January 27, 2023

Adaptive Spectrum and Signal Alignment Incorporated (ASSIA)
303 Twin Dolphin Drive, Suite 600
Redwood City, CA 94065

The Wireless Institute,
University of Notre Dame
275 Fitzpatrick Hall,
Notre Dame, IN 46556

Teresa Dailey
Contracting Officer/OMD
Federal Communications Commission/OMD
Email: Teresa.Dailey@fcc.gov

Dear Ms. Dailey

Adaptive Spectrum and Signal Alignment, Incorporated (ASSIA®) and the Wireless Institute of the University of Notre Dame are pleased to submit our joint response to RFI-OET2022-MBA, Request for Information: Fixed Broadband Measurement Measuring Broadband America (MBA) Program, December 15, 2022. If you have any questions regarding this response please feel free to contact Mr. Peter Silverman, Sr. Director Law and Technology at ASSIA via email at psilverman@assia-inc.com with a cc: to Dr. Monisha Ghosh at the Wireless Institute at Notre Dame, email: mghosh3@nd.edu.

Please note that our response to the required questions in the RFI begins in Section 5 of our response, beginning on page 14.

ASSIA and the Wireless Institute thank you for giving us opportunity to respond to the FCC's RFI and look forward to further discussions with the Commission.

Regards,

Peter Silverman,
Sr. Director Law and Technology
ASSIA
847 226 5069
psilverman@assia-inc.com

Dr. Monisha Ghosh
Professor
Department of Electrical Engineering,
University of Notre Dame
574 631 6215
mghosh3@nd.edu

1 INTRODUCTION

ASSIA and University of Notre Dame Wireless Institute together (hereafter **WE**) are pleased to submit this joint response to the FCC's Request for Information on the Fixed Broadband Measurement Measuring Broadband America (MBA) Program - RFI-OET2022-MBA. In Section 2 of RFI-OET2022-MBA, the FCC describes both the requirements for the Fixed Broadband Measurement in the MBA process and the FCC's present method of operations (PMO). This RFI response will observe that the PMO fails to achieve the requirements of the Broadband Data Improvement Act of 2008 to provide ubiquitous, continuous, unbiased, statistically valid, and complete measurements and analysis of fixed broadband performance throughout the United States. This RFI response thus describes an improved system and process that can be implemented today to achieve the Act's goals. A limited Proof of Concept (PoC) is suggested to demonstrate the feasibility and value of this improved system.

1.1 COMMENTS ON THE BACKGROUND – THE FCC'S PRESENT METHOD OF OPERATIONS

The FCC, in order to meet the requirements of the Broadband Data Improvement Act of 2008 as well as later acts of Congress[1], has need for more ubiquitous and continuous monitoring of broadband internet connectivity and performance. With broadband services becoming the backbone of the United States' economic viability, pervasive, continuous, anonymous, and federated oversight of Broadband and its associated Wi-Fi performance cannot require specialized boxes placed at consumer-home locations. Rather, the data must be based upon ISP or other service provider collecting and providing the properly anonymized and certifiably accurate performance data during these ISP's normal network operation. Today ordinary customer premises equipment's internal agents collect and forward this performance data, which can be forwarded to an unbiased independent entity that performs analysis, without the need for expensive specialized equipment. The collection is thus pervasive and continuous; it provides statistically relevant data that enable accurate overview of network-performance and its relation to broadband consumer's perceived Quality of Experience (QoE) and Quality of Service (QoS). This approach also avoids statistical errors produced by the small sample size inevitable with specialized monitoring equipment's use. Performance-data anonymization preserves broadband consumers' privacy. This document addresses performance-data collection requirements to implement such analysis consistently and persistently over many ISPs and their full broadband consumer bases.

Current broadband performance measurements monitor only service providers offered downstream and upstream speeds. This simple characterization does not necessarily account for service-quality dependency on latency and availability. Further, there are many broadband-performance measures relevant to particular services, particular parts of the network, and particular aspects of service delivery. For example, while in-premises Wi-Fi isn't physically part of a broadband access link, the user perceives it to be so. Also, saturated Wi-Fi bandwidth usage or other Wi-Fi impediments directly impact broadband service quality in many serving areas, rendering a subsidy less effective. Simply put, if the quality of overall customer experience is to

[1] For example, *The Infrastructure Investment and Jobs Act: Division F – Broadband,* Pub.L117-58 and *The Broadband Interagency Coordination Act of 2020, Pub.L. 116-260;*

be measured it must be possible to separate and sectionalize the performance of the Wi-Fi at the customers premises from the performance of the broadband access, and this separation can be performed today without specialized equipment at the customer's premises. An implementation of this RFI's wide range of performance parameters and relations between parameters permits time-indexed evaluation and tracking and thus comprehensive network status.

This RFI response presents a schema to support pervasive data collection and analysis. Performance-data parameters pertinent to service quality across broadband and Wi-Fi networks are defined. Most of these parameters are already standardized and specified in data models such as the Broadband Forum's TR-181 Data Elements Technical Report. This document's data-performance parameters also partition into levels, where increasing levels probe deeper into network performance. The RFI response also describes the phases of data collection, from the equipment itself through management systems to presentation. It is shown how to perform further data analyses across a population, including individual statistics such as averages, or histograms, or derived performance measures.

In order to separate the performance of the Wi-Fi link from the fixed broadband link, one needs to quantify the quality of the Wi-Fi link. This can be done quite easily today using apps on mobile devices that are capable of extracting the relevant parameters such as Received Signal Strength Indicator (RSSI), Wi-Fi frequency being used (2.4, 5 or 6 GHz), Wi-Fi channel bandwidth being used (20, 40, 80, 160, 320 MHz), transmit/receive link capability, number of stations associated with the access point (AP)and interference from other Wi-Fi APs on the same channel. This information, combined with the fixed link parameters identified above can be used to build a much deeper understanding of the end-to-end broadband experience compared to the existing MBA process.

1.2 Overview of Proof of Concept

ASSIA and University of Notre Dame Wireless Institute (hereinafter **WE**) suggest a Proof-of-Concept (PoC) deployment to provide a one-time analysis of US residential broadband performance, including Wi-Fi connectivity in US broadband subscribers' homes in a jurisdiction to be agreed with FCC (hereinafter **LOC**), but initially specified as South Bend, Indiana. The PoC analysis will be based on continuous and pervasive collection of anonymized broadband and Wi-Fi performance data from customers of a selected broadband service providers' (hereinafter "**ISPs**") residential broadband network in **LOC**. Data for 10,000 to 50,000 links will be collected continuously over a 3-month period beginning in 2023. **WE** will analyze this collected data and provide several significant connectivity measures including data rate, broadband throughput, latency, Wi-Fi interference and Wi-Fi throughput. The report can also contain other sophisticated measures, enabling analysis of broadband quality of service (QoS) received by the measured **ISP**s' customers and the identification and analysis of Wi-Fi specific limitations on subscriber connectivity and performance. **WE's** consequent report will summarize findings. The report will use a format that can be extended to enable future monthly or quarterly reporting, or online instantaneous snapshots of broadband connection speeds and performance metrics provided to consumer end devices and applications.

