Before the
The Federal Communications Commission
Washington, DC

In the Matter of:

Office of Engineering and Technology Seeks Comment on Technological Advisory Council Spectrum Policy Recommendations	))))	ET Docket No. 17-340

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I. Introduction and summary

I commend the Office of Engineering and Technology (OET) for seeking comment on the spectrum policy recommendations that the FCC's Technological Advisory Council (TAC) has made to the Commission in recent years.[1] I am very grateful to FCC staff for their tireless efforts and creative contributions over many years to bring this work to fruition.

As a member of the TAC's Spectrum and Receiver Performance Working Group I was involved in writing the papers cited in the Public Notice, and I stand by the conclusions and recommendations. I will take this opportunity to comment on developments in these topics since the TAC papers, and to draw connections between (and beyond) the issues the TAC raised.[2]

Section II offers a commentary on the TAC's Basic Spectrum [Management] Principles that address the statistical nature of the electromagnetic environment, the value of interference limts, and the verifiability of technical work product.[3] It notes that ways to define and measure harm claim thresholds have been refined since the TAC's original papers. Section III addresses the TAC recommendations about risk-informed interference assessment (RIIA). It cites work that suggests that this approach is gaining momentum, including several case studies, the use of engineering risk metrics by Ofcom, and endorsement by the Commerce Spectrum Management Committee (CSMAC).[4] It also notes the importance of disclosing baseline performance data, and complementing RIIA with economic analysis. Section IV provides perspectives on the TAC's recommended steps for improving interference resolution.[5] It points out that the TAC's work is supported and complemented by that of the CSMAC, which noted the critical importance of the

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[1] *Office of Eng'g and Tech. Seeks Comment on Tech. Advisory Council Spectrum Policy Recommendations,* ET Dkt. No. 17-340, Public Notice, 32 FCC Rcd 10160 (2017) [hereinafter *OET PN*].

[2] I am an Executive Fellow and Co-Director of the Spectrum Policy Initiative of Silicon Flatirons, a center for innovation at the University of Colorado Boulder. The views expressed here are my own, and not those of the Silicon Flatirons Center or the University of Colorado.

[3] *See OET PN, supra* note 1, at 2–5.

[4] *See id.* at 5.

[5] *See id.* at 5.

adoption of metrics like harm claim thresholds. It also observes that dispute resolution would be improved if private parties could file spectrum interference complaints against one another directly. Section V responds to the OET's question regarding implementation of the principles in FCC spectrum policy by recommending both more extensive use of existing techniques like statistical service rules, and pilot applications of new ones like RIIA.[6]

II. The TAC's *Basic Spectrum Principles*

The work of the TAC Spectrum and Receiver Performance Working Group culminated in the December 2015 white paper, "Basic Principles for Assessing Compatibility of New Spectrum Allocations."[7] This publication synthesized the Working Group's findings into nine principles that "will lead to more efficient and effective use of the spectrum."[8] In other words, applying the principles will enable the Commission to maximize the value of all the services it regulates as a whole "in the best interests of both society and users of the spectrum."[9] This contrasts with optimizing the performance of—or minimizing interference to—individual services.

The *Basic Spectrum Principles White Paper* focuses attention on outputs (services that bring value to users) rather than inputs (e.g., the rights of frequency band licensees in isolation), and highlights the realities of radio operation. These realities include the role of receiving system characteristics and the need to anticipate non-harmful interference; they lead to the conclusion that the Commission should not base its rules on exceptional events.[10] I will comment on three of the TAC's Principles that bear on this conclusion.

Principle 3 states that operators should plan for the unpredictable nature of the electromagnetic environment. It highlights the importance of a statistical approach in designing both regulations and

[6] *See id.* at 6.
[7] FCC TAC, Basic Principles for Assessing Compatibility of New Spectrum Allocations (Dec. 11, 2015), https://transition.fcc.gov/bureaus/oet/tac/tacdocs/meeting121015/Principles-WhitePaper-Release-1.1.pdf [hereinafter *Basic Spectrum Principles White Paper*].
[8] *Id.* at 30.
[9] *Id.* at 30.
[10] *See id.* at 7–13.

wireless systems, and the need for care when using worst-case analysis.[11] This is reflected in the recommendations regarding interference limits policies and harm claim thresholds discussed below.

