



Requirements for Commercial Operation in the U.S. 3550-3700 MHz Citizens Broadband Radio Service Band

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Requirements for Commercial Operation in the U.S. 3550-3700 MHz Citizens Broadband Radio Service Band

1 Scope

This document specifies the requirements for commercial operations in the 3550-3700 MHz band in the United States. The requirements are based on Federal Communications Commission (FCC) rules adopted in the 2015 (FCC 15-47 [1]) and 2016 (FCC 16-55 [7]) Orders in FCC docket GN 12-354, “Amendment of the Commission’s Rules with Regard to Commercial Operations in the 3550-3650 MHz Band”. The CBRS-specific rules themselves are codified in Part 96 of Title 47 the U.S. Code of Federal Regulations [2]. The FCC’s Part 96 rules will hereafter be referred to as “the FCC Rules,” “the Rules,” or “Part 96,” and reference to specific items in the rules will be given in the form of, for example, 96.15(a)(1) if from Part 96. If the reference is to a different rule part, the reference will be of the form 47 CFR 2.106, which refers to Title 47 of the Code of Federal Regulations, Part 2, section 106.

The document defines the requirements on the Spectrum Access System (SAS), Citizens Broadband Radio Service Device (CBSD), End User Device (EUD), Priority Access License (PAL), and General Authorized Access (GAA) equipment to specify the necessary operation and standards interface between such equipment to effect a properly functioning spectrum sharing environment in the 3550-3700 MHz band.

To assist the reader, we include below the SAS Functional Architecture with defined interfaces.

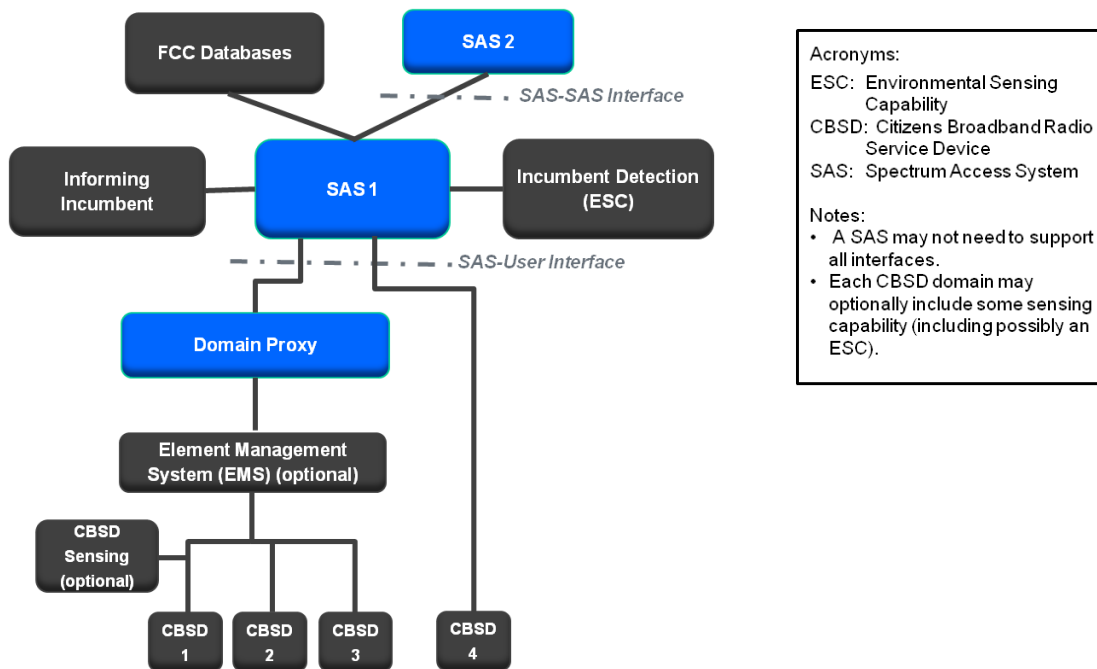


Figure 1: SAS Functional Architecture

2 Definitions and Abbreviations

The Wireless Innovation Forum Spectrum Sharing Committee (SSC) leverages the definitions provided by the FCC from their Title 47 Part 96 rules. These definitions and others are also available at reference [3].

2.1 Wireless Innovation Forum Definitions

This document uses these definitions:

AMSL: Above (or below) Mean Sea Level

CBRS-wide: Across the entire CBRS system including all CBRS entities (note: this is equivalent to system-wide).

CBSD-ID: The system-wide unique identifier for registered CBSDs.

CBSD Group Identifier (CGI): An identifier used to allow one or more registering CBSDs to identify as a group that the CBSD User for those CBSDs has established.

CBSD Registration: The process required to register a valid Citizens Broadband Radio Service Device (CBSD) with a SAS. This includes providing CBSD information, the User identity, the CBSD installation parameters (e.g., location parameters) and, if applicable, the CBSD antenna parameters, and, in case of successful registration, receiving a unique CBSD identifier.

CBSD User: The registered entity that has operational responsibility for the CBSD.

Certified Professional Installer Device Information (CPIDI): The body of information required to be entered by a CPI to register a valid CBSD with a SAS for installation and to allow for spectrum grant requests and transmission pursuant to Part 96 rules, industry standards, or SAS specific requests.

Certified Professional Installer Registration Identifier (CPIR-ID): The unique identifier provided by the CPI Accrediting Body through the CPI Training Program to CPIs who are validly and currently certified and registered as CPIs.

Certified Professional Installer Training Program: A required training curriculum contained in a valid program, as defined by the CPI Accrediting body, for certification of a CPI. Such curriculum may have mandatory (such as Part 96 and rules based requirements) and optional components (such as industry best practices or manufacturer or SAS specific training).

Cluster List: The set of CBSDs, identified by their CBSD-IDs, that define a PPA. The PAL Holder provides this Cluster List to the Managing SAS. These are the CBSDs that provide service and coverage within the claimed PPA.

Coexistence Group: A group of CBSDs that coordinate their own interference within the group according to a common interference management policy.

CPI: Certified Professional Installer: Any individual trained and currently validly certified from an accredited CPI Training Program based on the relevant Part 96 rules and associated technical best practices for the Citizens Broadband Radio Service (CBRS).

CPI Accreditation Standard: Standard defining how a CPI Training Program Administrator can be accredited to run a Certified Professional Installer (CPI) Training Program. The CPI Accreditation Standard includes a curriculum standard defining the requirements necessary for trainees to be certified as a Certified Professional Installer. The CPI Accreditation Standard includes a requirement for an objective certification test to be administered by a program administrator as part of the CPI Training Program. Passing this test is a prerequisite for an individual to be considered a Certified Professional Installer.

CPI Accrediting Body: Entity that accredits a CPI Training Program Administrator to offer a CPI Training Program based on the CPI Accreditation Standard. This entity must be independent from CPI Training Program Administrators.

CPI Training Program Administrator: Entity such as a network equipment operator, an equipment vendor, a SAS administrator or a 3rd party training organization that develops a Certified Professional Installer (CPI) Training Program, gains accreditation, administers the objective certification test and maintains certification records.

Domain Proxy: An entity engaging in communications with the SAS on behalf of multiple individual CBSDs or networks of CBSDs. The Domain Proxy can also provide a translational capability to interface legacy radio equipment in the 3650-3700 MHz band with a SAS to ensure compliance with Part 96 rules.

Dynamic Protection Area (DPA): A predefined protection area which is activated or deactivated to protect a federal incumbent radar. An activated DPA must be protected from aggregate CBSD interference. A deactivated DPA is not protected from CBSD interference.

HAAT: Height Above Average Terrain

Initial Certification: Initial Certification in this specification applies to Release 1; however, after Initial Certification, each SAS administrator could have an alternate method that, when approved by the FCC, would be allowed.

Largest Allowable PPA Contour Method: The FCC mandated contour calculation method that defines the largest allowable size of a PPA. This is based upon the Managing SAS calculated protection area of the CBSDs on the PPA's Cluster List, the CBSDs' largest allowable EIRPs, the CBSDs' antenna heights and antenna parameters, the RF propagation model, and a -96 dBm/10 MHz threshold.

Managing SAS: The SAS that administers a PAL and serves the CBSDs that form the Cluster List of a PPA registered to a PAL Holder that is authorized to use that PAL. This Managing SAS is the SAS which accepts, checks, and validates a PPA claim and which issues a PPA-ID for a valid PPA, and which shares the PPA-ID and the PPA vertex points with all SASs.

Subsequently, the Managing SAS serves the CBSDs on the PPA Cluster List. The Managing SAS also serves CBSDs using GAA grants and their CBSD Users.

Non-Public Registration Data: CBSD registration data that would allow one to identify a licensee and must [shall] therefore be obfuscated pursuant to FCC Requirement 96.55(a)(3).

PAL-ID: The system-wide unique identifier for a PAL.

PAL Database: The system-wide accessible database that allows the look-up of a PAL boundary and PAL ownership based upon the PAL-ID.

PAL Holder: The registered entity who has legal rights to make PPA claims under the registered PAL.

PPA-ID: The system-wide unique identifier for a PPA.

PPA Database: The system-wide accessible database that allows the look-up of a PPA boundary and associated PAL information based upon the PPA-ID.

Public Registration Data: Data that SAS Administrators must share with the public according to FCC requirement 96.55(a)(3).

SAS Essential Data: SAS-Essential Data are defined as data shared between any two SASs which are required to fulfill all SAS functions required by 47 C.F.R Part 96

SMLA: Secondary Market Leasing Agreement. The leasing terms by which PAL rights are conveyed from a PAL licensee to an eligible lessee.

UR-ID: User Registration ID. The system-wide unique identifier for Registered Users of the CBRS; these may be CBSD Users or PAL Holders.

2.2 Abbreviations

3GPP	3rd Generation Partnership Project
CBSD	Citizens Broadband radio Service Device
CGI	CBSD Group Identifier
DoD	U.S. Department of Defense
ESC	Environmental Sensing Capability
EUD	End User Device
FCC	Federal Communications Commission
FFS	For Further Study
FSS	Fixed-Satellite Service
GAA	General Authorized Access
IAP	Iterative Allocation Process

IMG	Interference Margin Group
JSIR	Joint Spectrum Interference Resolution
NTIA	National Telecommunications and Information Administration
OpenSSRF	Open source Standard Spectrum Resource Format
UR-ID	User Registration ID
PA	Priority Access
PAL	Priority Access License
PPA	PAL Protection Area
SAS	Spectrum Access System
SMLA	Secondary Market Leasing Agreement
WBS	Wireless Broadband Service (FCC Rules Part 90, Subpart Z)

3 Requirement Organization

Requirements shall be uniquely identified by: R#-<CATEGORY>-<XX>-<Y>. Where

- R0-: Requirements directly from FCC Rules
- R1-: Requirements derived from FCC Rules
- R2-: Requirements imposed by WINN Forum

- <CATEGORY>

Code	Category
SGN	SAS General
IPM	Incumbent Protection Management
IMZ	SAS Interference Management and Exclusion Zones
SAD	SAS Administration
SPU	SAS Requirements for PAL Users
SGU	SAS Requirements for GAA Users
ISC	Inter-SAS Communication
PAL	Priority Access Licensee and PAL Protection Requirements (Leasing, Transfer of Control, etc.)
DEV	CBSD and EUD Requirements
DPX	Domain Proxy
SRR	System Registration Requirements (includes CBSD User, CBSD & Certified Professional Installer Registration)
ESC	Environmental Sensing Capability
CPI	Certified Professional Installer

- <XX>: Unique number to identify the requirement

- <Y>: Optional and used to identify subordinate requirements, typically captured in an alphabetical list following the main requirement number <XX> (e.g., R0-IPM-01-a).

Requirements taken from the FCC Rules are included as “R0” and we attempted to use the FCC Rules without change. In some instances, the FCC uses “must” or “will” for rules, which we have included below as a requirement; however, we insert [shall] to indicate we consider this as a formal requirement.

The following terms are used within this document and should be interpreted as described in RFC-2119 [Ref-9]:

- SHALL is a mandatory requirement (negative is SHALL NOT)
- SHOULD is recommended requirement /best practice (negative is SHOULD NOT)
- MAY is an optional requirement, i.e. something that is allowed (negative is NEED NOT)

4 SAS Requirements

4.1 SAS General Requirements (SGN)

R0-SGN-01: DEPRECATED

R0-SGN-02: DEPRECATED (converted to R1-SGN requirement)

R0-SGN-03: The SAS assigns channels for PALs to use. [Ref-2, 96.11, 96.13, 96.25 & 96.59]

- a. The SAS shall authorize 10 MHz channels in the 3550-3650 MHz frequency band to PAL Holders following a spectrum request. Note: 10 MHz channels shall be contiguous spectrum unless the PAL licensee agrees to subdivide the spectrum [Ref-1, para 74]
- b. The SAS shall not assign more than seven PALs in any given License Area at any given time.
- c. The SAS must [shall] assign multiple channels held by the same Priority Access Licensee to contiguous channels in the same License Area, to the extent feasible, and to the extent indicated by the PAL holder and consistent with the other requirements of the SAS.
- d. The SAS may temporarily reassign individual PALs to non-contiguous channels to the extent necessary to protect Incumbent Users or if necessary to perform its required functions under subpart F of Part 96 [2].
- e. Priority Access Licensees may request a particular channel or frequency range from the SAS but will not be guaranteed a particular assignment.

R0-SGN-04: GAA users may operate in the 3550-3700 MHz frequency band. [96.11(a)(1)]

PAL channels [in the 3550-3650 MHz frequency band] shall be made available for assignment by the SAS for General Authorized Access use only in areas consistent with 96.25 and 96.41(d). [96.11(a)(2)]

- a. A CBSD will [shall] be considered to be in use for purposes of calculating a PAL Protection Area once it is registered and authorized for use on a Priority Access basis by a SAS consistent with 96.39, 96.53, and 96.57.
 - i. Priority Access Licensees must [shall] inform the SAS if a previously activated CBSD is no longer in use.
 - ii. Any CBSD that does not make contact with the SAS for seven days shall not be considered in use and will be excluded from the calculation of the PAL Protection Area until such time as contact with the SAS is re-established.
- b. The default PPA protection contour will [shall] be determined by the SAS as a -96 dBm/10 MHz contour around each CBSD. The default protection contour will be calculated based on information included in the CBSD Registration and shall be determined and enforced consistently across all SASs.
 - i. The default protection contour is the outer limit of the PAL Protection Area for any CBSD but a Priority Access Licensee may choose to self-report protection contours smaller than the default protection contour to the SAS.
 - ii. If the PAL Protection Areas for multiple CBSDs operated by the same Priority Access Licensees overlap, the SAS shall combine the PAL Protection Areas for such CBSDs into a single protection area.
- c. The PAL Protection Area may [shall] not extend beyond the boundaries of the Priority Access Licensee's Service Area.

R0-SGN-05: SAS interface security [Ref-2, 96.61 & 96.39]

- a. An SAS must [shall] employ protocols and procedures to ensure that all communications and interactions between the SAS and CBSDs are accurate and secure and that unauthorized parties cannot access or alter the SAS or the information it sends to a CBSD.
- b. Communications between CBSDs and an SAS, between an ESC and a SAS, between individual CBSDs, and between different SASs, must [shall] be secure to prevent corruption or unauthorized interception of data. An SAS must be protected from unauthorized data input or alteration of stored data.
- c. An SAS must [shall] verify that the FCC identification number supplied by a CBSD is for a certified device and must not provide service to an uncertified device.

R0-SGN-06: The purposes and functionality of the SAS include [Ref-2, 96.53]:

- a. To enact and enforce all policies and procedures developed by the SAS Administrator pursuant to section 96.63.
- b. To determine and provide to CBSDs the permissible channels or frequencies at their location.
- c. To determine and provide to CBSDs the maximum permissible transmission power level at their location.

- d. To register and authenticate the identification information and location of CBSDs.
- e. To retain information on, and enforce, Exclusion Zones and Protection Zones in accordance with sections 96.15 and 96.17.
- f. To communicate with the ESC to obtain information about federal Incumbent User transmissions and instruct CBSDs to move to another frequency range or cease transmissions.
- g. To ensure that CBSDs operate in geographic areas and within the maximum power levels required to protect federal Incumbent Users from harmful interference, consistent with the requirements of sections 96.15 and 96.21.
- h. To ensure that CBSDs protect non-federal Incumbent Users from harmful interference, consistent with the requirements of section 96.17 and 96.21 [Reference R0-SGU-01:(b)].
- i. To protect Priority Access Licensees from interference caused by other PAL Users and from General Authorized Access Users, including the calculation and enforcement of protection areas, consistent with section 96.25 [Reference R0-SGU-01:(b)].
- j. To facilitate coordination between GAA users operating Category B CBSDs, consistent with section 96.35.
- k. To resolve conflicting uses of the band while maintaining, as much as possible, a stable radio frequency environment.
- l. To ensure secure and reliable transmission of information between the SAS and CBSDs.
- m. To protect Grandfathered Wireless Broadband Licensees consistent with section 90.1307, 90.1338, and 96.21. [Ref-13]
- n. To implement the terms of current and future international agreements as they relate to the Citizens Broadband Radio Service.
- o. To receive reports of interference and requests for additional protection from Incumbent Access users and promptly address interference issues.

R0-SGN-07: The SAS shall maintain current information on registered CBSDs, the geographic locations and configuration of protected FSS locations as set forth in section 96.17, and the federal Incumbent User Exclusion Zones and Protection Zones. [Ref-2, 96.55]

- a. For registered CBSDs, such information shall include all information required by section 96.39 and 96.45.
- b. SAS Administrators must [shall] make all information necessary to effectively coordinate operations between and among CBSDs available to other SAS Administrators.
- c. SAS Administrators must [shall] make CBSD registration information available to the general public, but they must [shall] obfuscate the identities of the licensees providing the information for any public disclosures.

- d. For non-federal Incumbent Users, the SAS shall maintain a record of the location of protected earth stations as well as [all the] registration information required by section 96.17.

R0-SGN-08: The SAS shall maintain records not pertaining to federal Incumbent User transmissions for at least 60 months. [Ref-2, 96.55]

R0-SGN-09: The SAS shall only retain records of information or instructions received regarding federal Incumbent User transmissions from the ESC in accordance with information retention policies established as part of the ESC approval process. [Ref-2, 96.55]

R0-SGN-10: The SAS shall be technically capable of directly interfacing with any necessary FCC database containing information required for the proper operation of an SAS. [Ref-2, 96.55]

R0-SGN-11: The SAS shall process and retain acknowledgements by all entities registering CBSDs that they understand the risk of possible interference from federal Incumbent User radar operations in the band. [Ref-2, 96.55]

R0-SGN-12: SAS Registration, Authentication and Authorization of CBRS Devices [Ref-2, 96.57]

- a. An SAS must [shall] register, authenticate, and authorize operations of CBSDs consistent with this rule part.
- b. CBSDs composed of a network of base and fixed stations may employ a subsystem for aggregating and communicating all required information exchanges between the SAS and CBSDs. [Note: Related to Domain Proxy Requirements & R2-SRR-13 & 14].
- c. An SAS must [shall] also verify that the FCC identifier (FCC ID) of any CBSD seeking access to its services is valid prior to authorizing it to begin providing service. A list of devices with valid FCC IDs and the FCC IDs of those devices is to be obtained from the Commission's Equipment Authorization System. [Note: Related to R0-SRR-01 & -02]
- d. An SAS must [shall] not authorize operation of CBSDs within Protection Zones except as set forth in section 96.15.
- e. An SAS must [shall] calculate and enforce PAL Protection Areas consistent with section 96.25 and such calculation and enforcement shall be consistent across all SASs.

