Before the

NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION, U.S. DEPARTMENT OF COMMERCE

In the Matter of	)	
Spectrum Monitoring Pilot Program	)	Docket No. 130809703-3703-01
	)	

Comments of Key Bridge Global LLC

Key Bridge Global LLC (Key Bridge) respectfully submits these Comments in response to the "Spectrum Monitoring Pilot Program" notice of inquiry recently published in the Federal Register by the Office of Spectrum Management, National Telecommunications and Information Administration (NTIA) of the U.S. Department of Commerce. Key Bridge appreciates the opportunity to respond and we hope that the NTIA will find these comments and our experience in operating a spectrum monitoring system helpful in the planning and execution of the spectrum monitoring pilot program.

Introduction.

Key Bridge is a Virginia small business and a trusted, neutral supplier of online information systems and spectrum-related services to Commercial, Government and U.S. Military customers.

Key Bridge offerings are available through three defined business segments: Spectrum Services, Information Services and Enterprise Services. Key Bridge is also an FCC-designated White Space spectrum administrator.

In considering the quantity of data collected from our managed Spectrum Monitoring platform we believe Key Bridge currently maintains one of the largest private databases of wireless service and spectrum occupancy information in the world. We make this information available to educational, commercial and non-commercial users through a comprehensive portfolio of well-documented, standards-compliant web services and data models, fostering innovation in cognitive radio, White Space spectrum sharing, and other third party systems and solutions.

Key Bridge produces a commercial off the shelf Wideband Spectrum Monitoring System that we believe can be a useful component in the NTIA pilot. Key Bridge has operated a managed version of our Spectrum Monitoring system in the Washington DC metro area since 2010 to support customer evaluation and third-party data collection and analysis. This system was first demonstrated to the FCC as a candidate solution for conducting a radio spectrum inventory. [1] An enhanced version of the system was also demonstrated as an effective environmental sensor before JEIDDO. [2]

Key Bridge appreciates the opportunity to respond and we hope that the NTIA will find these commends and our experiences helpful in the planning and execution of its spectrum monitoring program.

Initial Comments

Key Bridge supports the NTIA's goal as stated in the Notice of Inquiry (NOI) to qualify and to quantify the nature and extent of actual spectrum usage and occupancy within the United States.

---

1 The Key Bridge Wideband Spectrum Monitoring System provides a powerful and cost-effective turn-key solution to establish detailed spectral awareness across large geographic areas and over extended periods of time. The demonstrated version anticipated bills before the 111th Congress, 1st Session: H.R. 3125 and S.649: “To require an inventory of radio spectrum bands....”

2 The demonstrated instance incorporated a ruggedized GPS-enabled vehicle-mount sensor version that also included real-time spectrum signal processing with a local transmitter database.

We concur that the NTIA's identified benefits of such a program logically follow and are dependent upon more and better data, especially for the evaluation of sharing opportunities, dynamic frequency access technologies, and development of innovative access and management methods in other frequency bands.

Key Bridge designed our own spectrum monitoring implementations following and implementing the contents of a number of ITU recommendations and reports. We believe the most recent report on spectrum occupancy measurements and evaluation can also inform the NTIA on many key aspects of its inquiry. [3]

Key Bridge generally believes that empirical spectrum monitoring can be most effective when combined with known-source databases and used to update and adjust area propagation models. Monitoring alone provide local quantitative source and background data, whereas a more holistic approach can be useful for efficient spectrum management, band plan modeling, network planning, and a number of other activities. We recommend that in addition to an archive of raw data as anticipated in the NOI the NTIA pilot project consider the incorporation and correlation of its data with licensing databases and other known or inferred transmitter databases.

In general we suggest the NTIA's pilot project should be designed to foster at minimum the following outcomes:

- a mathematically rigorous assessment of actual spectrum occupancy versus authorized occupancy
- validation of carrier location and transmission characteristics with issued licenses or assignments

3 Report SM.2256-0 (2012) *Spectrum occupancy measurements and evaluation*

- a spectrum data archive to foster further research and development

The Key Bridge Wideband Spectrum Monitoring System

The Key Bridge Wideband Spectrum Monitoring System is a commercial off the shelf (COTS) product offering cost-effective and turn-key spectrum monitoring capability for large geographic areas and over extended periods of time. The Key Bridge System is an integrated spectrum capture, monitoring and data management solution that transforms off-air data into meaningful, actionable information in real-time. The Key Bridge COTS solution supports a variable sized constellation of intelligent spectrum sensors; each conducting localized data collection, storage and processing that may be streamed or intermittently uploaded to a central system controller and archive.

