Before the
DEPARTMENT OF COMMERCE
NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION
Washington, D.C. 20230

In the Matter of	)	
	)	
Developing a Sustainable Spectrum Strategy for America's Future	)	Docket No. 181130999–8999–01
	)	
	)	

Comments of Shared Spectrum Company

I. Introduction

Shared Spectrum Company (SSC) submits these comments in strong support of Developing a Sustainable Spectrum Strategy for America's Future in the *Notice* issued on December 21, 2018 by the National Telecommunications and Information Administration (NTIA). SSC congratulates NTIA for taking the lead and cooperating in advancing the frontier of innovative spectrum sharing technologies, which will provide benefits to all users of the spectrum by greatly increasing effective communications capacity.

Shared Spectrum Company (SSC) was founded in 2000 to develop technology that dramatically increases the efficient use of RF spectrum resources. During that same year, SSC became the first company to file comments at the Federal Communications Commission (FCC) proposing the shared use of "white spaces" in the television band for broadband Internet access. Over the past 19 years, SSC has become a leading expert and innovator in the development of cognitive radio technologies. SSC pioneered the research and development of Dynamic Spectrum Access (DSA) technology for the U.S. Department of Defense. The company is expanding into the commercial sector with the development of DSA solutions for a wide array of applications.

II. Overall Comments and Recommendations

a. A Distributed Architecture with Dynamic Local Adaptation Increases Spectrum Sharing Efficiency

Fixed centralized architectures require extensive pre-planning using estimates for many key factors that govern whether interference occurs. Factors such as key equipment or interference performance thresholds can be hard to obtain and factors such as propagation path loss, shadowing, and fading are included using statistical models with large uncertainty. Additionally, assumptions on node mobility greatly increase the path loss uncertainty resulting in increased exclusion zones.

Estimates are inherently inaccurate – even the best estimates introduce cascaded margins to account for projected conditions. This results in either:

- Optimistic assumptions on parameters to allow sharing that lead to interference when those assumptions aren't met, or
- Conservative assumptions to minimize the occurrence of interference that lead to missed opportunities for spectrum sharing because sharing erroneously was not permitted.

Both centralized and local spectrum sharing systems are needed. Not all radios needing to share spectrum will have the ability to operate using local information. These systems will rely on centralized spectrum sharing (i.e., databases) for access to shared spectrum bands. Local distributed systems that can react to the spectrum environment encountered by the radio(s) offers more efficient spectrum sharing. To achieve increased spectrum sharing over time, the rules should support and encourage the development of local distributed spectrum sharing solutions.

Centralized architectures provide authorization for system operation, but are unaware of whether that spectrum is actually being used at a given place and time. This results in loss of spectrum sharing opportunities that could be detected by real-time local distributed spectrum sharing systems.

Local adaptation allows system to respond to the spectrum use environment it is experiencing. This removes margins included in the calculation of required exclusion zones for path loss uncertainty, node mobility patterns, and other system assumptions.

b. Interference-Resistant Systems Improve Spectrum Sharing Efficiency

Standard definitions for interference are needed for evaluating spectrum sharing scenarios. NTIA has defined interference in terms of Interference-to-Noise (INR) levels with some systems tolerant to interference at -6 dB INR. Improving this to -3 dB or 0 dB INR would permit smaller exclusion zones and increased spectrum sharing / reuse at closer distances. Regulators can help drive the industry towards equipment and system design performance improvements that benefit both system operation and spectrum sharing. As technology advances, regulators should review performance capabilities and adjust INR tolerance levels accordingly to continue to increase sharing. This approach further accelerates spectrum sharing development as higher INR ratios lead to relaxed sensor performance requirements which reduces development and implementation costs of distributed spectrum sharing systems.

Stovepipe spectrum assignments were made to prevent the occurrence of interference between systems. Since automated detection and resolution of interference were unavailable, large margins were used to establish exclusion zones. INR thresholds were established to be well below the thermal noise floor. As automated detection and interference resolution (i.e., spectrum sharing) solutions emerge, the likelihood of long-term persistent harmful interference between systems is greatly reduced since the adaptive system can detect and resolve the interference conditions. This reduces interference events to short-term (on the order of seconds) events. Since interference occurs occasionally, and for short durations, the systems sharing the spectrum should be required to accept and/or tolerate some reasonable level of interference. Permitted interference durations and INR levels can be adjusted based on the requirements of the specific systems, with a corresponding trade-off between interference protection and spectrum sharing efficiency.

c. Anomalous Propagation Affects Spectrum Sharing

RF ducting is an anomalous propagation phenomenon that occurs when humidity and temperature inversions in the atmosphere causes RF energy to be focused along a particular path. Ducting causes the path loss between two points to be significantly less than occurs during non-ducting conditions. Thus, ducting results in increased coupling (interference) between two systems sharing frequency. Ducting is typically ignored in spectrum sharing decisions and/or is inaccurately estimated using simplistic propagation models.