R0-SGN-13: SAS Assignment of Frequencies [Ref-2, 96.13c, 96.59]

- a. An SAS must [shall] determine the available and appropriate channels/frequencies for CBSDs at any given location using the information supplied by CBSDs, including location, the authorization status and operating parameters of other CBSDs in the surrounding area, information communicated by the ESC, other SASs, and such other information necessary to ensure effective operations of CBSDs consistent

with this part. All such determinations and assignments shall be made in a non-discriminatory manner, consistent with this part.

- i. Upon request from the Commission or a CBSD, an SAS must [shall] confirm whether frequencies are available in a given geographic area.
- ii. Upon request from the Commission, an SAS must [shall] confirm that CBSDs in a given geographic area and frequency band have been shut down or moved to another available frequency range in response to information received from the ESC.
- iii. If an SAS provides a range of available frequencies or channels to a CBSD, it may require that CBSD to confirm which channel or range of frequencies it will utilize.
- b. Consistent with the requirements of 96.25, an SAS shall assign geographically contiguous PALs held by the same Priority Access Licensee to the same channels in each geographic area, where feasible. The SAS shall also assign multiple channels held by the same Priority Access Licensee to contiguous frequencies within the same License Area, where feasible.
- c. An SAS may temporarily assign PALs to different channels (within the frequency range authorized for Priority Access use) to protect Incumbent Access Users or if necessary to perform its required functions.

R0-SGN-14: We [the Commission] require[s] that the SAS and the ESC must [shall] not have any connectivity to any military or other sensitive federal database or system. Nor shall they store, retain, transmit, or disclose operational information on the movement or position of any federal systems. The SAS shall only retain records of information or instructions received from the ESC in accordance with information retention policies established as part of the ESC approval process. These policies will [shall] include appropriate safeguards for classified and other sensitive data and will be developed by the Commission in coordination with NTIA and DoD. [Ref-2, 96.63n & para 330]

R1-SGN-01: The SAS must [shall] not collect, track, or store information on End User Devices or their users without user consent. [Ref-1, para 333]

R1-SGN-02: The SAS shall set CBSD initial transmission authorization time and extend each reauthorization request according to Part 96.15(a)(4) and 96.15(b)(4). The signal sent by a SAS to deny reauthorization shall enable the SAS to direct CBSDs to cease transmission associated with that authorization as soon as technically possible.

R2-SGN-01: A SAS may request measurement reports from a CBSD, and the measurement report requested by a SAS shall be consistent with the CBSD measurement capabilities reported during the registration process.

R2-SGN-02: Any grants issued to a CBSD, for which the CBSD has not made contact with the SAS for seven days, shall be considered by the SAS to have been relinquished. (Related to R0-SGN-04).

R2-SGN-03: For Initial Certification, SAS shall use the NTIA ITS Irregular Terrain Model (ITM)¹, in point-to-point mode, for propagation determination for use in FSS earth station, DPA protection, and ESC sensor protection. Consideration of propagation models, including hybrid or application-specific models, may advance beyond this initial model, subject to FCC approval. If the CBSD is indoors, add 15 dB to the computed loss to account for attenuation due to building loss.

Note: The reference implementation is maintained in the WinnForum code repository.²

R2-SGN-04: Propagation Model Requirements for the use in PPA and GWPZ Calculation

- a. For Initial Certification, SAS shall use the propagation models described in this Requirement (which is based on the NTIA Technical Report TR-15-517 3.5 GHz Exclusion Zone Analyses and Methodology³) for propagation loss determination for use in PAL Protection Area (PPA) (both -96 dBm coverage and -80 dBm PPA protection calculations), Grandfathered Wireless Protection Zone (GWPZ) calculations, and protection of all systems outside of 3550-3700 MHz.⁴
- b. After Initial Certification, the SAS may use other propagation models, subject to approval by the FCC.
- c. For PPA contour calculation, SAS shall use the region type, r , corresponding to the location of the CBSD. For PPA and GWPZ protection calculations, SAS shall determine the region type (urban, suburban, or rural) by a method that effectively averages the National Land Cover Database (NLCD) land category within the protection area (PPA or GWPZ). Each NLCD 1 arc second pixel shall be sampled within the protection area, and assigned a value for averaging as designated in the table below. The values for all pixels within the protection area are averaged together, and the resulting average determines the appropriate region to use in all propagation calculations involving the protection or extent of that region, as designated in the table below.

¹ NTIA – ITS Irregular Terrain Model (ITM) (Longley-Rice) (20MHz-20 GHz):

<http://www.its.bldrdoc.gov/resources/radio-propagation-software/itm/itm.aspx>

² <https://github.com/Wireless-Innovation-Forum/Spectrum-Access-System>

³ NTIA Technical Report TR-15-517 3.5 GHz Exclusion Zone Analysis and Methodology:

<http://www.its.bldrdoc.gov/publications/2805.aspx>

⁴ The reference implementation of all the required propagation models is maintained in the WinnForum code repository:

<https://github.com/Wireless-Innovation-Forum/Spectrum-Access-System>

NLCD Land Cover Class	Region r	Value Assigned for Averaging	Use this Region Type if Protection-Area-Wide Average Value is in the Range:
23 or 24	Urban	2	$> 1 \frac{1}{3}$
22	Suburban	1	$[2/3, 1 \frac{1}{3}]$
All others	Rural	0	$< 2/3$

d. Propagation loss shall be calculated based on the following table:

Distance d [km]	Formulas
$d \leq 0.1$	$\text{Loss} = L_{fs}(f, d) = 20 \log_{10}(R) + 20 \log_{10} f_{\text{MHz}} - 27.56,$ where $R = \sqrt{(1000d)^2 + (h_{\text{cbstd}} - h_m)^2}$
$0.1 < d < 1.0$	$\text{Loss} = L_{fs}(f, 0.1) + [1 + \log_{10}(d)] \cdot [L_{\text{EHB}}(f, h_{\text{cbstd}}, h_m, r, d = 1 \text{ km}) - L_{fs}(f, 0.1)]$
$1.0 \leq d \leq 80.0$	$\text{Loss} = \begin{cases} L_{\text{ITM}} & \text{if } L_{\text{ITM}}^{\text{MED}} \geq L_{\text{EH}} \\ L_{\text{EH}} & \text{otherwise} \end{cases}$
$80.0 < d$	$\text{Loss} = L_{\text{ITM}}(f, h_{\text{cbstd}}, h_m, p(d)) + J,$ where $J = \max[L_{\text{EH}}(f, h_{\text{cbstd}}, h_m, r, p(d_{80})) - L_{\text{ITM}}^{\text{MED}}(f, h_{\text{cbstd}}, h_m, p(d_{80})), 0]$
ANY	$\text{Loss} = L_{\text{ITM}} \text{ if } h_b \geq 200 \text{ m or } r = \text{"Rural"}$

Note: The nomenclature used in the formulas:

- L_{ITM} : ITM point-to-point loss (in dB) using desired values of reliability and confidence factors.
- $L_{\text{ITM}}^{\text{MED}}$: Median ITM point-to-point loss (in dB) using reliability and confidence factors of 0.5.
- L_{EH} : The loss (in dB) computed using the extended Hata model as defined in TR 15-517, with all site-specific corrections (effective height, rolling hilly terrain, etc.) applied. Note, however, the effective height corrections are not applied on the receive side of the link.
- L_{EHB} : The loss (in dB) computed using the site general extended Hata model (i.e., without any site-specific correction factors applied).

- h_{cbds} : The structure height of the CBSD antenna (i.e., the height above ground of the center line of the antenna), in meters. h_{cbds} shall not be less than 20 m regardless of the actual structure height of the CBSD antenna.
- h_b : The effective height of the CBSD antenna, in meters, as defined here:

For path lengths less than 3 km, h_b is the structure height of the CBSD antenna (i.e., $h_b = h_{cbds}$).

For path lengths greater than or equal to 3 km but less than or equal to 15 km, h_b is the structure height, h_{cbds} , plus $(d-3)/12$ times the difference between the terrain elevation at the CBSD antenna and the average terrain elevation over a distance of 3 km to the location of the receiver.

For path lengths greater than 15 km, h_b is the structure height, h_{cbds} , plus the difference between the terrain elevation at the CBSD and the average terrain elevation over the range 3 – 15 km.

h_b shall not be less than 20 m regardless of the calculated effective height of the CBSD antenna.

- h_m : The receiver height, in meters. SAS shall use the structure height as defined in TR 15-517. Effective height is not used for this side of the link. For PPA and GWPZ calculations, h_m shall be 1.5 [m].
- r : Refers to “urban,” “suburban,” or “rural,” as derived from the NLCD land cover database and used by the extended Hata model.
- $p(d_{point})$: Terrain elevation profile from the transmitter to the d_{point} km point along the great circle path. When d_{point} is d , $p(d)$ is full terrain elevation profile from the transmitter to the receiver.
- f : Frequency of the signal. For all purposes, f shall be fixed at a value of 3625 MHz.

e. If the CBSD is indoors, add 15 dB to the computed loss to account for attenuation due to building loss.

R2-SGN-05: Terrain and land cover data

- For Initial Certification, the SAS shall use terrain data⁵ and land cover⁶ classification data only. The terrain and land cover data shall have an intrinsic angular resolution of 1 arc second, i.e., intrinsic spatial resolution of approximately 30 meters for propagation calculations.

⁵ https://nationalmap.gov/3dep_prodserv.html (1 arc second 3DEP Seamless DEM)

⁶ <http://www.mrlc.gov/nlcd2011.php>

- b. After Initial Certification, the SAS may use terrain and land cover data that advance beyond these requirements (e.g., including buildings, etc.) subject to FCC approval.

R2-SGN-06: For Initial Certification, the SAS shall assume that data for propagation calculations specified relative to the NAD83 and WGS84 datum⁷ are equivalent, and perform no translation between these two reference systems.

R2-SGN-07: Given transmitter and receiver locations, for Initial Certification, the SAS propagation calculations shall employ Vincenty's Inverse Solution [Vincenty⁸, sections 3 and 4] to compute the great circle distance and the azimuth from the transmitter to the receiver. The procedure uses Equation 13, the iterations over Equations 14-17, 18, 10 and 11, and subsequently Equations 3, 4, 6, 19 and 20 of Vincenty.

R2-SGN-08: For Initial Certification, the SAS shall choose a great circle path spacing that is as close to 30 m as possible without exceeding 30 m for R2-SGN-07 calculated distances up to 45 km for the propagation and path loss calculations. Beyond 45 km, SAS shall use 1500 equally spaced points along the great circle path for path loss calculations.

R2-SGN-09: Given the transmitter and receiver locations, great circle path distance and transmitter-receiver azimuth (R2-SGN-07), and desired spacing of points along the great circle path (R2-SGN-08), for Initial Certification, the SAS shall employ Vincenty's Forward Solution [Vincenty⁹, section 3] to determine the latitude and longitude of the points along the great circle path from the transmitter to the receiver for propagation calculations. The procedure uses Equations 1-4, the iterations over Equations 5-7, and subsequently Equations 8-11 of Vincenty.

R2-SGN-10: Given the equally spaced points with latitude and longitude calculated in R2-SGN-09, SAS shall use bilinear interpolation using the elevation at the four nearest locations in the 1 arc second 3DEP seamless DEM database to yield an estimate of the elevation at the latitude/longitude of each equally spaced point.

R2-SGN-11: DEPRECATED

R2-SGN-12: Aggregate Interference Calculations

- a. For Initial Certification, the aggregate interference calculations done by the SAS shall employ a method that results in no smaller aggregate interference than that calculated by a Monte Carlo method using 1000 sampling iterations. Each iteration uses interference realizations from a specified set of interfering CBSDs, determined by drawing a random

⁷ <https://vdatum.noaa.gov/docs/datums.html>

⁸ Vincenty, T., Direct and Inverse Solutions of Geodesics on the Ellipsoid with application of nested equations, Survey Review, XXIII (misprinted as XXII) (176): 88-93.

⁹ Ibid

contribution from the Cumulative Distribution Function (CDF) of the interference caused by that CBSD.

- b. For the ITM model, the CDF to be used for interference realizations shall be that given by fixing the confidence parameter at 0.5 and varying the reliability parameter. Note: this value can be calculated relative to a median value for a specific path by using the ‘avar’ method in the reference implementation.
- c. For the eHata model, the CDF to be used for interference realizations shall be that given by the situation-dependent log-normal distribution using a standard deviation given by equations A-18(a,b,c) in [TR 15-517 ref].
- d. For the model defined in R2-SGN-04, the CDF to be used shall be that for the ITM or eHata model as selected by the criteria for the specific path.
- e. A given percentile estimate of the aggregate interference for all nearby interfering CBSDs shall then be computed by taking that specified percentile value of the resulting Monte Carlo probability distribution.
- f. The description of an Area-Protection-Reference-Standard is as follows:
 - i Define a fixed grid spanning candidate CBSD locations and to be used by all SASs. The grid has points separated by 2 arc seconds in north/south and east/west directions. The grid is aligned to integer latitude and longitude lines.
 - ii Let a protection area be defined by a set of bounding contours. Protection points of a protection area are grid points of the fixed grid within the protection area. Protection to this area provided by a SAS aims to ensure that estimated aggregate interference exceeds that of [R2-SGN-12] at each protection point. The aggregate interference calculations shall be performed assuming the use of an isotropic antenna integrating over a 10 MHz bandwidth and using a specified elevation above ground level.
 - iii A conservative SAS estimate of aggregate interference from interfering CBSDs is expected to be less than or equal to a specified protection level for all protection points in the protection area. Due to variability in approximation methods and artifacts of terrain, propagation, and statistical models, to fulfill the protection standard the SAS must show that it succeeds for the specified minimum fraction (per the corresponding requirements that refer to this requirement) of the protection points in the protection area.

R2-SGN-13: DEPRECATED

R1-SGN-03: The SAS shall coordinate the operation of all Citizens Broadband Radio Service Devices (CBSDs) in the frequency band 3550 – 3700 MHz. [Ref: 96.11]

R2-SGN-14: DEPRECATED

R2-SGN-15: SAS-SAS ESC Sensor Information sharing: If an ESC operator requests protection of an ESC sensor, a SAS shall share with other SASs the location, height, antenna pattern, and alternate protection level (if any) of the protected ESC sensor antenna(s). [Reference R2-ESC-07]

R2-SGN-16: Margin Allocation

- a. If CBSDs are deployed in the neighborhood of protected entities as defined in Table 1 and require power limitations on them in order to meet aggregate protection thresholds, the SAS shall assign maximum power for CBSD transmissions so as to satisfy the following constraints:
 - i No aggregate interference protection level of an affected incumbent, PPA, or ESC sensor shall be violated by any grant made by any SAS.
 - ii The SAS shall ensure that grants to CBSDs located within the neighborhood of a corresponding protected entity (incumbent, PPA or ESC sensor, as described in Table 1), will be at or lower than the aggregate interference threshold for each protected entity.

Note: For protected entities that are defined to have an area of protection, the aggregate interference threshold is applied to each of the protection points within the area of protection according to R2-SGN-12. The distance indicated in Table 1 is to a particular location in the protected area. For protected entities that are defined by a single point, the distance indicated is to the protected antenna.

Table 1. Criteria for consideration of protection points for a given CBSD.

Protected Entity Type: Incumbent/PAL/ESC Sensor	Maximum distance for consideration from a CBSD to a given protection point within the neighborhood of a protected entity	Type of CBSD/Grant for consideration
Grandfathered Wireless Protection Zone	40 km	GAA only
PAL Protection Area	40 km	GAA and PAL
ESC Sensor	40 km for Category A CBSDs; 80 km for Category B CBSDs	GAA and PAL [1]
Inland co-channel federal incumbent site [See 96.15(b)(2)]	80 km	GAA and PAL

In-band FSS site [as pass-band interferer – 96.17(a.2)]	150 km	GAA and PAL
In-band FSS site [as a blocker 96.17 (a.3)]	40 km	GAA and PAL
Out-of-band FSS site [as pass-band interferer – 96.17 (b.1)]	40 km	GAA and PAL
Out-of-band FSS site [as a blocker – 96.17 (b.2)]	40 km	GAA and PAL

[1] Channels that are considered as protection constraints for ESC protection need to take into consideration [R2-ESC-07].

- iii Each protection constraint, $\langle p, ch \rangle$, is associated with a protected frequency (ch) and a protection point (p) within the neighborhood of a protected entity according to Table 1. For each protection constraint $\langle p, ch \rangle$, there is a number, $N_{p,ch}$, corresponding to the total number of CBSDs having or requesting a qualifying grant within the neighborhood of that protection point, p , associated with the frequency range, ch , that is required to be protected for the given protected entity.
- b. The SAS shall make maximum power assignments to all CBSDs with qualifying grants as follows:
 - i Each SAS shall allocate an EIRP limit to a CBSD (unless otherwise limited by the CBSD's radio capabilities or requested EIRP) such that the mean of the interference contribution of the CBSD for every qualifying protected point for every protected entity is allowed by the SAS to be at least $(1/N_{p,ch})$ of the allowable interference protection level for the given CBSD's most constraining applicable protected point. Specifically, the EIRP limit shall be assigned by the SAS such that the interference contribution is no less than $\min_p(Q_{p,ch}/N_{p,ch})$, where $Q_{p,ch}$ is the total allowable interference protection level for protected point p and frequency range ch , reduced by sum of all the modest remainders of interference margin that SAS Administrators agree to reserve.
 - ii When allowing CBSD grants to exceed these $1/N_{p,ch}$ limits, the SAS shall use an allocation procedure for all CBSDs it manages producing substantially similar results to the Iterative Allocation Process (IAP) defined below. Substantially similar is defined to mean that the resulting allocations are within a reasonable tolerance of results of the IAP, with that tolerance limit to be determined as part of the test and certification specifications.

