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

In the Matter of	)	
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Advancing Understanding of Non-Federal Spectrum Usage	)	WT Docket No. 23-232
	)	
	)	

NOTICE OF INQUIRY

Adopted: August 3, 2023 **Released: August 4, 2023**

Comment Date: October 3, 2023
Reply Comment Date: November 2, 2023

By the Commission: Chairwoman Rosenworcel and Commissioner Starks issuing separate statements.

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I. INTRODUCTION

1. In this *Notice of Inquiry* (*NOI*), we explore the exciting potential to advance our understanding of non-Federal spectrum usage by leveraging new data sources, technologies, and methods.[1] While academics, industry researchers, and regulatory bodies have devoted considerable attention to the topic, we have traditionally relied on third parties for metrics regarding actual spectrum usage rather than conduct our own studies. Spectrum usage information is generally non-public and made available infrequently. As the radiofrequency (RF) environment grows more congested, however, we anticipate a greater need to consider such data to improve spectrum management. That is especially true as the burgeoning growth of machine learning (ML) and artificial intelligence (AI) offer revolutionary insights into large and complex datasets. Leveraging today's tools to understand tomorrow's commercial

[1] Consistent with prior analyses in this area, this *NOI* uses the terms "usage," "utilization," and "occupancy" interchangeably. As discussed in section III.A., we seek comment on how best to define this concept.

spectrum usage can help identify new opportunities to facilitate more efficient spectrum use, including new spectrum sharing techniques and approaches to enable co-existence among users and services.

2. This *NOI* continues our efforts to bring next-generation techniques and data-driven analysis to our spectrum management toolkit. Most recently, our 2023 *Spectrum Policy Statement* outlined a refreshed set of forward-looking principles to govern the Commission's actions and stakeholder expectations regarding interference, including the responsibilities of receivers to operate resiliently in congested spectrum bands.[2] Our holistic framework seeks to keep pace with emerging technologies to maximize the efficient use of spectrum.

3. In the spirit of our recent efforts, this *NOI* represents a technical inquiry on how to better obtain more sophisticated knowledge of non-Federal spectrum usage—and how we could take advantage of modern capabilities for doing so in a cost-effective, accurate, scalable, and actionable manner. Given the technical nature of this proceeding, we do not invite comment on substantive changes to our underlying spectrum policies or service rules, including eligibility criteria, buildout requirements, band allocations, technical limitations, sharing regimes, or licensing frameworks. We also recognize, but do not seek comment on, the economic or social value created by operators' spectrum-based services.

II. BACKGROUND

A. Existing Commission Resources to Understand Spectrum Usage

4. While the Commission tracks static spectrum allocations, assignments, and other characteristics in multiple ways, our existing repositories provide limited, if any, real-time data on the extent of actual spectrum utilization, either on a nationwide, regional, or local basis.

5. *FCC databases.* The Commission maintains "snapshot-in-time" information on spectrum allocations and licensees in those allocations throughout multiple databases. As one example, the Universal Licensing System (ULS) maintains retrievable details on licensees and authorizations where the FCC issues individual licenses,[3] including the radio service code, spectrum band, license size, applicant name, application purpose, and call sign. ULS also provides capability to download data in machine readable format, which mapping software can use to display the location of authorized services. ULS, however, does not contain real-time information regarding the use of licensed spectrum. The same is true of the Commission's other databases, including the International Communications Filing System (ICFS), Experimental Licensing System (ELS), and Licensing and Management System (LMS), among others.

6. *Spectrum sharing administrators.* The FCC authorizes administrators to track spectrum usage data to allow non-interfering use of shared spectrum bands. Spectrum Access Systems (SAS) are systems maintained by approved third parties to monitor spectrum utilization and to coordinate activity among disparate services in a single band.[4] White Space Databases (WSDs) and Automated Frequency Coordination (AFC) systems track available spectrum for opportunistic, secondary use. However, unlike the SAS, the WSD and AFC do not track spectrum usage or assign users to specific channels.[5]

[2] *Principles for Promoting Efficient Use of Spectrum and Opportunities for New Services*, Policy Statement, FCC 23-27, ET Docket No. 23-122 (rel. Apr. 21, 2023) (2023 Spectrum Policy Statement).

[3] ULS does not contain information on licensees that operate under the License by Rule construct. *See, e.g.*, 47 CFR § 95.305(b).

[4] *See, e.g.*, 47 CFR § 96.53. While the Commission can get access to some of the data collected and maintained by the SAS administrators, the Commission must request such information. 47 CFR § 96.63(k). Additionally, much of the information collected and maintained by the SAS administrators is not publicly available without first being aggregated. 47 CFR § 96.55.

[5] However, similarly to SAS, the Commission can request the data collected and maintained by both WSD and AFC administrators. *See* 47 CFR §§ 15.713(k), 15.407(k). Generally, the data collected and maintained by WSD administrators are also publicly available. See 47 CFR § 15.715(m).

7. *Speed and drive testing.* The Commission may periodically direct mobile operators to conduct speed and drive testing to measure network coverage and broadband speeds in various parts of the United States and report those results to the Commission. Speed tests collect information about the download speed, upload speed, and other measures affecting performance such as latency and signal strength. Drive tests are a subset of speed tests, involving testing while in a vehicle or through an externally mounted antenna, performed either in motion or stationary.[6]

B. USG, Industry, and Academic Efforts to Study Spectrum Usage

8. The United States government, industry, and academia have long studied ways to assess spectrum usage, well before the ubiquity of modern wireless services.[7] Since 1973, the National Telecommunications and Information Administration (NTIA) has collected data on Federal use of the RF spectrum for its Spectrum Analysis Program.[8] The Institute for Telecommunication Sciences (ITS) operates measurement systems to help support NTIA functions including spectrum resource assessments, analysis of electromagnetic compatibility problems, and interference resolution.[9] The results of ITS surveys have been published in an ongoing series of NTIA Reports beginning in 1995.[10]

9. In 2013, the President directed NTIA to "design and conduct a pilot program to monitor spectrum usage in real time in selected communities throughout the country to determine whether a comprehensive monitoring program could disclose opportunities for more efficient spectrum access, including via sharing."[11] In response to the Presidential Memorandum, the Wireless Spectrum Research and Development Senior Steering Group (WSRD) convened a workshop of policymakers, academics, and industry experts to "discuss how the use of spectrum data and monitoring can be used to better inform spectrum policy and management decisions, improve regulatory enforcement, and coordinate more efficient and dynamic spectrum usage."[12] While the report found that monitoring could improve spectrum policy and enforcement, panelists identified many challenges, including cost, the diversity of band-specific considerations, and the need for uniform metrics and data collection requirements.[13]

10. Following the 2013 Presidential Memorandum, NTIA developed a plan to quantitatively assess spectrum usage based on data reported by Federal users and validated through real-time occupancy measurements.[14] NTIA and NIST also established the Spectrum Monitoring Pilot Program. Among other things, the program sought to establish a distributed cluster of databases that collected occupancy data

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[6] *See*, *e.g.*, 47 CFR § 1.7006(e)(4).

[7] The efforts described in this section are not intended to be comprehensive. To the extent other governmental, industry, or academic studies may bear on the questions posed in this *NOI*, we invite commenters to discuss them.