Sensors may be remotely deployed and connected over any standard TCP/IP network including cable, fiber, remote dial up and 3G cellular to provide high performance remote signal monitoring and near real-time carrier detection – within a building, city-wide, or across an entire theater of operation.

The Key Bridge Wideband Spectrum Monitoring system is built around a custom developed, network-aware, digital RF sensing system with two sensor package versions supporting 5 MHz to 2,500 MHz or 100 Khz to 3,000 MHz. The System provides for rapid identification of fixed and transient signals in most all commercially and tactically relevant parts of the spectrum.

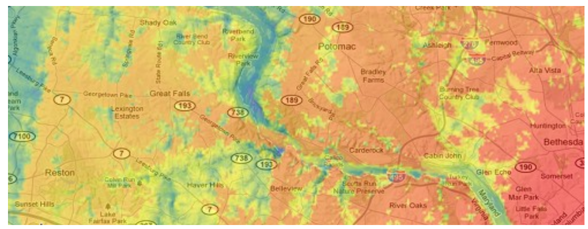
Management Options

End-to-end proprietary systems are typically required when the information must remain private or secure. If the information security profile permits cloud-based operations and shared infrastructure then a managed, leased system may offer a compelling lower-cost alternative.

Popular with commercial and enterprise users, a Key Bridge managed spectrum monitoring system can reduce start-up and ongoing expenses and allow rapid access to critical spectrum data without the operational overhead of running and maintaining a sensor network.

Mapping and Visualization

The Wideband Spectrum Monitoring System leverages Key Bridge Spectrum Mapping technologies to provide quick and detailed visual inspection of the spectrum environment. The System leverages patent pending methods to combine predicted coverage models with empirical measurement and presents a highly accurate digital representation of real-world and predicted spectrum environments.



Signal coverage estimation is correlated with empirical measurement. Map data © Google

Fixed and Mobile Multi-Sensor Networks

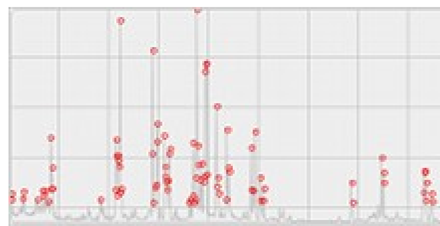
Captured spectrum data is automatically time stamped and geo-tagged whenever a GPS receiver is attached to the RF sensor. With the device's internal storage and persistent configuration the System supports mobile sensing and on-the-move survey applications out-of-the-box and with no additional configuration required.

Spectrum data is time and geo-tagged for real-time and off-line analysis.

If desired, a laptop computer or tablet can directly interface with the device to view spectrum survey data and receive alerts in real-time. Data is recorded and automatically synchronized with the System Manager when network connectivity is reestablished.

Automated Carrier Detection and Identification

Continuous and transient candidate signals are automatically identified and marked for inspection in near real-time. When connected to a network each detector attempts to match detected signals with ITU allocation type and known entities in the licensed or unlicensed transmitter database.



Carriers are automatically identified and may be correlated with a known transmitter database.

Spectrum plan information may be configured several ways: automatically via external data services, bulk data import into the System's own database, semi automatically via user acknowledgement of detected signals, or via user data entry.

Continuous & Sustained Long-Term Monitoring

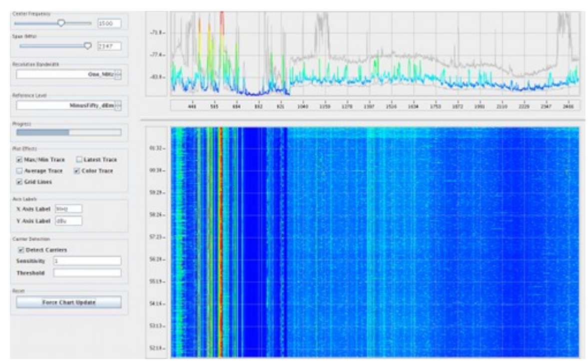
Accurate spectrum monitoring requires continuous data acquisition over extended periods. Whether ensuring the presence of known carriers, assuring the absence of unwelcome or unauthorized transmitters or monitoring transient or unlicensed activities, only continuous, long-term monitoring can provide meaningful context and perspective.