- iii SASs may collaborate to modify the IAP to provide for a modest remainder of interference margin to enable ease of operations during CBSD deployment, and to create a coordinated schedule for execution of the IAP. The limits on how large this modest remainder of interference margin may be for each SAS, how it will be consistently applied by all SASs, and how the associated testing and certification process will be defined by a SAS administrator's operational agreement. Any further revisions to, or use by the SAS of allocation methods different from, the IAP, including grouping of protection points to improve processing efficiently, are FFS and shall be made consistently by SASs and publicly disclosed.
- iv Subject to agreements (beyond the scope of this specification) between the SAS Administrator and the CBSD Users comprising an Interference Margin Group (IMG), SASs may allow CBSD grants to exceed individual interference margin allowances when all of the following conditions are satisfied:
 - a. Associated CBSD grants were assigned as a result of application of the IAP.
 - b. The aggregate interference contribution from all of the CBSDs that share any given IMG shall be no greater than the total allowable interference assigned to the given IMG as a result of application of the IAP.
- v SASs shall share sufficient information to determine the numbers and qualification criteria of CBSDs registered with all SASs so as to allow other SASs to perform the IAP consistently.
- vi SASs shall share the grant requested information of CBSDs so as to allow other SASs to perform the IAP consistently.
- vii SASs shall share sufficient information to identify the membership of IMGs so as to allow other SASs to perform the IAP consistently.
- viii The IAP is applied for every CBSD and over every qualifying protection point p (according to Table 1) and for every applicable frequency range ch . $Q_{p,ch}$ for a co-channel requirement is normalized by the portion of the channel that overlaps the frequency range used by the corresponding protected entity.

The IAP is applied to all existing and pending grants.

The IAP consists of the following steps:

1. For each CBSD grant that remains unsatisfied:
 - i $I_{cbds,p,ch}$ is the estimated mean of the aggregate interference contribution of that CBSD grant request

- to the quota for each protection point p and frequency range ch , either based upon the EIRP level that the CBSD requested or reduced after adjustment in Step 4.
- ii For all such protection points p and the frequency ranges ch for the CBSD grant:
 - If $I_{cbds,p,ch} < Q_{p,ch}/N_{p,ch}$ corresponding to the CBSD grant and for all relevant protection points p and frequency ranges ch , then the grant is satisfied.
 2. Satisfied CBSD grants are removed from consideration in future steps, and the interference quota reduced by the sum of $I_{cbds,p,ch}$ for all satisfied CBSD grants, and $Q_{p,ch}$ and $N_{p,ch}$ will be reduced appropriately for all relevant protection points p .
 3. Repeat steps 1 and 2 until no more CBSD grants can be satisfied.
 4. If any CBSD grants remain unsatisfied, then for each such CBSD grant, decrease the maximum EIRP level that it will be allocated by 1 dB each and repeat steps 1, 2 and 3 until all grants are satisfied.

Note: For Initial Certification, choices of specific frequency range assignment for use in testing of the IAP are left FFS.

R2-SGN-17: Use of the ITM Model:

- a. The following inputs shall be used for path loss predictions when using the ITM implementation of the Longley-Rice propagation model:
 - i Polarization = 1 (vertical)
 - ii Dielectric constant = 25 (good ground)
 - iii Conductivity = 0.02 S/m (good ground)
 - iv Confidence = 0.5
 - v Mode of Variability (MDVAR) = 13 (broadcast point-to-point)
- b. For path loss calculations that are not for the purpose of aggregate interference calculations, the reliability factor shall be set to 0.5. For aggregate interference calculations, the statistical methods of R2-SGN-12 shall be followed.
- c. The surface refractivity value varies by location and shall be derived by the methods and associated data files in ITU-R Recommendation P.452¹⁰.

¹⁰ Specifically, the data file N050.txt shall be used, in the manner prescribed in Section 2 of Attachment 1 of Annex 1 of ITU-R Recommendation P.452-16, available at <https://www.itu.int/rec/R-REC-P.452-16-201507-I/en>.

The refractivity values shall be evaluated at the mid-point of the great circle path between transmitter and receiver.

- d. The climate value varies by location and shall be derived by the methods and associated data files in ITU-R Recommendation P.617¹¹.

Note: Although polarization, dielectric constant, and conductivity vary by application and location, predicted losses with the ITM propagation model do not have a strong dependency on these values.

R1-SGN-04: Unless directed otherwise by the FCC, SASs shall authorize CBSD activity only within the boundary defined by international borders and the United States coastline (the mean low water line – see 47 CFR 96.3, definition of Coastline). The NOAA National Shoreline MLLW tidal datum is the reference for this coastline. The NOAA National Shoreline MHW tidal datum may be used where MLLW data is incomplete. For inland waterways or where both are unavailable, the SAS may use the NLCD Open Water classification as delineating areas outside the coastline.

R2-SGN-18: Unless directed otherwise by the FCC, SASs shall authorize no CBSD activity within the borders of quiet zones without the appropriate coordination. (Ref-4: 47 CFR 1.924)

R1-SGN-05: Unless directed otherwise by the FCC, SASs shall consider the United States border with Canada and Mexico to be defined by geographical information available at the URLs:

- a. <https://transition.fcc.gov/oet/info/maps/uscabdry/uscabdry.zip>
- b. http://www.ibwc.gov/GIS_Maps/downloads/us_mex_boundary.zip

R1-SGN-06: The SAS shall support registration of CBSDs prior to CBSD initial service transmission. [Ref-2, 96.39]

R2-SGN-19: Unless directed otherwise by the FCC, or informed of alternative international protection arrangements, the SAS shall make no authorizations near the United States borders defined by R1-SGN-05 as follows (Ref-4: 47 CFR 90.1337):

- a. No Category B CBSD operation within 8 km of the borders if its antenna looks only within the 160-degree sector oriented away from the closest point on the border.
- b. No Category B CBSD operation within 56 km of the borders if its antenna looks within the 200-degree sector oriented towards the closest point on the border.
- c. No outdoor Category A operation within 8 km of the closest point on the border.

R2-SGN-20: CBSD Antenna Gain used in Aggregate Interference Calculations: For Initial Certification, SAS shall apply the following procedure to estimate the CBSD

¹¹ Specifically, the data file TropoClim.txt shall be used, in the manner prescribed in Section 2 of Annex 1 of ITU-R Recommendation P.617-3, available at <https://www.itu.int/rec/R-REC-P.617-3-201309-I/en>.

antenna gain in the direction toward a receiver in aggregate interference calculations.

If the antenna beamwidth and pattern are not available, the SAS shall assume that the maximum gain, as reported during registration, is directed towards the receiver. Otherwise, the following procedure shall be applied to compute the CBSD antenna gain:

1. The azimuth angle, AZ, relative to True North from the CBSD toward a receiver location shall be computed from the associated latitudes and longitudes using Vincenty's formula [Ref-10].
2. The CBSD antenna azimuth, α , shall be used to calculate the off-axis angle θ , i.e., the angle between the axis of the main beam of the CBSD and the line between the CBSD and receiver location, via

$$\theta = \alpha - AZ \text{ (degrees)}$$

3. SAS shall then calculate the CBSD antenna gain in dBi using $G(\theta) + G$ where G is the CBSD peak antenna gain and $G(\theta)$ is either obtained from the horizontal antenna pattern, if available, or calculated using the methodology in [Ref-11]:

$$G(\theta) = -\min \left[12 \left(\frac{\theta}{\theta_{3dB}} \right)^2, A_H \right] \text{ (dBi)}$$

where $A_H = 20$ dB and θ_{3dB} is CBSD reported beamwidth of antenna in degrees.

After initial certification, the algorithm to calculate CBSD antenna gain may advance beyond this initial requirement to include the CBSD downtilt and the vertical antenna pattern, subject to FCC approval.

R2-SGN-21: FSS Earth Station Antenna Gain in direction of the CBSD:

- a. For Initial Certification, SAS shall apply the following procedure to estimate the FSS antenna gain in the direction toward a CBSD in aggregate interference calculations
 - i The azimuth angle, AZ, relative to True North from the FSS earth station toward the CBSD shall be computed from the associated latitudes and longitudes using Vincenty's formula [Ref-10].
 - ii The elevation angle, ϕ_1 , from the FSS earth station toward the CBSD is computed by the method which is equivalent to the `hzns()` subroutine [Ref-12].
 - iii AZ, ϕ_1 , the FSS earth station antenna elevation (ϕ_2), and FSS earth station antenna azimuth (α) are used to calculate the off-axis angle θ , i.e., the angle between the axis of the main beam of the FSS earth station and the line between the FSS earth station and the CBSD via:

$$\theta = \frac{180}{\pi} \cos^{-1}(\cos \phi_1 \cos \phi_2 \cos(\alpha - AZ) + \sin \phi_1 \sin \phi_2) \text{ (degrees)}$$

- iv θ shall then be used with FSS earth station antenna patterns $G_{GSO}(\theta)$, defined in section 25.209(a)(1), and $G_{GSO\perp}(\theta)$, defined in section 25.209(a)(4). These patterns shall be combined using weights w_1 and w_2 according to the FSS earth station skew angle¹² to get the gain from an FSS earth station to a CBSD as

$$G(\theta) = w_1 G_{GSO}(\theta) + w_2 G_{GSO\perp}(\theta)$$

- v If the FSS earth station registration data includes values for w_1 and w_2 , SAS shall use these values. Otherwise SAS shall assume $w_1=0$ and $w_2=1$.
- b. After Initial Certification, procedure to estimate the FSS antenna gain may advance beyond this initial requirement, subject to FCC approval.

R2-SGN-22: Interference Margin Allocation Calculation: For purposes of Interference Margin Allocation calculations (including the IAP), the following methods shall be employed for initial certification:

- a. When ITM path loss is used, the mean interference contribution of a grant shall be computed as $EIRP * \langle 1/L \rangle$, where L is the ITM path loss on a linear scale, and $\langle \cdot \rangle$ is the statistical mean computed using confidence = 0.5 and 99 reliability values uniformly spaced between reliability=0.01 and 0.99.
- b. When extended Hata path loss is used, the mean interference contribution of a grant shall be computed as $EIRP_{dBm} - L_{mean,dB}$, where $L_{mean,dB}$ is computed starting with the extended Hata median path loss in dB ($L_{med,dB}=L_{EH}$ or $L_{med,dB}=L_{EHB}$ as defined in R2-SGN-04). Then defining $\xi = \frac{10}{\ln 10}$, $L_{mean,dB} = L_{med,dB} + \frac{\sigma^2}{2\xi}$ where σ is the land use category (urban or suburban) dependent log-normal distribution using a standard deviation given by equations A-18(a,b,c) in [TR 15-517 ref] and the land category is chosen using R2-SGN-04.

R2-SGN-23: SAS DPA Protection

- a. When a SAS receives notification from the ESC that a DPA needs protection on certain frequencies, the SAS shall activate that DPA on those frequencies

¹² The “skew angle” is the angular difference between the major axis of the antenna and the geostationary arc when the antenna is pointed at the serving satellite but located at a different longitudinal position than the satellite. Thus, at 0° skew angle, antenna performance is dictated solely by the azimuth gain pattern. As skew angle increases, the elevation gain pattern contributes to overall antenna performance and the combined pattern broadens to reflect this contribution

- b. The SAS shall be capable of determining that an ESC failure has occurred.
- c. If the SAS loses communications with the ESC or otherwise determines that the ESC has failed, the SAS shall activate all DPAs monitored by the failed ESC, over the entire frequency range for which the DPAs must be protected.
- d. In the absence of an ESC, all DPAs are considered activated on all frequencies.
- e. Specific coordinates for the DPAs will be available at [Ref-14].

R2-SGN-24: DPA Protection Procedure

- a. In the case of co-channel frequency range protection for offshore or inland DPAs, for each protection point, p , under consideration within the given DPA and for any co-channel frequency range ch , designate the protection constraint $c = \langle p, ch \rangle$ and define N_c to be the total number of CBSDs having or requesting a co-channel grant that includes any portion of the frequency range ch , and that are within a neighborhood of protection point p .

For each protection constraint c , the SAS shall determine the N_c CBSDs that are considered to be within the neighborhood of protection constraint $\langle p, ch \rangle$ in a manner that is substantially similar¹³ to the following procedure:

- i A Category A CBSD $_i$ shall be included in the neighborhood of protection constraint $\langle p, ch \rangle$ if and only if all of the following conditions are true:
 - a. CBSD $_i$ is less than or equal to 150 km from protection point p .
 - b. CBSD $_i$ is within the exclusion area defined by [Reference NTIA 15-517].
- ii A Category B CBSD $_i$ shall be included in the neighborhood of protection constraint $\langle p, ch \rangle$ if and only if either of the following two conditions are true:
 - a. CBSD $_i$ is less than or equal to 200 km from protection point p .
 - b. All of the following conditions are true:
 - i. CBSD $_i$ is greater than 200 km from protection point p ,
 - ii. CBSD $_i$ is less than or equal to 300 km from protection point p , and

¹³ Substantially similar is defined to mean that this determination is within a reasonable tolerance of the results of the DPA Protection Procedure, with the tolerance limit to be determined as part of the test and certification specification.

- iii. the height above average terrain (h_{AAT}) for $CBSD_i$ is greater than or equal to 200 m.
- b. In the case of out-of-band frequency range protection for inland DPAs, for each protection point, p , under consideration within the given DPA and for any protected out-of-band frequency range, ch , designate the protection constraint $c = \langle p, ch \rangle$ and define N_c to be the total number of CBSDs having or requesting any grant, and that are within a neighborhood of protection point p .

For each protection constraint c , the SAS shall determine the N_c CBSDs that are considered to be within the neighborhood of protection constraint $\langle p, ch \rangle$ to be all Category B CBSDs that are within 25 km of the DPA protection point p .
- c. For every protection constraint, c (i.e., for each of the protection constraints $\langle p, ch \rangle$ corresponding to every protection point p under consideration within a given protection area DPA and for every applicable frequency range ch), the SAS shall determine the associated move list M_c (see [R2-SGN-24 (d)]) using a method that generates results that are substantially similar¹⁴ to the following procedures:
 - i Form the ordered list $S_{c,sorted} = [CBSD_1, CBSD_2, \dots, CBSD_{N_c}]$, sorted according to increasing values of $(P_{CBSD,ch} + G_{CBSD_i \rightarrow c} - L_{CBSD_i,c})$, where $P_{CBSD,ch}$ is the CBSD conducted power (in dBm) on frequency range ch , $G_{CBSD_i \rightarrow c}$ is the CBSD antenna gain in the direction of the protection point p (in dBi) [R2-SGN-20], and $L_{CBSD_i,c}$ is the median path loss based on ITM model as defined in [R2-SGN-03] from $CBSD_i$ to the protection point p (in dB).
 - ii Find the largest n_c , $1 \leq n_c \leq N_c$, such that $CDF_{c,a}(n_c)$ does not violate 95% threshold for all potential azimuths, a , where $CDF_{c,a}(n_c)$ is the CDF of sum of the interference from the first n_c elements of $S_{c,sorted}$ (i.e., $CBSD_1, CBSD_2, \dots, CBSD_{n_c}$) given radar gain $G_{r,c \rightarrow a}$ (per [R2-IPM-04]) for a federal incumbent radar r , hypothetically located at the protection point p associated with constraint c , in the direction of azimuth a .
 - iii The associated move list, M_c , corresponding to protection constraints c is determined to be $\{CBSD_{n_c+1}, CBSD_{n_c+2}, \dots, CBSD_{N_c}\}$.
- d. The SAS shall determine the move list for protection area DPA on frequency range ch , $M_{DPA,ch}$, to be the union of M_c for all protection constraints c , where the associated p is within the protection area DPA .

¹⁴ Substantially similar is defined to mean that this determination is within a reasonable tolerance of the results of the DPA Protection Procedure, with the tolerance limit to be determined as part of the test and certification specification.

- e. Whenever any DPA, DPA , is activated on any given channel, ch (per channel definition as given in R2-SPU-01), a Managing SAS for any CBSDs under its management that are members of the move list $M_{DPA,ch}$ shall ensure that those CBSDs are not transmitting using any grant that has a frequency range that overlaps with the channel ch from a time starting no later than 300 seconds after the activation of the DPA until no earlier than the time when the DPA becomes deactivated.

R1-SGN-07: CBSD Antenna Height Above Average Terrain (HAAT): The Height Above Average Terrain (HAAT) of a CBSD antenna is determined by taking 50 evenly spaced elevation points (with the elevations above or below mean sea level [AMSL]) along 8 evenly spaced radials from the transmitter site (starting at 0 degrees [True North]). The 50 evenly-spaced points are sampled in the segment between 3 to 16 km along each radial. The elevation points along each radial are averaged, then the 8 radial averages are averaged to provide the final average value. This value is subtracted from the CBSD antenna's height AMSL to determine the antenna's height above average terrain.

The terrain database used for HAAT calculations shall be the same database used for the SAS propagation calculations, and consistent with R2-SGN-05.

R2-SGN-25: SAS ESC Sensor Protection

- a. SASs shall manage CBRS interference for all ESC sensors that require protection such that the aggregate mean interference at the reference ESC filter output of the protected sensor in 3550-3700 MHz does not exceed -109 dBm/MHz. The reference ESC filter has 0.5 dB insertion loss in the passband.
- b. For initial certification, the SAS shall treat Category B CBSDs operating within the frequency range 3650-3680 MHz, and Category A CBSDs operating within the frequency range 3650-3660 MHz, as co-channel to ESCs and apply the same protection described above, after assuming a straight line 1 dB per MHz ESC reference filter roll-off from 3650-3680 MHz.
- c. SAS shall calculate the CBRS interference using the CBSD antenna gain defined in R2-SGN-20 and the ESC antenna gain using the antenna pattern specified in R2-ESC-07(a) or the effective antenna pattern specified in R2-ESC-07(b). The angle-off boresight between the ESC sensor antenna and the CBSD shall be determined using an azimuth angle relative to true north from the ESC sensor toward the CBSD computed from the associated latitudes and longitudes using Vincenty's formula [Ref-10]. ESC protection criteria may evolve as the U.S. Department of Defense defines new waveforms that require detection. [Ref R2-ESC-01].

R2-SGN-26: CBSD Digital Certificate Modification

If a CBSD's digital certificate is modified (e.g. it is exposed and a new valid certificate is generated for the CBSD by a valid root certificate), the CBSD is required to re-register at the SAS with its new certificate.

R2-SGN-27: International Border Protection Consistent with Arrangement R

- a. To fulfill Arrangement R along US-Canada border, (https://transition.fcc.gov/ib/sand/agree/files/can-nb/Arrangement_R.pdf) sections 4.1 and 7.1, in addition to R2-SGN-19, SASs shall protect the single Canadian FSS site located at coordinates that will be provided by the FCC using the same criteria as used for FSS co-channel and blocking protection.
- b. SAS shall only allow spectrum grants to outdoor CAT A CBSDs, located less than 22 km away from the border, only if the PFD at the border is predicted to be less than -110 dBW/m²/MHz at a height of 1.5 meters above ground level.
- c. SAS shall only allow spectrum grants to indoor CAT A CBSDs, located less than 4 km away from the border, only if the PFD at the border is predicted to be less than -110 dBW/m²/MHz at a height of 1.5 meters above ground level.