[8] United States Government Accountability Office, Report to Congressional Committees, Spectrum Management: NTIA Planning and Processes Need Strengthening to Promote the Efficient Use of Spectrum by Federal Agencies, GAO-11-352 at 16 (April 2011), https://perma.cc/AGS9-3J26.

[9] ITS, *Spectrum Monitoring*, https://perma.cc/98ZP-MNRU (last visited July 7, 2023).

[10] *See, e.g.*, Frank H. Sanders, Measured Occupancy of 5850–5925 MHz and Adjacent 5-GHz Spectrum in the United States, NTIA Report 00-373 (1999), https://perma.cc/PE5Q-Q9ML.

[11] Memorandum for the Heads of Executive Departments and Agencies, Expanding America's Leadership in Wireless Innovation (rel. June 14, 2013), 78 Fed. Reg. 37431 (June 20, 2013), https://perma.cc/7VK9-WRWL.

[12] NITRD, Understanding the Spectrum Environment: Data and Monitoring to Improve Spectrum Utilization, NITRD Wireless Spectrum R&D Senior Steering Group Workshop V Report (2014), https://perma.cc/EW5E-QYQ9 (2014 NITRD Workshop Report).

[13] *See generally* 2014 NITRD Workshop Report.

[14] NTIA, Fourth Interim Progress Report on the Ten-Year Plan and Timetable and Plan for Quantitative Assessments of Spectrum Usage at Appendix A (June 5, 2014), https://perma.cc/SHU7-AJ5G.

from Federal users based on low-cost RF sensors developed by ITS.[15] In 2016, NTIA summarized the results of its quantitative assessments in select Federal bands.[16] This report also restated NTIA's methodology to quantitatively assess Federal spectrum occupancy.[17]

11. In 2016, NSF convened a workshop on spectrum measurements, which generated a report that featured a "high-level roadmap for a national spectrum measurement infrastructure, the architectural considerations, technical challenges involved in realizing such a vision and the identification of key areas of research needed to make this vision a reality."[18] Earlier this year, NIST held a WSRD workshop on obtaining better data for spectrum management, with particular focus on the challenges with obtaining, disseminating, and using these data for policymaking, operations, and research and development.[19]

12. Federal agencies have continued to monitor band occupancy based on intervening regulatory and social developments. As one example, NIST monitored spectrum usage across 21 bands in 16 locations throughout Colorado to better understand access to broadband infrastructure during the COVID-19 health emergency.[20] Most recently, an ITS study measured band utilization in CBRS by using quarterly operational data from SAS administrators to measure the growth of occupied CBRS channels and CBRS-authorized fixed stations and access points over a two-year period.[21]

C. International Efforts to Monitor Spectrum Usage

13. *International Telecommunication Union.* The International Telecommunication Union's (ITU) Radio Regulations require administrations to periodically check "the emissions of stations under their jurisdiction."[22] This monitoring, according to the ITU, serves the objectives of facilitating spectrum management, resolving interference, ensuring acceptable reception of public broadcasting, and identifying non-compliant emissions.[23] Article 16 establishes a framework and rules for monitoring spectrum utilization.[24] The ITU's International Monitoring System (IMS) consists of stations that collect data and send reports to the ITU.[25] As of 2022, more than 400 monitoring stations operated across 81 countries.[26]

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[15] Michael Cotton, et al., *An Overview of the NTIA/NIST Spectrum Monitoring Pilot Program*, International Workshop on Smart Spectrum at IEEE WCNC 2015 (2015), https://perma.cc/4BX6-H5NG (NTIA/NIST Spectrum Monitoring Pilot Program).

[16] NTIA, Quantitative Assessments of Spectrum Usage (2016), https://perma.cc/9KQX-U9YH (2016 NTIA Quantitative Assessments Report).

[17] *Id*. at 12–21.

[18] NSF Workshop on Spectrum Measurements Infrastructure, Workshop Report (2016), https://perma.cc/RBZ9-DTCV (2016 NSF Workshop Report).

[19] NIST, *WSRD Workshop: Making Data Available for National Spectrum Management* (2023), https://perma.cc/FS9X-CGZH.

[20] NIST, *COVID-19 Spectrum Occupancy Project* (2020), https://perma.cc/5GUT-FMQL; *see* D. Keuster, et al., *Radio Spectrum Occupancy Measurements Amid COVID-19 Telework and Telehealth*, Technical Note (NIST TN), National Institute of Standards and Technology (2022), https://perma.cc/JAQ7-ZP6V (2022 NIST TN COVID-19 Telework and Telehealth).

[21] NTIA, An Analysis of Aggregate CBRS SAS Data from April 2021 and January 2023, NTIA Report 23-567 (2023), https://perma.cc/E6KK-M5PA (2023 CBRS Usage Report).

[22] *See* ITU, Radio Regulations, Vol. 1, Article 3, Radio Regulations (RR) No. 13.14 (2020).

[23] ITU, Spectrum Monitoring Handbook at 4–5 (2011), https://perma.cc/72UF-PJJZ (ITU Spectrum Monitoring Handbook).

[24] ITU, Radio Regulations, Vol. 1, Article 16, Radio Regulations (RR) Nos. 16.1–16.8 (2020).

[25] *Id.*

[26] ITU, List IIIV, List of International Monitoring Stations 2022 Edition (2022), https://perma.cc/N6YF-HD55 (List IIIV). There are 14 such stations in the United States and Puerto Rico; however, these stations are limited to high

(continued….)

The ITU periodically publishes summaries based on the information it receives from these stations.[27] The ITU Spectrum Monitoring Handbook also outlines principles and procedures for monitoring spectrum usage, including permissible equipment, technical measurements, and other requirements. ITU-R Recommendations also provide guidance for monitoring systems, including their specified tasks, measurement techniques, and standard data formats.[28]

14. *Other jurisdictions.* National governments, through their telecommunications regulators, may periodically monitor spectrum usage. In the United Kingdom, spectrum detectors are deployed throughout the country to aid in enforcement and to understand spectrum use in geographic areas.[29] Switzerland has deployed monitoring equipment to ensure compliance of telecommunications systems.[30] And the Communications Research Centre Canada has developed an advanced prototype system to create visualizations with spectrum monitoring data.[31]

III. DISCUSSION

15. In this *NOI*, we explore the feasibility, benefits, and limitations of techniques to understand non-Federal spectrum usage. First, we invite comment on various aspects of spectrum usage, including how spectrum usage should be defined, and whether its study could generate accurate and actionable insights. We then seek comment on best practices, operational considerations, and technical parameters that might correspond to different aspects of spectrum usage across different radio services. Next, we ask about the data necessary to study aspects of spectrum usage, and how such information could be obtained. We also seek comment on the practical, technical, and legal considerations associated with any potential study of spectrum usage.

A. Defining Spectrum Usage

16. We begin our inquiry by soliciting feedback on what definitions appropriately capture the extent to which a set of frequencies is being utilized. To that end, we seek comment on previous efforts, both domestically and abroad, to define spectrum usage and understand its dimensions. Are there best practices or consensus frameworks for assessing aspects of spectrum usage? What insights do different definitions of spectrum usage generate, and how could each inform the Commission's potential analysis of the RF environment? We encourage commenters to identify, with specificity, the benefits and drawbacks of previous initiatives to define, understand, and measure spectrum usage.

