

**Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554**

In the Matter of)
)
Expanding Flexible Use in Mid-Band) GN Docket No. 17-183
Spectrum Between 3.7 and 24 GHz)
)
To: The Commission)

**COMMENTS OF THE IEEE DYNAMIC SPECTRUM ACCESS NETWORKS
STANDARDS COMMITTEE (DYSPAN-SC) ON EXPANDING FLEXIBILITY
IN THE SPECTRUM BETWEEN 3.7 AND 24 GHz VIA THE USE OF
SPECTRUM CONSUMPTION MODELS**

The Institute of Electrical and Electronics Engineers (IEEE) DySPAN Standards Committee (DySPAN-SC) hereby submits its Comments on the above-captioned Proceeding. This document was prepared and approved by the IEEE 1900.5 Working Group within the DySPAN-SC.

The IEEE Dynamic Spectrum Access Networks Standards Committee (DySPAN-SC) is a component of the IEEE Standards Association, one of the Major Organizational Units of the Institute of Electrical and Electronics Engineers (IEEE). IEEE has about 420,000 members in about 190 countries, and supports the needs and interests of engineers and scientists broadly. In submitting this document, DySPAN-SC acknowledges and respects that other IEEE Organizational Units may have perspectives that differ from, or compete with, those of DySPAN-SC. Therefore, this submission should not be construed as representing the views of IEEE as a whole.

DySPAN-SC is a consensus-based industry standards body for Dynamic Spectrum Access Networks (DySPAN), and has the following technical scope:

- dynamic spectrum access radio systems and networks with the focus on improved use of spectrum,
- new techniques and methods of dynamic spectrum access including the management of radio transmission interference
- coordination of wireless technologies including network management and information sharing amongst different dynamic spectrum access radio networks.

We appreciate the opportunity to provide these comments to the Commission.

Introduction

1. The DySPAN-SC commends the Commission for its work in soliciting input focused on expanding the flexible use of Mid-Band spectrum between 3.7 and 24 GHz
2. The DySPAN-SC strongly believes that dynamic spectrum access (DSA) technologies and techniques have the potential to enable more efficient use of spectrum resources. The DySPAN-SC further believes that the benefits of the dynamic spectrum access techniques requires a regulatory framework that will encourage business development of products and services that use advanced DSA technologies. The acceptance of these advanced technologies by both the business and regulatory communities is dependent on DSA standards developed by international Standards Development Organizations (SDOs) such as the DySPAN-SC. Thus, the regulatory community, the wireless industry, and SDOs must work in close harmony to achieve the spectrum efficiency benefits associated with DSA radio systems and networks.
3. Since 2012 the IEEE 1900.5 working group on Policy Language and Architectures for Managing Cognitive Radio for DSA Applications has been working on IEEE standard 1900.5.2 which aims to standardize a method for modeling spectrum consumption. This work is directly applicable to the expansion of flexibility in the frequency bands detailed in the NOI.
4. In the text below, the DySPAN-SC identifies solutions provided by IEEE 1900.5.2 to some of the technical issues and questions mentioned in FCC 17-104. It mainly describes how spectrum consumption models can enable flexible use of the mid-band spectrum bands listed in FCC 17-104.

Description of the Spectrum Consumption Models (SCMs) and related standardization work

5. The IEEE 1900.5.2 standard defines an approach to model spectrum consumption via spectrum consumption models (SCMs) and the attendant computation methods and algorithms to arbitrate compatibility among these models. SCMs are used to capture the boundaries of RF spectrum use by all types of RF devices and systems of RF devices. These models enable Model-Based Spectrum Management (MBSM), which is spectrum management executed through the creation and exchange of SCMs. MBSM allows distribution of the spectrum management problem where spectrum users can model their use of spectrum independent of other users, without the need to reveal proprietary details, and share those models directly or via a MBSM system. A common set

of algorithms can then be used to compute the compatibility of the models. The compatibility computation determines whether the spectrum uses expressed via SCMs will generate interference to one or more of the devices/systems considered in the computation. SCMs are machine readable and they can also serve as a means to convey RF spectrum use parameters to devices.

6. The IEEE 1900.5.2 standard is on track for final release and approval by IEEE in December of 2017.

7. SCMs capture the boundaries of spectrum use by capturing the key characteristics of RF systems and phenomena that determine spectrum use. Currently the modeling method uses 11 construct elements that can collectively capture transmission power, spectral emissions, receiver susceptibility to interference, intermodulation effects, propagation, antenna effects, location (both fixed and mobile), time of use, and radio behaviors that enable compatibility. These construct elements can also capture the uncertainty of what is being modeled.

