

**Before the
Federal Communications Commission
Washington, D.C. 20554**

In the Matter of

Amendment of the Commission's Rules with)	
Regard to Commercial Operations in the 3550-)	GN Docket No. 12-354
3650 MHz Band)	

Comments of Pierre de Vries

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I. Introduction

My name is Pierre de Vries. I am a Senior Adjunct Fellow at the Silicon Flatirons Center at the University of Colorado, Boulder, and the Co-Director of its Spectrum Policy Initiative. I respectfully submit these comments in the above captioned proceeding as a scholar whose research focuses on ways to maximize the value of radio operations and minimize the cost of radio interference problems as increasingly diverse services are packed ever more tightly together. These comments reflect my views alone, and not those of the Silicon Flatirons Center or any other party.

In this proceeding (“NPRM”),¹ the Commission takes an important and commendable step in facilitating more intensive use of wireless technology. Packing increasingly diverse services into prime frequencies will require new ways to manage inter-service interference. Giving all parties an explicit, upfront indication of their radio rights and responsibilities would make determining liability in the event of interference a transparent and straightforward process. A clearer understanding of rights and responsibilities would also reduce the role of government by facilitating marketplace and other voluntary transactions that find the optimal balance between parties’ interests without involving the regulator.

As the NPRM notes,² the Receiver Working Group of the Federal Communication Commission (“FCC” or “Commission”) Technological Advisory Council (“TAC”) has developed “an approach based on interference limits that would establish expectations as to the

¹ Amendment of the Commission’s Rules with Regard to Commercial Operations in the 3550-3650 MHz Band, GN Docket No. 12-354, *Notice of Proposed Rulemaking*, 12 FCC Rcd 15594 (rel. December 12, 2012) (“NPRM”).

² *NPRM* 12 FCC Rcd at 15639, ¶ 141.

signal levels each service should expect to tolerate in order to have a valid claim of harmful interference.”³ While the NPRM builds on the PCAST recommendations regarding spectrum sharing and small-cell architectures,⁴ the PCAST Report also recommended the use of receiver interference limits.⁵ This filing outlines how the interference limits policy approach described in the PCAST Report and elaborated upon in the TAC White Paper can be applied in this proceeding.

The PCAST and TAC recommendations flow from the fact that harmful interference arises from the interaction between transmitter and receiver characteristics. Harm claim thresholds, the interfering signal levels that must be exceeded before a service can claim harmful interference (described in more detail below), can be used to establish an optimal and explicit balance between transmission permissions and receiver protections.⁶ Harm claim threshold values can be developed using a multi-stakeholder process, reducing the role of government to the final step of enshrining them in rules.

Harm claim thresholds are not receiver standards or receiver performance mandates: operators are free to determine how to build and deploy receiving systems that can tolerate allowed interfering signals. Setting thresholds allows government to play a constructive role in

³ FCC Technological Advisory Council Receivers and Spectrum Working Group, *Interference Limits Policy: The Use of Harm Claim Thresholds to Improve the Interference Tolerance of Wireless Systems*, (rel. Feb. 6, 2013) (TAC White Paper), at 6, available at <http://transition.fcc.gov/bureaus/oet/tac/tacdocs/WhitePaperTACInterferenceLimitsv1.0.pdf>.

⁴ PCAST, Report to the President: Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth (rel. July 20, 2012) (PCAST Report), available at http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf.

⁵ PCAST Report at 33-38, 107-115.

⁶ J. Pierre de Vries & Kaleb A. Sieh, *The Three Ps: Increasing Concurrent Operation by Unambiguously Defining and Delegating Radio Rights*, 2011 IEEE SYMPOSIUM ON NEW FRONTIERS IN DYNAMIC SPECTRUM ACCESS NETWORKS 56-70 (2011) available at <http://dx.doi.org/10.1109/dyspan.2011.5936248>.

facilitating more intensive spectrum use by setting expectations for receiver performance, without becoming enmeshed in determining device specifications. Harm claim thresholds serve the public interest by enabling more intensive radio operation while preserving industry's freedom to innovate.