Principle 8 flags the utility of interference limits (also known as harm claim thresholds) in defining the rights to protection from harmful interference.[12] Since the TAC work cited in the *Basic Spectrum Principles White Paper*, subsequent research has fleshed out how to define and measure harm claim thresholds using drive test data and specific statistical tools; and described how a regulator could specify the different classes of parameters needed in a harm claim threshold approach.[13]

The Commission rightly places great value on quantitative, evidence-based reasoning. This is reflected in Principle 9, which recommends that "[a] quantitative analysis of interactions between services shall be required before the Commission can make decisions regarding levels of protection."[14] It is essential that the TAC recommendations regarding transparency and reproducibility be implemented not only in the Commission's own publications, but also by encouraging transparency and reproducibility in regulatory filings. Where feasible, the Commission should also encourage standards bodies and international institutions to ensure that their work product is independently verifiable.

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[11] *See* FCC TAC, Interference Limits Policy: The use of harm claim thresholds to improve the interference tolerance of wireless systems, (Feb. 6, 2013), http://transition.fcc.gov/bureaus/oet/tac/tacdocs/WhitePaperTACInterferenceLimitsv1.0.pdf; *see also* FCC TAC, A Quick Introduction to Risk-Informed Interference Assessment, ii, 5 (Apr. 1, 2015), http://transition.fcc.gov/bureaus/oet/tac/tacdocs/meeting4115/Intro-to-RIA-v100.pdf ("Selecting single values, often extreme "worst case" values, is not representative of actual risk. Indeed, tailoring rules to avoid very severe but highly unlikely interference can lead to unnecessarily wide guard bands and low transmit power that prevent the full potential of spectrum use to both incumbents and new services from being realized.").

[12] *See Basic Spectrum Principles White Paper*, *supra* note 7, at 20-23.

[13] *See* Janne Riihijarvi et al., *A Study on the Design Space for Harm Claim Thresholds*, IEEE Xplore, Jun. 2014, DOI: 10.4108/icst.crowncom.2014. 255404, http://ieeexplore.ieee.org/document/6849715/; *see also* Janne Riihijarvi et al., *Statistical Inference on Spectrum Data for Design and Enforcement of Harm Claim Thresholds*, IEEE Xplore, Aug. 30, 2017, DOI: 10.1109/TCCN.2017.2746578.

[14] *Basic Spectrum Principles White Paper*, *supra* note 7, at 23-26.

III. Risk-informed-interference-assessment (RIIA)

The interference risk assessment work pioneered by the TAC is gaining momentum.[15] There are now detailed case studies illustrating the application and value of this method in assessing the risk of interference (1) to weather satellite earth stations from LTE handsets;[16] (2) to Wi-Fi systems from LTE devices in unlicensed bands;[17] and (3) between non-geostationary orbit satellite constellation networks.[18]

Independently of the TAC work, the British regulator Ofcom has used engineering risk (defined as the likelihood and severity of hazards) in interference analysis. For example, it uses the percentage of DTT households that will experience interference (likelihood) and the number of single transient picture interruptions per hours of viewing (severity) to report the results of a technical analysis of coexistence between future mobile services in the 700 MHz band and digital terrestrial television (DTT) in the adjacent band in terms.[19]

The approach has also been endorsed by the CSMAC's 5G Subcommittee, which recommended that the NTIA should "Use probabilistic risk assessment (…) rather than worst-case analysis (…) as

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[15] FCC TAC, A Quick Introduction to Risk-Informed Interference Assessment (Apr. 1, 2015), http://transition.fcc.gov/bureaus/oet/tac/tacdocs/meeting4115/Intro-to-RIA-v100.pdf.