The obvious benefits of sustained monitoring are often not realized as spectrum analyzers are prohibitively expensive, not network aware, and cannot be easily installed or controlled remotely. Key Bridge solves this problem with a custom-developed, low-cost, network-enabled intelligent receiver that leverages local processing and storage with central management, analysis and control.

The Key Bridge sensor client software, when running on a dedicated local computer, can control and receive streamed data and import data files from a number of third party spectrum analyzers. This unique capability can provide a new lease for older desktop spectrum analyzers and laboratory equipment.

Local plus Remote Monitoring and Control

The spectrum sensor is designed to simplify a technician's task load while ensuring reliable, high-performance data acquisition at minimal cost. It has no front panel controls and is fully capable of independent or remotely controlled operation.



Each sensor may be individually monitored, configured and remotely controlled.

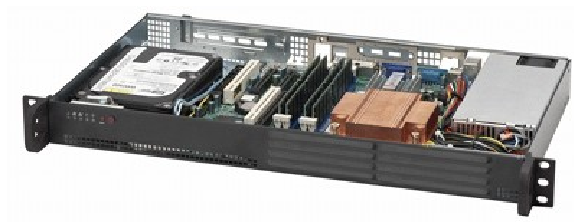
Key Bridge provides a fully-functional desktop application for individual sensor control and out-of-box configurations. Once deployed in the field a sensor is capable of autonomous, independent operation and can be securely managed and controlled remotely.

Intelligent Spectrum Sensor

The spectrum sensor is designed to simplify a technician's task load while ensuring reliable, high-performance data acquisition at minimal cost. It has no front panel controls and is fully capable of independent operation out of the box.

Indoor Enclosure

The indoor configuration is a 1-rack unit, 1/2 depth rack mountable standard computer chassis similar to the configuration shown with a factory-installed and integrated sensor subsystem (not shown).



The indoor configuration is standard rack-mount.

Indoor configurations are delivered with a BNC antenna connector.

Outdoor Enclosure

The outdoor configuration has the sensor installed in a painted die cast aluminum outdoor enclosure configured with a 20mm hole for a CAT5 or other cable feed through and a cutout for mounting an N type bulkhead connector for attaching an external antenna.

The outdoor configuration is standard pole mount.

The enclosure is gasket sealed for protection from the elements and meets a NEMA 4X / IP65 rating for weatherproofing and comes with a u-bolt bracket kit for mounting to a wall or to a pole with diameter up to 1.7".

Mobile Installations

Mobile installations are custom engineered according to the vehicle and ruggedness requirements.

Technical Specifications

The system's modular design creates an affordable entry point that easily scales to support high-availability, load balancing and fail-over redundancy. Two sensor ranges are supported.

Parameter	**Specification**
Frequency Coverage	5 MHz to 2,500 MHz or 100 kHz to 3,000 MHz
Span Width	1 MHz to 1,250 MHz or 10 Hz to 1,500 MHz
Resolution Bandwidth	0.01 MHz to 1 MHz
RF Sensitivity	Greater than -85 dBm typical
Reference Levels	-10 dBm to -50 dBm
Dynamic Range	40 dB
Receiver Accuracy	+/- 1 dB typical
Frequency Accuracy	+/- 0.001 MHz typical
Input Connector	BNC & N type (Others optional)
CPU Intel	Atom Z2760 dual core
Memory	1 GByte DDR3
Storage	1 TB HDD (128 GB Solid State Drive optional)
Networking	2 x 1000 BaseT Ethernet 802.11g WLAN optional 3G mobile optional
Operating System	Security Enhanced Linux, Embedded
Size	17" x 8" x 2" for indoor unit 11" x 9" x 5" for outdoor unit
Weight	4 lbs for indoor unit 5 lbs for outdoor unit (w/o battery)
Power Requirements	+12 VDC / 25 W maximum draw
Operating Temperature	0 to +40 deg C

Response to Questions

1. How should a measurement system be designed to measure a variety of emissions, including weak or intermittent signals, airborne platforms, and radar systems, while keeping incremental costs in check?

Key Bridge concurs with the ITU's recommendations on this topic: that the most efficient use of spectrum can be achieved when the distribution in time, magnitude and location of occupying transmitters is known. [4]

Our own product development and sourcing experience indicate a sharp rise in system cost for spectrum monitoring platforms capable of sensing above 3,000 MHz. Our experience is that system sensing above and below 3,000 MHz can vary in price by a factor of 2 to 10 with most system in the higher frequencies being about 4 to 5 times more expensive than those below.

