**Criteria for Standards Development - P802.22, Revision to IEEE Std. 802.22-2011**

# IEEE 802 criteria for standards development (CSD)

The CSD documents an agreement between the WG and the Sponsor that provides a description of the project and the Sponsor's requirements more detailed than required in the PAR. The CSD consists of the project process requirements, 1.1, and the 5C requirements, 1.2.

## Project process requirements

### Managed objects

Describe the plan for developing a definition of managed objects. The plan shall specify one of the following:

1. The definitions will be part of this project.
2. The definitions will be part of a different project and provide the plan for that project or anticipated future project.
3. The definitions will not be developed and explain why such definitions are not needed.

*Ans: a)* The definitions will be part of this project. The Amendment P802.22a on MIBs and Management Plane Procedures will be folded into the base IEEE Std. 802.22-2011 as part of this revision.

### Coexistence

A WG proposing a wireless project shall demonstrate coexistence through the preparation of a Coexistence Assurance (CA) document unless it is not applicable.

1. Will the WG create a CA document as part of the WG balloting process as described in Clause 13? (yes/no)
2. If not, explain why the CA document is not applicable.

*yes*

**1.2 - 5C Requirements**

**1.2.1. Broad Market Potential**

**a) Broad sets of applicability**

Since 2005, when the 802.22 PAR was first submitted and approved, the Federal Communications Commission (FCC) in the USA, OfCom in UK, South Africa, Infocomm Development Authority (IDA) in Singapore, Colombia, Malawi, Uganda, Botswana and other regulators have broadened their horizons for cooperative spectrum sharing approaches in order to optimize spectrum utilization. See, for example, the Tutorial titled “Spectrum … Be Prepared for Sharing” [1] and Tutorial on TV WhiteSpaces [17] that were presented during the IEEE 802 March 2019 Plenary Meeting.

Various regulators are in the process of opening new spectrum bands that specifically require multiple levels of regulated users to share the spectrum utilizing cognitive radio behavior. For our purposes, we define spectrum sharing as a mechanism which ensures that primary services are protected from interference while allowing other opportunistic devices to share the spectrum. While these new bands have been or are being specified by the FCC for the United States [3]-[5], these bands may have different specifications in other countries [6]. Moreover, the TV White Space regulations in the US have been updated since completion of the standard [7], while TV White Space regulations in other countries such as the UK [8], South Africa, Colombia, and others have been completed as well. The intention of this PAR is to revise the current 802.22 standard, and to align it with emerging regulations which will enable wide sets of applications of technologies.

Wireless device manufacturers are seeking a common protocol to be used across these shared spectrum bands and for multiple applications. Hence, the aim is to change the spectrum management framework to align 802.22 to be used in these other bands. For example, 802.22 may be used in the proposed radar bands (e. g. 2,700 MHz‑3,700 MHz) which allow spectrum sharing, since 802.22 already contains the basic cognitive radio capabilities and mechanisms that are needed to enable spectrum sharing. One other potential emerging application for 802.22 based services is cost-effective middle-mile connectivity and backhaul for rural broadband applications [2]. Affordable access mechanisms that can provide backhaul using shared spectrum has become extremely important and necessary.

The proposed revision will enable a number of new broadband applications in bands that allow spectrum sharing such as Television White Spaces (TVWS) as well as newly available Government bands such as radar bands. The revision will enable 802.22 networks to be deployed to provide broadband services and monitoring applications.

**b) Multiple vendors and numerous users**

It is expected that this revision will be applicable in all markets where the 802.22 technology will be used. The new features of the revision are expected to bring new equipment vendors, manufacturers and users of semiconductor, personal computer, enterprise networking devices, consumer electronic devices, home networking equipment, mobile devices, wireless internet service providers etc.

Due to the slow evolution of spectrum regulation in markets such as the United States and emerging regulations in many other countries around the world, the pace of TV WhiteSpace deployments has been slow. A few chipset and device vendors have exited the market, however new vendors have seized on this opportunity and trials using such equipment have been performed [9-16].