17. Spectrum usage has been defined in various ways. In one technical paper, for instance, NTIA and NIST defined "band occupancy" as "the percentage of frequencies or channels in the band with

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frequency (HF) monitoring and minimal space monitoring. The stations' activities are confined to spectrum below 30 MHz to help public safety and federal agencies locate interference and to provide assistance during emergencies. *See* 47 CFR §§ 0.121, 1.924(c). *See also* FCC, *Over-the-Air Spectrum Observation Capabilities*, https://www.fcc.gov/over-air-spectrum-observation-capabilities (last visited July 10, 2023).

[27] ITU, *International monitoring*, https://perma.cc/3MBA-RBLQ (last visited June 13, 2023). Stations carry out frequency measurements, field strength or power-flux density measurements, and spectrum occupancy surveys among other types of measurements. List IIIV at Preface 4.

[28] ITU, *Recommendations related to Monitoring System (SM series)*, https://perma.cc/R6NQ-2DKS (last visited July 10, 2023).

[29] Ofcom, Supporting the UK's wireless future: Our spectrum management strategy for the 2020s at 5, 20 (2021), https://perma.cc/BCC9-7Z5E.

[30] Switzerland Federal Office of Communications, *Radio Monitoring and Equipment (RA)*, https://perma.cc/BB32-5QZH (last visited June 14, 2023).

[31] Kelly Hill, *Sensors, big data fuel Canadian research on spectrum visibility*, RCR Wireless News, Aug. 14, 2017, https://perma.cc/JM8Q-N5DL.

a detected signal level that exceeds a default or user-defined threshold."[32] Likewise, in its 2020 study of CBRS, NTIA characterized occupancy "at any given time as the fraction of frequencies (or channels) with a detected signal level that exceeds a predetermined threshold."[33] The ITU defines "spectrum occupancy" as "the probability that, at a randomly selected moment in time, a radio channel, frequency band or other frequency resource being analyzed will be in use for the transmission of information."[34] In 2011, the Sharing Working Group of the FCC's Technological Advisory Council (TAC) defined a taxonomy and metrics for assessing spectrum efficiency and occupancy for different services.[35] Do commenters find these definitions applicable for assessing the use of non-Federal bands? To what extent do these definitions obscure or limit greater comprehension of spectrum usage? Do any relevant differences in the Federal or international context make these definitions unsuitable here? Are there other definitions of spectrum usage that might be better suited to non-Federal spectrum? If utilization is defined as the exceedance of a power flux density (PFD), spectral occupancy, geographic, or other threshold, how should the threshold's values be established? Should the threshold PFD value vary by service or frequency range? Commenters should provide details and justification regarding the factors that should be considered in developing evaluation PFDs and how those relate to different radio services or frequency bands.

18. Some studies have broken spectrum usage into discrete components, such as geographic usage, frequency usage, and time usage.[36] We invite comment on the utility of such an approach. We also seek comment on how to define these components for evaluating the intensity of spectrum use. For frequency usage, what is the appropriate size of a band segment for possible study? Should it correspond to authorized licenses or to an entire band or specific channels regardless of the number of licenses? For geographic usage, what principles should guide the appropriate area for study, considering differences in license size, population density, topology, climate, and other variables? When evaluating the geographic component, comments should consider that the Commission has licensed various services over varying geographic regions ranging from counties to partial economic areas to the contiguous United States, and regions in between. Moreover, for certain services the licensee can request to use the spectrum at the locations they choose.[37] With respect to time usage, could hourly, daily, or seasonal variations affect conclusions about spectrum usage?[38] How do network peak traffic busy hours factor into spectrum

[32] NTIA/NIST Spectrum Monitoring Pilot Program at 3.

[33] Michael Cotton, et al., *3.45–3.65 GHz Spectrum Occupancy from Long-Term Measurements in 2018 and 2019 at Four Coastal Sites*, NTIA Report 20-548 (Apr. 2020), https://perma.cc/X9R5-SJEV.

[34] ITU, Spectrum occupancy measurements and evaluation: Report ITU-R SM.2256-1 at 37 (June 2016), https://perma.cc/Q7ND-L6S3.

[35] FCC Technical Advisory Council, Sharing Working Group, Spectrum Efficiency Metrics (December 20, 2011), https://transition.fcc.gov/bureaus/oet/tac/tacdocs/SpectrumEfficiencyMetricsV1-12-20-11.docx (2011 TAC Report).

[36] For example, the 2016 NTIA Quantitative Assessments Report required agencies to supply data for each system's individual transmitting and receiving stations to develop an approximation of each system's actual use of spectrum using parameters for frequency and bandwidth, geographic area, and estimated time of usage. Frequency usage refers to the number of frequency assignments that fall within a predefined band segment. Geographic usage refers to the percentage of the population impacted by the transmit and receive station spectrum usage contours and the percentage of the geographic area that is available. Time usage refers to the duration that a station is being used. 2016 NTIA Quantitative Assessments Report at 3.

[37] *See generally* 47 CFR pt 90.

[38] For example, in the context of AM stations, there are difficulties associated with attempting to determine the frequency and time usage reflected in the difference between and AM station's 0.5 mV/m 50% Skywave Contour and its 0.5 mV/m Groundwave Contour hours. The same Class A AM station's Groundwave Contour may extend over less than one-third of that population during the daytime hours. *See, e.g.*, WABC(AM), New York, NY (Facility ID 70658).

usage?[39] We recognize that there are special considerations with regard to public safety and critical infrastructure spectrum needs. We seek comment on defining the most appropriate metric for evaluating public safety geographic, frequency, and time usage, including how to best collect data on public safety usage, who should collect these data, and how they should protect the data given the special public safety considerations.[40]

19. We also seek comment on whether other components beyond geographic, frequency, and time usage could inform the intensity of spectrum use. We believe other RF engineering metrics beyond the mere presence of a signal at a particular strength could shed light on spectrum usage, such as: (1) throughput; (2) population actually or potentially served; and (3) the number or density of end-user devices or access points.[41] Are there other metrics that could help evaluate spectrum use, such as power spectral density or modulation levels? If so, we ask commenters to describe how these metrics correspond to spectrum use. For example, should the "capacity" of a system or its ability to accommodate a high density of users factor into any study of spectrum utilization? What about the number of actual users compared to overall capacity, expressed as a percentage? How should we think about utilization in services where operators "spread" their capacity or "balance" their traffic dynamically across multiple bands and/or users? In addressing these questions, commenters should also consider the appropriate methods to collect such metrics, discussed below in Section III.C.

20. Our *Spectrum Policy Statement* also noted many design techniques to help satisfy performance and reliability expectations, including analog and digital filtering, antenna design, adaptive modulation and coding techniques with error correction, dynamic frequency selection, automatic gain control, intermodulation rejection, and countless other methods. How should these features affect spectrum usage evaluation? For example, how should we consider RF power at or above the sensitivity of receivers for a given band?[42] How should we consider uplink and downlink transmissions, and should we distinguish between the occupancy of transmitters and receivers?

21. We also inquire whether metrics of spectrum usage can be combined to generate a holistic understanding of the RF landscape. We note, for example, that the NTIA's *Plan for Quantitative Assessment of Spectrum Usage* derived a "Total Spectrum Usage" metric by aggregating components of frequency use, geographic use, and time of use.[43] The ITU uses what it calls the "spectrum utilization factor," defined as the "product of frequency bandwidth, geometric (geographic) space, and the time

[39] FCC, Twelfth Measuring Broadband America Fixed Broadband Report 4.b (January 6, 2023), https://www.fcc.gov/reports-research/reports/measuring-broadband-america/measuring-fixed-broadband-twelfth-report ("[S]peeds experienced by a consumer may vary during the day if the aggregate user demand during busy hours causes network congestion. Unless stated otherwise, the data used in this report is based on measurements taken during peak usage periods, which we define as 7 p.m. to 11 p.m. local time.").