R2-SGN-28: SAS Handling of CBSDs with Grants from multiple SASs simultaneously

- a. If a SAS determines that a CBSD has been authorized to use spectrum by other SASs simultaneously, the SAS shall revoke all the privileges of that CBSD to use spectrum which are managed by that SAS and associated with that CBSD.
- b. If a SAS determines that a CBSD already has an authorization to use spectrum from another SAS, the SAS shall reject all grant requests from that CBSD until it determines that the CBSD no longer has the authorization from another SAS.
- c. If a managing SAS fails, CBSDs authorized to use spectrum with the failed SAS may attempt to switch to an alternate SAS as the new managing SAS. The alternate SAS shall confirm the original managing SAS has failed, prior to becoming the new managing SAS.

R2-SGN-29: FSS OOB Purge List

- a. For each FSS TT&C protection entity, the SAS shall determine the *N_c* CBSDs that are within the 40km of the of the FSS TT&C location.
- b. For every FSS TT&C OOB protection point, SAS shall determine the associated Purge List.
- c. The process of calculating purge list is done before interference margin allocation process (such as IAP).
- d. Purge List will be only calculated for the first channel segment (*RefBW*), starting from the lowest frequency of the passband above or at 3700MHz.
- e. The *RefBW* size shall be 5MHz.
- f. SAS shall determine the associated Purge List using a method that generates results that are substantially similar to the following procedures:
 - i For CBSDs having multiple grants, the grant closest to *RefBW* is taken into account.

- ii An ordered list, S_{FSS} , will be formed where $S_{FSS} = [CBSD_1, CBSD_2, \dots, CBSD_{N_c}]$, sorted according to increasing values of $(MCBSD_{i,ch} + GCBSD_i + PL_{inv_i} + GFSS_i)$, where $MCBSD_{i,ch}$ is the CBSD conducted power (in dBm) on frequency segment, ch , using the Tx mask of CBSD according to R0-DEV-05(e), $GCBSD_i$ is the CBSD antenna gain in the direction of the FSS protection point (in dBi) [R2-SGN-20], $PL_{inv_i} = 10 \log_{10} <1/PL_i>$, as defined in R2-SGN-22, and PL_i is ITM path loss from $CBSD_i$ to the FSS protection point in linear scale, and $GFSS_i$ is the antenna gain (in dBi) of FSS receiver as defined in [R2-SGN-20].
- iii Find the largest n_c , $1 \leq n_c \leq N_c$, such that aggregation of $(MCBSD_{i,ch} + GCBSD_i - LCBSD_i + GFSS_i)$, for the ordered list that do not cross $-129\text{dBm} + 10 \cdot \log_{10}(\text{RefBW} / 1\text{MHz})$.
- iv The associated Purge list, P_{FSS} , corresponding to protection of FSS TT&C is determined to be $\{CBSD_{n_c+1}, CBSD_{n_c+2}, \dots, CBSD_{N_c}\}$.
- v If a CBSD's grant is purged, all the CBSD's grants that have the same emission mask (-13 or -25dBm/MHz) at RefBW as the purged grant shall be terminated. If the CBSD has grants with a lower emission mask at RefBW , the lower emission grant has to be added back to the sorted list, and the purge process is re-executed.
- vi The CBSD(s) that are in the purge list, P_{FSS} , will not be considered as part of calculation for IAP for any other protection entities.

4.2 Incumbent Protection Management (IPM)

R0-IPM-01: Protection of Existing FSS earth stations in the 3600-3650 MHz Band, the 3650-3700 MHz Band, and the 3700-4200 MHz Band [Ref-2, 96.17]

- a. FSS earth stations licensed to operate in the 3600-3650 MHz band listed at fcc.gov/cbrs-protected-fss-sites shall be protected from CBSD operation consistent with [the requirements below]. The protections shall only apply to registered FSS earth stations that are authorized to operate on a co-primary basis consistent with 47 CFR 2.106.
 - i FSS earth stations in the 3650-3700 MHz band will be afforded protection consistent with these requirements only after the conditions set forth in 47 CFR 96.21(c) are satisfied.
 - ii *Co-channel*: The aggregate passband RF power spectral density at the output of a reference RF filter and antenna at the location of an FSS earth station operating in the 3600 – 3700 MHz band, produced by emissions from all co-channel CBSDs (within 150 km) operating in the Citizens Band Radio Service shall not exceed a median

RMS¹⁵ value of -129 dBm / MHz. The reference antenna system requires SAS to calculate antenna gain using § 25.209(a)(1) and 25.209(a)(4), and a reference RF filter between the feed-horn and LNA/LNB, with 0.5 dB insertion loss in the passband.

- iii *Blocking*: The aggregate RF power at the output of a reference RF filter and antenna at the location of an FSS earth station operating in the 3600 – 3700 MHz band, produced by emissions from all CBSDs (within 40 km), shall not exceed a median RMS value of -60 dBm. The reference antenna system requires an SAS to calculate antenna gain using § 25.209(a)(1) and 25.209(a)(4), and a reference RF filter between the feed-horn and LNA/LNB, with a filter mask of 0.6 dB/MHz attenuation to 30.5 dB at 50 MHz offset below the lower edge of the FSS earth station's authorized passband, and 0.25 dB/MHz attenuation to 55.5 dB at an offset greater than or equal to 150 MHz below the lower edge of the FSS earth station's authorized passband.
- b. Registered FSS earth stations in the 3700-4200 MHz band listed at: fcc.gov/cbrs-protected-fss-sites, shall be protected from CBSD operation in accordance [with this section]. Only licensed FSS earth stations used for satellite telemetry, tracking, and control (TT&C) operations will be protected under this section. Other licensed 3700-4200 MHz earth stations may be protected consistent with section 96.17(f)
 - i *Out-of-Band Emissions into FSS*: The aggregate passband RF power spectral density at the output of a reference RF filter and antenna at the location of a TT&C FSS earth station operating in the 3700 – 4200 MHz band, produced by emissions from all CBSDs (within 40 km) operating in the Citizens Band Radio Service shall not exceed a median RMS value of -129 dBm / MHz. The reference antenna system requires SAS to calculate antenna gain using § 25.209(a)(1) and 25.209(a)(4), and a reference RF filter between the feed-horn and LNA/LNB, with 0.5 dB insertion loss in the passband.
 - ii *Blocking*: The aggregate RF power at the output of a reference RF filter and antenna at the location of a TT&C FSS earth station operating in the 3700 – 4200 MHz band, produced by emissions from all CBSDs (within 40 km), shall not exceed a median RMS value of -60 dBm. The reference antenna system requires SAS to calculate antenna gain using § 25.209(a)(1) and 25.209(a)(4), and a reference RF filter between the feed-horn and LNA/LNB, with a filter mask of 0.6 dB/MHz attenuation to 30.5 dB at 50 MHz offset below the lower edge of the FSS earth station's authorized passband, and 0.25 dB/MHz attenuation to 55.5 dB at an offset

¹⁵ RMS means Root Mean Squared received signal power (as opposed to peak or peak envelope power). Median applies to the statistics of the signal including the effects of propagation and /or the aggregation of multiple emitters.

greater than or equal to 150 MHz below the lower edge of the FSS earth station's authorized passband. [A graphical representation is shown in Figure 2]

- c. These protection criteria will [shall] be enforced by the Spectrum Access System authorized consistent with section 96.53,[Ref-2] et seq. below.
- d. FSS earth station licensees requesting protection under this Part must [shall] register with the Commission annually, no later than 30 days before the end of the preceding calendar year, or upon making changes to any of the operational parameters listed in this section. Registration information will [shall] be made available to all approved SASs.
 - i Annual registration for each earth station shall include, at a minimum: the earth station's geographic location (Using NAD83 coordinates); antenna gain; azimuth and elevation antenna gain pattern; antenna azimuth relative to true north; and antenna elevation angle; whether the earth station is used for satellite telemetry, tracking, and control (for earth stations in the 3700-4200 MHz band).
 - ii Such information must [shall] be made available to SAS Administrators and maintained consistent with section 96.55.
- e. CBSDs may operate within areas that may cause interference to FSS earth stations, in excess of the levels described in R0-IPM-01 (a) & (b), provided that the licensee of the FSS earth station and the authorized user of the CBSD mutually agree on such operation and the terms of any such agreement are provided to an SAS Administrator that agrees to enforce them. The terms of any such agreement shall be communicated promptly to all other SAS Administrators.
- f. FSS earth station licensees in the 3600-3700 and 3700-4200 MHz bands may request additional protection from SAS Administrators to prevent harmful interference into their systems. SAS Administrators must establish a process to receive and address such requests, consistent with section 96.53(o) and 96.63 and shall make good faith efforts to address interference concerns, consistent with their other responsibilities under this Part. In addressing such requests, SASs shall assume that 3700-4200 MHz earth stations are utilizing filters with the characteristics described in sections 96.17(a)(3) or (b)(2) as appropriate for the 3600-3700 or 3700-4200 MHz band.

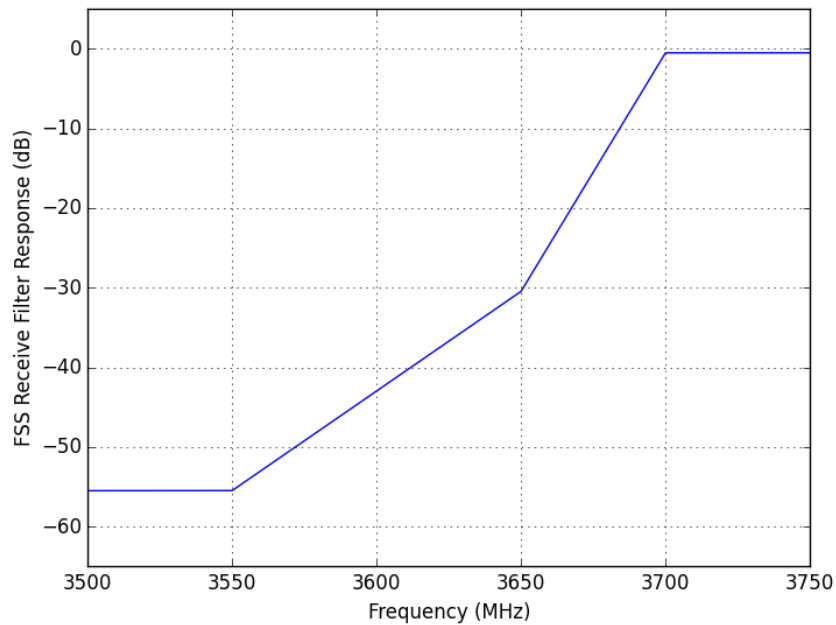


Figure 2: Filter curve plot for FSS Receive Filter Response vs. Frequency
Graphical representation of the filter described in R0-IPM-01(b)(ii) or 96.17(b)(2)

R0-IPM-02: Protection of Existing Operators in the 3650-3700 MHz Band [Ref-2 96.21, Ref-13]

- a. Grandfathered Wireless Broadband Licensees shall be granted Incumbent User status consistent with sections 90.1307 and 90.1338. Notwithstanding this status, Grandfathered Wireless Broadband Licensees shall not cause harmful interference to federal Incumbent Users and grandfathered FSS earth stations consistent with the rules governing Citizens Broadband Radio Service operators in this part.
 - i. Incumbent User protections for a Grandfathered Wireless Broadband Licensee shall only apply within its Grandfathered Wireless Protection Zone.
 - ii. Incumbent User protections for a Grandfathered Wireless Broadband Licensee shall only apply to Grandfathered Wireless Protection Zones around base or fixed stations that are registered in ULS on or before April 17, 2015 and constructed, in service, and fully compliant with the rules in Part 90, subpart Z as of April 17, 2016. Grandfathered Wireless Protection Zones will [shall] be reduced in geographic area and/or applicable frequency range if portions of the protected network fail to meet the above criteria after April 17, 2016. Grandfathered Wireless Protection Zones will [shall] not be defined for subscriber units operated by Grandfathered Wireless Broadband Licensees, regardless of whether they have been registered in ULS.

- iii. Grandfathered Wireless Protection Zones must [shall] be registered in the SAS for these protections to apply.
- b. Grandfathered Wireless Broadband Licensees may operate within their Grandfathered Wireless Protection Zones and operational frequencies consistent with the technical rules in Part 90, subpart Z, consistent with the transition period set forth in sections 90.1307 and 90.1338.
- c. Grandfathered Wireless Broadband Licensees and Citizens Broadband Radio Service users must [shall] protect authorized grandfathered FSS earth stations in the 3650-3700 MHz band, consistent with the existing protection criteria in part 90, subpart Z until the last Grandfathered Wireless Broadband Licensee's license expires within the protection area defined for a particular grandfathered FSS earth station. Thereafter, the protection criteria in section 96.17 applicable to FSS earth stations in the 3600-3700 MHz band shall apply.

R1-IPM-01: Protection of Federal Incumbent Users from CBSDs operating in the 3550-3650 band [Ref-2, 96.15]

- a. CBSDs and End User Devices must [shall] not cause harmful interference to and must accept interference from federal Incumbent Users authorized to operate in the 3550-3700 MHz band and below 3550 MHz.¹⁶
- b. The SAS shall only authorize the use of CBSDs consistent with information on federal frequency use obtained from an approved ESC, except as provided in this section.
- c. For Category A CBSDs, Exclusion Zones shall be maintained along the Coastline, as shown at ntia.doc.gov/category/3550-3650-mhz. Exclusion Zones shall also be maintained around federal radiolocation sites as set forth at ntia.doc.gov/category/3550-3650-mhz. The Zones shall be updated if and when NTIA notifies the Commission in writing if the list of protected federal radiolocation sites is updated. Exclusion Zones shall be maintained and enforced until one or more ESCs are approved and used by at least one SAS, in accordance with section 96.67. Thereafter, Exclusion Zones shall be converted to Protection Zones.
 - i. Category A CBSDs may be authorized by an approved SAS in geographic areas outside of Exclusion Zones before an ESC is approved.
 - ii. Once an ESC is approved and used by at least one SAS, Category A CBSDs may only be authorized consistent with information on federal frequency use provided to the SAS by an approved ESC.
 - iii. Category B CBSDs may only be authorized consistent with information on the presence of a signal from a federal system provided to the SAS by an approved ESC. [Ref-2, 96.45b]

¹⁶ The FCC rules do not explicitly state how far below 3550 MHz that federal Incumbent Users must be protected. However, primary federal allocations extend to 3100 MHz

- d. Within 300 seconds after the ESC communicates to the SAS that it has detected a signal from a federal system in a given area, or the SAS is otherwise notified of current federal incumbent use of the band, the SAS must [shall] either confirm suspension of the CBSD's operation or its relocation to another unoccupied frequency, if available. If the President of the United States (or another designated Federal Government entity) issues instructions to discontinue use of CBSDs pursuant to 47 U.S.C. § 606, SAS Administrators must instruct CBSDs to cease operations as soon as technically possible (but no more than 300 seconds).
- e. The SAS shall adapt to changes in the Exclusion Zones or Protection Zones to protect current and future federal Incumbent Users.
- f. The SAS shall adapt to temporary changes in Exclusion Zones and Protection Zones to protect temporary operations by federal Incumbent Users as may be modified by the FCC. Federal Incumbent Users will [shall] coordinate with the Commission prior to the beginning of any non-emergency operation requiring additional protection. Such modifications will [shall] be communicated to the SAS along with the expiration date and time of any modification.

R1-IPM-02: Protection of Federal Incumbent Users from CBSDs operating in the 3650-3700 band [Ref-2, 96.15 & Ref-7 para 64]

- a. CBSDs and End User Devices must [shall] not cause harmful interference to and must accept interference from federal Incumbent Users.
- b. Exclusion Zones shall be maintained for an 80 km radius around the federal radiolocation sites listed in 47 CFR 90.1331 [Ref-4] and 47 CFR 2.106 footnote US 109 [Ref-4]. These Exclusion Zones shall be maintained and enforced until one or more ESCs are approved and used by at least one SAS, in accordance with section 96.67. Thereafter, Exclusion Zones shall be converted to Protection Zones.
- c. CBSDs may only be authorized within these Protection Zones consistent with information on the presence of a signal from a federal system provided to the SAS by an approved ESC, in accordance with section 96.67.
- d. Within 300 seconds after the ESC communicates to the SAS that it has detected a signal from a federal system in a given area, or the SAS is otherwise notified of current federal incumbent use of the band, the SAS must [shall] either confirm suspension of the CBSD's operation or its relocation to another unoccupied frequency, if available. If the President of the United States (or another designated Federal Government entity) issues instructions to discontinue use of CBSDs pursuant to 47 U.S.C. § 606, SAS Administrators must instruct CBSDs to cease operations as soon as technically possible (but no more than 300 seconds).

R2-IPM-01: Impacts from CBSD and EUD transmissions shall be managed to achieve an aggregate interference level at 3550-3700MHz for federal incumbent radars not to exceed an I/N of -6 dB at the incumbent radar system receiver if its position

is known, or within the possible operating area of the radar system if its position is not known [NTIA Report 15-517 section 4.3]. In the absence of other information, a nominal noise figure of 3 dB for the incumbent radar receiver may be assumed.

Note: A nominal noise figure of 3 dB was used in the derivation of the R2-ESC-02.

- R2-IPM-02: SASs shall manage CBSD transmissions for all co-channel CBSDs within 40 km of a particular point in a Grandfathered Wireless Protection Zone such that aggregate interference protection at that point is equal to or better than the Area Protection Reference Standard (R2-SGN-12) using:
- a protection level of -80 dBm/10MHz for a reference isotropic antenna 1.5m in elevation,
 - a protection Monte Carlo percentile of 50% (median),
 - a protection point minimum fraction of 95%.
- R2-IPM-03: SASs shall manage CBSD transmissions for all considered co-channel CBSDs (per R2-SGN-24(a)) to an activated co-channel offshore Dynamic Protection Area (DPA) such that aggregate interference protection level at the point within the DPA is equal to or better than the Area Protection Reference Standard (R2-SGN-12) using:
- the protection level and reference antenna described in R2-IPM-04,
 - a protection Monte Carlo percentile of 95% with a minimum of 2000 trials, and
 - CBSD antenna gain modeled per R2-SGN-20
- R2-IPM-04: For co-channel offshore DPAs, unless otherwise specified in the DPA database [Ref-14], the protection level applied at DPA protection points shall be -144 dBm/10MHz, and the reference antenna shall be 50 m above sea level in elevation with a reference gain of 0 dBi relative to the protection level within the beamwidth, and a beamwidth of 3 degrees and side-lobe gain of -25 dBi outside the beamwidth, using 1.5 degree analysis increments beginning with the main beam boresight at true north.

For inland co-channel DPAs, unless otherwise specified in the DPA database [Ref-14], the protection level applied at DPA protection points shall be -144 dBm/10MHz, and the reference antenna shall be 10 m above ground level in elevation with a reference gain of 0 dBi relative to the protection level within the beamwidth, and a beamwidth of 3 degrees and side-lobe gain of -25 dBi outside the beamwidth, using 1.5 degree analysis increments beginning with the main beam boresight at true north.

