October 2, 2023

ASSIA is pleased to submit our comment in response to FCC*'s* Notice of Inquiry on *Advancing Understanding of Non-Federal Spectrum Usage* - WT Docket No. 23-232*.*

ASSIA looks forward to engaging with FCC in a further exploration of the issues we have raised in this comment through an ex parte presentation, or other appropriate public process.

Best regards,

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FCC*'s* Notice of Inquiry on *Advancing Understanding of Non-Federal Spectrum Usage* - WT Docket No. 23-232 - Comment from Adaptive Spectrum and Signal Alignment, Incorporated (ASSIA®), 303 Twin Dolphin Drive, Suite 600, Redwood City, CA 94065.

1. Introduction

In the introduction to the FCC's Notice of Inquiry *Advancing Understanding of Non-Federal Spectrum Usage,* the FCC states:

> "*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 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*[1] "

ASSIA has responded to a number of FCC and NTIA enquiries over the past two years related to ensuring the quality of broadband access for all Americans[2,3,4,5]. While the subject of these enquiries and ASSIA's responses were specifically related to the determination of overall broadband quality provided to America's broadband users, both wired and wireless, our observations regarding the nature of that problem and potential solutions also relate to issue raised in the current NOI, that is the availability of accurate, publicly available, and pervasive data regarding spectrum usage. Quoting the first sentence of the FCC's introduction to the current NOI as cited above, "*Spectrum usage information is generally non-public and made available infrequently*" indicates that the FCC already recognizes the essence of the problem relates to public access to the "*large and complex datasets*" needed to understand the issues related to spectrum usage.

2. Opportunities for Pervasive and Accurate Measurements and Analysis

In sections34, through 38 36 of the current NOI, the FCC raises questions specifically focused on these concerns:

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[1] FCC NOI *Advancing Understanding of Non-Federal Spectrum Usage* - WT Docket No. 23-232*, §1.*

[2] NTIA - Request for Comments on Broadband Programs in Bipartisan Infrastructure Law – [Docket No. 220105–0002] Comment from Adaptive Spectrum and Signal Alignment, Incorporated (ASSIA®) 203 Redwood Shores Parkway, Suite 100, Redwood City CA, 94065

[3] FCC*'s* Request for Comments on *Empowering Broadband Consumers Through Transparency* – CG Docket No. 22-2 – *FCC 22*-7: Comment from Adaptive Spectrum and Signal Alignment, Incorporated (ASSIA®), 203 Redwood Shores Parkway, Suite 100, Redwood City, CA 94065.

[4] FCC's Request for Comments on the Interagency Broadband Coordination Agreement [WC Docket No. 22-251] Comment from Adaptive Spectrum and Signal Alignment, Incorporated (ASSIA®) 203 Redwood Shores Parkway, Suite 100, Redwood City CA, 94065

[5] ASSIA and Ghosh response to the National Telecommunications and Information Administration [Docket No.: 230224–0051] RIN 0660–XC055 Digital Equity Act of 2021; Request for Comments

- "*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*"[6].

- Crowdsourcing. "… *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, 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?*[7]*"*

- External data sources. *"... 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.' Many private companies have also described their own current data collection efforts. 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 going-forward basis to attain greater visibility? Can we take action to make these data more open source? ..."*[8].

- Data modeling and simulation "…*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?*[9]

- Direct observation. "*Several approaches taken over the past twenty years seek to directly observe the spectrum environment. We seek comment on whether these frameworks are suitable for studying non-Federal spectrum usage. ... 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*"[10]

Even though the issues related to analysis of broadband access covered in ASSIA's previous comments to the FCC and NTIA are not identical to those required for exploring spectrum usage, they do overlap both in terms of technical solutions and regulatory direction. The commonality in all of ASSIA's

[6] FCC NOI Advancing *Understanding of Non-Federal Spectrum Usage* - WT Docket No. 23-232, *§34.*
[7] FCC NOI Advancing *Understanding of Non-Federal Spectrum Usage* - WT Docket No. 23-232, *§35.*
[8] FCC NOI Advancing *Understanding of Non-Federal Spectrum Usage* - WT Docket No. 23-232, *§36*
[9] FCC NOI Advancing *Understanding of Non-Federal Spectrum Usage* - WT Docket No. 23-232, *§37*
[10] FCC NOI Advancing *Understanding of Non-Federal Spectrum Usage* - WT Docket No. 23-232, *§38*

previous FCC and NTIA comments applies to the issues raised in the current NOI, especially those in sections 34, 35, 36, and 37.