**1.2.2. Compatibility**

Each proposed IEEE 802 LMSC standard should be in conformance with IEEE Std 802, IEEE 802.1AC, and IEEE 802.1Q. If any variances in conformance emerge, they shall be thoroughly disclosed and reviewed with IEEE 802.1 WG prior to submitting a PAR to the Sponsor.

Ans: The revision will be compatible with IEEE 802 family of standards, specifically 802 overview and architecture, 802.1 including 802.1AC and 802.1Q.

**1.2.3. Distinct Identity**

**a) Substantially different from other IEEE 802 standards**

The proposed standard will produce a revision to the IEEE std. 802.22-2011

The fundamental assumption behind the operation of IEEE 802.22 systems is that spectrum is shared with primary users. Hence the shared spectrum may or may not be available at all times and at all the locations. The radio will have to automatically change its characteristics and behavior to operate in appropriate alternate spectrum as directed by the cognitive sharing mechanism (e. g. database, spectrum access system, sensing or beaconing). Hence 802.22 is highly applicable for use in bands that allow spectrum sharing such as the TV Broadcast bands and radar bands between 2700 MHz to 3700 MHz in the United States.

Some other similar projects are listed below -

1. IEEE Std. 802.11TM-2016 : IEEE Standard for Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications
2. IEEE Std. 802.15.4TM-2015: IEEE Standard for Local and Metropolitan Area Networks Part 15.4: Low Rate Wireless Personal Area Networks
3. IEEE P1900.7: Radio Interface for White Space Dynamic Spectrum Access Radio Systems Supporting Fixed and Mobile Operation

The IEEE Std. 802.11-2016 contains the IEEE 802.11af amendment on TV White Spaces Operation for 802.11 Systems. The IEEE Std. 802.15.4-2015 contains the IEEE 802.15.4m amendment on TV White Spaces Operation between 54 MHz and 862 Mhz.

Below is the summary of how the proposed Revision to the IEEE 802.22 Standard is likely to be substantially different from these on-going or completed projects:

1. No other IEEE standard supports all the three mechanisms of spectrum sharing namely, sensing, database access and beaconing. There is no other Cognitive Radio IEEE 802 standard or project, for combined broadband services and monitoring applications aimed at wireless regional area networks.
2. The IEEE 802.11 and IEEE 802.15.4 projects define Carrier Sense Multiple Access Collision Avoidance (CSMA-CA) MAC, whereas the IEEE 802.22 proposes Time Division Multiple Access (TDMA) MAC.
3. The IEEE 802.11 systems are generally designed for shorter ranges due to a smaller cyclic prefix, in-home and enterprise applications.
4. IEEE 802.15.4 defines PHY and MAC for low rate communications services (where throughputs range from 50 kb/s to 6.25 Mb/s) such as smart grid and machine to machine applications.
5. P1900.7 defines two PHYs, one using multi-carrier modulation and the other using Direct Sequence Spread Spectrum (DSSS). P1900.7 defines CSMA-CA MAC.
6. IEEE 802.22 and its amendments defne a PHY and a MAC that is designed for long distance regional area networks with typical ranges of 10 km up to 30 km as a result of Orthogonal Frequency Division Multiplexing (OFDM) and Orthogonal Frequency Division Multiple Access (OFDMA) with larger Fast Fourier Transform (FFT) sizes (1024 and 2048) and a larger Cyclic Prefix (CP). Such a CPs can absorb channel delay spreads of as much as 74 us. MAC features utilize TDMA to allow Downlink (DL) and Uplink (UL) designs which accomodate distances of up to 100 km. Cognitive radio capabilities such as sensing, beaconing and database access have been added to accommodate for dynamic spectrum sharing. Additional security sublayer has been added to protect cognitive functions. Spectrum management functions have also been added to manage channel allocations dynamically when the channel availability is not guaranteed e. g. in the TV Broadcast VHF and UHF Bands between 54 MHz to 862 MHz.
7. The new revision PAR proposes additional capabilities that will allow 802.22 systems to operate in bands that allow spectrum sharing between primary services and opportunistic communications devices (e. g. Incumbent Access, Priority Access and General Authorized Access in the 3.55 to 3.7 GHz in the United States). The revision PAR will modify the spectrum management framework to align 802.22 to be used in these other bands that may require slightly different operation – e. g. interfacing to a Spectrum Access System (SAS).
8. This revision may also introduce new clauses on how 802.22 systems can be used for other applications. For example, backhaul and broadcast services have now been recognized as critical components to serve rural and remote areas in developed and developing countries. These new clauses may describe the requirements, architecture and specifications for the use of 802.22 systems for such uses.