Unless otherwise noted by NTIA, inland out-of-band DPAs (below 3500 MHz) are defined as the 3 km exclusion zone around the sites listed in TR 15-517 (check if an existing Reference in document). For inland out-of-band DPAs, the protection level applied at DPA points shall be -125 dBm/MHz, and the

reference antenna characteristic is an isotropic antenna 5 m above ground-level.

- R2-IPM-05: SASs shall manage CBSD transmissions within a neighborhood of a particular point in a co-channel or out-of-band inland DPA such that aggregate interference protection at that point is equal to or better than the Area Protection Reference Standard (R2-SGN-12) using:
- protection level and reference antenna as described in R2-IPM-04,
 - a protection Monte Carlo percentile of 95% with a minimum of 2000 trials, and
 - CBSD antenna gain modeled per R2-SGN-20.

4.3 SAS Interference Management and Exclusion Zones (IMZ)

- R0-IMZ-01: Citizens Broadband Radio Service operation in the 3550-3700 MHz band is [shall be] subject to current and future international agreements with Mexico and Canada. The terms of these agreements shall be implemented by the SAS. [Ref-2, 96.19]

4.4 SAS Administrators (SAD)

- R0-SAD-01: SAS Administrators are [shall be] designated by the FCC to provide nationwide service.

Note: The Commission may, at its discretion, permit the functions of a SAS, such as a data repository, registration, and query services, to be divided among multiple entities; however, it [the FCC] shall designate one or more specific entities to be a SAS Administrator responsible for coordinating the overall functioning of a SAS and providing services to operators in the Citizens Broadband Radio Service. [Ref-2, 96.63]

- R0-SAD-02: Each SAS Administrator designated by the Commission must [shall]: [Ref-2, 96.63]
- Maintain a regularly updated database that contains the information described in section 96.55 [2].
 - Establish a process for acquiring and storing in the database necessary and appropriate information from the Commission's databases, including PAL assignments, and synchronizing the database with the current Commission databases at least once a day to include newly licensed facilities or any changes to licensed facilities.
 - Establish and follow protocols and procedures to ensure compliance with the rules set forth in this part, including the SAS functions set forth in section 96.53 [2], et seq.
 - Establish and follow protocols and procedures sufficient to ensure that all communications and interactions between the SAS, ESC, and CBSDs are

- accurate and secure and that unauthorized parties cannot access or alter the SAS or the information transmitted from the SAS to CBSDs.
- e. Provide service for a five-year term. This term may be renewed at the Commission's discretion.
 - f. Respond in a timely manner to verify, correct or remove, as appropriate, data in the event that the Commission or a party brings a claim of inaccuracies in the SAS to its attention. This requirement applies only to information that the Commission requires to be stored in the SAS.
 - g. Securely transfer the information in the SAS, along with the IP addresses and URLs used to access the system, and a list of registered CBSDs, to another approved entity in the event it does not continue as the SAS Administrator at the end of its term. It may charge a reasonable price for such conveyance.
 - h. Cooperate to develop a standardized process for coordinating operations with other SASs, avoiding any conflicting assignments, maximizing shared use of available frequencies, ensuring continuity of service to all registered CBSDs, and providing the data collected pursuant to section 96.55 [2].
 - i. Coordinate with other SAS Administrators including, to the extent possible, sharing information, facilitating non-interfering use by CBSDs connected to other SASs, maximizing available General Authorized Access frequencies by assigning PALs to similar channels in the same geographic regions, and other functions necessary to ensure that available spectrum is used efficiently consistent with this part.
 - j. Provide a means to make non-federal non-proprietary information available to the public in a reasonably accessible fashion in conformity with these rules.
 - k. Ensure that the SAS shall be available at all times to immediately respond to requests from authorized Commission personnel for any and all information stored or retained by the SAS.
 - l. Establish and follow protocols to respond to instructions from the President of the United States, or another designated Federal government entity, issued pursuant to 47 U.S.C. 606.
 - m. Establish and follow protocols to comply with enforcement instructions from the Commission.
 - n. Ensure that the SAS operates without any connectivity to any military or other sensitive federal database or system, except as otherwise required
 - o. Ensure that the SAS does not store, retain, transmit, or disclose operational information on the movement or position of any federal system or any information that reveals other operational information of any federal system that is not required by this part to effectively operate the SAS.

R0-SAD-03: An SAS Administrator may charge Citizens Broadband Radio Service users a reasonable fee for provision of the services [Ref-2, 96.65]

R1-SAD-01: SAS Administrators to [shall] implement protocols to respond to directions from the President of the United States or another designated federal entity to manually discontinue operations of its associated CBSDs in a given area pursuant to 47 U.S.C. § 606. SAS Administrators must [shall] also implement protocols to manually discontinue operations of their associated CBSDs in response to enforcement actions taken by the Commission. [Ref-1, para 268]

R1-SAD-02: SAS Administrators must [shall] develop policies and procedures to ensure CBRS users accept and acknowledge that they may receive potentially harmful interference from federal radar systems as a condition of their authorization. [Ref-1, para 274]

R1-SAD-03: SAS Administrator Reporting

- a. A SAS Administrator shall provide a capability for receiving reports of exceptional circumstances requiring the attention of the Administrator. A SAS Administrator shall provide a capability for receiving reports from various entities of exceptional circumstances requiring the attention of the Administrator from the following entities:
 - i The Federal Government
 - ii Operators of incumbent Fixed-Satellite Earth Stations
 - iii Operators of incumbent Wireless Broadband Service stations operating in the 3650-3700 MHz band
 - iv Operators of networks protected by Priority Access licenses
 - v Operators of network equipment licensed by GAA rules
 - vi Other SAS Administrators
 - vii ESC Operators
- b. Such reports shall support communication to the SAS Administrator of the following exceptional circumstances:
 - i The report of erroneous data in the SAS database.
 - ii The report of harmful interference experienced by an incumbent station or Priority Access licensee which is prohibited by Part 96 rules.
 - iii The report of an alternative interference protection relationship between an incumbent user and CBSDs operating under Part 96 (e.g. an FSS user, see 96.17(e)).
 - iv The report of an alternative interference protection relationship between a network operator protected by a Priority Access license and other CBSDs operating under Part 96 (see 96.41(d)(1)). Details FFS.

- v The report by the FCC of an enforcement action, including any action taken regarding a particular CBSD or group of CBSDs or regarding a particular CBRS user or group of users.
- vi Information on waivers the FCC has granted to provide an exception to Part 96 rules for CBSDs or other CBRS entities.
- vii Information on waivers the FCC has granted to non-CBRS entities which impact CBRS operations.
- viii The request by an FSS earth station licensee pursuant to 47 CFR 96.17(f) for additional SAS protection of a licensed site.
- c. When in receipt of such a report of exceptional circumstances, a SAS Administrator shall provide the full details of such a report to all other SAS Administrators.
 - i Reports originated by the Federal Government shall always be provided to other SAS Administrators without delay.
 - ii Reports of alternative interference protection relationships between incumbents and CBSDs or between Priority Access and General Authorized Access users shall always be provided to other SAS Administrators without delay.
 - iii Reports leading to corrections in the SAS database shall be communicated to other SAS Administrators without delay insofar as the correction will impact previously-communicated information the SAS Administrator has corrected as a result of the report.
 - iv Reports of harmful interference may be communicated to other SAS Administrators in the process of responding to such a report.
- d. The tools provided by a SAS Administrator for the reporting of harmful interference should provide sufficient information for the reporter of such harmful interference to follow standardized reporting procedures such as OpenSSRF formats and the JSIR process. Such tools shall also inform the user that reports may be acted upon by the FCC.
- e. A SAS Administrator shall respond in a timely fashion corresponding to the nature of the report of exceptional circumstances, including those of harmful interference.

Note: FCC actions regarding an ad hoc exclusion zone or an emergency reclamation of spectrum are addressed in requirement R2-ISC-01.

[Ref-2, 96.17(f), 96.35(e), 96.41(d)(1), 96.41(e)(4), 96.63(f) and Ref-1 para. 37, 214, 399]

4.5 SAS Requirements for PAL Holders (SPU)

R0-SPU-01: Each PAL[shall] consist[s] of a single License Area (Census Tract). [Ref-2, 96.25]

R0-SPU-02: DEPRECATED

R0-SPU-03: Priority Access Licensees may aggregate up to four PAL channels in any License Area at any given time. The criteria to attribute partial ownership and other interests for the purpose of applying the aggregation limits are defined in 47 CFR 20.22 (b). [Ref-2, 96.31]

R2-SPU-01: The following channels are defined for PAL assignments in the 3550-3650 MHz band:

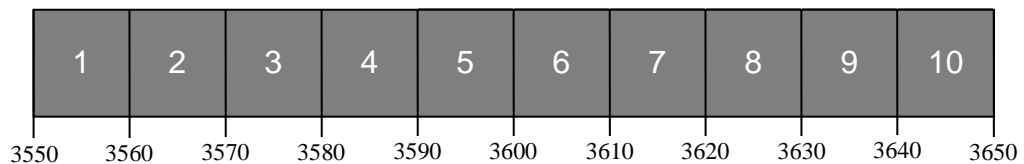


Figure 3: Channels defined for PAL assignments in the 3550-3650 MHz band

[Ref-1 paragraph 59]

Informative Note: Future studies will examine the relative utility of each channel for single-carrier and aggregate emissions, in the context of out-of-band emissions limits, fixed-satellite and Part 90 incumbent protections, and other considerations.

R2-SPU-02: PAL Registration ID (PAL-ID): Each PAL shall have a system-wide unique ID number assigned (the PAL-ID) per census tract and per logical licensed frequency channel.

R2-SPU-03: PAL Database: SAS Administrators shall cooperate to define and maintain a database of registered PAL-IDs and associated information that is available to all SASs.

The PAL database shall contain at least the following information:

- The PAL-ID
- The PAL licensee identity from the auction results.
- The User Registration ID (UR-ID) that corresponds to the above PAL licensee identity.
- The PAL initiation date
- The PAL termination date
- The FCC license area identifier (e.g. FIPS identification number for a census tract).

- g. The FCC frequency channel identity (identification numbers) corresponding to a 10 MHz frequency channel; this identifier is independent of the actual frequency allocation.
- h. The vertex points that define the PAL census tract area boundaries.
- i. License validity status information on a PAL.
- j. Any channel assignment information associated with this PAL

R2-SPU-04: PPA

- a. A PAL Holder shall register a PAL Protection Area (PPA) with the Holder's selected SAS, which shall be the Managing SAS for the PAL holder.
- b. The PAL Holder shall provide the following information to the Managing SAS:
 - i Proof of ownership (or valid lease) of a valid PAL as indicated by the PAL-ID.
 - ii A Cluster List of registered CBSDs whose protection area is within the PPA.
- c. The Managing SAS shall further register the following information for the PPA:
 - i The user identifier (User Registration ID (UR_ID)).
 - ii The PAL-ID or PAL-IDs upon which the PPA is based.
 - iii The list of vertex points that define the PPA boundary.
- d. For each established PPA (and PPA-ID), the Managing SAS shall maintain and share the PPA boundary with any and all other SASs.
- e. The Managing SAS shall assign a system-wide unique PPA-ID number for each established PPA.
- f. The PAL Holder shall coordinate with the Managing SAS to ensure that the Cluster List results in a single geographically contiguous PPA.

R2-SPU-05: Each SAS shall exchange the information related to each PPA to all SAS Administrators. The exchanged PPA information shall include the following:

- a. The PPA-ID
- b. The associated PAL-ID(s)
- c. The PPA initiation date
- d. The PPA termination date
- e. The vertex points that define the PPA boundaries

R2-SPU-06: PPA Conflict Resolution: A PPA that conflicts, overlaps or coincides with an existing PPA record associated with the same PAL shall cause the Managing SAS Administrator to reject the new or modified PPA.

For PPAs based upon leased PAL rights, it shall be the responsibility of the licensee to coordinate with the lessee(s) and for such PPA to be made with the advice and consent of both the owner and the lessee(s).

R2-SPU-07: PAL Owner Validation: The Managing SAS shall have the capability to validate the rights to a PAL when a PAL Holder claims a PPA. The Managing SAS shall have the capability to validate PAL leasing and that a lessee is a valid lessee as per FCC rules and requirements if the PPA is made under the auspices of a lease on behalf of a lessee.

- a. The Managing SAS shall, via the use of the PAL-ID database, be able to verify:
 - i The identity and validity of the PAL licensee.
 - ii The identity and validity of any subsequent PAL Holder
 - iii The identity, the lessee pre-registration information and valid eligibility of the PAL Lessee (if any).
 - iv The geographic validity of the PPA within the appropriate parent PAL(s).
 - v The identity and validity of the parent PAL(s) based upon the PAL-ID(s).
- b. Any SAS shall be able to access such records from the PAL database.

R2-SPU-08: PPA Tied Back to PAL: The PPA-ID shall be tied back to the parent PAL-ID(s) such that if any parent PAL expires or is revoked then the derived PPA(s) shall also expire. If a ‘child’ PPA has more than one ‘parent’ PAL, then if any (one) parent PAL expires, then the whole PPA (the whole Cluster List that spans more than one PAL) shall also expire.

R2-SPU-09: PPA Cluster List Use: The Managing SAS shall be able to determine if a CBSD is entitled to the use of a PAL channel by determining if the CBSD is on the PPA’s Cluster List.

R1-SPU-01: The Managing SAS shall allow the PPA Boundary to be defined by a contour (e.g. the vertex points of a polygon) supplied by the PAL Holder. For each PPA Boundary claimed by the claimant where the claimant provides the defining PPA vertex points, the Managing SAS shall verify that the claimed PPA Boundary is within the ‘Largest Allowable PPA Protection’ contour (See R1-SPU-02).

R1-SPU-02: The Managing SAS shall allow the PPA Boundary to be defined by a contour determined by the Managing SAS. The Managing SAS shall determine the size and shape of the Largest Allowable PPA Protection contour as per the FCC mandate. The SAS shall use: 1) the locations of the CBSDs on the Cluster List, 2) the CBSDs’ maximum allowable EIRPs, 3) the appropriate RF propagation model, 4) the CBSDs’ antenna height, 5) antenna gain and, if available, antenna radiation patterns, 6) the -96 dBm/10 MHz receiver criteria

assuming a 0 dBi measurement antenna at a height of 1.5 meters above the ground level to perform an RF model of the Largest Allowable Protection contour.

R1-SPU-03: DEPRECATED <moved to R2-SPU-10>

R1-SPU-04: PAL Steady State Channel Assignment: A SAS shall assign the “steady-state” channels designated per R2-SPU-10 to all CBSDs included in the user’s PPA Cluster List as defined by the PPA and the governing PAL held by that licensee.

R1-SPU-05: Temporary PAL Channel Reassignment: According to 96.25(b)(1)(i) and 96.25(b)(2)(i), and to the extent necessary to protect Incumbent Users or if necessary to perform its required functions under Part 96 subpart F, SAS may temporarily reassign individual PALs (and their associated PPAs and CBSDs) held by the same licensee to channels different than the “steady-state” channels assigned per R2-SPU-10.

R2-SPU-10: PAL Channel Assignment Planning: At the conclusion of the auction and prior to PAL use commencing, and at the times requested by the Commission, SAS Administrators shall cooperate to apply appropriate protocols to allocate and to assign “steady-state” frequencies to PAL Licensees to meet FCC requirements 96.11 (a)(3), 96.13, 96.31, 96.25(b)(1)(i), and 96.25(b)(2)(i), as well as meeting incumbent protection requirements. The SAS Administrators may consider additional constraints and objectives provided by PAL Licensees. The proposed allocation methodology shall be presented to the PAL Licensees for review and comment.

4.6 SAS Requirements for GAA Users (SGU)

R0-SGU-01: General Authorized Access Users shall be permitted to use frequencies assigned to PALs when such frequencies are not in use, as determined by the SAS, consistent with R0-SGN-04:. Frequencies that are available for General Authorized Access Use shall be made available on a shared basis. [Ref-2, 96.35]

- a. General Authorized Access Users shall have no expectation of interference protection from other General Authorized Access Users operating in accordance with this part.
- b. General Authorized Access Users must [shall] not cause harmful interference to and must accept interference from Priority Access Licensees and Incumbent Users in accordance with this part. [Reference R0-SGN-06:(h) and R0-SGN-06:(i)]
- c. General Authorized Access Users operating Category B CBSDs must [shall] make every effort to cooperate in the selection and use of available frequencies provided by an SAS to minimize the potential for interference and make the most effective use of the authorized facilities. Such users shall coordinate with an SAS before seeking station authorization, and

make every effort to ensure that their CBSDs operate at a location, and with technical parameters, that will minimize the potential to cause and receive interference among CBSDs.

- d. Operators of CBSDs suffering from or causing harmful interference are [shall be] expected to cooperate and resolve interference problems through technological solutions or by other mutually satisfactory arrangements.

R0-SGU-02: DEPRECATED

R0-SGU-03: CBSDs used for General Authorized Access must [shall] register with the SAS and comply with its instructions. [Ref-2, 96.33]

R1-SGU-01: SASs shall facilitate GAA coexistence among all GAA CBSDs, including those registered as Category A and Category B. [Ref-1 para 321, Ref-7 para 197, 96.53(k), 96.59(a)]

R2-SGU-01: Coexistence Groups

- a. The SAS shall provide a way for a CBSD to identify itself to the SAS as belonging to one or more Coexistence Group(s), and to voluntarily designate that the Coexistence Group(s) and/or other applicable coexistence-related information is to be shared with other CBSDs and CBSD Users.
- b. SASs shall share this coexistence-related information (including any designated Coexistence Group(s)) with other SASs, subject to all Operational Security restrictions [Ref-8] and in compliance with information sharing agreements the SAS has with other SAS administrators for disclosure of such information.

R2-SGU-02: Subject to all Operational Security restrictions [Ref-8], terms of service agreements the SAS has with CBSD operators, and in compliance with information sharing agreements with other SAS administrators related to the disclosure of such information, the SAS shall provide to a CBSD any coexistence information that is voluntarily provided for sharing with CBSDs by other potentially interfering GAA CBSDs. This information is provided in order to support CBSD to CBSD coordination in the selection of available GAA frequencies, and in order to minimize the potential for interference with other users of the band. This information includes, but is not limited to:

- a. Coexistence Group(s), if any, associated with the CBSDs for the purposes of facilitating cooperation with other GAA CBSDs that could potentially interfere with the GAA CBSD; and
- b. Information related to radio operating parameters for each potentially available GAA channel at the CBSD's location, such as the estimated maximum EIRP.