[40] *See, e.g.*, FCC, Emergency Communications during the Minneapolis Bridge Disaster: A Technical Case Study by the Federal Communications Commission's Public Safety and Homeland Security Bureau's Communications Systems Analysis Division (Nov. 13, 2008), https://transition.fcc.gov/pshs/docs/clearinghouse/references/minneapolis-bridge-report.pdf.

[41] 2011 TAC Report at 3. Although the 2011 TAC Report acknowledges no single measure of spectrum efficiency applies across all services, it developed metrics for distinct service classes that allow efficiency comparisons across a variety of satellite and terrestrial based systems categories, all of which are generally defined based on throughput (bits per second) per bandwidth per geographic area or number of users simultaneously served.

[42] As mentioned in the 2016 NSF Workshop, it is important that receivers are "fit for purpose" and appropriate filtering is designed into a spectrum usage monitoring system. 2016 NSF Workshop Report at 15.

[43] 2016 NTIA Quantitative Assessments Report at 3–6.

denied to other potential users."[44] We seek comment on whether, and to what extent, this kind of aggregation can supply accurate and actionable insights.

B. Band-Specific Considerations

22. Spectrum bands do not have uniform service requirements, operational systems, or technical characteristics. Past efforts to study the issue have concluded that "[t]here is not a one-size-fits-all approach to measuring spectrum usage."[45] Do commenters agree? We note, for example, that several bands may exhibit infrequent usage that are nonetheless mission critical for their intended uses, such as public safety.[46] If commenters agree that a band-agnostic approach will not work, how should the concept of spectrum usage vary by frequency, service, or other factors? For example, how should fixed point-to-point or fixed-to-multipoint services be evaluated differently from mobile services? Should radiolocation services (e.g., radar) be evaluated differently than systems that only transmit data or systems that use waveforms that can both transmit data and determine location?[47] Should subscriber-based services be evaluated differently from privately controlled systems? And should services, such as those associated with aeronautical or maritime use or assigned for public safety, be evaluated differently than other services? How should underlying reliability or service requirements inform how we consider usage? How is usage impacted by access model (i.e., shared access, point-to-point, point-to-multipoint, broadcast, etc.)? How should unlicensed use be factored in, if at all? Unlicensed users operate on a non-interference basis and in almost all cases, operate as an underlay to licensed or industrial, scientific, and medical equipment (ISM) use. Should usage metrics be adjusted based on the geographic area over which a license is issued? Given that licenses covering large geographic areas may vary between urban, suburban, and rural areas, would any metrics tend to over- or understate the intensity of usage?

23. We also solicit feedback on whether usage can or should be studied through representative sampling. Participants in the NSF Spectrum Measurement Infrastructure Workshop expressed reasonable support to focus on urban deployments and strong agreement that any system should have near continuous coverage over the deployment area.[48] Should observation efforts focus on those types of geographic areas? Should there be different analyses of urban, suburban, and rural environments?[49] Can specific urban, suburban, or rural areas serve as a reliable proxy for nationwide conclusions? Are there other appropriate metrics to prioritize studying spectrum usage?

24. We next seek comment on how to prioritize data collection when each issue or band has its own challenges. The 2016 NSF workshop surveyed dozens of stakeholders and experts across academia, industry, and federal agencies and found "strong support" for measuring traditional fixed and

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[44] ITU, Definition of spectrum use and efficiency of a radio system: Recommendation ITU-R SM.1046-3 at 3 (Sept. 2017), https://perma.cc/E66L-DT9B.

[45] 2014 NITRD Workshop Report at 13; *accord* 2016 NSF Workshop Report at 5.

[46] We recognize that public safety has high reliability needs, particularly in emergencies and may require different considerations. *See generally* 2023 Spectrum Policy Statement.

[47] The TAC Report focused on seven broad classes of systems: (1) Satellite Broadcast Systems; (2) Point-to-Point Satellite Systems; (3) Terrestrial Broadcast Systems; (4) Terrestrial Personal Communication Systems; (5) Terrestrial Point-to-Point Systems; (6) Terrestrial Hybrid Systems – Public Safety / Utility; and (7) Radar Systems. However, the Working Group concluded at the time of writing the TAC Report that it was unable to identify or evaluate suitable spectrum efficiency metrics for radar systems. The Working Group noted in the TAC Report that it did not address spectrum efficiency metrics for "passive" (mostly scientific) uses of the resource or short range systems that typically operate on an unlicensed or "licensed by rule" basis. 2011 TAC Report at 8.

[48] 2016 NSF Workshop Report at 8.

[49] *See* 2023 CBRS Usage Report at 10 (distinguishing between urban and rural locations based on the 2020 Census-proposed criteria).

mobile terrestrial transmitters and "very strong support" for measuring bands below 6 GHz.[50] Do commenters agree with these conclusions? Have developments since 2016 shifted this priority?

C. Data Considerations

25. We seek comment on data sources that could facilitate greater understanding of spectrum usage. We invite commenters to describe with specificity information necessary to inform elements of spectrum usage, along with the kinds of insights that unique data elements might produce.

26. As a threshold matter, we first solicit feedback on our existing data sources.[51] Recognizing that our databases were not built to observe spectrum usage or collect such data, do they nonetheless contain information that would be useful for such an exercise? What data do we lack? What additional data would be useful for the Commission to collect? Do the Commission's existing databases and collection procedures provide opportunities to obtain better information? How should we weigh the benefits of collecting additional information against the burden of collecting such information?

27. To the extent we lack information on non-Federal spectrum usage, we seek comment below on various aspects of data collection. We start by considering challenges to data collection including cost and burden, standardization, and technical accuracy. We then turn to various methods for obtaining such data. Commenters should consider data-related questions alongside the definitional and band-specific issues discussed in the previous sections.

1. Data-Related Challenges

28. We foresee many potential challenges inherent to obtaining better data. They include cost and burden; standardization; and technical accuracy. We seek comment on these and other challenges, and whether the state of the art can offer solutions to overcome them.

29. *Cost and burden.* We are especially mindful of the cost and burden of collecting spectrum usage data. The *2014 NITRD Workshop Report* noted, for instance, that the "[c]ost of sensors for monitoring and associated data systems need to be significantly reduced to enable wide spread deployment and use" to assess spectrum utilization.[52] That report also stressed the need to identify resources to defray "the costs associated with monitoring,"[53] which was deemed "significant and will remain a barrier."[54] The *2016 NSF Workshop Report*, likewise, observed that "cost considerations" would prevent widespread "deployment of high quality, special purpose, trusted measurement platforms."[55] Indeed, that report found that the "top research areas" were also significant cost drivers.[56] Researchers have also noted the significant cost of maintaining and curating vast amounts of usage data.[57]

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[50] 2016 NSF Workshop Report at 8.