Summarizing this commonality: Policy decisions, whether related to ensuring broadband quality or understanding spectrum needs and optimally allocating spectrum, need be based upon pervasive and continuously collected data actually delivered to users. Such pervasive collection must be (1) secure, (2) anonymous, (3) non-interfering, (4) statistically valid, and (5) highly accurate. When based on common requirements and processes, use of information readily available in the used endpoint equipment can become a common resource that is used by government, industry, and others to understand a nation's broadband infrastructure, which includes understanding spectrum allocation.

In the area of broadband technologies, including Wi-Fi, cellular services such as 5G, and wired broadband access, ASSIA with its *ASSIA Reports* project develops technologies that enable such pervasive data collection, analysis, and presentation of overall end-to-end and sectionalized performance of broadband networks. ASSIA's technologies enable network-wide data collection and analysis that meet all five of the aforementioned requirements. This is based on instrumentation of customer premise equipment, including wireless access devices. In some cases, this information is already collected by network operators and other service providers and the instrumentation is already available on the equipment or easily added through techniques such as firmware upgrade. The basis of this collection and analysis is performance information available from a vast majority of network users rather than a small sample of volunteers who agree to provide information. In many cases the relevant data is already collected by the user devices and can be updated in a timely manner from essentially all broadband network users, wireless and wired, while preserving anonymity, privacy, and protecting personal information.

In response to the issues raised in sections 34, 35, 36, 37, and 38 of the current NOI, ASSIA proposes both an architectural framework and requirements to guide regulatory development with respect to collection, presentation, and analysis of spectrum usage and performance data from pervasively available sources. A regulatory framework based on these requirements for data availability, collection, presentation, and analysis will help ensure that all stakeholders, e.g., the government, industry, and the public, have the information available for appropriate allocation of spectrum resources.

3. Data Collection and Analysis Framework

ASSIA has presented a similar architectural framework in our comments to the FCC and NTIA regarding validation of broadband quality as received by end-users. [11,12,13,14] This architecture provides the basis for federated collection, analysis, and presentation of pervasively collected, anonymized data, that is statistically valid. ASSIA believes that a similar solution will address the issues raised in understanding spectrum usage and allocation.

3.1. Data Collection and Analysis Phases

The need to enable the use of commonly collected and comparable data to support disparate analysis invites the following division into process 'phases' for gathering and analyzing spectrum usage and allocation data:

Phase 0: Raw data and measurements are collected from network and user devices. Installing a software agent on the devices is an effective way to run tests and gather measurements.

Phase 1: Devices send data reports to a remote server or cloud database. Here, an agent is very useful for aggregating raw data. A standardized protocol is recommended for the formatting and sending of the data.

Phase 2: Determination of statistical performance across the population is performed. Histograms, max, min, average and other statistics are effective outputs of Phase 2.

Phase 3: Evaluation is performed, where metrics and figures of merit are produced and presentations generated (e.g. plots, trends, and overall scores such as the Quality of Experience Delivered (QED) metric as defined in Broadband Forum BBF MR 452.2).

Figure 1 illustrates the data collection and analysis phases.

[11] NTIA - Request for Comments on Broadband Programs in Bipartisan Infrastructure Law – [Docket No. 220105–0002] Comment from Adaptive Spectrum and Signal Alignment, Incorporated (ASSIA®) 203 Redwood Shores Parkway, Suite 100, Redwood City CA, 94065

[12] FCC's Request for Comments on *Empowering Broadband Consumers Through Transparency* – CG Docket No. 22-2 – *FCC 22*-7: Comment from Adaptive Spectrum and Signal Alignment, Incorporated (ASSIA®), 203 Redwood Shores Parkway, Suite 100, Redwood City, CA 94065.