R2-SGU-03: SAS Administrators may provide information for CBSD operators to perform coordination, including location, radio technology, and radio operating parameter selection before or after they seek authorization [96.35(e)], subject

to all Operational Security restrictions [Ref-8], terms of service agreements the SAS has with CBSD operators, and in compliance with information sharing agreements with other SAS administrators related to the disclosure of such information. Coexistence information can include (but is not limited to) CBSD registration data that could be helpful in enabling location and technical parameter selection during network planning.

Requirements on the SAS administrators and/or CBSD operators for the determination of potential interference, for the resolution of conflicting uses of the band, and for the coordination of coexistence operations with other SAS administrators are FFS.

4.7 Inter-SAS Communication (ISC)

R1-ISC-01: Moved to R2-ISC-06

R1-ISC-02: Moved to R2-ISC-07

R1-ISC-03: Moved to R2-ISC-08

R2-ISC-01: When a SAS Administrator receives instructions from the President of the United States or another designated Federal government entity issued pursuant to 47 U.S.C. 606, or instructions from the FCC pursuant to FCC enforcement actions, that SAS Administrator shall, without delay, inform all other designated SAS Administrators of those instructions.

[Ref-2, 96.63(l & m) & Para 268; Title 47 USC 606]

R2-ISC-02: When a SAS Administrator receives communication that the Commission has temporarily extended or modified an Exclusion Zone or Protection Zone to protect temporary operations by federal incumbent users, that SAS Administrator shall, without delay, inform all other designated SAS Administrators of such communication. This information shall include the nature of the extension or modification as well as any accompanying expiration date and time specified by the Commission. [Ref-2, 96.15(a)(6)]

R2-ISC-03: Sharing of ESC incumbent detection information between SASs:

- Sharing of ESC incumbent detection information between SASs is as defined in [Ref-8].
- SASs shall exchange on a timely basis all CBSD data required for each SAS to correctly participate in aggregate federal incumbent radar protection relying on an ESC without reference to the behavior of any other SAS.
- In addition, SAS administrators shall perform any necessary pre-arrangement of protection behavior needed to ensure the protection of federal incumbent radar activity.

R2-ISC-04: SAS Essential Data: The following Data records shall be classified as SAS-Essential Data:

- a. ESC sensor location, height, antenna characteristics, and protection level records
- b. CBSD physical installation parameters (e.g., location, indoor/outdoor status, antenna parameters as required by Part 96)
- c. CBSDs are identified by a system-wide unique designator assigned by the Managing SAS
- d. CBSD coexistence parameters (e.g. interference coordination group memberships, air interface standards)¹⁷
- e. Information on all active CBSD grants: CBSD grant information (frequency ranges), power, grant type, grant expiration time, requested authorization status (Priority Access or General Authorized Access)
- f. PAL Protection Area (PPA) records (note: PPA Records = PPA Database defined in R2-SPU-05)
- g. SAS-SAS Coordination Event records (note: SAS Coordination Records are defined as the records from: R1-SAD-03 items p, q, r, s; R2-ISC-01 and R2-ISC-02)

R2-ISC-05: Exchanging SAS Essential Data between SASs: Incremental SAS-Essential Data should be exchanged in near-real-time. Exchange of SAS-Essential Data between any SASs shall use mechanisms which reliably enable the SASs to perform their functions.

If requested by a peer SAS, exchange mechanisms of SAS-Essential Data should provide for an expected reliable latency of incremental SAS-Essential Data provided to the requesting SAS in less than 10 seconds.

R2-ISC-06: CBSD Registration Data Classification:

- a. Public Registration Data are data that SAS Administrators must [shall] share with the public according to FCC requirement 96.55(a)(3). Specifically, such data is limited to CBSD registration data that would not allow one to identify a CBSD licensee. The CBSD registration data that may be shared both with other SAS administrators and with the public pursuant to FCC requirement 96.55(a)(3) are:
 - i FCC identification number
 - ii CBSD class (Category A/Category B)
 - iii Operating indoors or outdoors (for CAT A)
 - iv Air interface technology
 - v Sensing capabilities (if supported)
- b. Non-Public Registration Data are CBSD registration data that would allow one to identify a licensee and must [shall] therefore be obfuscated pursuant to FCC Requirement 96.55(a)(3). A SAS administrator may share Non-Public Registration Data with another SAS administrator, but must [shall] maintain it as confidential pursuant to FCC Requirement

¹⁷ Coexistence information is associated with the CBSD and setup at registration

96.55(a)(3) absent i) express order of a court, FCC, or other [legal] controlling authority, or ii) a binding, generally applicable public rule or order by the FCC. Such non-public registration data includes:

- i CBSD Licensee name
 - ii Horizontal location (Latitude, Longitude) of antenna
 - iii Vertical location (height above ground level) of antenna
 - iv User contact information
 - v Unique manufacturer serial number
 - vi Maximum EIRP
 - vii Antenna Characteristics -- antenna gain, beam width, azimuth, down tilt angle, antenna model
 - viii Call sign
- c. SAS administrator shall “obfuscate” Non-Public Registration Data pursuant to FCC Requirement 96.55(a)(3) in any disclosure of Public Registration Data by redacting the information or by substituting a dummy variable.
 - d. SAS administrators shall not publicly disclose data shared with them by other SASs.

R2-ISC-07: SAS Essential Data: SAS-Essential Data are defined as data shared between any two SASs which are required to fulfill all SAS functions required by 47 C.F.R Part 96.

- a. SAS-Essential Data should be subject to governing peering agreements among SAS Administrators, supported by the WINNF to provide privacy and data protection certainty to the users of SAS (such as CBSD Users, etc.).
- b. SAS-Essential Data shall be exchanged symmetrically between all pairs of SASs.
- c. SAS-Essential Data shall be exchanged on demand by SASs. SASs shall also share such data proactively.
- d. Use of SAS-Essential Data by a SAS Administrator is limited to satisfying obligations under 47 C.F.R Part 96. SAS administrator should enter into agreements to document this requirement, as well as the requirement to maintain all such data confidentiality, except Public Registration Data.

R2-ISC-08: SAS Public Data Set: The following Data records shall be classified as Public Data:

- a. SAS Administrator FCC registration records, including identity, contact information, SAS certification date and term, and mode of operation (Phase I, without ESCs deployed, or Phase II, with ESCs deployed)
- b. Public Registration Data
- c. PAL Area and Service Area records (47 C.F.R 96.3), resulting from FCC auctions
- d. Federal Incumbent Exclusion Zone records

- e. Non-Federal Incumbent records

5 Priority Access Licensee Requirements (PAL)

R0-PAL-01: Priority access assignments of authorization, transfers of control, and leasing arrangements [Ref-2, 96.32]

- a. Priority Access Licensees may transfer or assign their licenses and enter into de facto leasing arrangements in accordance with 47 CFR 1.
- b. Priority Access Licensees may not partition or disaggregate their licenses or partially assign or transfer their licenses nor may they enter into de facto leasing arrangements for a portion of their licenses.
- c. Priority Access Licensees may enter into spectrum manager leasing arrangements with approved entities as prescribed in 47 CFR 1.9046. Priority Access Licensees may only enter into leasing arrangements for areas that are within their Service Area and outside of their PAL Protection Areas.

R0-PAL-02: A SAS Administrator may accept and support leasing notifications, in which case that SAS Administrator shall: [Ref-2, 96.66]

- a. Verify that the lessee is on the certification list, as established in 47 CFR 1.9046.
- b. Establish a process for acquiring and storing the lease notification information and synchronizing this information, including information about the expiration, extension, or termination of leasing arrangements, with the Commission databases at least once a day;
- c. Verify that the lease will not result in the lessee holding more than the 40 megahertz of Priority Access spectrum in a given License Area;
- d. Verify that the area to be leased is within the Priority Access Licensee's Service Area and outside of the Priority Access Licensee's PAL Protection Area;
- e. Provide confirmation to licensee and lessee whether the notification has been received and verified;
- f. During the period of the lease and within the geographic area of a lease, SASs shall treat any CBSD operated by the lessee the same as [a] similarly situated CBSD[s] operated by the lessor for frequency assignment and interference mitigation purposes.

R2-PAL-01: SASs shall manage CBSD transmissions for all co-channel CBSDs within 40 km of a particular point in a PAL Protection Area such that aggregate interference protection at that point within the defining contours of that area is equal to or better than the Area Protection Reference Standard (R2-SGN-12) using:

- a. a protection level of -80 dBm/10MHz (and e.g. -83 dBm/5 MHz for a 5 MHz partially overlapping emission) for a reference isotropic antenna 1.5m in elevation,

- b. a protection Monte Carlo percentile of 50% (median),
- c. a protection point minimum fraction of 95%.

R2-PAL-02: PAL Protection Contour Methodology: PAL Protection Contour shall be determined by a SAS in a manner that yields substantially similar results as generated by the following methodology:

- a. For a particular CBSD in a PPA cluster list, SAS shall define 360 radials where each radial corresponds to the line extending out to 40 km from the CBSD location with heading defined relative to due north by angles, $\theta = 0, 1, \dots, 359$ degrees.
- b. SAS shall estimate the received power of the signal from the CBSD in accordance with R2-SGN-04 and R2-SGN-20 at regularly spaced points along each radial where the regular spacing “M” of the points shall be 200 meters for Initial Certification.
- c. SAS shall determine $N(i)$ for all radials ($0 \leq i \leq 359$), which is the number of points along the i -th radial with signal strength greater than or equal to -96 dBm/10 MHz.
- d. SAS shall generate a first contour, $C(\theta)$, which is comprised of 360 vertex points where the i -th vertex point is the point at distance $M \times N(i)$ along the i -th radial.
- e. The PAL Coverage Contour $S(\theta)$ shall be generated by smoothing $C(\theta)$ using a Hamming filter of size 15.
- f. SAS shall compute contours, $S(\theta)$, for each CBSD in the PPA cluster list. Subsequently, SAS shall determine the union of the coverage contours for all CBSDs within the PPA cluster list. This union is denoted the “PAL Coverage Contour”

R2-PAL-03: DEPRECATED

R2-PAL-04: PAL CBSD coverage boundaries

- a. A set of boundaries around the PAL CBSD coverage union determined in [R2-PAL-03] shall then be determined by SAS using a polygon union function operating on the individual boundaries¹⁸. Any interior holes with area less than 0.5 km² shall be removed.
- b. SAS shall determine and share with other SASs the polygon representing the outer extent of the boundary as well as the polygon representing any hole.
- c. In some circumstances, this method will produce a single boundary. In such cases, this boundary shall be used as the PPA boundary.
- d. Multiple PPAs may be produced in scenarios where the per-CBSD individual boundaries do not overlap.

R2-PAL-05: The PPA created by a SAS shall be close to the PPA created by the reference methodology described in R2-PAL-02 and R2-PAL-04 such that the area of the

¹⁸ Example implementation: Python Shapely library “cascaded_union” function.

difference shall be no more than 10% of the area of the PPA created by the reference methodology.

6 CBSD and EUD Requirements (DEV)

R0-DEV-01: The Citizens Broadband Radio Service is [shall be] authorized in the 3550-3700 MHz frequency band. General Authorized Access Users may operate in the 3550-3700 MHz frequency band. Priority Access License Holders may operate in the 3550-3650 MHz frequency band. Grandfathered Wireless Broadband Licensees may continue to use the 3650-3700 MHz band in accordance Ref-2. [Ref-2, 96.11]

R0-DEV-02: All CBSDs must [shall] be able to determine their geographic coordinates (referenced to the North American Datum of 1983 (NAD83)) to an accuracy of ± 50 meters horizontal and ± 3 meters of elevation. Such geographic coordinates shall be reported to an SAS at the time of first activation from a power-off condition. [Ref-2, 96.39]

- a. For professionally installed CBSDs, geographic coordinates to the same accuracy specified above may be determined and reported to the SAS as part of the installation and registration process. Geographic coordinates must [shall] be determined and reported each time the CBSD is moved to a new location.
- b. Non-professionally installed CBSD must [shall] check its location and report to the SAS any location changes exceeding 50 meters horizontal and ± 3 meters elevation from its last reported location within 60 seconds of such location change.

R0-DEV-03: A CBSD must [shall] register with and be authorized by an SAS prior to its initial service transmission. The CBSD must [shall] provide the SAS upon its registration with its geographic location, antenna height above ground level (in meters), CBSD class (Category A/Category B), requested authorization status¹⁹ (Priority Access or General Authorized Access), FCC identification number, call sign, user contact information, air interface technology, unique manufacturer's serial number, sensing capabilities (if supported), and additional information (see below) [Ref-2, 96.39].

- a. CBSD Category-A devices must [shall] also indicate if they are operating indoors or outdoors. [Ref-2, 96.43b]
- b. CBSD Category-B devices must [shall] also provide: antenna gain, beamwidth, azimuth, downtilt angle, and antenna height above ground level. [Ref-2, 96.45d]
- c. If any of the registration information changes, the CBSD shall update the SAS within 60 seconds of such change, except as otherwise set forth in section 96.39 [Ref-2].

¹⁹ Note: Part 96 Registration/Authorization process includes portions of the WINNF Forum Registration and Spectrum Grant process.

- d. All information provided by the CBSD to the SAS must [shall] be true, complete, correct, and made in good faith. [Ref-2, 96.39]

R0-DEV-04: CBSD technical operation [Ref-2, 96.39]

- a. All CBSDs must [shall] be capable of two-way operation on any authorized frequency assigned by an SAS. Equipment deployed by Grandfathered Wireless Broadband Licensees during their license term will be exempt from this requirement
- b. A CBSD must [shall] operate at or below the maximum power level authorized by an SAS, consistent with its FCC equipment authorization, and within geographic areas permitted by an SAS on the channels or frequencies authorized by an SAS.
- c. A CBSD must [shall] receive and comply with any incoming commands from its associated SAS about any changes to power limits and frequency assignments. A CBSD must [shall] cease transmission, move to another frequency range, or change its power level within 60 seconds as instructed by an SAS.
- d. A CBSD must [shall] report to an SAS regarding received signal strength in its occupied frequencies and adjacent frequencies, received packet error rates or other common standard metrics of interference for itself and associated End User Devices as directed by an SAS [Note: See R2-SGN-01].
- e. If directed by the SAS, a CBSD that receives a range of available frequencies or channels from an SAS must [shall] promptly report to the SAS which of the available channels or frequencies it will utilize.
- f. CBSDs shall incorporate security measures sufficient to ensure that they are capable of communicating only with SASs operated by approved SAS Administrators, and that communications between CBSDs and SASs, between individual CBSDs, and between CBSDs and End User Devices are secure to prevent corruption or unauthorized interception of data.
- g. For purposes of obtaining operational limits and frequency availabilities and their updates, CBSDs shall only contact SASs operated by SAS Administrators approved by the Commission in accordance with subpart F [of Ref. 2].
- h. All communications between CBSDs and SASs must [shall] be transmitted using secure methods that protect the systems from corruption or unauthorized modification of the data.
- i. Communications between a CBSD and its associated End User Devices for purposes of obtaining operational power, location, and frequency assignments shall employ secure methods that protect the system from corruption or unauthorized modification of the data.
- j. All CBSDs and End User Devices must [shall] contain security features sufficient to protect against modification of software and firmware by unauthorized parties. Applications for certification of CBSDs and End User Devices must [shall] include an operational description of the technologies and measures that are incorporated in the device to comply

with the security requirements of this section. In addition, applications for certification of CBSDs and End User Devices must [shall] identify at least one of the SAS databases operated by an approved SAS Administrator that the device will access for channel/frequency availability and affirm that the device will conform to the communications security methods used by such databases.

- k. Airborne operations by CBSDs and End User Devices are [shall be] prohibited.

R0-DEV-05: CBSD and End User Devices General Radio Requirements [Ref-2, 96.41]

- a. Digital Modulation: Systems operating in the Citizens Broadband Radio Service must [shall] use digital modulation techniques.
- b. Conducted and Emitted Power Limits: Unless otherwise specified in this subsection, the maximum EIRP and maximum Power Spectral Density (PSD) of any CBSD and End User Device must [shall] comply with the limits shown in the table below:

Device	Maximum EIRP (dBm/10 megahertz)	Maximum PSD (dBm/MHz)
End User Device	23	n/a
Category A CBSD	30	20
Category B CBSD*	47	37

* Category B CBSDs will only be authorized for use after an ESC is approved and commercially deployed consistent with [Ref-2, 96.15 and 96.67].

- c. Power Management: CBSDs and End User Devices shall limit their operating power to the minimum necessary for successful operations.
 - i. CBSDs must [shall] support transmit power control capability and the capability to limit their maximum EIRP and the maximum EIRP of associated End User Devices in response to instructions from an SAS.
 - ii. End User Devices shall include transmit power control capability and the capability to limit their maximum EIRP in response to instructions from their associated CBSDs.
- d. Received Signal Strength Limits:
 - i. For both Priority Access and GAA users, CBSD transmissions must [shall] be managed such that the aggregate received signal strength, for all locations within the PAL Protection Area of any co-channel PAL, shall not exceed an average (RMS) power level of -80 dBm in any direction when integrated over a 10 megahertz reference bandwidth, with the measurement antenna placed at a height of 1.5 meters above ground level, unless the affected PAL licensees agree to an alternative limit and communicate that to the SAS.

- ii. These limits shall not apply for co-channel operations at the boundary between geographically adjacent PALs held by the same Priority Access Licensee.
- e. 3.5 GHz Emissions and Interference Limits:
 - i. General protection levels. Except as otherwise specified below, for channel and frequency assignments made by the SAS to CBSDs, the conducted power of any emission outside the fundamental emission (whether in or outside of the authorized band) shall not exceed -13 dBm/MHz within 0-10 megahertz above the upper SAS-assigned channel edge and within 0-10 megahertz below the lower SAS-assigned channel edge. At all frequencies greater than 10 megahertz above the upper SAS assigned channel edge and less than 10 MHz below the lower SAS assigned channel edge²⁰, the conducted power of any emission shall not exceed -25 dBm/MHz. The upper and lower SAS assigned channel edges are the upper and lower limits of any channel assigned to a CBSD by an SAS, or in the case of multiple contiguous channels, the upper and lower limits of the combined contiguous channels.
 - ii. Additional protection levels. Notwithstanding paragraph (d)(i) of this section, the conducted power of any emissions below 3530 MHz or above 3720 MHz shall not exceed -40 dBm/MHz.
 - iii. Measurement procedure:

Compliance with this provision is [shall be] based on the use of measurement instrumentation employing a resolution bandwidth of 1 megahertz or greater. However, in the 1 megahertz bands immediately outside and adjacent to the licensee's authorized frequency channel, a resolution bandwidth of no less than one percent of the fundamental emission bandwidth may be employed. A narrower resolution bandwidth is permitted in all cases to improve measurement accuracy provided the measured power is integrated over the full reference bandwidth (i.e., 1 MHz or 1 percent of emission bandwidth, as specified). The emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power.