We also note that signals at or above 3,000 MHz are typically localized, directional, well characterized by their licenses and assignments or a combination of all three. Monitoring such signals requires the sensor to be more carefully or closely located, potentially increasing overall system cost by requiring a larger number of fixed sensors.

We therefore propose the NTIA approach its goal of monitoring and characterizing spectrum occupancy for frequencies below 6,000 MHz fist by partitioning the band based upon sensor economics. We submit that a separate strategy is warranted for frequencies below 3,000 MHz than for those above this level.

Below 3,000 MHz the NTIA pilot program may benefit from the relatively low cost of individual sensors and the propagation characteristics of carrier signals by increasing the number of

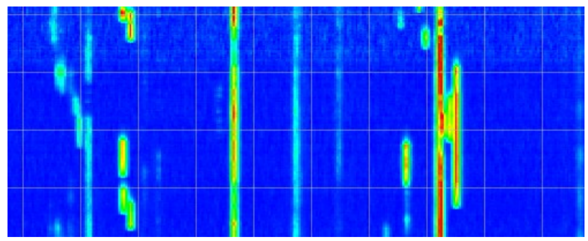
---

4 ITU-R SM.2256 *Spectrum occupancy measurements and evaluation.* This report provides a comprehensive analysis and technical guidance for spectrum occupancy measurement and can help to inform the NTIA's pilot design.

detectors in and around locations and areas of interest.

Above 3,000 MHz the NTIA pilot program must be more selective with fixed detector placement to maximize each node's probability of transmitter detection and to respect the program's budget. In some circumstances regular mobile surveys may be a more appropriate sensing strategy for these higher frequencies.

Detection of intermittent signals requires a shorter sensor scan rate or longer integration time than the queried signal pulse duration. The Key Bridge System supports a sweep rate of 25 kilo-samples per second and has successfully demonstrated the detection and characterization of extremely intermittent commercial air-to-ground, ground-to-air and ground-to-ground communications, scanning a 2 MHz span at 10 times per second with high precision.



Key Bridge sensor plot chart showing the detection of air traffic control transmissions

2. What types of measurement/monitoring techniques should be used for the different types of radio services?

Objective transmitter characterization requires relatively expensive apparatus and extensive manual intervention and configuration. To keep program costs low Key Bridge therefore recommends the NTIA pilot focus on spectrum occupancy; that is, the identification and characterization of radio energy in a band.

Except for a few known bands most all transmitters the NTIA pilot will encounter are licensed or registered in a database. The emission characteristics of most carriers will therefore be known beforehand, and we recommend that the pilot program does not incorporate widespread demodulation and carrier analysis.

3. What frequency bands should initially be measured during the pilot phase of the program?

Key Bridge sees no particular reason why all bands below 3,000 MHz can not be analyzed, nor any reason why area or path analysis of the bands between 3,000 and 6,000 MHz can not be undertaken at reasonable cost.

4. How should measurement and monitoring parameters (e.g., resolution and video bandwidths, sampling rate, dwell time, detector selection, antennas, pre-selector filtering, dynamic range) be specified?

Modern measurement equipments is able to measure signals with a large dynamic range and across a wide frequency domain. When coupled with local processing and centralized transmitter databases the determination and correlation of transmitter characteristics can be achieved with great precision.

The Key Bridge system supports, and we see no reason why the pilot program should not require that measurement and monitoring parameters may be adjusted and updated throughout the pilot program. This will accommodate both general surveys and also focused analysis of expected signal types in any given band allocation.

5. Which geographic locations within major metropolitan areas or other communities throughout the country would provide the greatest value for the pilot?

No response.

6. How should individual measurement units be deployed in each community?

Fixed remote sensors generally only require three critical components: real-estate, electricity and a connection to the Internet. Community service and public safety facilities like police stations, post offices, fire stations and libraries could therefore serve as excellent installations.

Key Bridge submits that a relatively large portion the the pilot's budget will likely be required for the installation and operation of a fixed sensor network, particularly to cover recurring real-estate, electricity and network charges.

7. How could the long- or short-term placement of multiple fixed units within the same general geographic area improve the accuracy and reliability of the data collected in each community and at what incremental cost?

The incremental cost to add additional sensors to a Key Bridge spectrum monitoring system is limited to the per-unit sensor cost (plus any third-party installation and facility charges). There are no additional per-sensor licensing, management or data handling fees.

8. How could mobile or portable units be utilized to supplement data collected at fixed sites within a community and at what incremental cost?