[51] In addition to ULS, the FCC also maintains several other databases including the International Communications Filing System (ICFS), which allows for electronic filing of the following types of applications and forms: space station, earth station, Section 214, cable landing license, accounting rate change, recognized operating agency, international signaling point code (ISPC), data network identification code (DNIC), foreign carrier affiliation notification filings, and milestone/bond filings. ICFS also provides users with a whole host of query and reporting options. See https://licensing.fcc.gov/myibfs/. The OET Experimental Licensing System (ELS) allows the public to electronically file Forms 442, 405, 702, 703, and requests for Special Temporary Authority (STA), including all necessary exhibits. *See* https://apps.fcc.gov/oetcf/els/index.cfm.

[52] 2014 NITRD Workshop Report at 17.

[53] *Id.* at 16.

[54] *Id.* at 15.

[55] 2016 NSF Workshop Report at 19.

[56] *Id.* at 25.

[57] 2014 NITRD Workshop Report at 17.

30. We seek comment on these observations. What are the kinds of costs that might drive efforts to understand spectrum usage? Have these costs gone down in recent years due to improvements in technology? Is it possible to reduce costs by leveraging existing sources such as FCC databases, SAS administrators, or other existing data sources, or limiting scope by prioritizing certain bands? Would reviewing the number of applications filed for new facilities, applications filed for modified facilities, as well as the number and nature of interference complaints filed with respect to those facilities provide useful data? Would having licensees certify that their authorized facilities are operating with their licensed technical parameters help to verify the data the FCC already collects? Can the scope of data collection be limited to certain urban, rural, and suburban areas and serve as a proxy for the rest of the country? If so, which areas? How can we make use of resources across the country to measure, provide, and assess data? For example, can we leverage the NSF Spectrum Innovation Initiative and its connection to university researchers to conduct measurements and report back to us in some standard format or database? How should we view the costs of understanding spectrum usage relative to the benefits? Is there a less burdensome or costly approach than those implemented or proposed by NTIA, ITU, NSF, or other bodies that would generate comparable insights?

31. *Standardization*. Prior research initiatives have noted the need to standardize data sources, measurement methodologies, and equipment. The *2014 NITRD Workshop Report* noted that "[m]easurements are not well defined and converting measurement data into useful information is difficult."[58] Accordingly, "[r]egardless of how the data was collected and measured, the resulting information must mean the same thing to all stakeholders. This may require standardizing data, and data collection methodologies based on the desired use, such as: location information, comparing license/assignment data, aggregating bands, predicting interference events, etc."[59] We seek comment on these views. In what ways are existing data sources not uniform? What challenges do non-standardized data sources pose for greater understanding of spectrum usage? Do standardized data formats and methodologies exist today? Can we feasibly evaluate spectrum usage if they do not? Are there open-source platforms or repositories that might be leveraged for cross-validation to allay standardization concerns? Should a standard reporting schema be implemented? If so, what are the data elements that are essential to fully evaluate spectrum usage? How many data are consistent across different radio services and what data elements are unique to various radio services? How should these differences be accounted for? We also seek comment on standardization as it pertains to measurement equipment, such as the calibration values for antenna height and gain.

32. *Technical accuracy.* Past reports have stressed that collected data must be sufficiently accurate to generate trust in spectrum usage conclusions.[60] These reports have observed, for example, that sensors should have very high sensitivity to distinguish between intended signals and out-of-band noise.[61] In addition to accuracy, what are the technical challenges associated with collecting precise data given a particularly cluttered RF environment? Also, equipment should be calibrated to localize geographic accuracy within a specified distance, and power levels should be measured within a sufficiently small uncertainty. Do these technical challenges remain today? Could other factors complicate the accuracy of spectrum usage data? We note that for certain bands, such as spectrum licensed for flexible use, our rules generally do not require transmitter or receiver registration. Must we know the location of transmitters and receivers to properly measure spectrum usage? Is it possible to assess spectrum usage of unlicensed users or in licensed-by-rule bands? We also note that the *2014 NITRD Workshop Report* observed that "[d]espite the low cost, ad hoc monitoring does not produce a

[58] *Id.*

[59] *Id.* at 5.

[60] *Id.* at 10.

[61] 2016 NSF Workshop Report at 9.

great deal of value and fails to generate the necessary trust in measurements."[62] Do commenters agree? Is there an inherent tradeoff between accuracy and expense?

33. We also seek comment on the level of accuracy and granularity sufficient for effective measurements. We note that previous utilization analyses defined a range of technical parameters, such as reference signal received power (RSRP), minimum signal-to-noise ratio, and noise-figure, as inputs for their models.[63] What values should spectrum utilization analyses consider and how should they be defined? What are the right analytical models, such as propagation or network traffic models, to translate data into actionable information? Can the data required for these models be passively collected or are there some values that will require an active network connection to help assess spectrum utilization? To what extent should backhaul capacity or other network and infrastructure-related considerations factor in? How can we leverage AI/ML to reliably extrapolate limited quantities of data?

2. Methods for Data Collection

34. Given the challenges of cost and burden, standardization, and technical accuracy, we seek comment on the benefits and drawbacks of various methods to gather more robust data. In past reports, stakeholders have identified different approaches, including: (1) crowdsourcing, (2) external data sources, (3) modeling, and (4) direct observation. We seek comment on the feasibility, benefits, and drawbacks of these and other techniques to understand spectrum usage.

35. *Crowdsourcing.* The *2014 NITRD Workshop Report* recommended greater reliance on crowdsourcing techniques to measure utilization.[64] How, if at all, can we leverage crowdsourcing to gain greater visibility into utilization? Can crowdsourcing promise sufficient accuracy and data uniformity? Could the Commission leverage or extend commercially available apps to monitor occupancy through smartphones,[65] particularly as such equipment is widely available for consumer use? Should we consider embedded "receiver monitoring and reporting" features, such as those in handheld devices, that do not require user activation, to minimize separate and costly receiver monitoring infrastructure? Additionally, a NIST study on usage during COVID-19 found that, due to the lockdowns in place at the time, researchers could develop techniques for tuning sensors when precision laboratory calibration was not available, as well as calibration methods for assembled SDRs, and assessments of the performance of spectrum sensors in the field.[66] These techniques made it possible for non-experts to manage occupancy measurements in their own homes using commercial off-the-shelf devices. Could consumers use such equipment to study spectrum utilization in an at-home environment?

36. *External data sources.* Participants of the 2014 NITRD Workshop acknowledged that an "enormous amount of spectrum monitoring information" is "currently being collected by cellular providers, wireless tower companies, satellite providers, wireless research organizations, the federal government, and even universities."[67] Many private companies have also described their own current data collection efforts.[68] What non-public data exist from these efforts? Are such data useful or standardized? How, if at all, are private entities leveraging spectrum usage data to optimize network traffic management or use spectrum more efficiently? How can we better understand the non-public sources available? How can we encourage or incentivize access to these data? What can we do on a

[62] 2014 NITRD Workshop Report at 17.

[63] 2016 NTIA Quantitative Assessments Report at 3.

[64] 2014 NITRD Workshop Report at 19.

[65] Note that this would limit such assessments to the specific bands built into the phone, and depending on implementation, may impact device battery life.

[66] 2022 NIST TN COVID-19 Telework and Telehealth.

[67] 2014 NITRD Workshop Report at 9–10.