When measuring unwanted emissions to demonstrate compliance with the limits, the CBSD and End User Device nominal carrier frequency/channel shall be adjusted as close to the licensee's

²⁰ The text is intended to be read as: At all frequencies greater than 10 megahertz above the upper SAS assigned channel edge and [at frequencies] less than 10 MHz below the lower SAS assigned channel edge, the conducted power of any emission shall not exceed -25 dBm/MHz. [i.e., At all frequencies greater than 10 MHz outside the assigned channel edge, the conducted power of any emission shall not exceed -25 dBm/MHz]

authorized frequency block edges, both upper and lower, as the design permits.

Compliance with emission limits shall be demonstrated using either average (RMS)-detected or peak-detected power measurement techniques.

- iv. When an emission outside of the authorized bandwidth causes harmful interference, the Commission may, at its discretion, require greater attenuation than specified in this section.
- f. Reception Limits: Priority Access Licensees must [shall] accept adjacent channel and in-band blocking interference (emissions from other authorized Priority Access or GAA CBSDs transmitting between 3550 and 3700 MHz) up to a power spectral density level not to exceed -40 dBm in any direction with greater than 99% probability when integrated over a 10 megahertz reference bandwidth, with the measurement antenna placed at a height of 1.5 meters above ground level, unless the affected Priority Access Licensees agree to an alternative limit and communicates that to the SAS.

Note to paragraph (f): Citizens Broadband Radio Service users should be aware that there are Federal Government radar systems in the band and adjacent bands that could adversely affect their operations.

- g. Power Measurement: The peak-to-average power ratio (PAPR) of any CBSD transmitter output power must not exceed 13 dB. PAPR measurements should be made using either an instrument with complementary cumulative distribution function (CCDF) capabilities or another Commission approved procedure. The measurement must be performed using a signal corresponding to the highest PAPR expected during periods of continuous transmission.

R0-DEV-06: Category A CBSDs shall not be deployed or operated outdoors with antennas exceeding 6 meters height above average terrain. CBSDs deployed or operated outdoors with antennas exceeding 6 meters height above average terrain will be classified as, and subject to, the operational requirements of Category B CBSDs. [Ref-2, 96.43a]

R0-DEV-07: Any CBSD operated at higher power than specified for Category A CBSDs in section 96.41 [R0-DEV-05:] will be classified as, and subject to, the operational requirements of a Category B CBSD. [Ref-2 96.43c]

R0-DEV-08: Category B CBSDs must [shall] be professionally installed. [Ref-2, 96.45a]

Note: See Ref-3 for the definition of a Category B CBSD.

R0-DEV-09: Category B CBSDs are [shall be] limited to outdoor operations. [Ref-2, 96.45c]

R0-DEV-10: Each transmitter used for operation under this part and each transmitter marketed as set forth in section 2.803 [Ref-4, Chapter I, Subchapter A, Part 2] must [shall] be of a type which has been certificated for use under this part.

Any manufacturer of radio transmitting equipment to be used in these services must [shall] request equipment authorization following the procedures set forth in Subpart J [Ref-4, Chapter I, Subchapter A, Part 2]. [Ref-2, 96.49]

Communication between individual CBSDs must [shall] be secure to prevent corruption or unauthorized interception of data. [Ref-2, 96.61]

R1-DEV-01: A CBSD shall support at least one measurement metric that can be reported to the SAS and the CBSD shall indicate the supported measurement reporting capability in the CBSD registration process [Ref-2, 96.39(d)].

R2-DEV-01: For a CBSD supporting received power reporting before authorization for transmission, it shall, as directed by a SAS, over the entire CBRS band measure the radio frequency energy received over a set of frequency ranges during a measurement interval and report the results to a SAS for each of the multiple frequency ranges in terms of effective received power for each frequency range. The measurement bandwidth for each individual measurement shall not exceed 10 MHz

R2-DEV-02: A set of CBSDs may provide, where necessary due to physical limitations of the CBSD antennas and where appropriate for the type of measurement, common signal level measurement(s) for a group of coherent radiators, each of which is registered as a unique CBSD. A coherent radiator group identifier shall be indicated by each CBSD in the group during registration of the CBSDs.

Informational note: Such a signal level measurement, e.g. received power, is applicable to e.g., Distributed Antenna Systems (DASs), where muting of all but one CBSD to perform individual measurements is not feasible.

R1-DEV-02: When a CBSD Grant expires, the CBSD shall cease transmissions on the channel within 60 seconds, in accordance with 96.39(c)(2).

R0-DEV-11: End User Device Radios must [shall] also comply with CBSD General Radio Requirements stated above in R0-DEV-05. [Ref-2, 96.41].

R0-DEV-12: End User Devices may [shall] not be used as intermediate service links or provide service over frequencies listed in section 96.11 to other End User Devices or CBSDs. [Ref-2, 96.3]

R0-DEV-13: End User Devices may operate only if they can positively receive and decode an authorization signal transmitted by a CBSD, including the frequencies and power limits for their operation. An End User Device must [shall] discontinue operations, change frequencies, or change its operational power level within 10 seconds of receiving instructions from its associated CBSD.

Any device operated at higher power than specified for End User Devices in section 96.41 [R0-DEV-05:] will [shall] be classified as, and subject to, the operational requirements of a CBSD. [Ref-2, 96.47]

R1-DEV-03: If SAS informs the CBSD that it is subject to enforcement action, the CBSD shall cease all transmissions, consider all grants void, and consider itself deregistered.

R2-DEV-03: A CBSD shall not be authorized to use spectrum by multiple SASs simultaneously.

7 Domain Proxy Requirements (DPX)

The following requirements related to the Domain Proxy

R1-DPX-01: Domain Proxy to CBSD operational requirements: A Domain Proxy must [shall] ensure that all of the CBSD requirements of 96.39 [Ref-2] are met by CBSDs for which the Domain Proxy is communicating to the SAS.

R1-DPX-02: Domain Proxy to SAS interface security [Ref-2, 96.61]

- a. A Domain Proxy must [shall] employ protocols and procedures to ensure that all communications and interactions between the Domain Proxy and SAS are accurate and secure and that unauthorized parties cannot access the Domain Proxy via this communication path or alter the information exchanged between the Domain Proxy and the SAS.
- b. Communications between a Domain Proxy and a SAS must [shall] be secure to prevent corruption or unauthorized modification of data
- c. A Domain Proxy must [shall] incorporate security measures sufficient to ensure that it is capable of communicating only with SASs operated by approved SAS Administrators.

R1-DPX-03: Domain Proxy to CBSD communications security [Ref-2 96.3, 96.61, 96.39(f), R0-SGN-05:]

- a. A Domain Proxy must [shall] employ protocols and procedures to ensure that all communications and interactions between the Domain Proxy and CBSDs are accurate and secure and that unauthorized parties cannot access the Domain Proxy via this communication path or alter the information exchanged between the Domain Proxy and the CBSD.
- b. Communications between a Domain Proxy and a CBSD must [shall] be secure to prevent corruption or unauthorized modification of data.

R2-DPX-01: Domain Proxy to CBSD communications security implementation: The protocols and procedures to fulfill and enforce Domain Proxy to CBSD security requirements are out of the scope of this document and are not specified.

R2-DPX-02: Domain Proxy+CBSD Certification and Operation: Some models of CBSDs may only meet CBRS certification requirements as part of a collective entity

with a Domain Proxy function and any other network elements necessary for CBRS certification. Such models of CBSDs shall only be operated in conjunction with the Domain Proxy and other necessary elements with which they were collectively certified. Domain Proxies shall only provide for SAS communications with the models of CBSDs with which they were collectively certified.

Note: the definition of “model of CBSD” is to be determined by Working Group 4 in coordination with the FCC.

8 System Registration Requirements (SRR)

Registration is a rather complex process and we provide Informative Annex A.1 with information to help explain the process.

R2-SRR-01: User Registration Information: The User Registration and associated database requires the CBRS User (either a CBSD user or a PAL holder) to provide the following information:

- a. User legal identity (corporate or individual),
- b. User mailing address (contact address), User’s physical address (may or may not correspond to the mailing address),
- c. User’s legal address (may or may not correspond to the mailing address),
- d. User’s email contact address,
- e. User’s phone number (contact)

R2-SRR-02: During the User Registration process, the SAS Administrator shall provide to the user in a secure manner the following:

- a. A system wide unique User Registration Identity (UR-ID) to identify the User,
- b. A method to authenticate the User when accessing the User account (e.g, password)

R2-SRR-03: During the User Registration process and subsequent account maintenance, the SAS shall record and maintain the following information associated with that Registered User:

- a. User Registration date,
- b. User Registration expiration or term,
- c. User Registration state (valid, expired, pending enforcement, revoked),
- d. Registering Agent (FCC, SAS, or other agent),
- e. Optional Registration Fee Paid (true or false indication).
- f. A list of the CBSDs (CBSD-IDs) registered by the user.

Note: These CBSDs may be managed within nested lists that correspond to groupings by area, by Domain Proxy, by network, or other useful groupings.

- g. A list of PALs owned by that registered user.
- h. A list of PPAs registered to that user.

- i. A list of PPAs leased by a licensee to lessees.
Note: these leased PPAs may be managed within nested lists that correspond to useful groupings by area, by tenant, by network, or other useful groupings.
- j. A list of CGIs (CBSD Group Identifiers) that the user has created to form groups of CBSDs (exact requirements FFS.)

Note: These requirements assume that reports of claimed PPAs are adequate for SMLA reporting to the FCC. We are awaiting clarification from the FCC on this question. If further SMLA reporting is required by the FCC, WINNF will add requirements to define the SMLAs, the SMLA lists associated with the registered user's account, vertex points that define the area for the SMLA within the PAL, the initiation and termination dates for the lease terms for the SMLA, and the terms of the SMLA.

R1-SRR-01: During User Registration, the User shall provide and the SAS shall record:

- a. Acknowledgment of part 96 license rules, [Ref-2, 96.55(e) & para 274]
- b. Acknowledgement of federal operations risk [Ref-2, 96.55(e) & para 274]

R2-SRR-04: User Validation: The User credentials (whether an individual or business) shall be validated by the SAS to ensure the user is who they represent, and whether the user has a valid contact information & address.

R2-SRR-05: Maintenance of account: The Registered User, using a password or other security feature, shall be able to:

- a. Update contact information
- b. Update the list of fielded CBSDs by registering or deregistering CBSDs associated with a user account,
- c. Update information lists associated with that user account, including the following:
 - i Addition, deletion or administration of groupings of CBSDs (administer CGIs).
 - ii Update the list of PPAs by means of the associated unique PPA-ID (administer PPAs).
 - iii Addition, deletion or administration of groupings of registered PPAs.
 - iv For each and every PPA, the PAL Holder shall be able to update the list of CBSDs on that PPA's Cluster List. (Note: adding or deleting a CBSD from the PPA's Cluster List alters the PPA and creates a new PPA and a new PPA-ID.)
 - v For each and every PPA, the PAL Holder shall be able to update the list of vertex points (boundary definitions) for that PPA.

This shall require SAS approval consistent with the PPA Largest Allowable Claim Contour.

- vi For each and every PPA, the PAL Holder may be able to query the SAS for the SAS calculated Largest Allowable Claim Contour.
- vii For each and every PPA, the PAL Holder may be able to query the SAS for the existing registered vertex points defining the PPA boundary.
- viii For each and every leased PPA, the PAL Holder shall be able to update the list of lessee claimed PPAs. (These are PPAs on behalf of others where PAL rights have been leased to others.)
- ix The PAL Holder may be able to add, delete or administer groupings of Leased PPAs.
- x For each and every leased PPA, the PAL Holder shall be able to update the list of CBSDs on that lessee's PPA's Cluster List. (Note that adding or deleting a CBSD from the PPA's Cluster List alters the PPA and creates a new PPA and a new PPA-ID.)
- xi For each and every leased PPA, the PAL Holder shall be able to update the list of lessee's vertex points that define the boundary for that PPA.
- xii For each and every leased PPA, the PAL Holder shall be able to update the initiation and termination dates for that leased PPA.
- xiii For each and every leased PPA, the PAL Holder shall be able to query the SAS for the existing SAS registered initiation and termination dates for that leased PPA.

Note: These requirements assume that reports of claimed PPAs are adequate for SMLA reporting to the FCC. We are awaiting clarification from the FCC on this question. If further SMLA reporting is required by the FCC, WINNF will add requirements to maintain the SMLAs within the Registered user's account, including: the SMLA lists associated with the registered user's account, vertex points that define the area for the SMLA within the PAL, the initiation and termination dates for the lease terms for the SMLA, and the terms of the SMLA.

R2-SRR-06: Association of a CBSD with the CBSD User: The SAS Administrator and the CBSD User shall exchange information that establishes a secure mechanism to identify the CBSD User identity and to establish the relationship between the CBSD and its user. The user information association shall be established per individual CBSD in such a way that CBSD users may revoke the CBSD's identity within the CBRS.

R2-SRR-07: CBSD-ID: The CBSD Registration process shall establish a CBRS-wide unique CBSD ID.

R2-SRR-08: The CBSD-ID shall have a one-to-one correspondence with the combination FCC ID + CBSD S/N and may be identical to that combination and may include a suffix.

R2-SRR-09: DEPRECATED

R0-SRR-01: Category A CBSD Parameter Set: Prior to the SAS enabling spectrum use by the CBSD, the following Category A CBSD information shall be provided to the SAS. The information shall be uploaded either via the CBSD communicating with the SAS or entered by a Certified Professional Installer via a mechanism provided by the SAS administrator.

- a. <DEPRECATED>
- b. CBSD Serial number [required by Ref-2 96.39(c)],
- c. FCC Identification number [required by Ref-2 96.39(c)],
- d. Call Sign [required by Ref-2 96.39(c)],
- e. Secure information to associate CBSD with the User,
Informative Note: this will link a valid User with the CBSD [required by Ref-2 96.39(c)]
- f. CBSD Air Interface Technology [required by Ref-2 96.39(c)]
- g. CBSD Sensing capability [required by Ref-2 96.39(c)],²¹
- h. CBSD installation location (Indoor or Outdoor, required for Category A CBSDs) [Ref-2 96.43(b)],
- i. Location information: latitude, longitude, and antenna height above ground level (in meters) [Ref-2 96.39(c) & Ref-1 para 219],
- j. Certified Professional Installer Registration ID (if information provided to the CBSD was manually entered by a Certified Professional Installer)
- k. Optional vendor specific information fields. The SAS shall allow CBSDs to provide optional vendor specific information which can be used by the SAS. Examples include: CBSD Vendor, CBSD model number, CBSD HW version number, CBSD SW and/or FW version number, hardware characteristics, etc.

R0-SRR-02: Category B CBSD Parameter Set: Prior to the SAS enabling spectrum use by the CBSD, the following Category B CBSD information shall be provided to the SAS. The information shall be uploaded either via the CBSD communicating with the SAS or entered by a Certified Professional Installer via a mechanism provided by the SAS administrator.

- a. <DEPRECATED>
- b. CBSD Serial number [required by Ref-2 96.39(c)],
- c. FCC Identification number [required by Ref-2 96.39(c)],
- d. Call Sign [required by Ref-2 96.39(c)],
- e. Secure information to associate CBSD with the User,

²¹ To be defined by the Sensing & Measurement Task Group

Informative Note: this will link a valid User with the CBSD [required by 96.39(c)]

- f. CBSD Air Interface Technology [required by Ref-2 96.39(c)].
- g. CBSD Sensing capability [required by Ref-2 96.39(c)],²²
- h. Location information: latitude, longitude, and antenna height above ground level (in meters) [Ref-2, 96.39(c) & Ref-1 para 219],
- i. Certified Professional Installer Registration ID (if information provided to the CBSD was manually entered by a Certified Professional Installer)
- j. Antenna gain [Ref-2 96.45(d)],
- k. Antenna beamwidth [Ref-2 96.45(d)],
- l. Antenna azimuth pointing direction [Ref-2 96.45(d)],
- m. Antenna downtilt angle [Ref-2 96.45(d)],
- n. Optional vendor specific information fields. The SAS shall allow CBSDs to provide optional vendor specific information which can be used by the SAS. Examples include: CBSD Vendor, CBSD model number, CBSD HW version number, CBSD SW and/or FW version number, hardware characteristics, etc.

R1-SRR-02: During the CBSD Registration process, the SAS shall provide the following information to the registering CBSD:

- a. A system wide unique CBSD-ID to identify the CBSD,
- b. An indication if the Registration was successful or what additional information is needed to complete the registration process.

This information is required to register the CBSD and to establish a CBSD-ID. This CBSD-ID shall be linked to a specific user through the associated UR-ID, but each user may register multiple CBSDs. A CBSD-ID corresponds to a single CBSD that can request a spectrum assignment from a SAS.

For a managed network with a Domain Proxy, the Domain Proxy may register on behalf of one or more CBSDs under its control. Each CBSD shall require its own CBSD-ID for its own parameters and location.

R2-SRR-10: A SAS shall be able to provide the following information on CBSD registration status to the CBSD User, Professional Installer of the CBSD, other SASs or the FCC:

- a. Whether the CBSD registration is revoked, pending or completed
- b. Whether the CBSD has been taken out of service (decommissioned)
- c. Whether the CBSD has any enforcement actions initiated against it or determined to be in effect

R2-SRR-11: Category A CBSDs unable to automatically determine their location to within the requirements set forth by the FCC Rules shall be installed by a Certified Professional Installer. [Ref-2, 96.39 & Ref-1 para 221]

²² To be defined by the Sensing & Measurement Task Group

R2-SRR-12: CBSD Group Identifier (CGI): While registering a CBSD, a CBSD Group identifier may be specified along with other required device information. If present, this identifier designates a CBSD as a member of a particular group (or network) of CBSDs.

Note: It is anticipated that a system-wide naming convention will be established such that CBSD Group Identifiers can be easily selected by entities (such as Users or Domain Proxies). Support for multiple group identifiers is left for further study.

R2-SRR-13: CBSD Group Assignment Indicator: A Group Assignment Indicator may be provided to the SAS with the CBSD Group Identifier and other required device information, where this value shall indicate whether all CBSDs in the group prefer or require a common radio frequency assignment and reassignment when frequency reassignment is necessary.

R2-SRR-14: Domain Proxy Relationship with SAS: The SAS shall ensure that manager information and the credentials for the Domain Proxy are known to, and verified by, the SAS administrator prior to providing service to any CBSD that is subordinate to that Domain Proxy.

R2-SRR-15: Professional Installer information provided to the CBSD: If a professional installer accesses the CBSD to provide additional information for Category A or Category B CBSDs, the professional installer shall provide to the CBSD their associated Certified Professional Installer Registration ID.