[13] FCC's Request for Comments on the Interagency Broadband Coordination Agreement [WC Docket No. 22-251] Comment from Adaptive Spectrum and Signal Alignment, Incorporated (ASSIA®) 203 Redwood Shores Parkway, Suite 100, Redwood City CA, 94065

[14] ASSIA and Ghosh response to the National Telecommunications and Information Administration [Docket No.: 230224–0051] RIN 0660–XC055 Digital Equity Act of 2021; Request for Comments

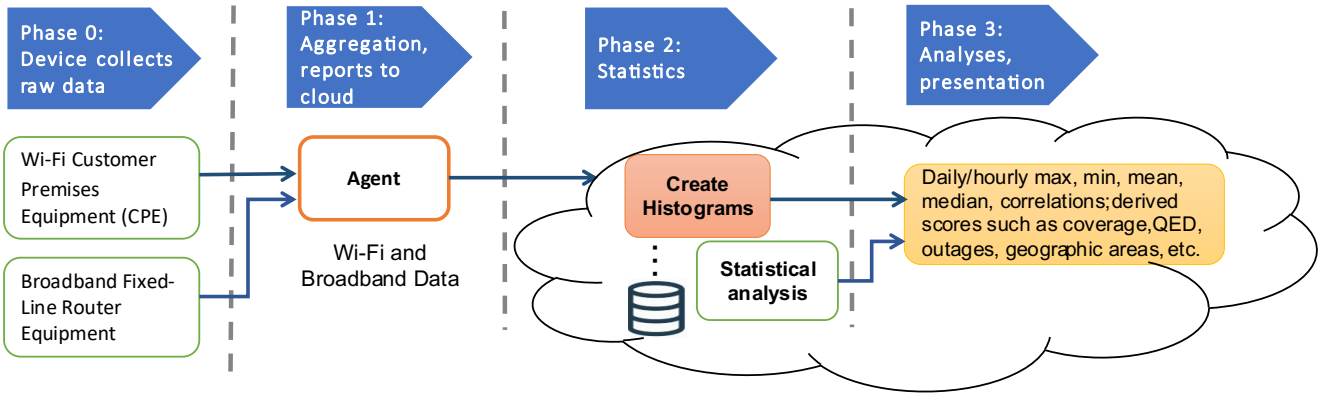

Figure 1 – Overview of the Phases of Data Collection and Analysis of Spectrum Related QoS and Reliability Data[15]

The opportunity exists, as indicated by the current NOI, for the FCC to both encourage standardization and to provide regulatory guidance to specify requirements for Phase 0 and Phase 1 data collection and aggregation of spectrum usage information. By enabling standardized and pervasive collection of data, a wide and versatile range of Phase 2 and Phase 3 data aggregation and analysis will also be enabled. With specification of the parameters and their characteristics that need to be collected in Phase 0, Phase 1 requirements would support uniform collection formats and reporting intervals. The requirements to support Phases 2 and 3 would largely relate to the analyses and presentation of the final data.

Illustrating the importance of world-wide of frameworks that would provide pervasive, federated, and accurate measurements of broadband QoE and QoS to the governments, industry, and the public, the report of the workshop held June 20 to 21, 2023 6G and Future Wireless Systems A Joint, Member-Led Event between The Royal Swedish Academy of Engineering Sciences (IVA) and The US National Academy of Engineering (NAE) emphasized the importance of pervasive and federated measurements of both QoE and QoS Quoting from the report in the section titled 'Research Directions'[16]

> "Foremost, the panel discussed the importance of robustness, reliability, sustainability, and packaging, pointing out there is much work yet to be done regarding the characterization of sustainability as a key performance indicator (KPI). While there is much interesting research being conducted (ORAN, for example) it is essential to focus on technology that is sufficiently scalable. The panel emphasized that mobile wireless communication should be a sort of "network of the people, for the people and by the people", and so there must be identified KPIs that are more user-centric than technology-centric. The quality of experience (QoE) of

[15] While this figure has a specific focus on Broadband Access, whether wired or wireless, and Wi-Fi in particular, the framework can be extended to other spectrum usage issues.

[16] *Workshop Output Report 6G and Future Wireless Systems: A Joint, Member-Led Event between The Royal Swedish Academy of Engineering Sciences (IVA) and The US National Academy of Engineering (NAE)*. Dr. Mallik Tatipamula, CTO Ericsson, Silicon Valley; Professor Albert P. Pisano, NAE Dean of Engineering, UC San Diego; Prof. John M. Cioffi, Stanford University; Prof. Muriel Medard, MIT

> users must be defined in terms of latency and bandwidth in a way that is interpretable by an application programming interface (API)."