WE's PoC will also support evaluation of the PoC process extension for possible future use to provide ongoing overviews of the entire US Broadband and Wi-Fi performance. As required by the MBA WE will assist in evaluation of the potential deployment of a federated US broadband reporting system for all US consumers, based on the techniques used in this PoC. Such a federated reporting enables a continuous and statistically valid overview of US broadband capabilities free of the need for special customer premises equipment or other specialized data collection techniques

2 BROADBAND DATA COLLECTION FRAMEWORK FOR AN ENHANCED MBA

A number of variables should be specified to have consistent MBA results that are directly comparable across network operators and regions. Data collection, their distillation, and broadband parameter definitions are inherently variable and need such agreed specification. This section presents a broadband data collection framework that can support the requirements for an accurate "Broadband Nutrition Label" and other mandates of the Infrastructure Act. This framework defines the phases of data collection, stratifies broadband parameters into levels, and details parameters.

2.1 DATA COLLECTION 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 broadband performance 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. For this phase, a software agent is very useful for aggregating raw data, such as averaging many 5 second measurements and then reporting every 15 minutes to limit telemetry traffic. A standardized protocol such as Broadband Forum TR-69 or TR-369 is recommended for sending the data.

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

Phase 3: Evaluation is performed where derived 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.

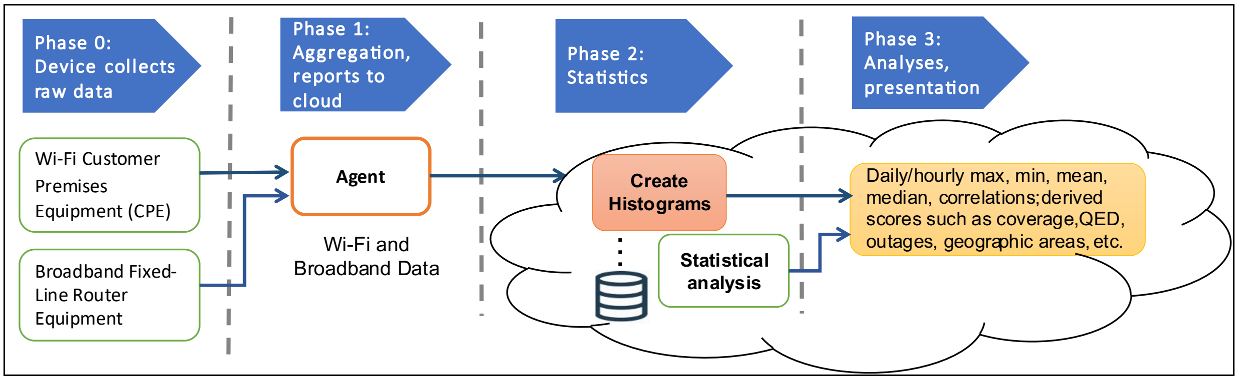

Figure 1 – Overview of the Phases of Analysis of Broadband QoS and Reliability Data

Examining the QoS and reliability requirements of Section 60102 of the Infrastructure Act, the regulations promulgated by the Government -- including the FCC with respect to the Broadband Nutrition Label, should specify requirements for Phase 0 and Phase 1 as seen in this model to enable a wide and versatile range of Phase 2 and Phase 3 data aggregation and analyses. The FCC, in coordination with the NTIA and the Department of Agriculture and other interested government bodies, would specify the parameters and their characteristics that need to be collected in Phase 0, then Phase 1 requirements would support uniform collection formats and reporting intervals. The requirements to support Phases 2 and 3 would largely relate to the analysis and presentation of the final data. In the case of the Broadband Nutrition Label, this analysis would be specific to the requirements of the regulations defining the Label.

2.2 Broadband Parameters Levels and Definitions

The collected information partitions into 'Levels' that stratify parameters. A Broadband Nutrition Label should include parameters in Levels 0-2 defined here, with Level 0 and Level 1 being the most visible, while Level 2 is also important. Level 3 opens vistas into sensing and cognitive experience/reaction of consumers to their service.

- Level 0: Advertised broadband speeds as stated by service providers or regulation. Level 0 values are not measured per-se but rather are stated and published. The rules being developed should specify the Level 0 parameters that underlie the regulations.
- Level 1: Salient performance measures (e.g., measured speed and latency). Perceptible by consumers, these measures required for evaluating conformance with broadband performance targets.
- Level 2: Further parameters that directly influence service quality (e.g., availability, loss rates) for network operators to determine service issues, perform diagnostics, and determine performance. Moreover, Level 2 parameters help determine network bottlenecks, for example, assessing overall link poor-performance causes between the broadband access link and the consumers' Wi-Fi link. Sectionalization is important firstly because a broadband access guarantee is not necessarily responsible for the

performance of a consumer's own Wi-Fi and secondly because problem location can further regulatory actions, such as, spectrum allocation to Wi-Fi or encouragement of industry research or standardization to address these quality issues. Such knowledge could have very significant impact on infrastructure funding decisions. For instance, if expensive fiber deployment is undertaken in an area where the in-home-end Wi-Fi link is limited, then this fiber investment does not produce immediate benefit. Instead, funds to improve spectrum use and assignment might best first be spent.

- Level 3: Level 3 parameters may not be of explicit concern for these rules. These parameters indirectly influence performance, for deep-dive diagnostics and troubleshooting. Level 3 measurements are used by a network operator to diagnose issues and engineer their networks. Level 3 parameters also enable sensing information, which can be useful in emergencies or system dynamics.

The parameters to be collected to support broadband measurement requirements are listed in Table 1 and defined in the text below.

Table 1. Broadband access parameters and levels

Parameter	Direction	Recording Frequency	Unit	Level
Offered speeds	Downstream and upstream	N/A	Mbps	0
Throughput	Downstream and upstream	Daily (hourly also optional)	Mbps	1
Latency	Roundtrip	Daily (hourly also optional)	Milliseconds	1
Packet loss rate	Downstream and upstream	Daily	Percent	2
Internet Down Count		Daily	Number of occurrences/day	2
Internet Down Duration		Daily	Seconds/day	2

Broadband throughput

Broadband throughput (speed) is measured as the average throughput for upstream and downstream in Megabits per second (Mbps). Speed tests measure the upload/download speeds of the Broadband service. Typically, speed or throughput is measured between the broadband gateway and a test server. Test servers are geographically distributed, and the broadband gateway dynamically selects the closest speed-test server (e.g., through cached latency tests), performs throughput measurements, and reports the results to the remote server. Each speed test result sent by the device contains broadband throughput data.