[68] *Id.* at 10–12.

going-forward basis to attain greater visibility? Can we take action to make these data more open source? Are there particular technologies or approaches to facilitate data sharing? Who should be responsible for establishing and maintaining a data sharing mechanism? Additionally, do current licensees have sufficient data to facilitate their understanding of utilization? What data do operators have that could be made available to the FCC for spectrum utilization assessment? How can we leverage shared access frameworks (e.g., SAS) to measure utilization? To that end, we invite commenters to discuss whether prior United States government efforts to assess spectrum usage, such as those outlined in Section II.B above, have resulted in greater spectrum efficiency or sharing opportunities.

37. *Data modeling and simulation.* Spectrum consumption models (SCMs) identify how devices or systems use spectrum resources in a particular environment by capturing spectral, spatial, and temporal characteristics of spectrum usage for any specific transmitter, receiver, system, or collection of systems.[69] Using a defined set of constructs, an SCM then translates the inputs from the various constructs into a model that can be used to predict the utilization of specific frequency bands. A 2013 MITRE report outlines 12 constructs typically used to understand propagation, coverage, and interference to build an SCM.[70] These constructs are then combined for the final spectrum consumption model. We seek comment on the SCM approach to spectrum utilization modeling. Are there other algorithms to model spectrum usage? Could data modeling and simulations allow for cost-effective spectrum usage studies? To what extent could modeling be used to accurately reflect spectrum utilization?

38. *Direct observation*. Several approaches taken over the past twenty years seek to directly observe the spectrum environment.[71] We seek comment on whether these frameworks are suitable for studying non-Federal spectrum usage.[72] For example, the NSF 2016 Workshop report recommended a "System of Systems" hierarchy of at least three classes of sensors: (1) high cost / high trust sensors at

[69] Carlos E. Caicedo Bastidas et al., *A Standard Method for Modeling Spectrum Consumption*, 2017 IEEE International Symposium on Dynamic Spectrum Access Networks (DySPAN) (2017).

[70] The 12 constructs include (1) total power (i.e., power at the transceiver to which values of the spectrum mask, underlay mask, and power map refer); (2) spectrum mask (i.e., relative spectral power density of emissions by frequency); (3) underlay mask (i.e., relative spectral power density of allowed interference by frequency); (4) power map (i.e., relative power flux density per solid angle); (5) propagation map (i.e., pathloss model per solid angle); (6) intermodulation mask (i.e., propensity of co-located signals to combine in nonlinear components of an RF system and be emitted by a transmitter or be received in the later stages of a receiver); (7) platform name (i.e., list of names of platforms on which a particular system is located); (8) location (i.e., where system components may be used); (9) start time (i.e., when the model takes effect); (10) end time (i.e., when the model no longer applies); (11) minimum power spectral flux density (i.e., power spectral flux density that when used as part of a transmitter model implies the geographical area in which receivers in the system are protected); and (12) protocol or policy (i.e., documentation accounting for system behaviors that allow different systems to be co-located and to coexist in the same spectrum). MITRE, Model-Based Spectrum Management, Part 1: Modeling and Computation Manual Version 2.0, MITRE Technical Report at 3-1 (2013), https://www.mitre.org/sites/default/files/publications/13-4541-MBSM_Modeling_Manual_v2%25200.pdf (2013 MITRE Technical Report).

[71] To that end, we seek comment on methods to determine whether detected signals are bona fide (i.e., transmissions relating to a request by an end user) as opposed to test signals that do not provide service to an end user.

[72] 2016 NSF Workshop Report at 9. The meeting illustrated that there are a very wide range of possible and in many cases deployed (at least at the prototype level) spectrum measurement architectures and the fact that no single architecture is likely to cover the full range of signal types that need to be measured. *See also* Report to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Energy and Commerce of the House of Representatives, available at https://www.fcc.gov/sites/default/files/report-congress-usps-broadband-data-collection-feasibility-05242021.pdf, which describes a program set up by the Commission to "test[] the feasibility of partnering with Federal agencies that operate delivery fleet vehicles, including the United States Postal Service (USPS or Postal Service), to facilitate the collection and submission' of mobile wireless broadband data for the purposes of supplementing and verifying wireless broadband coverage maps collected by the Commission pursuant to the Broadband DATA Act."

fixed locations; (2) mid-cost / mid trust sensors more widely deployed geographically between the first class of installations; and (3) crowd sourced sensors occupying the bottom tier of the structure.[73] In another example, NTIA used a system of sensors to measure Federal spectrum occupancy in the 3.45–3.65 GHz band to understand the potential for sharing.[74] After we adopted our CBRS rules, NTIA collected data from SAS administrators to quantify utilization in that bands.[75] The ITU recommends that countries establish centralized offices to report data collected by designated monitoring stations, which the ITU then aggregates and summarizes for periodic reports.[76] We seek comment on these various frameworks, mindful of the costs associated with each. Do formal monitoring efforts like those described above offer superior accuracy compared to crowdsourcing, modeling, and third-party data?

39. We are particularly interested in the current state of spectrum measurement tools, ranging from sophisticated and costly instruments to widely deployable and low-cost devices. We also invite comment on the direction for emerging and future tools. We seek comment on monitoring and sensing technologies available in the market today, with special attention to cost and scale. Can cost-effective, commercially available sensors be deployed to measure utilization? Is specialized equipment needed? Does spectrum monitoring technology exist today that is interoperable, low-cost, high-resolution, and privacy-preserving? Are there bands or measurements that might require custom-built monitoring equipment? How would these tools differ by band allocation? For example, how should bands with highly directional signals, such as in the fixed service, be monitored differently than mobile bands?[77] How should services that use new advanced antenna systems that do not blanket an area with energy be evaluated compared to similarly situated licensees that use traditional broad beamwidth antennas? Where might gaps exist due to lack of equipment for specific bands? What limitations are there with currently available spectrum monitoring technology particularly with monitoring short duration, ultra-wideband, and spread spectrum signals?

D. Other Concerns

40. *Data Protection, Privacy and Security*. How should data protection, privacy, cybersecurity, or physical security be taken into account and inform any study of spectrum utilization? What role do commercial sensitivities play? Do current privacy laws limit the Commission's ability to obtain useful spectrum utilization information? Would aggregating, coarsening, sampling, or anonymizing data allay privacy concerns?[78] We invite comment specifically on any limitations to our ability to obtain such information that might result from (1) Electronic Communications Privacy Act (ECPA),[79] including provisions that prohibit the installation of pen register and trap and trace devices

[73] 2016 NSF Workshop Report at 5.

[74] Michael Cotton, et al., *3.45–3.65 GHz Spectrum Occupancy from Long-Term Measurements in 2018 and 2019 at Four Coastal Sites*, NTIA Report 20-548 (Apr. 2020), https://perma.cc/DV8N-WQ88.

[75] *See* 2023 CBRS Usage Report.

[76] ITU Spectrum Monitoring Handbook at 10, 15–18.

[77] 2013 MITRE Technical Report at Table 3-1, defines both the Power Map and Propagation Map modeling constructs on a per solid angle basis, implying directionality, "where the values associated with solid angles are the pathloss model and power pairs." 2013 MITRE Technical Report also notes at 5–15: "Although the directional vector of propagation maps provides an unlimited ability to divide directions into different solid angles and therefore to fit a model to observations, doing so is usually not helpful. Increasing the number of directions and exponents used in a model increases the complexity of the computations of compatible reuse and decreases the efficiency of communicating the model. Modelers must weigh the benefit of having a higher resolution model against these costs."

[78] For examples of anonymized and aggregated data see the 2023 CBRS Usage Report.

