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| Abstract | This document is intended as a contribution and response from the 1900.5 WG to the DoD’s RFI on Defense Spectrum Sharing |
| Purpose |  |
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# ENABLING DYNAMIC SPECTRUM SHARING VIA THE USE OF SPECTRUM CONSUMPTION MODELS

*Note: once the whitepaper is approved, the following text should be added:*

*“Whitepaper prepared and approved by the IEEE 1900.5 Working Group within the Dynamic Spectrum Access and Networks Standardization Committee (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.

**Introduction**

Since 2012 the IEEE 1900.5 working group on Policy Language and Architectures for Managing Cognitive Radio for Dynamic Spectrum Access (DSA) Applications started working on IEEE standard 1900.5.2 with the aim to standardize a method for modeling spectrum consumption. The standard was completed in December of 2017. After receiving additional industry and feedback from entities that interact with DoD, the working group started an amendment to enhance the application domain of SCMs and the clarity of the information model (schema) on which it is based. The amendment should be finalized by early 2021.

This content of this whitepaper directly addresses questions K and L mentioned in the RFI.

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

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. These characteristics of SCM, directly address the following question of the RFI:

* K. How can spectrum modernization, including spectrum Information Technology (IT) modernization and automation, help facilitate faster spectrum sharing?
* L. Are there standards, including data standards, which could accelerate spectrum repurposing decisions? If so, what are they?

The rest of the document will explain the main characteristics of SCMs in more detail in relationship to the RFI.

SCMs capture the boundaries of spectrum use by capturing the key characteristics of RF systems and phenomena that determine spectrum use. Currently, as defined in IEEE 1900.5.2-2017, 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. SCMs are machine readable and they can also serve as a means to convey RF spectrum use parameters to devices.

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 spectrum sharing criteria.

It's worth mentioning that SCMs avoid the complications of terrestrial propagation effects dependent on common databases of terrain data by making propagation a derived model. Propagation effects estimated using a physics based model or measurements are fitted to a propagation map that is included in the SCM. 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 that two or more parties seeking to share spectrum would need to agree on.

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.

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.

# Dynamic Spectrum Sharing with SCMs

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. 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 [1-3].

MBSM can 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 [1].

Distributed spectrum management and dynamic spectrum sharing is accomplished by sharing SCMs between the entities wishing to share spectrum and/or wishing to check that their spectrum use won’t negatively interfere with another entity’s spectrum use and vice-versa. Each entity can specialize in knowing the details of their systems and the methods for building an 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 each entity to either know the performance and operating details of the other systems or the specific nuances of their ability to coexist.

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.

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. The use of SCMs 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 SCMs, 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.

SCM may also be used to convey policy directly to radios. SCM can convey spectrum available for use (via an Authorization model). SCMs may also provide constraints on spectrum use (via a Constraint model). Combinations of authorization models with constraint models provide a rich means to convey machine readable spectrum use policies to wireless device based on location and time of day.

**Conclusion**

The 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 in the DoD’s RFI.

We believe that a near term feasible solution to increasing the flexibility of spectrum use in mid-band spectrum 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.

Overall, SCMs and their related algorithms for computing spectrum use compatibility, allow for RF technology independent spectrum management which is very important for the implementation of sustainable spectrum management frameworks that expand dynamic spectrum sharing of mid-band spectrum and can adapt to the rapid evolution of wireless technologies.

**References**

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