SSC has conducted extensive simulations and measured the amount that ducting varies the propagation loss between terrestrial users. For example, we have operated a receiver at Ocean City, New Jersey for many months, and measured the received TV station power on all channels. At this location, the TV channel 18 typically has the received power level below the noise level, but quite often the received power is increased by more than 20 dB (Figure 1) and is above the noise. These power level increases are due to ducted signals causing anomalous propagation.

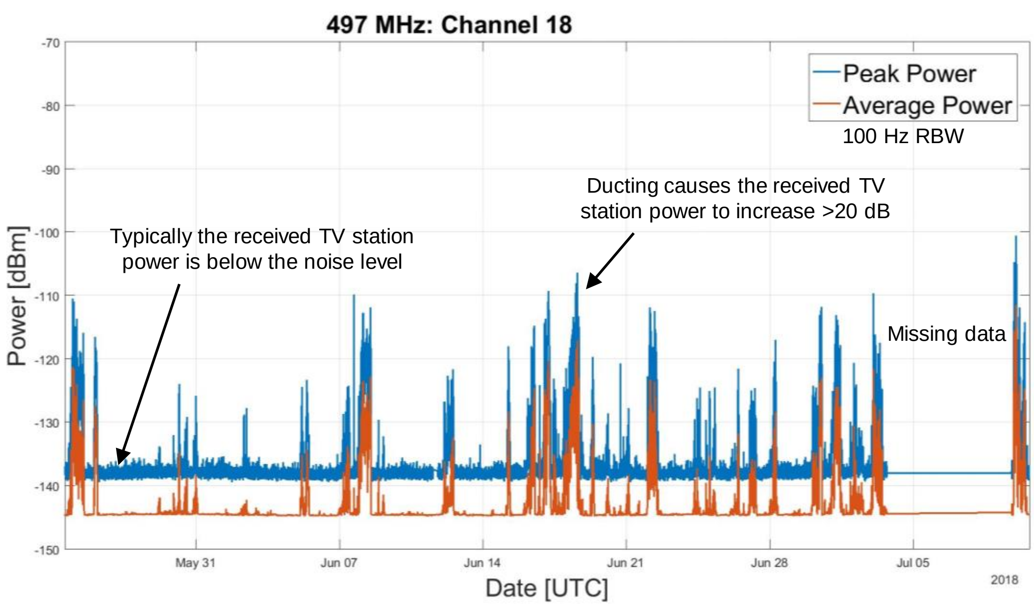

FIGURE 1. MEASURED TV SIGNAL POWER OVER A SEVERAL MONTH PERIOD AT OCEAN CITY, NJ SHOWING SIGNIFICANT POWER VARIATION DUE TO ANOMALOUS PROPAGATION (DUCTING)

There are three ways to deal with the occurrence of ducting:

- Ignore the effects of ducting in the calculation of exclusion zones. This results in interference between two systems a statistical percentage of time, even though they operate according to the specified exclusion zone distances.

- Include the effects of ducting at a defined percentage level in the calculation of exclusion zones. This reduces the occurrence of interference between systems, but also results in significantly increased exclusion zone distances and potentially dramatically decreased spectrum sharing opportunities.

- Operate using a real-time distributed spectrum sharing system that detects the energy from other systems and adapts operating frequency to avoid interference. This approach effectively mitigates ducting by sensing changes in the spectrum operating environment as they occur. The result is increased spectrum sharing opportunities while maintaining the adaptive ability to respond to ducting events without a corresponding increase in interference.

SSC believes that the NTIA should consider the impacts of ducting on the future spectrum strategy. NTIA should include ducting effects in all propagation models used for spectrum management. NTIA should move to distributed spectrum sharing approaches, which provide both low interference levels and high spectrum efficiency.

d. An Incremental Development and Implementation Approach is Needed

An extensive spectrum planning and management ecosystem has been developed for establishing, maintaining, and modifying spectrum assignments. The introduction of significantly increased spectrum sharing creates a new paradigm that will require enhancements to this ecosystem. However, given budget realities, these must be accomplished incrementally. The fundamentals of the existing analysis and planning tools remain consistent for computing the interaction between RF systems. What needs to change is the interpretations of the calculations to recognize the dynamic nature of spectrum sharing in both centralized and distributed spectrum sharing systems.

An incremental approach begins by designating certain sub-bands of spectrum as ‘primary’ spectrum sharing bands with well-defined rules for shared access. This incremental approach will generate practical spectrum sharing experience while transitioning spectrum for shared access.

Government conducted laboratory and field ‘demonstration’ and ‘testing’ coupled with technology improvement cycles of new spectrum sharing technology are needed to understand current and ultimate performance and benefits.

Another option for incremental adoption is to designate high power density systems as primary users in a specific spectrum assignment and allow lower power density systems to share the spectrum by detecting the presence of the high power density system. Aligning low power secondary uses with high power primary users facilitates detection and reduces the likelihood of harmful interference to the high power system.

e. Incentives Will Accelerate Spectrum Sharing Adoption

Adoption of any new technology involves some level of uncertainty. We are moving from the old paradigm where spectrum users are granted assignements with the expectation of no interference to a shared spectrum approach. Incentives are needed to motivate early adopters of this new approach.