[16] *See* FCC TAC, A Case Study of Risk-Informed Interference Assessment: MetSat/LTE Co-existence in 1695–1710 MHz (Dec. 9, 2015), https://transition.fcc.gov/bureaus/oet/tac/tacdocs/meeting121015/MetSat-LTE-v100-TAC-risk-assessment.pdf; *see also* Jean Pierre de Vries et al., *A Risk-Informed Interference Assessment of MetSat/LTE Coexistence*, IEEE Xplore, Mar. 23, 2017, DOI: 10.1109/ACCESS.2017.2685592

[17] *See* Andrea M. Voicu et al., *Risk-Informed Interference Assessment for Shared Spectrum Bands: A Wi-Fi/LTE Coexistence Case Study*, IEEE Xplore, Aug. 30, 2017, DOI: 10.1109/TCCN.2017.2746567.

[18] *See* FCC TAC, A Risk Assessment Framework for NGSO-NGSO Interference (Dec. 6, 2017), https://transition.fcc.gov/oet/tac/tacdocs/meeting12617/TAC-NGSO-risk-assessment-framework-v100-2017-12-06.pdf.

[19] *See* Consultation, Ofcom, Coexistence of new services in the 700 MHz band with digital terrestrial television, 1-2 §§ 1.6, 1.9 (May 9, 2017), https://www.ofcom.org.uk/__data/assets/pdf_file/0018/101619/Coexistence-of-new-services-in-the-700-MHz-band-with-digital-terrestrial-television.pdf.

the basis for determining sharing frameworks."[20] This is not surprising, since techniques like RIIA represent good engineering practice; risk assessment is widely used across many industries.[21]

The 5G Subcommittee also alluded to the value of other concepts developed by the TAC, such as considering both transmitter and receiver characteristics, and the use of harm claim thresholds:

> "Finally, as part of CSMAC future work, it is recommended that consideration be given on whether determining operational compatibility requires a consideration of both transmitter and receiver characteristics, and whether that is required for regulatory compatibility. Current spectrum management methods specify device characteristics (e.g., transmit power ceilings, and receiver interference protection criteria). It may be possible to decouple them by focusing on the signal strength resulting from transmitter deployments, and the radio signal environment in which interfered with systems must operate. Examples of such approaches could include Ofcom's spectrum user rights (SURs, defined as a statistical limit on the resulting signal level that a licensee can deliver in the same and neighboring bands) and the FCC TAC's harm claim thresholds (HCTs, in-band & out-of-band interfering signal levels that must be exceeded before a system can claim that it is experiencing harmful interference)."[22]

The TAC's 2015 risk assessment case study observed that "[t]he risk of interference to a system can only be accurately assessed in the context of the baseline performance level."[23] This underlines the importance of the *Basic Spectrum Principles White Paper*'s Principle 7, that services can only expect protection from harmful interference if they "disclose the relevant standards, guidelines and operating characteristics of their systems."[24] Baseline performance information is most readily available to service operators seeking protection. Withholding such data could make it difficult for a

[20] CSMAC 5G Subcommittee, Final Report, 23 (Nov. 17, 2017), https://www.ntia.doc.gov/files/ntia/publications/5g_subcommittee_final_report_2017.pdf.
[21] *See* J. Pierre De Vries, *Risk-informed interference assessment: A quantitative basis for spectrum allocation decisions*, 41 Telecomm. Policy 434, 437 (2017), http://dx.doi.org/10.1016/j.telpol.2016.12.007.
[22] CSMAC 5G Subcommittee, *supra* note 20, at 25.
[23] A Case Study of Risk-Informed Interference Assessment: MetSat/LTE Co-existence in 1695–1710 MHz, *supra* note 18, at 44.
[24] *Basic Spectrum Principles White Paper*, *supra* note 7, at 18–19.

potential interferer to demonstrate an acceptable risk of additional interference compared to baseline, and the Commission should do all it can to assure its disclosure when needed.

The work on RIIA to date has addressed engineering methods to assess interference hazards. Such analysis is necessary but not sufficient for effective spectrum management. It should be complemented by economic tools such as cost-benefit analysis of alternative mitigation strategies. I look forward to the Commission's new Office of Economics and Analytics engaging with the Wireless Bureau and OET to combine RIIA with economic assessments.