[79] "ECPA" commonly refers to three chapters of title 18, United States Code: 18 U.S.C. §§ 2510–2523, commonly referred to as the Wiretap Act; §§ 2701–2713, commonly referred to as the Stored Communications Act; and §§ 3121–3127, the Pen Register Act.

without a court order;[80] and (2) section 222 of the Communications Act and the Commission's implementing rules,[81] which govern the circumstances under which a telecommunications carrier can use, disclose, or permit access to proprietary information about other carriers and their customers, including customer proprietary network information. Do these or other laws restrict our ability to collect spectrum use information, whether or not through direct observation, or to gather it from third parties? Separate from privacy legal requirements, are there any privacy public policy considerations that should inform the Commission's approach to studying spectrum usage?

41. *Legal Authority.* The Commission believes that it has necessary statutory authority to study the usage of non-Federal spectrum under sections 4(i), 301, 302(a), 303(e), (f), and (r), and 403 of the Communications Act, as amended. We seek comment on any opportunities or limitations that our statutory authority under the Communications Act or any other source of authority may impose on our ability to assess utilization.

42. *Promoting Digital Equity and Inclusion*. The Commission, as part of its continuing effort to advance digital equity for all,[82] including people of color, persons with disabilities, persons who live in rural or Tribal areas, and others who are or have been historically underserved, marginalized, or adversely affected by persistent poverty or inequality, invites comment on any equity-related considerations[83] and benefits (if any) that may be associated with the proposals and issues discussed herein. Specifically, we seek comment on how these issues may promote or inhibit advances in diversity, equity, inclusion, and accessibility, as well the scope of the Commission's relevant legal authority.

IV. NEXT STEPS

43. We seek comment on what steps the Commission might take to further this inquiry. For example, how might we consider other means to better understand spectrum usage? Should the Commission consider different techniques for studying spectrum utilization based on the licensing and usage characteristics of a particular band? Would it be advisable to consider seeking usage data held by third parties? What steps might we take to encourage or incentivize data sharing? How would we develop a specification that would allow the exchange of data via a specific format (e.g., JSON, xml, SigMF,[84] SCOS,[85] etc.)? What data exchanges might help facilitate greater understanding of spectrum usage? Should our data specifications match other databases, such as those maintained by NTIA? Where can data be used most effectively to improve policy decisions?

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[80] 18 U.S.C. § 3121.

[81] 47 U.S.C. § 222; 47 CFR §§ 64.2001–2011.

[82] Section 1 of the Communications Act of 1934 as amended provides that the FCC "regulat[es] interstate and foreign commerce in communication by wire and radio so as to make [such service] available, so far as possible, to all the people of the United States, without discrimination on the basis of race, color, religion, national origin, or sex." 47 U.S.C. § 151.

[83] The term "equity" is used here consistent with Executive Order 13985 as the consistent and systematic fair, just, and impartial treatment of all individuals, including individuals who belong to underserved communities that have been denied such treatment, such as Black, Latino, and Indigenous and Native American persons, Asian Americans and Pacific Islanders and other persons of color; members of religious minorities; lesbian, gay, bisexual, transgender, and queer (LGBTQ+) persons; persons with disabilities; persons who live in rural areas; and persons otherwise adversely affected by persistent poverty or inequality. *See* Exec. Order No. 13985, 86 Fed. Reg. 7009, Executive Order on Advancing Racial Equity and Support for Underserved Communities Through the Federal Government (Jan. 20, 2021).

[84] SigMF, *The Signal Metadata Format Specification*, https://perma.cc/Y59X-FQK9 (last visited July 10, 2023).

[85] IEEE, *IEEE Standard for Spectrum Characterization and Occupancy Sensing* (2020), https://perma.cc/2VL6-UAK7.

44. We also invite comment on efforts that we could consider in the near term. Should we consider a field monitoring pilot program, followed by a report describing results? If so, how should we define the bands, geographic areas, and technical parameters of any such trial? Should we prioritize specific bands for initial study? Would it be advisable for this pilot to be conducted in concert with other agencies, universities, or private entities?

45. Longer term, could we consider non-binding guidance, such as a Policy Statement or data specifications outlining best practices and recommended data definitions, structure, and formatting, to set forth our approach to evaluating spectrum usage? Should such guidance define clear problem statements, use cases, and the methodology for monitoring or taking measurements in a specific band? Should such guidance outline the role of utilization data in band-specific proceedings? If we were to consider non-binding guidance, how should we frame the benefits and limitations of utilization data?

V. PROCEDURAL MATTERS

46. *Ex Parte Rules*. This Notice of Inquiry commences an exempt proceeding under the Commission's *ex parte* rules.[86] *Ex parte* presentations are permitted and need not be disclosed, except during a Sunshine Agenda period.[87] Participants in this proceeding may choose to submit written *ex parte* presentations or written summaries of oral *ex parte* presentations in the record, as described in the next paragraph.

47. *Comment Filing Procedures.* Pursuant to sections 1.415 and 1.419 of the Commission's rules, 47 CFR §§ 1.415, 1.419, interested parties may file comments and reply comments on or before the dates indicated on the first page of this document. Comments may be filed using the Commission's Electronic Comment Filing System (ECFS) or by paper. All filings must be addressed to the Commission's Secretary, Office of the Secretary, Federal Communications Commission.

- Electronic Filers: Comments may be filed electronically by accessing ECFS at https://www.fcc.gov/ecfs.
- Paper Filers: Parties who choose to file by paper must file an original and one copy of each filing. Paper filings can be sent by hand or messenger delivery, by commercial overnight courier, or by first-class or overnight U.S. Postal Service mail.
  - Effective March 19, 2020, and until further notice, the Commission no longer accepts any hand or messenger delivered filings. This is a temporary measure taken to help protect the health and safety of individuals, and to mitigate the transmission of COVID-19.[88]
  - Commercial overnight mail (other than U.S. Postal Service Express Mail and Priority Mail) must be sent to 9050 Junction Drive, Annapolis Junction, MD 20701.
  - U.S. Postal Service first-class, Express, and Priority mail must be addressed to 45 L Street NE, Washington, D.C. 20554.

48. *Availability of Documents*. Comments, reply comments, and *ex parte* submissions will be publicly available online via ECFS. These documents will also be available for public inspection during regular business hours in the FCC Reference Information Center, when FCC Headquarters reopen to the public.

49. *People with Disabilities*. To request materials in accessible formats for people with

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[86] *See* 47 CFR §§ 1.1200(a), 1.1204(b).

[87] *See* 47 CFR § 1.1203(a).

[88] *See* FCC Announces Closure of FCC Headquarters Open Window and Change in Hand-Delivery Policy, Public Notice, 35 FCC Rcd 2788 (2020), https://www.fcc.gov/document/fcc-closes-headquarters-open-window-and-changes-hand-delivery-policy.

disabilities (braille, large print, electronic files, audio format), send an e-mail to fcc504@fcc.gov or call the Consumer & Governmental Affairs Bureau at 202-418-0530 (voice), 202-418-0432 (tty).

50. *Further Information*. For additional information on this proceeding, contact Arpan Sura of the Wireless Telecommunications Bureau, at arpan.sura@fcc.gov or (202) 418-0964, or Madelaine Maior of the Broadband Division of the Wireless Telecommunications Bureau, at madelaine.maior@fcc.gov or (202) 418-1466.