Broadband latency

Broadband latency is measured and recorded as a daily average in milliseconds, using round-trip latency measurements between the broadband gateway and a network-located broadband speed test server. The broadband gateway periodically measures the Round-Trip-Time (RTT) to all the pre-configured speed-test servers and reports the results to the remote server. Broadband latency results are also used for detecting the closest speed-test server and for detecting Internet disconnections.

Broadband packet loss rate
The packet loss rate (PLR) is defined as the loss rate after all error correction is applied. The count of all lost or discarded received packets is divided by the total received packet count to determine the PLR.

Internet down count
Internet down count is a tally of the number of internet disconnections in a day. The device can record an internet down event if it cannot establish a connection to any remote speed-test server. While the internet is down, the broadband gateway or device will not have a connection to remote servers. In such times, the device will record internet connection error. When the internet connection is restored, the device uploads all the results to the server. The internet down count is incremented if the internet connection was down for all the speed tests (to different servers) reporting connection errors.

Internet down duration
Along with the detection of disconnections, the approximate time duration of internet disconnections is provided. Internet down events can be recorded on the device, and these events are uploaded to the remote server once the connection is restored. Internet down count and down duration are raw data that are useful for calculating broadband reliability and availability. Another way of determining availability is to run speed tests by only adding a limited amount of "headroom" test traffic above the current rate of user traffic; such tests can determine if the user perceives broadband to be available for their needs.

2.3 Wi-Fi Parameters

While not directly required for broadband access, determining the performance of the Wi-Fi link of the broadband connection is highly useful for sectionalization and identifying Wi-Fi bottlenecks. Salient Wi-Fi performance parameters are: throughput, latency, traffic, frame loss and retransmission rates, interference, congestion, channel utilization (airtime), Wi-Fi coverage, transmit rate, surrounding BSS's density, and received signal strength. These parameters should be combined into a single score that can be used on a Broadband Nutrition Label to represent a broadband network operator's expected Wi-Fi performance.

2.4 Stratification Dimensions

Each parameter may be further stratified into a list of separate parameters, one for each dimension or for each combination of dimensions. Upstream and downstream can typically be specified for each parameter, except for round-trip measurements such as latency.

Broadband parameters can also be further dimensioned or stratified by:

- Upstream and downstream
- Broadband type: DSL, cable, fiber, satellite, fixed wireless, etc.
- Area: Urban, suburban, and rural areas (can similarly stratify by for income level across a geographic area)
- Per service level or per application type

3 SUGGESTED REQUIREMENTS FOR THE MBA

3.1 UNIFORMITY

The performance and measurement requirements serve several purposes that include compliance verification with (infrastructure) grant terms, address of third-party challenges, and FCC data collection that assesses compliance with overall Congressional mandates, and future policy-direction guidance. 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 to perform Phase 0 and Phase 1 broadband data collection activities, and these systems and methods should be optimized to enable Phase 2 and 3 analysis and presentation. There are already existing standards Levels 0-2, and these should be used.

3.2 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 broadband network.

3.3 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 the broadband deployment, customer equipment, and support systems. Parameters can be sent from the device using standard protocols such as Broadband Forum 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 adverse impact to the user’s service. This can be limited, for example, by injecting only a limited amount of “headroom” test traffic and then summing user traffic plus test traffic to get total traffic.

Software-based data collection and analysis is generally more cost-effective than deploying a dedicated hardware box at the user’s premise. A most cost-effective solution is to deploy a software agent on home gateway devices that collects data and sends it up to the cloud. Running tests to measure speed and latency generally require such an agent. 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.

3.4 SUPPORT PROBLEM SECTIONALIZATION

A broadband system 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 broadband access performance requires that the information can support sectionalization. A broadband network operator may have a system that meets the requirements set by regulation, yet the customers' received QoS may be subpar due to problems in other components of the network, e.g., the customers' Wi-Fi networks, the internet, or the content provider's systems. Being able to separate these performance components is not only necessary to ensure that performance issues are addressed in systems that are supported by the grants, but also provides information that may identify global performance issues, where government and industry cooperation may be appropriate to ensure the goals of a nationwide broadband infrastructure. In particular, operator-provided Wi-Fi gateways have variable performance that users should be aware of.

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.

A suggested sectioning of the end-to-end connectivity measurements is the following:

1. Total Connectivity (end to end measurements)
2. Access Network Connectivity (fixed or mobile network section measurements of the broadband access itself)
3. Middle-Mile Connectivity (measurements of performance of the 'middle-mile', where broadband accesses are aggregated by the ISP or carrier from multiple fixed access nodes or the back-haul from mobile access points, e.g., cell towers)
4. Local Area Network Connectivity (fixed or Wi-Fi LAN section measurements at the customer premises)
5. Content Server Performance (Measurements 1,2, 3, or 4 made when communicating to a particular content site)

At a minimum, throughput, latency, stability measurements, and qualitative sub-scores should be gathered.

3.5 Stakeholder Independence

Measurements and analysis of the measurements could be made by multiple sources, each a stakeholder with different and possibly conflicting interests. These include the grantee, challengers, users, and government agencies at the local, state, and national level. 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.

3.6 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 PROOF OF CONCEPT

4.1 INTRODUCTION

WE propose a Proof-of-Concept (PoC) deployment to provide a one-time analysis of US residential broadband performance, including Wi-Fi connectivity in US broadband subscribers' homes in **LOC**. The PoC analysis will be based on continuous and pervasive collection of anonymized broadband and Wi-Fi performance data from customers of selected broadband **ISPs**' residential broadband network in **LOC**. Data for 10,000 to 50,000 links will be collected continuously over a 3-month period beginning in early 2023. **WE** will analyze this collected data and provide several significant connectivity measures including data rate, broadband throughput, latency, Wi-Fi interference and Wi-Fi throughput. The report likely also will contain other sophisticated measures, enabling analysis of broadband quality of service (QoS) received by the measured customers and the identification and analysis of Wi-Fi specific limitations on consumer broadband connectivity and performance. The consequent report will summarize findings. The report will use a format that can be extended to enable future monthly or quarterly reporting, or online instantaneous snapshots of broadband connection speeds and performance metrics provided to consumer end devices and applications.