Service operators should be allowed to negotiate mutually advantageous adjustments to harm claim thresholds. Technology and business model innovation happens quickly; the process by which beneficial boundary corrections can be made should be streamlined to reflect this reality. Harm claim thresholds offer considerable advantages over the current basis for negotiation, the qualitative harmful interference definition of 47 C.F.R. § 2.1(c), which requires referral to the FCC for adjudication in most if not all cases that involve different services.⁷ Delegating complex engineering and business decisions such as these from government regulators to the marketplace will serve the public interest well.

Harm claim thresholds facilitate the Commission and the NTIA's task by allowing more intensive use of shared bands while protecting vital services, for example by setting exclusion zones to the minimum area that effectively protects Incumbent Access ("IA") services, and by maximizing the utility of the Priority Access ("PA") and General Authorized Access ("GAA") services.

In summary, this filing argues that explicitly defining the rights of receiving systems to protection from harmful interference lies at the heart of this proceeding. Harm claim thresholds provide a reasoned and transparent way to establish and enforce the interference protection of

⁷ Pierre de Vries, *Radio Regulation Summit: Defining Inter-channel Operating Rules*, SILICON FLATIRONS SUMMIT REPORT (2009), available at <http://www.siliconflatirons.com/documents/misc/OOBSummit/Inter-channelSummitReportv1.0.1.pdf>.

incumbent services; they also provide an objective way to protect Priority Access users from General Authorized Access users, and to coordinate the operation of GAA devices. It recommends that harm claim thresholds should be developed jointly by all stakeholders, but that the resulting values should be included in service rules. It argues that harm claim thresholds will facilitate the enforcement of interference protection rights, and contends that this approach is less opaque, rigid and economically inefficient than the status quo alternative.

II. Receivers are at the heart of this proceeding

The NPRM invites comment “as to whether there are receiver issues that need to be taken into account as we repurpose this spectrum.”⁸ The operating characteristics of receivers and the protection of receiving systems against harmful interference are at the heart of this proceeding, and are key to finding the optimal balance between the rights of incumbents to interference protection, their responsibility to deploy systems with a reasonable amount of self-protection, and the benefits to be gained by allowing the operation of additional, non-interfering systems in the same frequency band.

As the NPRM notes in the same paragraph, the FCC TAC White Paper has described an approach based on interference limits that would establish expectations as to the signal levels each service should expect to tolerate in order to have a valid claim of harmful interference. This approach, implemented using harm claim thresholds as described below, provides a transparent way to establish the interference protection of services, to calculate the operating parameters of secondary and tertiary services, and to facilitate the enforcement of rights and responsibilities.

⁸ *NPRM* 12 FCC Rcd at 15639, ¶ 141.

III. Harm claim thresholds provide a reasoned and objective way to establish the interference protection of Incumbent Access services

The NPRM requires that Priority Access and General Authorized Access users provide interference protection to Incumbent Access users.⁹ Harm claim thresholds are a quantitative statement of such protection: they give the field strength level and probability of interfering signals, both inside and over some frequency range outside the protected service’s assigned frequencies (“in-block” and “out-of-block”), that must be exceeded at more than a given percentage of locations and times, observed at a given reference height or heights, before a radio system can claim that it is experiencing harmful interference.^{10,11} Since harm claim thresholds are defined both in-block and out-of-block, they allow co-channel exclusion zones and “frequency offset” guard bands to be treated in a unified way.

Since harm claim thresholds state the interference to be delivered to the antenna without making reference to receiver operating characteristics, they can protect confidential information about receiver systems. For fixed services such as satellite earth stations, the harm claim threshold needs to be defined only at the location of the earth station. The harm claim threshold

⁹ *Id.* 12 FCC Rcd at 15613, ¶ 55 (stating that “Priority Access users would be required to provide interference protection to ... Incumbent Access users.”); *Id.* 12 FCC Rcd at 15613, ¶ 56 (stating that “GAA users would be required ... to avoid causing harmful interference to any users in those [IA and PA] tiers.”).

¹⁰ TAC White Paper at 3.