NTIA should focus on 'carrot' incentives as much as possible. Mission related incentives will be the most persuasive. Possible incentives include access to additional spectrum, greater contiguous bandwidths, permitted operation at higher INR, etc. To facilitate this incentive, NTIA should provide to users typical spectrum use information (assignments, user activity, etc) from other parties within their bands so that users can calculate the benefits that they would obtain.

III. Responses to the Specific NTIA Questions

The following comments apply to the specific questions raised by NTIA:

1. In what ways could the predictability of spectrum access for all users be improved?

The need for predictability implies that a static spectrum management process is used. When spectrum is assigned as a static process, this results in either high levels of inefficiency or high levels or errors/interference. While statically assigned spectrum access is predictable, it is predictably poor.

Rather, spectrum access should be dynamic to match current conditions. The spectrum sharing problem is analogous to transportation systems such as air traffic control or road conditions which rely on local, dynamic conditions. For example, while a general plan for access (e.g., directions) is helpful, it would be terribly inefficient for each vehicle to reserve its spot on the highway for the duration of the trip before the journey begins.

2. To what extent would the introduction of automation facilitate assessments of spectrum use and expedite the coordination of shared access, especially among Federal and non-Federal spectrum stakeholders?

Automated spectrum sharing is critical a sustainable spectrum strategy to reduce labor costs. WiFi is an example where automated interference estimation and channel selection is used to reduce spectrum management costs. The appropriate automation approach will need to band specific to pursue an incremental development and deployment approach.

3. What is the practical extent of applying standards, incentives, and enforcement mechanisms to promote efficient and effective spectrum use?

Incentives will motivate early adopters of this new approach. Possible incentives include access to greater bandwidths, additional spectrum, permitted operation at higher INR, etc.

Currently federal spectrum operators don’t have sufficient knowledge of other operator’s spectrum use to determine the advantages of adopting an efficient spectrum sharing approach. NTIA needs to provide detailed spectrum assignment, use and scenario information that would enable spectrum operators to estimate the amount of benefit that the operator would obtained by using efficient spectrum sharing technology.

4. How might investment in RDT&E improve spectrum-utilization methods, and spectrum-sharing tools and techniques?

A major impediment to the deployment of distributed spectrum sharing systems has been a trust issue. Spectrum regulators and frequency planners need to be able to trust that dynamic adaptive systems respond as advertised under a wide range of spectrum conditions to ensure that interference is avoided.

NTIA or some other federal entity needs to sponsor additional efforts to validate spectrum sharing operation to demonstrate interference avoidance to increase trust in the operation of these systems. Spectrum sharing technologies need to demonstrate a high Test Readiness level to assure compliance to spectrum regulations.

5. What are the risks, if any, to the global competitiveness of U.S. industries associated with spectrum management and policy actions?

Congested spectrum resulting from stovepipe frequency assignment is not a US-only problem. The world is moving in this direction. The introduction of increased spectrum sharing technologies represents a risk for US industries. The risk is that the spectrum management technologies might impact the design of the communications system so that the U.S. competitor might not be competitive unless they had the ability to implement this technology. For example, in the UK spectrum sharing within the TV bands is currently an ongoing function.

6. How could a spectrum management paradigm be structured such that it satisfies the needs of commercial interests while preserving the spectrum access necessary to satisfy the mission requirements and operations of Federal entities?

There is no “one size fits all” solution to spectrum sharing due to the widely varying nature of the many different commercial and military spectrum-dependent systems. One approach would be to move towards establishing different bands with different sharing rules in the different bands based upon need and user authorizations. Possibilities for variations between bands include which systems are primary vs. secondary, what INR is permitted in the band, etc.

7. What are the likely future needs of spectrum users, both terrestrially and for space-based applications, within the next 15 years? In particular, are present

allocations of spectrum sufficient to provide next generation services like Fifth Generation (5G) cellular services and emerging space-based applications?

SSC believes that there will be intense pressure to obtain more spectrum access, especially at frequencies below 2 GHz (because of obstacle penetration). The need for increased spectrum is partially offset by the use of small area cells and the use of directional antennas, but these approaches have high recurring costs. It will be more cost effective to implement spectrum sharing technology coupled with using small cells and directional antennas to obtain spectrum access. 5G and other new standards are pursing small area cells and the use of directional antennas solution because of slow and expensive regulatory approach to implement spectrum sharing technology. A sustainable spectrum strategy incorporating multiple technologies is needed to maximize the use of available spectrum and increase our competitiveness.

Respectfully submitted,

Shared Spectrum Company
Mark A. McHenry
Scott Y. Seidel
1593 Spring Hill Road, Suite 700
Vienna, VA 22182-2249
703-462-6943

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