WE's PoC will also support evaluation of the PoC process extension for possible future use to provide ongoing overviews of the entire US Broadband and Wi-Fi performance. As required by the MBA, WE will assist in evaluation of the potential deployment of a federated US broadband reporting system for all US consumers, based on the PoC's techniques. Such a federated reporting enables a continuous and statistically valid overview of US broadband capabilities free of the need for special customer premises equipment or other specialized data-collection techniques

4.2 DATA REPORTED

The PoC will analyze **ISPs'** data provided as per Tables 1 (Wi-Fi) and 2 (fixed-line broadband). Data will be collected continuously for a three-month period from all broadband lines supported by the **ISPs** (in the US). The tables transmit rate is the reported full data rate (including overhead) achieved over the connections. Wi-Fi congestion measures a particular Wi-Fi system's performance and provides indication of that system's ability to support adequate user quality of experience (QoE). Congestion analysis further helps assess if additional spectrum might improve performance. Wi-Fi interference is similar but relates to disruption caused by neighboring Wi-Fi systems' use of the same spectrum. Interference analysis also helps determine whether allocation of additional spectrum is necessary. Traffic volume is reported, as is Wi-Fi link latency (which is a component of overall system/connection latency).

Much of this data exceeds the capabilities of commercially available "speed test" websites that only measure full cascaded-broadband-links' throughput and do not separate Wi-Fi. The PoC data will be collected during normal customer-premises-equipment operation. Data is collected without need of consumer test initiation, nor will it interfere with or degrade customer's perceived QoE.

Table 1 - ASSIA Reports Wi-Fi Analytics

Wi-Fi Throughput (speed)	Daily, 2.4 and 5 GHz bands
Wi-Fi Transmit Rate	Daily, 2.4 and 5 GHz bands
Wi-Fi throughput to transmit rate ratio	Daily, 2.4 and 5 GHz bands
Wi-Fi Congestion	Daily and max hour, 2.4 and 5 GHz bands
Wi-Fi Interference	Daily and hourly, 2.4 and 5 GHz bands
Wi-Fi Traffic	Daily and hourly, upstream and downstream, 2.4 and 5 GHz bands
Wi-Fi Latency	Daily, 2.4 and 5 GHz bands

Table 2's broadband measurements are similar to those collected on the Wi-Fi network and enable comparison of Wi-Fi performance at the customer's premises with that of the broadband connection to see which is limiting. Clearly, high-cost broadband infrastructure investment yields little return if the Wi-Fi performance would otherwise limit consumer perceived performance, e.g., QoS or QoE, at unacceptable levels.

Table 2 - ASSIA Reports Broadband Analytics	
Broadband Traffic	Daily and hourly, upstream and downstream
Broadband Throughput (speed)	Daily, upstream and downstream
Broadband Latency	Daily

For both Wi-Fi and broadband data, the reporting frequency enables analysis over the course of a day, and/or week, as to the time-of-day, or day-of-week when connection issues are limiting. Understanding the peak usage's time distribution helps understand the relation between network investment and quality of experience provided during rare but critical peak-use events.

4.3 Analytics Provided in PoC

The PoC will provide the following analytics based on the data collected:

i) Annualized Percent Change in Wi-Fi Data for ISP in the US: Summary
ii) Wi-Fi Traffic for ISP in the US – Graphical Summary

iii) Wi-Fi Latency evolution (ms) in the US
iv) US Hourly Wi-Fi Interference
v) Wi-Fi Congestion vs. Traffic in the US
vi) Busy Hour Wi-Fi Congestion in the US
vii) Overall SNS (Spectrum-Need Score) in the US
viii) Wi-Fi vs. Broadband Access Throughput Analysis in the US

Other analytics are also available upon request and negotiation with **WE**.

4.4 GEOGRAPHIC ANALYSIS

The proposed reports will use the reported IP address with accurate (paid) on-line geolocation to provide the location of users. The data will be aggregated to preserve anonymity and performance statistics will be reported by regions/location.

4.5 COLLECTION PROCESS AND ANONYMIZATION

ISPs will provide the raw data to ASSIA for the three-month PoC duration. Because ISPs most likely already gather the raw data for their internal business purposes, the measurement period may also include periods prior to the PoC start date.

4.6 REPORT GENERATION:

Upon measurement-period completion, **WE** will analyze the data and generate the report within six-weeks after the measuring period ends. This one-time report will provide an overview of the US's current broadband and Wi-Fi State. The report will provide the results of the analysis as listed above in section 3, as well as ASSIA's observations and recommendations.

Specifically, the report includes

(1) A PowerPoint summary
(2) A detailed written report
(3) WE will present of the results to the FCC.

WE will recommend possible next steps which may include processes to continue analysis and reporting periodically in the US, recommendations on processes to expand the participating ISPs beyond the initially selected **ISPs**, and possible additional analytics for such future endeavors.

With **ISP**s' permission, all or part of the raw data will be made available to partners for future use.

4.7 PERSONNEL:

ASSIA will allocate the time of Peter Silverman as program manager for regular interaction with our partner(s) on the reports and progress. Data scientists assigned to various tasks will include the involvement of the following individuals.

Dr. John M. Cioffi, IEEE Fellow, US National Academy of Engineering, IEE JJ Thompson award, Marconi Prize 2006, Alexander Graham Bell Medal 2010, Internet (2014) and Consumer Electronics (2018) Halls of Fame, chaired professor at Stanford University.

Dr. Peter Chow, IEEE Fellow, ASSIA CTO.

Dr. Mehdi Mohseni, ASSIA VP of Research, data analytics and machine-learning expert.

Dr. Monisha Ghosh, Professor, University of Notre Dame, IEEE Fellow, Former CTO at the FCC.

5 RESPONSE TO FCC QUERIES

Corporate Overview

1. Company Names.

Jointly Submitted by

Adaptive Spectrum and Signal Alignment, Incorporated (ASSIA)
and
The Wireless Institute at the University of Notre Dame

2. Company Address.
   Adaptive Spectrum and Signal Alignment, Incorporated (ASSIA)
   303 Twin Dolphin Drive, Suite 600
   Redwood City, CA 94065

   The Wireless Institute,
   University of Notre Dame
   275 Fitzpatrick Hall,
   Notre Dame, IN 46556

3. Unique Entity Identifier (UEI).
   TNM9FG2C7W53 – ASSIA
   CE6CNTZB32Q8 – University of Notre Dame

4. Cage Number.
   7BK31 – ASSIA
   1E5T8 – University of Notre Dame

5. Company Website URL.
   https://assia-inc.com
   https://wireless.nd.edu/

   Name, title, phone number, and email address of primary company point of contact.

   Peter Silverman
   Sr. Director Law and Technology
   ASSIA
   847 226 5069
   psilverman@assia-inc.com

   Dr. Monisha Ghosh
   Professor, University of Notre Dame
   574 631 6215
   mghosh3@nd.edu

6. Resumes for the Chief Systems Engineer and Chief Program Manager that shall oversee this work and interact with FCC personnel.