IV. Interference resolution and enforcement

The TAC's recommendations for improving interference resolution include defining a next-generation architecture for radio spectrum interference resolution, creating a public database of past radio-related enforcement activities, and incorporating interference hunters in the interference resolution process.[25]

These recommendations are supported and complemented by the CSMAC's 2015 Enforcement Subcommittee Report.[26] It recommended that the NTIA study a variety of mechanisms that could help lead to the effective policing of the radio spectrum, first among them the definition of harmful interference. The Subcommittee observed that the "adoption of a metric, such as the proposed harm claims threshold under consideration by the FCC, is critical to ensuring that parties have a full understanding of what interference would be constituted as harmful and would allow resources to be brought quickly to bear upon instances that would create harmful interference."

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[25] *See OET PN* , *supra* note 1, at 5 (citing March 2016 paper, "A Study to Develop the Next Generation Systems Architecture for Radio Spectrum Interference Resolution", https://transition.fcc.gov/oet/tac/tacdocs/reports/2016/A-Study-to-Develop-a-Next-Generation-System-Architecture-V1.0.pdf; June 2014 paper, "Introduction to Interference Resolution, Enforcement and Radio Noise", https://transition.fcc.gov/bureaus/oet/tac/tacdocs/meeting61014/InterferenceResolution-Enforcement-Radio-Noise-White-Paper.pdf).

[26] *See* Commerce Spectrum Management Advisory Committee, Enforcement Subcommittee Report (May 12, 2015), https://www.ntia.doc.gov/files/ntia/publications/csmac-enforcement_sc_responses_050415.pdf.

The TAC's recommendations address—rightly, given its remit—engineering steps the Commission should take. Interference resolution could also benefit from changes in regulatory structure so that parties could resolve conflicts without having to resort to the FCC. Currently, if an alleged interferer is unwilling to resolve a complaint, the aggrieved party must rely on the good offices of the FCC Enforcement Bureau, which may not have the resources to address its concern. One solution is to permit a private party to file a spectrum interference complaint against another private party directly with the Office of Administrative Law Judges.[27] Alternatively, or in addition, spectrum-related disputes could be heard in a newly created Court of Spectrum Claims.[28]

V. Integrating the TAC Principles into FCC spectrum policy

The OET invited comment on whether and how these principles might be integrated into FCC spectrum policy.[29] Some of the techniques discussed above are well understood; they should simply be used more extensively. For example, there are several precedents for statistically-based service rules including television broadcast contours, and the equivalent power flux density (EPFD) levels that may not be exceed for given percentages of time by non-geostationary orbit satellite systems.[30] Such statistical rules facilitate RIIA and provide a template for harm claim thresholds.

Other techniques, such as risk assessment, are novel in the spectrum context. In such cases it may be productive to begin with pilot projects in low-profile cases with relatively limited scope, such as waiver applications.[31]

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[27] *See* Samuelson-Glushko Technology Law & Policy Clinic (TLPC) & J. Pierre de Vries, Petition for Rulemaking: Spectrum Interference Dispute Resolution, RM-11750 (May 8, 2015); TPLC Reply Comments, RM-11750 (Dec 11, 2015).

[28] *See* J. Pierre de Vries & Philip J. Weiser, *Unlocking Spectrum Value through Improved Allocation, Assignment, and Adjudication of Spectrum Rights* 21 (Hamilton Project Discussion Paper 2014-1, 2014), http://www.hamiltonproject.org/papers/unlocking_spectrum_value_through_improved_allocation_assignment.

[29] *OET PN, supra* note 1, p. 6.

[30] *See* 47 C.F.R. §§ 73.625, .699 (2017); *see also* 47 C.F.R § 25.208(g)(Table 1G) (2017).

[31] *See* Tyler Cox et al., *Piloting Risk-Informed Interference Assessment Using Waivers* (Mar. 13, 2015) https://ssrn.com/abstract=2543632; *see also* Samuelson-Glushko Technology Law & Policy Clinic (TLPC) & J. Pierre de Vries, Piloting Risk-informed Interference Assessment in Radio Operation Waiver Proceedings (Dec. 9, 2016),

Respectfully submitted,

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