8. SCMs are complemented with defined methods for arbitrating the compatibility between models. A MBSM system is thus capable of managing coexistence of multiple types of users. Models can be constructed for any type of system that uses the RF spectrum and so compatibility can be managed among types of users differentiated by the purpose or service of their spectrum use. These methods support arbitrating compatibility based on both noise limited and interference limited sharing criteria.

9. Terrestrial propagation effects are greatly influenced by the environment and modeling it is difficult. Collaborative management requires modeling propagation in a common way. The urgency to field systems is likely to require commitment to models that are unproven in some bands and complicated to implement requiring common databases of terrain data. Later, they will be hard to upgrade. SCMs help avoid these complications by making propagation a derived model. Propagation effects estimated using a physics based model or measurements are fitted to a propagation map. This approach to modeling allows the continuous improvement of environmental modeling without requiring the concurrent revision of the decision support algorithms in the management tools. Additionally, the design of the constructs used in modeling seek to support the creation of decision support algorithms that are computationally simple to implement and that can operate on many and varied uses of spectrum

10. Thus, SCMs and their related compatibility arbitration algorithms, allow for RF technology independent spectrum management which is very important for the implementation of sustainable spectrum management frameworks that can adapt to the rapid evolution of wireless technologies.

11. The SCM information model is narrowly focused on spectrum consumption. It does not necessarily capture user identities, RF component nomenclatures, model numbers, equipment capabilities or operational mission descriptions. Rather it provides an assortment of constructs that attempt to convey spectrum use boundaries alone. This benefits users who do not want to reveal proprietary and sensitive information about the deployment of their systems.

12. In the subsequent sections we first describe how the SCM resolve the particular technical issues identified in the Commission's request for comments. We build from this discussion to propose an architecture to enable flexibility in several spectrum bands.

Flexible spectrum management with SCMs

13. The purpose of the SCMs is to capture the electromagnetic radiation that systems emit and the susceptibility of systems to interference by other system's electromagnetic emissions.

14. SCMs allow the creation of an *acceptable interference environment*. All SCMs capture the interference limits of the systems they model. The spectrum consumption modeling methods provide a means to identify the acceptable power spectral flux density of interference as well as the power spectral flux density of emissions and their dependence on propagation. All types of systems can be modeled and there is a common approach for resolving whether the models indicate that one system will violate another's interference limits.

15. SCMs provide *technical flexibility*. It is intended that any type of system can be modeled and so MBSM can also support the management of interference among very disparate systems including between radars and broadband communications. Modeling supports collaborative management where spectrum users of very different enterprises can communicate their spectrum use to each other without having to share sensitive information about the systems that are using the spectrum or of the operations using these systems.

16. Distributed spectrum management is accomplished by sharing SCM. Each enterprise can specialize in knowing the details of their systems and the methods for building SCM of their use of spectrum (i.e. Fixed Satellite Service (FSS), Fixed Service (FS), broadband mobile, etc). The methods for arbitrating compatibility are all standardized and based on the SCM and so it is not necessary for the spectrum managers of the enterprises to either know the performance and operating details of the other systems or the specific nuances of their ability to coexist.

17. This advancement in distributed spectrum management can also change the nature of spectrum management. With centralized systems, spectrum management by nature seeks

persistent solutions, that is, solutions that last until a new problem demands new analysis that dictates something else be done. The use of SCMs encourages the revelation of operational use of spectrum into the future, which includes spatial and temporal changes in use. Resolution in these dimensions, in turn, encourages less greedy spectrum assignments. The use of SCMs to define spectrum use and the full automation of arbitrating compatibility among SCMs remove much of the burden of dynamic spectrum management. SCMs that reveal the changing use of spectrum into the future would allow algorithms that operate on collections of models to reveal opportunities to reuse spectrum.

18. These characteristics advance database based spectrum management in several ways. In existing spectrum management systems, the role of the database is to arbitrate entry of new users based on their compatibility with incumbents. RF devices are certified to operate in a way that databases understand and regulation defines the approach to compute which channels are available to those devices based on device location and established “contours” of incumbent use. The databases do not manage secondary coexistence. Using SCM can change this management in two ways. First, assuming devices provide or the database can build an SCM of their spectrum use, compatibility can be computed and so coexistence can be managed. Second, since compatibility is based on using SCM, regulators no longer need to define the contours. Incumbent users can convey directly to databases their spectrum use with SCMs and these would be sufficient to serve as contours for a database to determine if new uses would be compatible. This outcome also holds true in an environment with multiple database administrators. So long as all databases have a common set of SCMs of spectrum users, they will arrive at the same conclusions on the admission of new users.