   Attached as Appendix A to this RFI Response

7. Company size standard and socio-economic standing, e.g., large business, small business, 8(a) small business, veteran-owned small business, service-disabled veteran-owned small business, HUB Zone small business, small, disadvantaged business, or women-owned small business.

   ASSIA is a small business per SBA requirements.

   University of Notre Dame is an IHE, a Tier 1 Research University.

8. Please confirm whether your company is currently a certified 8(a) program participant.

   Neither ASSIA nor the University of Notre Dame is an 8(a)-program recipient

9. If so, please provide the entry and exit dates of your company's participation in the 8(a) program

   N/A.

10. Please state whether your company is Tribally owned, an Alaska Native Corporation (ANC), a Native Hawaiian Organization (NHO), or Other Native American entity in relation to the 8(a) program.

    Neither ASSIA nor the University of Notre Dame is an organization as defined in question 12.

11. Please list any GSA Schedule contracts or Government Wide Acquisition Contract (GWAC) held by your company which may be relevant to the scope of the draft requirements described in this notice.

    N/A

12. If under the GSA Schedules, please identify the Special Item Numbers (SINs) under the GSA consolidated Multiple Award Schedule that would be required to provide a total solution for a requirement similar in size, scope, and complexity.

    N/A

13. Please share any questions you would be likely to ask if the requirements attached were included, as is, as part of the final solicitation.

    ASSIA and the University of Notre Dame believe that an RFP should include requirements related to pervasive data collection and analysis that are software based and do not require use of specialized hardware at the customer premises.

What, if any, risks or other factors does your company foresee that may deter your company from submitting a quote on this requirement?

ASSIA and the University of Notre Dame will evaluate the applicability of any RFP based upon the specific requirements stated in the request.

Capabilities: Test Infrastructure Development, Operation & Management, and Data Collection and Organization

Please describe your organization's experience and capabilities in the following areas:

Task 1: Creation, deployment, and operation of measurement infrastructures, followed by Collecting and Monitoring the associated Performance Measurements.

ASSIA was founded in 2003 and has developed the technology, encouraged the development of standards, and deployed the software and services, both the specifying the architecture, the underlying intellectual property, and developed and deployed software in the field that currently manages and optimizes over 100 million customer broadband-access links supported by tier 1 carriers worldwide. It has been ASSIA's business practice to work with partners and spin-off these products and services to ASSIA's partner companies.

The Wireless Institute (WI) at the University of Notre Dame is a research center within the prestigious College of Engineering at the University of Notre Dame. The Wireless Institute was established in January 2010 to leverage Notre Dame's extensive experience, tackle important interdisciplinary problems involving both radio technologies and spectrum policy, and broaden the University's impact on the world. WI engages faculty from the departments of electrical engineering, computer science, and engineering, sociology, law, and finance. WI created the first NSF Industry-University Cooperative Research Center (IUCRC) program at Notre Dame and now leads the NSF Spectrum Innovation Initiative (SII) Center.

Task 2: Design and Maintenance of Test Schedules and Recruitment of Test Panelists/Volunteers.

To support its products, ASSIA has developed test plans and proof of concepts for many customers. An example is the research ASSIA performed for the Dynamic Spectrum Alliance as described in https://dynamicspectrumalliance.org/wp-content/uploads/2021/06/ASSIA-DSA-Summit-Presentation-v7.8.pdf .

The WI has conducted mobile wireless measurements in collaboration with the city of South Bend, see data here: https://southbend.maps.arcgis.com/apps/instant/basic/index.html?appid=2b46a5c51b8a4f3bae499b5e19b7527a and. Past research on mobile measurements conducted by Dr. Monisha Ghosh is described in the following papers:

1) A. Narayanan, M. I. Rochman, A. Hassan, B. S. Firmansyah, V. Sathya, M. Ghosh, F. Qian and Z.-L. Zhang," A comparative measurement study of commercial 5G mmWave deployments," Infocom 2022.
2) M. I. Rochman, V. Sathya, N. Nunez, D. Fernandez, M. Ghosh, A. S. Ibrahim and W. Payne, "A Comparison Study of Cellular Deployments in Chicago and Miami Using Apps on Smartphones," ACM WiNTECH 2021.

Task 3: Provision of analysis, visualizations, and datasets for FCC reports.

ASSIA has not specifically worked with FCC reports and data; however the research performed for the Dynamic Spectrum Alliance (https://dynamicspectrumalliance.org/wp-content/uploads/2021/06/ASSIA-DSA-Summit-Presentation-v7.8.pdf_) illustrates ASSIA's experience in developing such visualization. ASSIA's experience also derives from developed products that have been deployed widely.

The WI has not specifically worked with FCC reports and data but has used FCC speed tests extensively along with data from a mobile app, SigCap, developed while Dr. Monisha Ghosh was a professor at the University of Chicago, to create coverage maps. The methodology of using SigCap with FCC Speed tests was used by the FCC in a pilot study conducted along with the USPS in 2021. The Report To Congress on this methodology is available here: https://www.fcc.gov/sites/default/files/report-congress-usps-broadband-data-collection-feasibility-05242021.pdf

Task 4: Support of Collaborative Work Activities Integral to this Study.

ASSIA's experience in support of this task is illustrated both in ASSIA's work with the Dynamic Spectrum Alliance and in managing the deployment of ASSIA's technologies with ASSIA's partners and customers.

WI has worked collaboratively with the city of south Bend on mobile data collection as described above.

Task 5: Support for service providers in validation of panelists information and data discussions.

ASSIA's experience with working with both services providers and vendors network equipment is extensive. Again, ASSIA's work with Dynamic Spectrum Alliance is an example of the quality of support for the proposed endeavors.

N/A for WI.

Additional Information

1. Whether the capability is available today or whether the proposed solution would have to be modified to meet the tasks described, e.g., hardware vs. software-based performance measurement approaches.

   ASSIA and ND (**WE**) first propose a proof of concept for the FCC based on existing standardized interfaces that exist with deployed customer premises equipment. This existing equipment hosts a software agent that provides the data necessary. This architecture was used for data and analysis that underlies the Dynamic Spectrum Alliance report referred to earlier (https://dynamicspectrumalliance.org/wp-content/uploads/2021/06/ASSIA-DSA-Summit-Presentation-v7.8.pdf). Central to ASSIA's architecture is that no specialized hardware need be deployed. Rather, a software agent can be increasingly deployed to provide federated and anonymized data to support this analysis required to meet the FCC's current and anticipated future requirements.

2. Description of previous clients as well as the nature and scope of past work delivering each task related to the Test Management and Support of Technical and Software Platforms. Also provide the following:

- Date(s) of service provided.