Key Bridge has developed and fielded a ruggedized mobile sensor system suitable for the U.S. Military. We do not believe this implementation would be cost-effective for civilian use. However, the Key Bridge management system is able to import raw data from a number of third-party spectrum monitor platforms. There is no incremental cost for this capability.

9. How long should measurement data be collected to provide statistically relevant results, particularly for intermittent operations, at each geographic location?

Characterizing channel occupancy of intermittent signals requires extended monitoring. An analysis of the number of dependent and independent sample required to produce a meaningful result is provided by the ITU. [5] To achieve a 95% confidence level when measuring channel

5 ITU-R SM.182-5, Question ITU-R 29/1 *Automatic monitoring of occupancy of the radio-frequency spectrum* at 5.

occupancy the required sampling period for any given signal can range from as short as 90 minutes up to 24 hours or longer.

10. How should the measurement system design take into account variations in population densities, buildings, terrain and other factors within or surrounding selected measurement locations (i.e., in urban, suburban, and rural parts of a metropolitan area)?

Key Bridge recommends that sensor locations are chosen to optimize their probability to detect known transmitters, which may be used as reference beacons, and to monitor areas and spectrum that should be vacant. Area propagation analysis of known transmitters can provide a good indicator of expected geographic signal extent and help with optimal location selection.

11. What steps can be taken to eliminate or minimize the possibility of "hidden nodes" when conducting measurements?

Key Bridge believes that unlicensed (Part 15) hidden nodes should not be considered.

Key Bridge believes that characterization of licensed or registered transmitters may be reasonably addressed through a combination of computer propagation modeling to identify suitable detector locations combined with overlapping sensor ranges and occasional mobile sweeps.

12. What kind of spectrum utilization and occupancy information (e.g., precise received field strength levels, time-of-day occupancy percentages, times that signals are measured above specified thresholds) would be most useful to spectrum stakeholders?

The Key Bridge System permanently archives each sensor sweep, called a "Trace" in a raw-data archive. Each Trace record in the archive provides a set of precise field strength levels corresponding to a frequency range and is location and time stamped. This raw data is then available for real-time and off-line analysis.

13. What detection thresholds should be used to measure and characterize the usage patterns of incumbent systems?

As above: Key Bridge notes that modern measurement equipments is able to measure signals with a large dynamic range and across a wide frequency domain. The detection thresholds may be dynamically programmed to accommodate each frequency band or a specific carrier as it is studied.

14. What data and information would be useful in evaluating potential sharing compatibility with wireless broadband devices?

No response.

15. How can the gathered data and analysis better inform spectrum policy decisions, enhance research and development of advanced wireless technologies and services?

No response.

16. What data formats and evaluation tools should be employed?

Please see response to Q17.

17. How can the large amounts of measurement data be effectively managed, stored, and distributed?

The NTIA pilot program will generate vast amounts of raw data and a meaningful data archive and retrieval strategy is required.

The Key Bridge system leverages existing Internet standards to losslessly archive spectrum sensing data as "tiled" data files with corresponding meta-data to describe each file's geolocation and time components. This strategy is based upon the Web Map Tile Service open standard and provides for dense, lossless permanent storage of spectrum information and for fast and efficient retrieval using standards-based communications and query protocols. [6]

18. What steps can be taken to ensure that sensitive or classified information will not be revealed to unauthorized parties?

Key Bridge concurs with the NTIA that not all pilot data should be immediately or generally available. To protect the operational sensitivities of the Government we believe that data availability can and should be determined on a band-by-band basis.

The Key Bridge System includes data access controls based upon user group privilege plus an ability to restrict access based upon data frequency range and sample time period.

For sensitive operations the Key Bridge sensor platform can also be configured to encrypt spectrum Trace data prior to local storage and forwarding to the system manager and central archive.

Conclusion

Key Bridge appreciates the opportunity to respond and we hope that the NTIA will find these commends and our experiences helpful in the planning and execution of its spectrum monitoring pilot program.

/s/

Jesse Caulfield, President

Key Bridge Global LLC
1600 Tysons Blvd., Suite 1100
McLean, VA 22102

---

6 Web Map Tile Service (WMTS) is a standard protocol for serving pre-rendered georeferenced map tiles over the Internet. The specification was developed and is maintained by the Open Geospatial Consortium. See OpenGIS Web Map Tile Service Implementation Standard at http://www.opengeospatial.org/standards/wmts