19. SCM may also be used to convey policy directly to radios. SCM can convey spectrum available for use. So long as a radio’s use of spectrum is within the boundaries of the SCM it may be used. SCM may also provide constraints. So long as a radio’s use of spectrum is compatible with the constraining SCM it meets the constraint. A radio that has self-awareness in the sense of knowing where it is operating and how it would generate its own SCM can use the standard algorithms for computing compatibility to compute whether spectrum is usable by assessing whether its use, as defined by an SCM, is within an authorizing SCM and compatible with any constraining SCM that it is given as policy.

20. Additionally, highly refined and detailed spectrum management policies will be feasible in the near future when the IEEE 1900.5.2 standard is complemented with the IEEE 1900.5.1 standard which defines a Policy Language for Dynamic Spectrum Access Systems. By World Wide Web

Consortium (W3C) standardized processes, the SCM information model may be translated into an OWL 2 ontology¹. Then, utilizing the 1900.5.1 defined Policy Language, based on the W3C RIF - Core language, compatibility and policy rules may be defined, that by virtue of a W3C standardized semantics are ensured to be interpreted and executed without any ambiguity across all participating devices.

Using SCMs to enable flexible use of spectrum in Mid-band spectrum between 3.7 and 24 GHz

21. We propose the use of SCM based Spectrum Access Systems (SCM_SAS) to coordinate the use and enable the sharing of spectrum in the 3.7-4.2 GHz band. This will allow more intensive use of the band for the deployment of point-to-multipoint FS broadband services and last mile point to point FS links. It will also allow the protection of incumbent FS and FSS operations in this band.

22. Some of the operational principles of the SAS systems used for the Citizens Broadband Service will apply to an SCM_SAS but centered around the exchange of SCMs among devices that need spectrum access in a specific geographical area.

23. Incumbent FS and FSS systems would submit and register with an SCM_SAS their respective SCM describing the boundaries of their spectrum use and required interference protection characteristics. New entrant RF devices or systems would submit their SCM to the SCM_SAS which in turn would compute the compatibility of the entrant's SCM with that of systems already registered in the SCM_SAS and if the new SCM is found compatible the entrant's system is registered in the SCM_SAS and granted permission for operation. In case the entrant's SCM is not found to be compatible, the entrant will be denied permission for operation until it submits a compatible SCM.

24. To support the scalability of the proposed SCM_SAS operation, different commercial entities could operate an SCM_SAS and elaborate one or several SCMs that communicate the aggregate of the spectrum use boundaries defined by the SCMs registered at each SCM_SAS. These aggregate SCMs can be exchanged between different SCM_SAS to protect registered devices/systems from interference irrespective of the SCM_SAS in which they registered.

¹ OWL=Web Ontology Language, a language for authoring ontologies.

25. The operation of SCM_SASs as described in the previous paragraphs is also applicable for managing the co-existence of incumbent devices with new entrant devices in the 5.925-6.425 GHz band and the 6.425-7.125 GHz band.

26. In the particular case that unlicensed sharing of spectrum in the 5.925 – 7.125 GHz was permitted by designating this frequency range as a U-NII band, a SCM_SAS could build a geo-referenced database to respond to queries from U-NII devices wishing to know if their transmissions would generate interference to systems that have registered their spectrum use boundaries via an SCM². Assuming that U-NII devices would have one or a restricted set of RF spectrum use characteristics and that these are standardized and well-know, the device would only need to identify itself as a U-NII device for the SCM_SAS to determine what SCM to use to determine the compatibility of its spectrum use. This procedure would help prevent or mitigate interference to incumbents in the frequency range previously mentioned.

Conclusion

27. The soon to be released IEEE 1900.5.2 standard (Standard Method for Modeling Spectrum Consumption) developed by the IEEE DySPAN-SC Working Group IEEE 1900.5 provides a feasible mechanism and information model to enable spectrum use flexibility in the bands mentioned by the FCC 17-104A NOI.

28. We believe that a near term feasible solution to increasing the flexibility of spectrum use in mid-band spectrum between 3.7 and 24 GHz can be built based on the integration of:

- i) spectrum consumption models (SCMs) as a well-defined means to convey the boundaries of spectrum use by any RF device/system
- ii) the spectrum use compatibility computations for SCM as defined by the IEEE 1900.5.2 standard and
- iii) the use of database technology to structure an SCM based Spectrum Access System that can be used under the suggested operational rules mentioned in this document.

29. Overall, SCMs and their related algorithms for computing spectrum use compatibility, allow for RF technology independent spectrum management which is very important for the

² This assumes the U-NII device has geo-location capabilities.

implementation of sustainable spectrum management frameworks that expand flexible use of mid-band spectrum and can adapt to the rapid evolution of wireless technologies.

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