  ASSIA has collected past broadband data over more than a decade and in-home Wi-Fi data for at least 5 years on 10's of millions of global internet broadband-to-end-device connections. ASSIA has migrated to an analytics business for those data collectors that presently licenses and enables the capability with other partners who will also provide data-collection capability. ASSIA would analyze and assist the FCC with such collected data. The data is typically owned by internet service providers, and so permission must be requested. ASSIA has received such permission to collect and use with the regulator in partnership with ISPs in other countries. That remains possible in the USA if the FCC has interest to pursue this further.

- Name of the Federal Agency/Organization.

  ASSIA has not yet provided such analysis to any US federal agency. ASSIA has received no federal agency funding.

  The Wireless Institute has been the recipient of NSF grants related research in evaluating broadband and network performance.
- Identify the size and type of services provided.

  The Wireless Institute has provided research services under the NSF grants.

3. Describe the vendor's past performance and experience supporting Fixed Price contracts related to the tasks described in Section 3B above, including ways your methodology is designed and operated to accommodate new tests and modify existing technical solutions in response to feedback from stakeholders and changes in internet networks. What costs, development time, or other concerns exist for supporting possible changes to your existing or proposed technical solution. What experience does your team have adapting technology on a weekly basis within existing contract constraints using "agile" or other project management techniques.

   ASSIA can provide a fixed price for PoC analytics as proposed here. The conclusion would be summarized in a report. Business arrangements for expansion upon the PoC's successful stimulation of further interest will be discussed in the future as appropriate.

   ASSIA works with standardized interfaces and multiple partners, both vendors and service providers. The intent of this business is to be agile and accommodate other practices, although accurate and reliable data collection will require some level of certification if used widely so that future reporting beyond the PoC can be consistent across all sectors. The PoC is meant to demonstrate the capability with a select one or few partners.

4. Describe experience working with broadband consumer premise equipment for consumer broadband internet services including cable, DSL, fiber-optic, and satellite modems, including any work identifying and mitigating measurement problems at different layers of Internet networks serving broadband consumers.

   ASSIA's experience with these requirements is extensive – ASSIA developed the technology, architecture, algorithms, and software and facilitated customer deployments for the Expresse® and Cloudcheck® products which were spun off by ASSIA in May of 2022. ASSIA has led the development of numerous broadband standards that support broadband access in the Broadband Forum, ITU-T, and

ANSI/ATIS T1 committees. ASSIA's work with Dynamic Spectrum Alliance illustrates ASSIA's value philosophy of instrumenting deployed CPE to gather operational data to measure broadband network performance with certified and validated vendor participation and in a way that protects customer and carrier personally identifiable information.

In its current business, ASSIA focuses on analytical consulting and reporting to groups such as regulatory groups, forums, consumer groups on internet connectivity, particularly in broadband access.

5. Describe past performance researching and analyzing consumer broadband market. The experience of staff in developing and analyzing network architectures for broadband networks, and techniques used to mitigate network impairments.

   ASSIA's developed and deployed the technology that underlies the Expresse® and Cloudcheck® broadband optimization products. ASSIA's May 2022 successful spin-off of these products illustrates ASSIA's experience with broadband analysis and management. These systems managed over 100 million broadband lines worldwide in at over 30 broadband carriers.

6. Describe staff's experience working with broadband internet service providers and other regulated common carriers, and experience leading industry standard meetings, working groups, and coordination with industrial stakeholders in the area of internet performance measurement.

   ASSIA's query 5 response above overviews ASSIA's experience working with Broadband Service Providers. ASSIA's engineers have held leadership positions in many international standards bodies including editorship on over 25 standard development efforts related to Broadband measurements and performance optimization in the Broadband Forum, Wi-Fi Alliance, UK NICC, ATIS TIE1, NIPP-NAI and COAST-NAI. Significant contributions to ITU-T SG-15 and to ETSI have been made by ASSIA. ASSIA Engineers have served on the Board of Directors of the Broadband Forum, and as Area Leaders for the Broadband Home Committee in the Broadband Forum.

7. Describe past performance developing open data for public release, identifying and mitigating privacy concerns in measurement data, and your approach to analyzing privacy risks and weighing tradeoffs. Describe the vendor's existing open data technical and privacy policies and methodologies.

   ASSIA's Dynamic Spectrum Alliance work ensured that all data used in the analysis was anonymized with respect to both protection of consumer Personally Identifiable Information (PII) and ISP identity and the ISP's proprietary business information. ASSIA's Software in these ISP deployments complied with the carrier's privacy and security requirements, including compliance with applicable laws and regulations including the EU GDPR, and applicable US and State regulations.

APPENDIX A: SUMMARY RESUMES FOR LEAD PERSONNEL

BIOGRAPHICAL SKETCH

NAME: John M. Cioffi

POSITION TITLE & INSTITUTION: Chairman and CEO, Adaptive Spectrum and Signal Alignment, Inc. (ASSIA®)

PROFESSIONAL PREPARATION

INSTITUTION	LOCATION	MAJOR/AREA OF STUDY	DEGREE (If applicable)	YEAR (YYYY)
U of Illinois	Urbana, IL	Electrical Engineering	BS EE	1978
Stanford U	Stanford, CA	Electrical Engineering	MS EE	1979
Stanford U	Stanford, CA	Electrical Engineering	PhD EE	1984

APPOINTMENTS

From - To	Position Title, Organization and Location
1978-1984	Member of Technical Staff, Bell Telephone Laboratories
1984-1986	Research Staff Member, IBM
1986 - 2023	Assistant, Associate, Full, Chaired professor (now recalled emeritus)
1991-1999	Chief Technical Officer (Founder and BoD member), Amati Com Corp (later Texas Ins); traded publicly in 1995 on NASDAQ, acquired by TI in 1998.
2003 - 2023	CEO and Chairman, ASSIA Inc.