¹¹ *Id.* at 9-14. *See also* ITU Radiocommunication Sector, *Aggregate interference criteria for space-to-Earth data transmission systems operating in the Earth exploration-satellite and meteorological-satellite services using satellites in low-Earth orbit*, RECOMMENDATION ITU-R SA.1026-4 at Table 1 (giving criteria for interference into satellite earth stations probabilistically, e.g. “Interfering signal power (dBW) in the reference bandwidth to be exceeded no more than 20% of the time” and “... no more than 0.0125% of the time”)

of an earth station may need to take into account differences in antenna gain in elevation and azimuth.¹²

Out-of-block harm claim threshold profiles provide a transparent way to calculate the guard bands required by incumbent services, including ground-based and airborne radar systems, without disclosing classified operating parameters.¹³

While harm claim thresholds can be tailored to each individual installation, the Commission should define generic protection thresholds in the first instance, and customize them only to the extent that additional protection is needed. This will reduce the complexity of calculating operating permissions for secondary systems, and thus reduce information costs.

Once receiver protection has been established using harm claim thresholds, the FCC and NTIA can determine the transmit power, guard bands and mitigation responsibilities required to meet these criteria. Given the locations of Priority and General Authorized Access transmitters and appropriate propagation models, the maximum allowed transmit power of such secondary transmitters can be chosen so that the resulting aggregate field strength does not exceed the Incumbent Access user's harm claim threshold.

Since harm claim thresholds are explicit criteria, the operating parameters of subsidiary systems (whether PA or GAA) could be determined automatically and in real time by the

¹² TAC White Paper. at 23-24.

¹³ *NPRM* 12 FCC Rcd at 15617, ¶ 67 (observing that the NTIA Fast Track Report recommends “a frequency offset of 40 megahertz or 50 megahertz”).

Spectrum Access System (“SAS”) contemplated in the NPRM.¹⁴ In order to realize this functionality, the harm claim thresholds of all systems seeking protection should be included in the SAS database.¹⁵

Since harm claim thresholds represent the maximum interference that a receiving system is required to tolerate, they stand at the nexus between transmitter and receiver design. They thus allow operators in adjacent services to find the optimal balance between their interests through negotiation. As matters stand today, federal users do not have incentives to reduce their spectrum use by making such adjustments.¹⁶ However, as institutional mechanisms are developed that enable the direct negotiation of interference rights between federal and non-federal users,¹⁷ adjustments to find the optimal balance between their interests can be made without necessarily involving the FCC and NTIA.

¹⁴ *NPRM* 12 FCC Rcd at 15614, ¶ 58; For a discussion of automated systems to control inter-system interference, see J. A. Stine and S. Schmitz, *Model-based Spectrum Management—Part 1: Modeling and Computation Manual* (2011), The MITRE Corporation, available at http://www.mitre.org/work/tech_papers/2011/11_2071/.

¹⁵ *Cf. NPRM* 12 FCC Rcd at 15628, ¶ 103 (asking “what information about stations should be included in the SAS, such as geographic coordinates, type and class of station, power level, antenna height and other antenna characteristics?”).

¹⁶ *See, e.g.*, PCAST Report at 55 (stating that “[u]nder the current ‘command and control’ system, Federal users obtain no reward for reducing their own need for spectrum . . . agencies have little or no reason to invest in technologies that could improve spectrum efficiency because they see little or no benefit from any resulting economies.”).

¹⁷ *See, e.g.*, PCAST Report at 56-60 (Recommendation 5.4)

IV. Harm claim thresholds also provide a way to protect Priority Access services from General Authorized Access users, and to coordinate the operation of GAA devices

General Authorized Access users are required to avoid causing harmful interference not only to Incumbent but also to Priority Access users.¹⁸ If harm claim thresholds are defined for PA systems, then the FCC (directly or via the rules governing the Spectrum Access System database) can determine the transmit power, guard bands and mitigation responsibilities of GAA users required to meet these criteria.