Dr. John Cioffi ASSIA's CEO, is a co-author of the report of this intentional event and chaired the discussion session related to Research Directions at the meeting. Further, in the report on the session titled Potential Collaboration Areas between USA and Sweden contained the following text:

"The panel identified a particular collaboration, among USA-Sweden governments and/or internet company contributions, to encourage internet service providers (ISPs) to provide data to a federated system that could be used to identify more coherently where improvements in future wireless are necessary."[17]

The report concludes with a quote from a joint statement by the President of the United States and the Prime Minister of Sweden regarding the critical importance of the topics covered in the workshop.[18]

ASSIA believes that the report from this meeting underscores the vital impacts world-wide achieved by implementing the architectural framework proposed in our comment.

3.2. Broadband Data Collection Framework

Uniformity

The performance and measurement requirements serve several purposes that include compliance verification with (infrastructure) grant terms, addressing third-party challenges, and assessing compliance of the FCC data collection with Congressional mandates, future policy-direction guidance, and the evolving needs of the citizens and industry. A particular system's measurements, possibly for a particular purpose, should be comparable to the same or similar measurements made by other systems for similar (and/or other) purposes. Systems that collect, store, and analyze data for these various purposes should have identical data definitions, algorithms, and presentation when the same types of data are collected and analyzed. Standardized, reusable systems and methods should be encouraged, and these systems and methods should be optimized to enable analysis and presentation. Where there are already existing standards, these should be utilized, and when standards data formats and structures do not exist, they need be developed.

Accuracy

Measurement accuracy requirements need specification. Tools and systems should enable information collection that is statistically sound from as large a sample space as possible to provide accurate consequent results across the population. Ideally, data collection is from most, if not all, customers served by a network.

[17] Ibid.
[18] Ibid.

Cost Effective

The requirements must be supportable by systems and processes that are cost effective. These systems should add little to the marginal cost of deployment, customer equipment, and support systems. Parameters can be sent from the device using standard protocols such as Broadband Forum's TR-69 or TR-369. There should also be support for control of the collected data's parameters and frequency of collection.

Another "cost" is any adverse impact to the user's service. This can be limited by careful specification of test and measurement procedures and methods.

Software-based data collection and analysis is generally more cost effective than deploying a dedicated hardware box at the user's premise. The most cost-effective solution is to deploy a software agent on user devices that collects data and sends it up to the cloud. Running tests to measure speed and latency generally require such an agent. The speed and latency of both the broadband connection and the Wi-Fi links can be accurately measured with an agent residing, for example, within the Wi-Fi-enabled broadband gateway at the customer's premises. The agent can also assist in reading and averaging or otherwise combining a great many performance parameters.

Support Problem Sectionalization

A broadband system or other network comprises a number of architectural components: the customer's (wired and/or wireless) LAN, the broadband access itself, the middle-mile infrastructure, the backend network, and the systems providing content. Measurements of spectrum usage, congestion, and performance are but part of the overall performance of system, and understanding the effects of spectrum allocation requires that other factors affecting performance can be identified as well. This requires that the information can support sectionalization of performance.

Clear data labeling is critical for understanding where a bottleneck occurs within the end-to-end connectivity that supports broadband applications and for identifying which service, content, or hardware provider in this end-to-end chain complies with the advertised performance parameters.

Stakeholder Independence

Measurements and analysis of the measurements could be made by multiple sources, each a stakeholder with different and possibly conflicting interests. The measurement and reporting systems and definitions should enable such multi-sourced measurements and ensure that the measurements are comparable regardless of source. The architectural separation of the problem of broadband data collection into the phases described in this comment will enable this independence.

Privacy

The systems, requirements, and methods must ensure data anonymity, particularly protection of the consumers' personally identifiable information as an inherent quality of the systems' requirements and

design. Data collection must be supported by secure systems and processes that enable anonymous, non-interfering, and non-invasive performance data collection.

4. Conclusions and Summary

The suggestions and methods outlined here can assist the FCC in specifying high-level, consistent requirements for data collection and analysis needed to understand spectrum allocation. These suggestions and methods can enable flexible, low cost, secure, and anonymous analysis that meets current needs and supports identifying future directions in spectrum allocation policy.

ASSIA looks forward to engaging with the FCC and other agencies in a detailed exploration of the issues raised in this comment through an ex parte presentation or other appropriate public process, during the FCC's development of its spectrum allocation measurement policy.