SYNERGISTIC ACTIVITIES

- Chair BoD, PhyTunes Inc. - PhyTunes is a venture-capital backed start-up, based in the San Francisco area that provides components that could eventually help enable the proposed research activities.
- Vice Chair BoD, The Marconi Society (Chair is Vinton Cerf), nonprofit, with general interest related to communications policy and research.
- Awards include: IEEE AG Bell (2010), Kirchmayer (2014) and Millennium Medals; Member Internet (2014) and Consumer-Electronics (2018) Halls of Fame; Marconi Fellow (2006); Member, US National (2001) and UK Royal (2009) Engineering Academies.
- Has served over a dozen corporate and non-profit boards of directors, presently PhyTunes (Chairman) and Marconi Society (Vice-Chairman). Several examples of Dr. Cioffi's significant service to the telecommunications industry is listed below:
  - Dr. Cioffi served Marvell Semiconductor's board during its growth from small private company, through IPO, and as a public company from 1999-2006, advising on Marvell's

entry from exclusively storage products into the communication semiconductor area (ethernet, Wi-fi, mobile), eventually serving as its Executive Committee Chair.
- Dr. Cioffi helped found and served for roughly 10 years on Teknovus board of directors. For Teknovus, a privately held corporation Dr. Cioffi helped steer their emergence into a leading role in GPON chip development, recruiting investment, executives and board members, prior to their acquisition by public company Broadcom in 2010.
- Dr. Cioffi helped found and served for roughly 10 years on ClariPhy's board of directors. For ClariPhy, also a privately held corporation, Dr. Cioffi helped guide their growth into a lead role in 10+ Gbps ethernet chip development, recruiting investment, executives and board members, prior to their acquisition by public company InPhi Semiconductor in 2016.
- As an example of Dr. Cioffi's work in the international realm,, he helped found and served for roughly 10 years on Beijing headquartered AltoBeam's board of directors, helping steer their leading role in digital TV (DTTB), Wi-Fi, TV tuners, and Bluetooth chip development, recruiting investment, executives and board members, retiring recently as an international IPO is anticipated for what is now one of China's most promising fabless semiconductor companies.
- Dr. Cioffi also serves nonprofits that support research and development in the field of telecommunications, in addition to his efforts for the Marconi Society, Dr. Cioffi's recently retired from the Board of Directors of CTTC, located in Barcelona Spain. During his 20+ years of service on the CTTC Board CTTC grew from its founding to its present status as a European-leading communications research institute.

- Over 800 published papers and over 150+ heavily licensed patents.

BIOGRAPHICAL SKETCH

NAME: Monisha Ghosh

POSITION TITLE & INSTITUTION: Professor, Electrical Engineering Department, University of Notre Dame

PROFESSIONAL PREPARATION

INSTITUTION	LOCATION	MAJOR/AREA OF STUDY	DEGREE (if applicable)	YEAR (YYYY)
University of Southern California,	Los Angeles, CA	Electrical Engineering	PhD	1991
University of Southern California,	Los Angeles, CA	Electrical Engineering	M.S.	1987
Indian Institute of Technology	Kharagpur, India	Electronics and Electrical Communication Engineering	Bachelor of Technology (Hons.)	1986

APPOINTMENTS

From - To	Position Title, Organization and Location
1991-1998	Senior Member of Research Staff, Advanced Television Research, Philips Laboratories, Briarcliff Manor, NY 10510
1998 - 1999	Member Technical Staff, Digital Communications Research, Bell Labs., Lucent Technologies Murray Hill, NJ 07974
1999 - 2011	Principal Member of Research Staff and Project Leader, Philips Research, Briarcliff Manor, NY 10510
2012 - 2015	Principal Engineer (Director-level), InterDigital, Melville, NY
2015 - 2021	Research Professor, University of Chicago
2017-2019	Program Director, NSF, CISE/CNS/NeTS
2020-2021	Chief Technology Officer, Federal Communications Commission
2022-Present	Professor, Electrical Engineering Department, University of Notre Dame

SIGNIFICANT PRODUCTS AND RESEARCH

- Physical Layer (PHY) technology development for IEEE 802.11ah (Sub-1 GHz non-TV White Spaces) in the areas of preamble design, multiple-antenna and multi-user modes.
- Cognitive radio in the TV White Spaces (2006 – 2011
- VSB receiver implementation: algorithm development for the key components of equalization, interference cancellation and trellis decoding

- Design and analysis of wideband wireless cellular data networks based on OFDM, low-complexity multiuser detection algorithms for CDMA, interference cancellation for Digital Audio Broadcast (DAB) systems
- Physical Layer (PHY) technology development for IEEE 802.11ah (Sub-1 GHz non-TV White Spaces) in the areas of preamble design, multiple-antenna and multi-user modes.
- Physical Layer (PHY) technology development for next-generation Wi-Fi (802.11ax).
- research and understand the co-existence of Wi-Fi (unlicensed) and Cellular (licensed) technologies in the unlicensed 5 and 6 GHz bands
- Was responsible for initiating one of the first major national funding programs for exploring machine learning applications in wireless networking, jointly with Intel (MLWiNS)
- FCC CTO, was to advise the Chairman of the FCC on all technical matters related to wireless communications with respect to US communications strategies, spectrum policies and standards.

SYNERGISTIC ACTIVITIES

- IEEE Fellow,
- Over 80 Academic Papers with over 7000 Citations
- Over 80 Patents
- Member of numerous industry and government advisory panels and committees for example:
  - Co-chair of the Advanced Spectrum Sharing Working Group of the Federal Communication Commission's Technological Advisory Council (FCC TAC)
  - Member of the National Spectrum Consortium's Task Group on Partnering to Advance Trusted and Holistic Spectrum Solutions (PATHSS)
  - Advisory Board Member of POWDER at the University of Utah (NSF PAWR Platform)
  - Member of ATIS NextG Alliance
  - Keynote speaker at IEEE 5G World Forum, “Blurring the lines between licensed and unlicensed: 6G or 6 GHz?” September 10, 2020

BIOGRAPHICAL SKETCH

NAME**:** Peter S. Chow

POSITION TITLE & INSTITUTION: Chief Technical Officer, Adaptive Spectrum and Signal Alignment, Incorporated (ASSIA®)

PROFESSIONAL PREPARATION

INSTITUTION	LOCATION	MAJOR/AREA OF STUDY	DEGREE (if applicable)	YEAR (YYYY)
Princeton University	Princeton, NJ	Electrical Engineering and Computer Science	BS EE/CS	1988
Stanford University	Stanford, CA	Electrical Engineering	MS EE	1989
Stanford University	Stanford, CA	Electrical Engineering	PhD EE	1993

APPOINTMENTS

From - To	Position Title, Organization and Location
1992- 1998	ADSL Program Manager; Software Systems Architect, Senior Design Engineer; Amati Communications; San Jose, CA
1998 - 2007	Director of Engineering for RGES BU, Northern California R&D Site Manager, CTO for DSL BU; Texas Instruments; Sunnyvale CA
2007 - 2008	Senior Director of Engineering & Emerging Technologies; Infineon Technologies; Milpitas, CA
2009 - 2010	Vice President of Engineering; Data Physics; San Jose, CA
2010 - 2022	CTO (2017-Present), Senior VP of Product Delivery (2014-2016), VP of Managed Services (2010-2013); ASSIA; Redwood City, CA

PRODUCTS

Products Most Closely Related to the Proposed Project

- Successfully defined, launched, and handed off world's first consumer Wi-Fi management software product.
- Inventor of multiple essential patents to consumer Wi-Fi and cellular wireless management software and systems.
- Led and drove G.hn home networking business and IP development efforts, including collaboration with other top tier semiconductor companies on joint RFI for 3rd party IP procurement.
- Played key role in the invention and development of the world's first DSL modem and made significant contributions to various national and international DSL standards.