If harm claim thresholds are also defined for GAA systems, then an SAS database can be used to ensure that interference between GAA devices is kept within reasonable bounds. While this would not weaken the duty of GAA users to accept interference from Incumbent and Priority Access users, it would be a way to provide “other access coordination and mitigation techniques [that] may be useful in managing access to the 3.5 GHz Band and preventing harmful interference between users”.¹⁹

V. Harm claim thresholds can be developed jointly by all stakeholders, but the resulting values should be included in service rules

The multi-stakeholder process for developing harm claim thresholds recommended by the FCC TAC White Paper is well suited to this proceeding.²⁰ As described there, a multi-stakeholder group could advise the Commission and the NTIA on the harm claim threshold

¹⁸ *NPRM* 12 FCC Rcd at 15613, ¶ 56 (“GAA users would be required to accept interference from Incumbent and Priority Access tier users and would be required to avoid causing harmful interference to any users in those tiers.”)

¹⁹ *Id.* 12 FCC Rcd at 15640, ¶ 146.

²⁰ TAC White Paper at 24-25.

parameters required to protect specific services, e.g. whether to define limits as field strength spectral density and/or aggregate field strength across an entire band, the required resolution of temporal and spatial measurements, measurement altitudes, waveform/threshold level interactions, etc. The multi-stakeholder group could also determine the values of those parameters, and decide to what extent the actual interference environment and/or interference protection criteria of incumbent systems would need to be measured and/or modeled. Finally, the stakeholder group could devise dispute adjudication and enforcement mechanisms. The recent draft report by CSMAC WG-1 on LTE operation in the 1695-1710 MHz Meteorological Satellite band is a model of such collaboration.²¹

While multi-stakeholder groups can play a vital role in developing harm claim thresholds, the outcome of their deliberations need to be included in service rules since threshold levels agreed by such a group may not reflect the interests of future users, and are not binding on them.

VI. Harm claim thresholds facilitate the enforcement of interference protection rights

As argued above, harm claim thresholds provide a reasoned and transparent way of allowing more intense, opportunistic use of shared spectrum bands while protecting Incumbent Access services and maximizing the utility of Priority and General Authorized Access services. However, the acceptance and effectiveness of any spectrum management approach, including harm claim thresholds, depends not only on effective rights definition and assignment, systems

²¹ See CSMAC, WG-1 1695-1710 MHz Meteorological-Satellite Report (draft rel. Jan. 17, 2013), *available at* <http://www.ntia.doc.gov/other-publication/2013/wg-1-report-01172013>.

design, and deployment, but also on the perception and the reality that potentially harmful interference can be detected, identified, located and mitigated promptly and predictably through appropriate enforcement actions.

The TAC White Paper provides a decision tree and supporting descriptions on how such an enforcement action would proceed using harm claim thresholds in a “base case” whose assumptions reflect the likely situation in the 3.5 GHz band reasonably well.²² However, the sixth assumption that “the interference being experienced does not produce an immediate threat to public safety services” is not applicable where IA and PA services protect public safety activities, and in these cases non-routine interventions, such as the precautionary shut-down of secondary services, may be required while the degree and extent of a harmful interference claim is being investigated.

Since harm claim thresholds are resulting signal strengths observed “in the air” at representative locations, the method does not require the observation of interference-to-noise ratios inside receivers, but lends itself to straightforward enforcement by sensor measurement, calculation of resulting signal strengths using propagation models, or a combination of the two methods. By comparison, the signal level defined by ITU-R Recommendation M.1461-1 at which radar receiver performance starts to degrade is based on an “interference-to-noise ratio at the detector input (IF output)”, i.e. in the depths of the receiver circuitry, rather than as a signal

²² TAC White Paper at 26-28; The fourth assumption that “the interference being experienced is widely distributed both geographically and temporally” is too strong, since spatially localized interference may degrade an IA service to an unacceptable degree; however, since harm claim thresholds for such users are likely to be spatially localized, too, the analysis outlined in the White Paper will go through.

level at the antenna.²³ Establishing whether this criterion has been met requires access to the receiver in question, whereas a harm claim threshold level can be measured or modeled independently of the receiver.

GAA devices deployed in very large numbers may present additional challenges to enforcement. Recent research suggests that aggregate interference from many secondary devices can be an issue for noise-limited primary systems.²⁴ A conservative choice of transmit power ceilings for GAA devices could address this concern; alternatively, a Spectrum Access System database that controls all GAA devices can be used to ensure that the aggregate interference from all GAA devices authorized at a given time and location does not exceed the harm claim threshold of IA and PA users.

