc.

- NTIA letter to FCC, accompanied by various test reports
- Letter notes that there are currently no federal, FCC, or industry developed GPS receiver standards (except for international standards for certified aviation devices), and that federal agencies would move forward in 2012 to develop and establish new GPS spectrum interference standards.

Madelaine Maior, *Efficient Interference Management: Regulation, Receivers, and Right Enforcement,* A report on a Silicon Flatirons Summit, held 18 October 2011 (Jan. 10, 2012), available at http://siliconflatirons.com/documents/Roundtables/2011.10.18-1021/EfficientInterferenceManagement.pdf.

- The group reached a rough consensus that receiver interference protection limits are preferable to receiver standards in regulating receiver-dependent radio interference.

* Federal Communications Commission, *Spectrum Efficiency Metrics* (Technical Advisory Council Sharing Working Group, White Paper, 2011), available at http://transition.fcc.gov/oet/tac/tacdocs/meeting92711/Spectrum_Efficiency_Metrics_White_Paper_by_TAC_Sharing_Working_Group_25Sep2011.doc.

- Appendix C presents a collection of instances where receiver performance played a significant role in spectrum allocation decisions and often related inefficiencies in the current use of the spectrum.

Joe Waz & Phil Weiser, *Internet Governance: The Role of Multi Stakeholder Organizations* (published in collaboration with Aug. 24-25, 2011 Silicon Flatirons roundtable), available at http://siliconflatirons.com/documents/publications/report/InternetGovernanceRoleofMSHOrgs.pdf.

- A research agenda exploring the utility of Multi Stakeholder Organizations (MSH) to develop standards and enforce good behavior
- Section II "What are Multistakeholder Organizations" provides a good introduction to their structure, process, subject matter and outputs.
- Section III. A. summarizes key topics regarding the characteristics, values, and best practices of MSHs, including openness, transparency and credibility.
- Waz and Weiser argue that MSHs are useful, although still developing, tools for use in Internet governance. The paper describes MSHs as organizations whose purpose is to serve a representational role for civil society and other interested parties in developing best practices and standards in Internet governance. The goal of the MSHs evaluated in the paper is to "bring some degree of order to how the Internet operates by employing fact-finding and dialogue to develop voluntary norms and best practices." Some open questions remain about how MSHs should operate. Some of the questions highlighted by Waz and Weiser include: Can MSH "build trust, knowledge, and expertise among a diverse set of interests;" and can MSH bring "greater flexibility, adaptability, speed, or efficiency to the governance process than is possible using traditional tools of government?"

Pierre de Vries, *Radio Regulation Summit: Defining Inter-channel Operating Rules*, A report on a Silicon Flatirons Summit on Information Policy, held September 8-9, 2009 (Dec. 2, 2009), available at http://siliconflatirons.com/documents/misc/OOBSummit/Inter-channelSummitReportv1.0.1.pdf.

- There was broad support among participants for taking receivers into account more explicitly when drafting rules, for example by regulating signal levels rather than in terms of the customary rules on individual transmitters.

John Pahl, Transfinite Systems Ltd., *Derivation of Power Flux Density Spectrum Usage Rights,* A technical report for Ofcom, (May 2008), retrieved from http://stakeholders.ofcom.org.uk/binaries/consultations/clearedaward/transfinite.pdf.

- This technical report provides examples of in-band and out-of-band resulting field strengths of various services that can be used to develop harm claim thresholds as part of an interference limits policy.

Department of Commerce, National Telecommunications and Information Administration, *Comment: Standards for Non-government Radio Receivers*, ET Docket No. 03-65, MM Docket No. 00-39. (Nov. 12, 2003), available at http://www.ntia.doc.gov/federal-register-notice/2003/comments-standards-non-government-radio-receivers.

- This responds to FCC 2003 NOI on Interference Immunity Performance Specifications for Radio Receivers, (see below).
- NTIA believes that receiver designs that do not take into account their operational environment are often vulnerable to interference from non-cochannel signals because of inadequate selectivity or other unwanted signal suppression provisions.
- Many recent instances of interference could have been prevented by receiver standards
- "Some examples enumerated in NTIA Report 03-404 include the following: commercial fixed-satellite service receiving earth stations that use low noise amplifiers at the antenna and have little or no filtering prior to active components, commercial digital radio relay receivers which use low noise amplifiers with little or no filtering prior to active components, consumer unlicensed Part 15 receivers such as garage door openers which use very wide bandwidths, analog television and other consumer receivers with generally very poor Radio Frequency selectivity, commercial Very High Frequency (VHF) Maritime receivers with insufficient selectivity resulting in interference from National Oceanic and Atmospheric Administration (NOAA) weather broadcasts and land mobile transmitters. Another example not mentioned in the report are wireless cable system receivers with insufficient selectivity resulting in interference from Air Traffic Control radars in the 2700 to 2900 MHz band," (See IV.)

Department of Commerce, National Telecommunications and Information Administration, *Receiver Spectrum Standards: Phase I - Summary of Research into Existing Standards*, NTIA Report 03-404 (Nov. 2003), available at http://www.ntia.doc.gov/files/ntia/publications/ntiareport03-404.pdf.

- An inventory of existing standards, both mandatory and voluntary; covered government and commercial, and US and international standards
- Section 2 provides a useful discussion of non-co-channel interference mechanisms

Federal Communications Commission, Notice of Inquiry, *In the matter of "Interference Immunity Performance Specifications for Radio Receivers,"* ET Docket No. 03-65, (Mar. 24, 2003), available at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-03-54A6.doc.

- Seeks comments on possible methods and means of improving receiver performance (looks to incentives, guidelines, or regulatory requirements - or combination of the three)
- Powell - "rely on market incentives and voluntary industry programs to establish receiver immunity guidelines."
- FCC sought information on whether it should incorporate receiver interference performance specification into spectrum policy decisions on a broad basis.
- NTIA "applauded" the FCC for beginning to consider the adoption of receiver interference immunity standards and urged the FCC to initiate a rulemaking to adopt appropriate industry-developed voluntary standards
- Terminated proceeding on May 2, 2007 (FCC-07-79A1).
- Commenters raised objections to the FCC's authority to regulate receivers and argued that receiver standards should be left to industry.

Federal Communications Commission, Spectrum Policy Task Force, *Report of the Spectrum Efficiency Working Group* (Nov. 2002), (*See* § (C)(1) Discouraging inefficient use - Receiver performance and § (C)(2) - Defining expectations), available at http://transition.fcc.gov/sptf/files/SEWGFinalReport_1.pdf.

- "The real problem with setting receiver performance requirements is how to approach each service."
- "There must be a balance between providing consistent and reasonable protection of licensee operations and enabling new use of the spectrum by systems that will not reasonably cause interference."

Federal Communications Commission, Office of Engineering and Technology, *Analysis of UHF TV Receiver Interference Immunities Considering Advanced Television* (Jan. 1989), available at http://ecfsdocs.fcc.gov/filings/1989/02/10/107583.html.

- In the early 80's, in an effort to increase available spectrum in the UHF TV bands, the FCC commissioned RF Monolithics to build a more selective TV receiver. While RF Monolithics did successfully develop and manufacture the receiver, a combination of challenges hindered actual deployment of the receivers. Michael Marcus has said that a combination of politics, lack of incentives, and failure to develop a transition plan a led to the collapse of this particular case.