**1.2.4. Technical Feasibility**

Each proposed IEEE 802 LMSC standard shall provide evidence that the project is technically feasible within the time frame of the project. At a minimum, address the following items to demonstrate technical feasibility:

**a) Demonstrated system feasibility**

TVWS regulations are being formulated in various regulatory domains. Overall testing and certification programs for the WhiteSpace Devices are being defined. Experimental licenses for the WhiteSpace devices are being issued and trials, pilots and deployments of the WhiteSpace devices have begun.

Many companies and other entities are currently working on their IEEE 802.22 prototypes and products. Some announcements for 802.22 can be found in [9, 10, 12].

Research and regulatory inquiries are ongoing to explore the possibility of using newer bands that could potentially be allowed for spectrum sharing [1]. These other potential bands, and some of the new bands that have recently been announced, may require slightly different spectrum management framework. The proposed revision project plans to align 802.22 to be used in these other bands and hence corresponding changes are likely to be made accordingly.

**b) Proven similar technology via testing, modeling, simulation**,

The PHY and MAC technologies used in 802.22, such as OFDMA for PHY and TDMA for MAC, have been thoroughly tested and commercially deployed by other IEEE 802 standards. Cognitive radio technology features to fulfil the requirements to operate in TVWS bands are being tested for compliance with requirements of various regulatory organizations (e.g. FCC in the USA, Infocomm Development Authority (IDA) in Singapore, Ofcom in the UK, etc.).

IEEE 802.22 prototypes are being developed and field tested [8]-[9].

Testing programs for WhiteSpace devices and databases have been established by various regulatory domains such as the Federal Communications Commission. Industry consortia such as the WhiteSpace Alliance are working on 802.22 (Wi-FAR™) inter-operability, compliance, testing and certification procedures.

**1.2.5. Economic Feasibility**

Each proposed IEEE 802 LMSC standard shall provide evidence of economic feasibility. Demonstrate, as far as can reasonably be estimated, the economic feasibility of the proposed project for its intended applications. Among the areas that may be addressed in the cost for performance analysis are the following:

**a) Balanced Costs**

The IEEE 802.22 systems are designed for operation in rural areas where the population density is likely to be low. However, an IEEE 802.22 Base Station (BS) covers a large area typically with 30 km radius implying a reasonable cost per geographical unit of coverage. The Customer Premises Equipment (CPEs) are expected to be inexpensive and hence cost for overall network performance would be reasonable.

Also, since 802.22 systems will operate in bands that allow spectrum sharing, the cost of spectrum is expected to be fairly low, hence resulting in a reasonable cost for performance.

**b) Known cost factors**

IEEE 802.22 uses OFDMA for PHY and a TDMA based MAC. The cost factors to implement an OFDMA PHY and TDMA based MAC are well known today. The mandatory cognitive radio features such as access to database can be easily implemented in software. Other cost factors such as geolocation based on Global Positioning System (GPS) technology are well known.

**c) Consideration of installation costs**

Installation costs will be those of the updated base standard and are expected to be reasonable. The current IEEE 802.22 BS and CPE [9], are already being deployed in countries such as South Africa, USA and India using experimental license.

**d) Consideration of Operational Costs**

The IEEE 802.22 systems are designed for operation in rural areas where the population density is likely to be low. However, an IEEE 802.22 BS covers a large area typically with 30 km radius implying a reasonable cost per geographical unit of coverage. The CPEs are expected to be inexpensive and hence cost for overall network performance would be reasonable.