Because of the precedent that the outcome of this proceeding may set for subsequent governmental actions to increase spectrum sharing in other bands and situations, the Commission and NTIA may want to consider taking a holistic look at enforcement tools and processes that can leverage the advanced technology that will be employed. For example, field measurements of intermittent interference produced at a particular time and place could be correlated with information on specific channel assignments or types of equipment contained in the SAS

²³ ITU Radiocommunication Sector, *Procedures for Determining the Potential for Interference between Radars Operating in the Radiodetermination Service and Systems in Other Services*, RECOMMENDATION ITU-R M.1461-1, at section 2.2.1, equation (4), available at http://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.1461-1-200306-I!!PDF-E.pdf.

²⁴ See, e.g., QUASAR, *Methods and Tools for Estimating Spectrum Availability: Case of Multiple Secondary Users* (rel. Mar. 31, 2012), available at http://www.quasarspectrum.eu/images/stories/Documents/deliverables/QUASAR_D5.3.pdf (stating that “Air traffic control (ATC) radars in 2.7-2.9 GHz are considered as the primary system, while low-power devices like LTE HeNBs act as secondary users for indoor broadband. The impact of aggregate interference is shown to be significant in this scenario. Large amount of additional protection margin is required to account for the high density of low-power secondary users.”).

database, thus speeding the identification and location of specific devices or types of devices that are causing interference.

VII. A harm claim threshold approach is less opaque, labyrinthine and economically inefficient than the status quo alternative

Since harm claim thresholds explicitly set the occurrence probability, field strength and observation protocol of the level of interference that will be deemed harmful, they are a transparent way of determining both reception protection and the transmission permissions that will achieve this protection. The status quo alternative is a more opaque, ad hoc process in which FCC and NTIA spectrum managers declare transmission permissions with scant information about the numerical reception protection levels that they are intended to achieve, and in which there is usually no workable legal standard for permissible interference.²⁵

The determination of harm claim thresholds requires that interference parameter values are visible to all stakeholders; this approach is more likely to lead to setting of permissions and protections that maximize social welfare than the status quo alternative where parties can use obscurity and asymmetric information to advance their private interests.

Since the status quo process of setting transmission permissions is opaque, it is more difficult to adjust parameter values when changes in technology or institutions lead to changes in the social welfare optimum; the entire rulemaking process may need to be repeated. Numeric threshold levels that explicitly tie together transmitter and receiver characteristics can be adjusted

²⁵ R. Paul Margie, *Can You Hear Me Now? Getting Better Reception from the FCC's Spectrum Policy*, 2003 STAN. TECH. L. REV. 5, available at http://stlr.stanford.edu/STLR/Articles/03_STLR_5.

without revisiting the entire rulemaking context. This minimizes the role of government and helps regulators use marketplace mechanisms to make complex commercial and engineering trade-offs wherever possible.

Operating permissions without numeric reception protection levels do not provide incentives to receiver operators to improve the quality of their systems. An interference limits approach allows operators of secondary systems to calculate the net benefit of raising the harm claim thresholds while (say) improving the receiver selectivity of incumbent systems.²⁶

While interference disputes can certainly be resolved under current arrangements, the process is tortuous, not least because the rights that parties have to protection as well as the criteria for harmful interference are usually uncertain. It is doubtful that the status quo approach – which is premised on a small number of parties, stable technology, and large legal budgets – will scale to the dynamic spectrum economy of coexisting “disparate unaffiliated spectrum dependent systems” and “more agile technologies and sharing mechanisms” envisaged in the NPRM.²⁷ Explicit harm claim thresholds will allow harmful interference problems to be identified more quickly and unequivocally, and to be resolved more expeditiously.

²⁶ Realizing this trade requires changes in institutional arrangements that would allow this transfer to occur. This is not yet possible under the status quo, but changes discussed in various forums (*see, e.g.*, PCAST Report, Finding 5.1 and Recommendation 5.4) may bring this about within the lifetime of the rules being decided in this proceeding.

²⁷ *NPRM* 12 FCC Rcd at 15596, ¶ 5.

VIII. Conclusion

with harm claim thresholds

hostile friends can coexist

tuning give and take