VI. ORDERING CLAUSES

51. Accordingly, IT IS ORDERED that, pursuant to sections 4(i), 301, 302(a), 303(e), 303(f), 303(r), and 403 of the Communications Act of 1934, as amended, 47 U.S.C. §§ 154(i), 301, 302(a), 303(e), 303(f), 303(r), 403, this Notice of Inquiry IS ADOPTED.

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch
Secretary

STATEMENT OF
CHAIRWOMAN JESSICA ROSENWORCEL

Re: *Advancing Understanding of Non-Federal Spectrum Usage*, Notice of Inquiry, WT Docket No. 23-232 (August 3, 2023)

Right now there are so many conversations about artificial intelligence in Washington, including right here at the Federal Communications Commission. Just last month we held a joint workshop with the National Science Foundation to consider what AI means for communications networks.

Let me put my cards on the table: I am much more hopeful about AI than pessimistic. A big reason why is that I am an optimist by nature. But that is not all. After all, where you stand has a lot to do with where you sit. From my perch as the head of our Nation's expert agency on communications, I can't help but be an optimist about the future of AI.

That might sound contrarian. So much of the news about AI is dark. How do we rein in this technology? What does it mean for the future of work? What will it mean for democracy and elections? What happens when AI models inherit the prejudices of the systems they are trained on and determine who gets a loan and who gets a job? What does it mean for competition? And does generative AI pose an existential risk to humanity that could lead to our extinction?

These are big questions. So let me get back to what at this agency we know best—communications. What we understand is that the airwaves around us are invisible infrastructure. How we allocate this resource supports—and constrains—what we can do with it.

Right now, so many of our commercial spectrum bands are growing crowded. Hundreds of millions of wireless connections—from smartphones to medical sensors—are using this invisible infrastructure. And that number is growing fast. But congestion can make it harder to make room in our skies for new technologies and new services. Yet we have to find a way, because no one wants innovation to grind to a halt. To do this we need smarter policies, like efforts that facilitate more efficient use of this scarce resource. I think of it as an abundance agenda.

Now enter AI. A large wireless provider's network can generate several million performance measurements every minute. Using those measurements, machine learning can provide insights that help better understand network usage, support greater spectrum efficiency, and improve resiliency by making it possible to heal networks on their own.

Today's inquiry is a way to understand this kind of potential and help ensure it develops here in the United States first. We start by focusing on spectrum utilization. For decades in this country, we have licensed large slices of our airwaves and come up with unlicensed policies for joint use in others. This scheme is not truly dynamic. But with demands on our airwaves growing with the internet of things, we want to better understand spectrum utilization in geography, frequency, and time. This is the kind of data that could help make our policies smarter and more effective. It could also help support new cognitive abilities that could teach our wireless devices to manage transmissions and avoid harmful interference on their own. In other words, smarter radios using AI can work with each other without a central authority dictating the best of use of spectrum in every environment.

If that sounds far off, it's not. Take a look at the work that the Defense Advanced Research Projects Agency and National Science Foundation have been doing for years on this subject. In particular, take a look at DARPA's Colosseum network emulator, designed to support the development of new radio network technologies, and DARPA's Spectrum Collaboration Challenge, which invited innovators to design new wireless networks using AI. The final round of this challenge was held a few years back in Los Angeles. Teams used AI-enabled radios to go head-to-head against each other demonstrating how machine learning can support real-time dynamic spectrum decision-making, increasing efficiency and decreasing interference. It was held in a dark auditorium in Los Angeles, but it was a bright look at our wireless future—I know, because I was there.

DARPA's Colosseum network emulator is now hosted by Northeastern University in Boston, in partnership with the National Science Foundation. At the FCC, we've supported these efforts by establishing special wireless Innovation Zones in Boston to support continued work with the emulator and in Salt Lake City, where the National Science Foundation has set up outdoor, city-scale wireless test beds. But I believe we can do more to increase our understanding of spectrum utilization and support the development of AI tools in wireless networks. That is what today's inquiry is all about. I look forward to the record that develops because I believe if we do this right, we can help turn spectrum scarcity into abundance.

I want to thank the staff who worked on this effort, including Jack Detiveaux, A. Cameron Duncan, Madelaine Maior, Roger Noel, Blaise Scinto, Arpan Sura, Joel Taubenblatt, and Andrew Ware from the Wireless Telecommunications Bureau; Chrysanthos Chrysanthou, Michael Davis, Martin Doczkat, Ira Keltz, Jonathan Lu, Robert Pavlak, Barbara Pavon, Ronald Repasi, and Sean Yun from the Office of Engineering and Technology; Deborah Broderson, William Dever, Douglas Klein, Anjali Singh, Elliot Tarloff, and Chin Yoo from the Office of General Counsel; Judith Dempsey, Catherine Matraves, and Giulia McHenry from the Office of Economics and Analytics; Thomas Eng, John Evanoff, David Furth, Debra Jordan, Brian Marenco, Roberto Mussenden, Renee Roland, and Rasoul Safavian from the Public Safety and Homeland Security Bureau; Shannon Lipp, Jeremy Marcus, David Marks, and Michael Rhodes from the Enforcement Bureau; and Jared Carlson, Nese Guendelsberger, Dante Ibarra, Ethan Lucarelli, Olga Madruga-Forti, Roxanne McElvane-Webber, Tom Sullivan, and Michele Wu-Bailey from the Office of International Affairs.

STATEMENT OF
COMMISSIONER GEOFFREY STARKS

Re: *Advancing Understanding of Non-Federal Spectrum Usage*, Notice of Inquiry, WT Docket No. 23-232 (August 3, 2023)

As many of you know, I've been a consistent advocate for enhancing data-driven decision-making. For example, leading up to the passage of the Broadband DATA Act, I proudly championed the need to improve our mapping capabilities so that we can succeed in extending connectivity everywhere. In addition, I've called for the periodic evaluation of FCC programs, including initiatives focused on expanding spectrum availability like the Enhanced Competition Incentive Program. And I also voiced concerns about the quality of data used to determine support amounts for rural hospitals and clinics—concerns that are now steering us toward new rules that do not leave rural patients behind in the age of telehealth and connected medicine.

Whether we're deciding which way to go in a complex proceeding, or simply looking back to see what we've done well and where there's room for improvement, having the right information at our fingertips can help us better serve the public and promote accountability. And where we embrace the use of data already, we should continue to search for ways to enhance its accuracy, reliability, and completeness for the many important tasks before us.

Which brings us to today, and the important task before us. Expanding spectrum access is particularly ripe for data-driven enhancements. Even though the resource is fixed, unused amounts are generally falling—all while demand only continues to build. Though the task often seems impossible, finding new ways to make more spectrum available is vital to our economic success and national security. As it turns out, developing accurate information about how we're using spectrum today may be one of the best ways to ensure we have enough of it available for use tomorrow. Better data can help us identify opportunities for greater usage, develop and enforce more efficient technical and service rules, and learn from past spectrum decisions.

Perhaps most importantly, these benefits propagate well beyond FCC walls. Researchers across industry, academia, and government regularly query our licensing databases. With greater visibility into how spectrum is used, they'll be even more able to unlock opportunities for coordination and efficient spectrum transactions and develop and deploy new wireless technologies. As I mentioned in June, advancements in AI could be part of this story.

Of course, there are significant and longstanding questions to be considered in this endeavor. I look forward to seeing a robust record, and how best to move forward.

I thank the staff for their hard work on this item. It has my full support.