Also, since 802.22 systems will operate in bands that allow spectrum sharing, the cost of spectrum is expected to be fairly low, and hence resulting in a reasonable cost for performance.

**e) Other areas, as appropriate.**

None

***References***

[1] Tutorial titled – “Spectrum … Be Prepared for Sharing,” presented at the IEEE 802 Plenary Meeting, March 2019.

[2] United States, Office of Scientific and Technology Policy (OSTP), Year 1 Highlights - <https://www.whitehouse.gov/wp-content/uploads/2018/03/Science-and-Technology-Highlights-Report-from-the-1st-Year-of-the-Trump-Administration.pdf>

[3] FCC, “In the Matter of Promoting Investment in the 3550-3700 MHz Band”, GN Docket No. 17-258, October 2018, <https://docs.fcc.gov/public/attachments/DOC-354370A1.pdf>, accessed March 2019.

[4] FCC, “In the Matter of Expanding Flexible Use of the 3.7 to 4.2 GHz Band; Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz; Petition for Rulemaking to Amend and Modernize Parts 25 and 101 of the Commission’s Rules to Authorize and Facilitate the Deployment of Licensed Point-to-Multipoint Fixed Wireless Broadband Service in the 3.7-4.2 GHz Band Fixed Wireless Communications Coalition, Inc., Request for Modified Coordination Procedures in Band Shared Between the Fixed Service and the Fixed Satellite Service”, GN Docket No. 18-122, GN Docket No. 17-183 (Inquiry Terminated as to 3.7-4.2 GHz), RM-11791, RM-11778, July 2018, <https://docs.fcc.gov/public/attachments/FCC-18-91A1_Rcd.pdf>, accessed March 2019.

[5] FCC, “In the Matter of Unlicensed Use of the 6 GHz Band; Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz”, ET Docket No. 18-295, GN Docket No. 17-183, October 2018, <https://www.federalregister.gov/documents/2018/12/17/2018-26013/unlicensed-use-of-the-6-ghz-band>

[6] Ofcom, “Enabling Opportunities for Innovation”, Consultation, December 2018, <https://www.ofcom.org.uk/consultations-and-statements/category-1/enabling-opportunities-for-innovation>, accessed March 2019.

[7] FCC, “In the Matter of Amendment of Part 15 of the Commission’s Rules for Unlicensed White Space Devices; Amendment of Part 15 of the Commission’s Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37 Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions”, ET Docket No. 16-56, RM-11745, ET Docket No. 14-165, GN Docket No. 12-268, March 2019, <https://docs.fcc.gov/public/attachments/FCC-19-24A1.pdf>, accessed March 2019.

[8] Ofcom, “Implementing TV White Spaces”, statement, February 2015, <https://www.ofcom.org.uk/__data/assets/pdf_file/0034/68668/tvws-statement.pdf>, accessed March 2019.

[9] Saankhya Labs launches the 802.22 product, <https://saankhyalabs.com/rural-broadband/>, accessed March 2019.

[10] WhiteSpace Alliance, [www.WhiteSpaceAlliance.org](http://www.WhiteSpaceAlliance.org), accessed March 2019.

[11] Dynamic Spectrum Alliance, [www.dynamicspectrumalliance.org](http://www.dynamicspectrumalliance.org) – World-wide trials and deployments - <http://dynamicspectrumalliance.org/pilots/>, accessed March 2019.

[12] Kyoto University, Hitachi Kokusai imPACT project: <https://www.youtube.com/watch?v=San7GcN1l0w>

[13] Carlson Wireless Ruralconnect 802.11af radio, <https://www.carlsonwireless.com/ruralconnect>

[14] HuWoMobility, <http://www.huwomo.com>

[15] Westica TV white space radios, <https://www.westica.co.uk/products/ultralink-e-band>

[16] Adaptrum, <https://www.adaptrum.com>

[17] Tutorial on WhiteSpaces, <https://mentor.ieee.org/802.22/dcn/19/22-19-0013-00-0000-tutorial-on-whitespaces.pdf>, presented during the IEEE 802, March 2019 Plenary Meeting.