Significant Products, Whether or Not Related to the Proposed Project

- Inventor of essential patents to Digital Subscriber Lines (DSL) technology, and key member of the original technical team that created world's 1st DSL modem**.**
- Directed DSL subsystem development at multiple R&D sites spanning 5 countries, including Germany,

Austria, U.S., Singapore, and India, with over 40 direct and 60 indirect reports.

- Oversaw and directed all product developments, including dynamic signal analyzers, vibration controllers, electrodynamic shakers, and power amplifiers.
- Built, retained, and directed high performance development teams; led over 100 direct and indirect reports spanning multiple R&D sites with < 5% annual voluntary attrition in the Bay Area
- Set up and streamlined product delivery teams, infrastructure, and process to support worldwide delivery of highly customizable telecom management software products and services, leading and managing teams in the U.S., Europe, and Asia in 2014 and 2015.

SYNERGISTIC ACTIVITIES

- IEEE Fellow,
- Named inventor on 40+ issued patents and multiple pending applications worldwide, including essential patents in wireline and wireless broadband technologies (DSL, Wi-Fi, 5G).
- Author of numerous journal, conference, and technical publications.
- Author and presenter of numerous technical contributions to U.S. and international standards organizations.
- Invited speaker and/or session chair at conference sessions and discussion panels.

BIOGRAPHICAL SKETCH

NAME: Mehdi Mohseni

POSITION TITLE & INSTITUTION: Chief Scientist, Adaptive Spectrum and Signal Alignment, Incorporated (ASSIA)

PROFESSIONAL PREPARATION

INSTITUTION	LOCATION	MAJOR/AREA OF STUDY	DEGREE (if applicable)	YEAR (YYYY)
Stanford University,	Stanford, CA	Electrical Engineering	PhD	2006
Sharif University of Technology,	Tehran, Iran	Electrical Engineering	BSc	2001

APPOINTMENTS

From - To	Position Title, Organization and Location
2006 – 2010	ASSIA, Technology Architect, Redwood City CA
2010 – 2012	ASSIA Manager Systems Engineering, Redwood City CA
2012 – 2015	ASSIA Director Systems Engineering, Redwood City CA
2016 – Present	ASSIA Chief Scientist, Redwood City CA
2019 – Present	CellarEye – CEO, CTO, and Co-founder, Palo Alto CA

SIGNIFICANT PRODUCTS AND RESEARCH

Dr. Mehdi Mohseni has 15+ years of startup R&D experience in building management solutions and recommendation engines for Broadband service providers around the globe.

Dr. Mohseni is an expert in performing predictive analysis on customers' quality of experience and satisfaction of service, estimation of complain calls and service cancellation likelihoods, identification of customers with service up-sell opportunities through big data analytics and machine learning algorithms.

He has a PhD in Electrical Engineering from Stanford University and is a holder of more than 30 patents in broadband management area and author of numerous research papers in peer reviewed journals.

BIOGRAPHICAL SKETCH

NAME: Peter J. Silverman

POSITION TITLE & INSTITUTION: Sr. Director Law and Technology, Adaptive Spectrum and Signal Alignment, Inc. (ASSIA)

PROFESSIONAL PREPARATION

INSTITUTION	LOCATION	MAJOR/AREA OF STUDY	DEGREE (if applicable)	YEAR (YYYY)
University of Chicago	Chicago, Il	Biological Sciences	BS Biology	1975
Illinois Institute of Technology	Chicago, Il	Undergraduate work in Computer Science		1976 – 1977
University of Illinois at Chicago	Chicago, Il	Graduate level work in Electrical Engineering, and Computer Science		1978 – 1980
Patent Agent, Registered with USPTO	Arlington, VA	Member of the US Patent Bar	Registration Number 77,563	2018

APPOINTMENTS

From - To	Position Title, Organization and Location
1980 – 1988	Senior Consultant, CAP Gemini America, Red Bank NJ and Lisle Illinois
1988 - 1998	Senior Member of Technical Staff, Ameritech Science and Technology, Hoffman Estates, IL
1998 – 2002	Senior Systems Architect, 3Com Corporation, Schaumburg, Il
2002 – 2003	Product Manager, Valo Inc, Petaluma, CA
2004	Owner, Peter Silverman, Technical Consulting, Evanston IL
2005 - 2022	Director Law and Technology (2016 - 2022, Director Technical Marketing (2009-2016), Director Standards (2005 – 2009), ASSIA, Redwood City, CA

PRODUCTS

Products Most Closely Related to the Proposed Project

Editor of 10 international standards including:

- Editor-in-chief Editor in Chief: DSL Anywhere, DSL Forum (Broadband Forum
- Editor: The ATIS Dynamic Spectrum Management Technical Report, Issues 1 and 2–.
- UK NICC Dynamic Spectrum Management Report.
- Broadband Forum MD-180 IPTV over DSL,
- Broadband Forum MD-257 Vectoring, Broadband Forum TR-310 – Vectoring Best Practices
- Led the network management task force of the multi-telco (four company) Joint Procurement Consortium (JPC) responsible for over $2 Billion in DSLAM purchases.

Other Significant Products, Whether or Not Related to the Proposed Project

- Responsible for management of prosecution ASSIA's worldwide patent portfolio of over 900 patents, valued at over $350 Million
- Developed Ameritech's operations plan for DSL deployment.
- Member of three-person architecture team that planned Ameritech's deployment for interactive digital video over Hybrid Fiber COAX.
- Designed and implemented automated test analysis tools for the Bell Labs 5ESS Project that saved Bell Labs over $25 million per year in software testing and validation costs.
- Responsible for 3COM's technical strategy for Voice over DSL (VoIP, VoATM
- Manage Prosecution of ASSIA's 900 patent portfolio valued at over $350 Million.
- Manage creation of ASSIA responses to all customer RFP, RFQ, RFI, and formal offers. Based on ASSIA's bid victories, over 120 million broadband access lines managed worldwide.
- Starr, Tom; Cioffi John; Silverman, Peter: Understanding Digital Subscriber Line Technology, Prentice Hall, 1999.
- Starr, Tom; Cioffi John; Sorbara, Massemo; Silverman, Peter: DSL Advances, Prentice Hall, 2002

SYNERGISTIC ACTIVITIES

- IEEE Senior Member,
- DSL Forum (Broadband Forum) "Circle of Excellence" Award
- Ameritech "Pinnacle" Award, and "Above & Beyond" Award
- Broadband Forum – Significant Contributor Award
- ATIS – Significant Contributor Award