R2-SRR-16: DEPRECATED

R2-SRR-17: DEPRECATED

R2-SRR-18: During the Certified Professional Installer Registration process, the SAS accessible centralized database (note: database to be managed by the CPI Accreditation Body. Database details are FFS) shall record and maintain the following information for the Certified Professional Installer:

- a. A system wide unique Certified Professional Installer Identity,
- b. A method to authenticate the Installer when accessing the Certified Professional Installer account

R2-SRR-19: Domain Proxy Manager Information: The following Domain Proxy manager information shall be known to the SAS administrator:

- a. Manager legal identity (corporate or individual)
- b. Manager contact (responsible individual in the case where legal identity is a corporate entity)
- c. Manager contact mailing address
- d. Manager contact email address
- e. Manager phone number

R2-SRR-20: DEPRECATED

R2-SRR-21: SAS Spectrum Information: The Managing SAS shall have some mechanism and protocol to inform the CBSD about which frequency range(s) are available.

R2-SRR-22: SAS Spectrum Availability Response: When providing frequency range(s) availability to a CBSD, the Managing SAS shall indicate whether an available frequency range is designated for use by that CBSD as PAL or GAA. CBSDs with PAL rights shall be provided with frequency range availability information for both available PAL frequency ranges and available GAA frequency ranges.

R2-SRR-23: Channel Grant: The Managing SAS shall allow a CBSD within a PPA to request use of GAA channel(s), a PAL channel(s), or both GAA and PAL channels together. When providing a grant to a CBSD, the Managing SAS shall indicate whether the grant is designated for use by that CBSD as PAL or GAA.

R2-SRR-24: CBSD registration update: When CBSD registration information changes, the CBSD shall send a registration update to the SAS with the updated information. The SAS may allow the CBSD registration information to be updated without the CBSD being deregistered or losing spectrum grants.

R2-SRR-25: A shared database shall be created and maintained with a list of supported CBSD Air Interface Technologies.

R2-SRR-26: Category A CBSD antenna gain: In addition to the requirements of R0-SRR-01, the maximum antenna gain of a Category A CBSD shall be provided to the SAS prior to the SAS enabling spectrum use by the CBSD. The information shall be uploaded either via the CBSD communicating with the SAS or entered by a Certified Professional Installer via a mechanism provided by the SAS administrator. Also, the following optional information may be provided to the SAS:

- a. Antenna beamwidth
- b. Antenna azimuth pointing direction
- c. Antenna downtilt angle

9 Environmental Sensing Capability Requirements (ESC)

R0-ESC-01: The following are ESC Requirements as identified in [Ref-2, 96.67]

- a. An ESC may only operate after receiving approval by the Commission.
- b. An ESC must [shall] be managed and maintained by a non-governmental entity.
- c. An ESC must [shall] accurately detect the presence of a signal from a federal system in the 3550-3700 MHz band and adjacent frequencies using

approved methodologies that ensure that any CBSDs operating pursuant to ESC will [shall] not cause harmful interference to federal Incumbent Users.

- d. An ESC must [shall] communicate information about the presence of a signal from a federal Incumbent User system to one or more approved SASs.
- e. An ESC must [shall] maintain security of detected and communicated signal information.
- f. An ESC must [shall] comply with all Commission rules and guidelines governing the construction, operation, and approval of ESCs.
- g. An ESC shall be available at all times to immediately respond to requests from authorized Commission personnel for any information collected or communicated by the ESC.
- h. An ESC must [shall] operate without any connectivity to any military or other sensitive federal database or system and does not store, retain, transmit, or disclose operational information on the movement or position of any federal system or any information that reveals other operational information of any federal system that is not required by this part to effectively operate the ESC.

R1-ESC-01: The rules governing the ESC are technologically neutral and ESC developers may utilize different sensing techniques that yield the desired result. These sensors shall be deployed in the vicinity of the Exclusion Zones described in section III(G) [Ref-1] to ensure that all federal radar use in and adjacent to the CBRS Band is accurately detected and reported to a SAS. [Ref-1, para 383]

R2-ESC-01: An ESC shall be capable of detecting those radar waveforms described in [NTIA Technical Memorandum 17-527] that are identified as required for ESC certification by the FCC.

R2-ESC-02: An ESC shall be capable of detecting in-band incumbent radars down to the peak sensitivity level established in [NTIA Technical Memorandum 17-527]. The ESC shall be capable of performing the detection in the presence of broadband Gaussian noise as described in [Technical Memorandum 17-527].

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R2-ESC-03: ESC Performance Monitoring: An ESC operator shall implement one or more methods to monitor ESC performance and detect ESC faults (including intrusion). Such methods shall be justified in the ESC certification process.

R2-ESC-04: DEPRECATED [per R2-ESC-10]

R2-ESC-05: Inland ESC: Operation of inland in-band ground-based incumbent radars may be detected by an ESC in the same manner as it detects shipborne radar operation in coastal areas.

R2-ESC-06: Detection of out-of-band radars: Future periodic reviews with the U.S. Government may establish metrics to detect out-of-band radars operating in the NTIA-defined federal radiolocation sites.

R2-ESC-07: ESC Sensor Protection:

- a. An ESC Operator shall request interference protection for all of its ESC sensors. An ESC Operator shall provide to its affiliated SAS(s) the location and height of the protected sensor antenna, as well as the sensor system's antenna gain in all horizontal directions, specified at 1 degree increments referenced to true north. [Reference R2-SGN-08 and R2-SGN-09].
- b. The ESC Operator may provide an equivalent antenna pattern in R2-SGN-07(a) that includes the effects of clutter and/or intentional shielding in the immediate area of the ESC sensor antenna.
- c. ESC Operators shall not deploy ESC sensor antennas that unreasonably restrict operation within the CBRS band.

R2-ESC-08: Figures of Merit: For a signal exceeding the threshold of detection as established in [NTIA Technical Memorandum 17-527], an ESC shall be capable of detecting, and informing the SAS of, in-band incumbent radar activity within 60 seconds with 99% probability. These time scales and performance characteristics may be adjusted as a consequence of future periodic ESC review. [Ref NTIA Technical Memorandum 17-526.]

R2-ESC-09: ESC Data Retention:

- a. ESC detection records shall not be retained within the ESC system for a time past the cessation of incumbent activity longer than the detection time figure of merit plus any additional randomized deactivation period determined by the ESC. The time period may be subject to periodic review and adjustment.
- b. ESC operators may propose keeping statistical records for the purposes of behavior analysis and reporting during the approval process, but any such record keeping will be subject to DoD review and may be declined.

R2-ESC-10: Dynamic Protection Area Monitoring by ESCs

- a. For any DPA whose geographic area is fully monitored by the ESC, the ESC shall notify the SAS of the presence and absence (as defined in [NTIA Technical Memorandum 17-527]) of a signal from a federal system in that DPA pursuant to [R2-ESC-12]. The geographic area of a DPA is fully monitored by the ESC if the ESC can fulfill [R2-ESC-02] for a signal from a federal system anywhere in the DPA.
- b. For any DPA whose geographic area is not fully monitored by the ESC, that ESC shall notify the SAS that the DPA requires protection for the entire frequency range for which that DPA must be protected.
- c. For any DPA whose geographic area is fully monitored by the ESC but for which a portion of the frequency range over which the DPA must be protected is not monitored, the ESC shall notify the SAS that the DPA

requires protection for the portions of the required frequency range not monitored by the ESC.

R1-ESC-02: DEPRECATED

R2-ESC-11: ESC Periodic Review: ESC requirements are subject to periodic review and modification by FCC, NTIA, and/or the Department of Defense.

R2-ESC-12: Federal Incumbent Detection Event:

- a. Notice from the ESC to the SAS resulting from a detection of federal incumbent activity in the band shall be made expeditiously subsequent to the detection of that activity by the ESC. Information relevant to federal activity passed from an ESC to a SAS in an incumbent detection event record shall be limited to the following information:
 - i The DPA or DPAs in which activity has been detected.
 - ii A frequency range which defines the extent of federal incumbent activity to be protected. This range shall be limited according to any constraints described by [Ref-8]
 - iii An activation time for this protection (which may be the current time).
 - iv A deactivation time for this protection (optional)
 - v A retention time for this record within the SAS, which shall be obeyed by the SAS following notification by the ESC that the incumbent detection event has expired. This retention time shall be limited to the constraints described by [Ref-8]
 - vi The ESC shall not notify the SAS of the deactivation of a DPA until after at least two hours past the absence of detected federal incumbent radar activity. This requirement could be modified in the future by FCC/NTIA/DoD.
- b. Upon cessation of the incumbent detection event, the information passed from an ESC to a SAS relevant to the federal activity shall be limited to the amount necessary to identify which incumbent detection event record is no longer active.
- c. Other information as needed for SAS and ESC operational concerns may also be passed by the ESC to the SAS as necessary and as in conformance with [Ref. 8].

R1-ESC-03: DEPRECATED

10 Certified Professional Installer Requirements (CPI)

- R1-CPI-01: SAS Administrators shall cooperate with the multi-stakeholder community to define a common CPI Accreditation Standard to be applied to Certified Professional Installer Training Programs. This CPI Accreditation Standard shall be used by a designated CPI Accrediting Body to accredit and regularly evaluate accreditation status of Certified Professional Installer Training Programs.
- R2-CPI-01: The Certified Professional Installer Accreditation Standard shall require that CPI Training Programs use a curriculum including the following elements:
- a. An explanation of the importance of the CPI role in the CBRS ecosystem.
 - b. An explanation of the structure of the CBRS band, including the support of incumbent, PAL, and GAA users. (Three-tier architecture)
 - c. An explanation of CBSD devices including examples of such devices. This explanation shall include the definitions of Category A and B devices and examples of such.
 - d. An explanation of the impacts of such devices on other users of the band, including incumbent users and Grandfathered Wireless Broadband Licensees.
 - e. An explanation of high-level responsibilities of the SAS to protect incumbent and PAL users of the band from harmful interference and to facilitate coordination among GAA users and resolve conflicting uses of the band. This explanation shall include the SAS ecosystem functional architecture and explain the roles of the architectural elements.
 - f. An explanation of the radio characteristics of harmful interference.
 - g. An enumeration of the CBSD registration parameters which Part 96 defines, including an explanation of each CBSD registration parameter including examples of how the parameter can be measured by the Professional Installer. Consistent use of parameter names, types, and units shall be employed by all CPI Training Programs.
 - h. An explanation of the interaction of a CBSD with the SAS including but not limited to registration, grants, heartbeats, transmission, suspension, revocation, reassignment and deregistration.
 - i. A minimum number of worked examples, both indoors and outdoors, providing case studies of gathering a full set of CBSD registration data for a particular CBSD or set of CBSDs.
 - j. An explanation of the responsibility of the CPI to seek out methods for gathering CBSD registration data for unfamiliar equipment, and the responsibility to do so before providing such data to the SAS.
 - k. An explanation of the processes whereby collected information may be provided to the SAS by a CPI.
 - l. An explanation of the relationship of the Part 96 registration data to any other industry-defined data (as defined in [this: 0112] document) which may be required to be collected and provided to the SAS as part of the installation process for particular CBSD equipment.

- m. An explanation that the CPI is fully responsible for CBSD registration data reported to the SAS, even when working with other people or systems which may assist in gathering such data.
- n. An explanation of the processes whereby a CPI can interface with the SAS to correct inaccurate data discovered in the course of operations.
- o. An explanation of the processes whereby a CPI can retrieve data from the SAS about the CBSDs for which they have provided registration parameters.
- p. An explanation of the division of responsibility between the CBSD User and the CPI in the installation process and ongoing operation.
- q. An explanation of the ongoing responsibilities of a CPI to maintain registration with the CPI Training Program to receive notice of any updates to Part 96 regulations or CPI Training Program requirements, as well as periodic renewal of certification status.
- r. An explanation that CPI data will be subject to accuracy checks by other parties and systems; and the obligation to provide correct data.
- s. An explanation of the corrective actions the CPI Training Program will be entitled to take pursuant to inaccuracies in data provided to the SAS by a CPI.
- t. An explanation of any actions available to the Federal Government pursuant to negligence or willful misuse of the powers of a CPI.

Accredited CPI Training Programs may include additional information not subject to the CPI Accreditation Standard, but such information, if included, shall not be contradictory to the required curriculum.

R2-CPI-02: CPI Accreditation Standard Overview

- a. The CPI Accreditation Standard shall establish consistent and objective criteria for successful completion of such a CPI Training Program.
- b. The CPI Accreditation Standard shall require that candidate CPI Training Programs administer objective testing of individual CPIs to prove their understanding of the current material.

R2-CPI-03: Certified Professional Installer Registration Information: The Certified Professional Installer Registration process requires the CPI Training Program Administrator to collect the following information from a Certified Professional Installer and provide it to the CPI Accrediting Body, which stores it and makes it available to a SAS Administrator upon request:

- a. Legal identity (name),
- b. Mailing address,
- c. Legal address,
- d. Email contact,
- e. Phone contact,
- f. Accredited certification number from a CPI Training Program (CPIR-ID),
- g. License initiation date, expiration date,
- h. CPI Training Program successfully completed

- R2-CPI-04: Professional Installer information provided to the SAS: When a professional installer provides additional information on Category A or Category B CBSDs via a mechanism provided by the SAS administrator, the professional installer shall provide:
- The CBSD serial number and FCC ID (to uniquely identify the CBSD),
 - The associated Certified Professional Installer Registration ID (CPIR-ID)
- R2-CPI-05: CPI Registration Data Accountability
- The SAS shall hold CPIs accountable for the CBSD registration data those individuals provide to the SAS. Note: the CPIR ID is a mechanism for tracking the association of a CPI with provided CBSD registration data.
 - If a CBSD User alters the deployment of a CBSD such that new registration data is required (as per Part 96.39), it is the responsibility of the CBSD User to engage a CPI (if required) to provide updated CBSD registration data to the SAS.
- R2-CPI-06: CPI Accreditation Standard Training Program
- The CPI Accreditation Standard shall require CPI Training Programs to document processes for any instructor selection, training, and continuing education they do. The Standard shall impose record keeping requirements on CPI Training Programs to track the participation of instructors and CPIs in the CPI Training program.
 - The Standard shall establish consistent continuing education requirements to be satisfied by CPI Training Programs and disciplinary actions available to CPI Training Programs should CPIs be found to be providing inaccurate data to the SAS. Note: such continuing education requirements are expected to reflect rules, requirements, and technology changes.
 - The standard shall ensure that candidate CPI Training Program administrators receive acknowledgement and legal consent by CPIs to abide by the disciplinary structure developed as part of the CPI Accreditation Standard. Such a structure may include retraining, suspension and revocation of CPI certification status.
 - The Standard shall require CPI Training Program administrators to be contractually bound by an obligation to carry out the disciplinary actions set forth in the CPI Accreditation Standard, including an acknowledgement and consent to the consequences of failure to carry out such duties, which shall include the suspension or revocation of accreditation status as a Certified Professional Installer Training Program Administrator.
 - The Standard shall require CPI Training Program administrators to agree to transfer the pertinent information in their records (e.g., ongoing training status, responsibility to contact a CPI for certification renewal) to another accredited CPI Training Program administrator in the event it ceases operation. It may charge a reasonable fee for such conveyance.

- R2-CPI-07: CPI re-accreditation of CPI Training Programs

- a. The CPI Accreditation Standard shall establish periodic re-accreditation requirements to be agreed to by CPI Training Programs.
- b. The registry of CPI Training Programs maintained by the CPI Accrediting Body shall contain at least the following information:
 - i Name of CPI Training Program Administrator
 - ii Accreditation status
 - iii Accreditation dates
 - iv Accreditation review history
 - v Legal identity of responsible party or parties
 - vi Contact information for responsible party
- c. The CPI Accreditation Standard shall require CPI Training Program Administrators to maintain contact information such that any updates promulgated in the CPI Accreditation Standard itself or in its program requirements can be communicated to the CPI Training Programs and adopted in a timely fashion.

R2-CPI-08: CPI Interface to enter CBSD Registration Parameters

- a. SAS administrators shall provide a means whereby their SASs will accept CBSD registration parameters from CPIs.
- b. This means shall include an interface containing standardized terminology used in the CPI Accreditation Standard for the identification of CBSD registration parameters common to Part 96 operations. Any additional parameters which users of this interface may be permitted to provide to the SAS shall not conflict with Part 96 CBSD registration parameters.
- c. The SAS shall validate that only individuals who are CPIs in good standing have the capability to use such interfaces to provide CBSD registration parameters to the SAS.
- d. If a CBSD or network management system supervising one or more CBSDs provides an interface to a CPI to facilitate the collection and/or provision of CBSD registration parameters, that interface should use standardized terminology used in the CPI Accreditation Standard for the identification of CBSD registration parameters common to Part 96 operations. (Note: legacy devices are exempted from this requirement.)

11 References

[1] Federal Communications Commission, “Amendment of the Commission’s Rules with Regard to Commercial Operations in the 3550-3650 MHz Band,” GN Docket 12-354, FCC 15-47, Report and Order and Second Notice of Proposed Rulemaking, Released April 21, 2015, available at https://apps.fcc.gov/edocs_public/attachmatch/FCC-15-47A1_Rcd.pdf

[2] Title 47, Code of Federal Regulations, Part 96 (2015), available at: <http://www.ecfr.gov/cgi-bin/text-idx?node=pt47.5.96&rgn=div5>.

[3] Wireless Innovation Forum, Spectrum Sharing Committee, “Definitions Related to Commercial Operations in the U.S. 3550-3700 MHz Citizens Broadband Radio Service Band” available at: <http://www.wirelessinnovation.org/fcc-definitions>

- [4] Title 47, Code of Federal Regulations (various parts referenced), available at: www.ecfr.gov.
- [5] National Telecommunications and Information Administration, “An Assessment of the Near-Term Viability of Accommodating Wireless Broadband Systems in the 1675-1710 MHz, 1755-1780 MHz, 3500-3650 MHz, and 4200-4220 MHz, 4380-4400 MHz Bands,” October 2010 (“Fast Track Report”). Available at:
https://www.ntia.doc.gov/files/ntia/publications/fasttrackevaluation_11152010.pdf
- [6] National Telecommunications and Information Administration, “Spectrum Occupancy Measurements of the 3550-3650 Megahertz Maritime Radar Band near San Diego, California,” Technical Report TR-14-500, January 2014. Available at:
<http://www.its.bldrdoc.gov/publications/2747.aspx>
- [7] Federal Communications Commission, “Amendment of the Commission’s Rules with Regard to Commercial Operations in the 3550-3650 MHz Band,” GN Docket 12-354, FCC 16-55, Order on Reconsideration and Second Report and Order, available at:
https://apps.fcc.gov/edocs_public/attachmatch/FCC-16-55A1_Rcd.pdf
- [8] Wireless Innovation Forum, Spectrum Sharing Committee, “CBRS Operational Security Technical Specification” available at:
http://www.wirelessinnovation.org/assets/work_products/Specifications/winnf-15-s-0071-v1.0.0%20cbars%20operational%20security.pdf
- [9] RFC-2119, “Key words for use in RFCs to Indicate Requirement Levels”, March 1997. Available at: <https://tools.ietf.org/html/rfc2119>
- [10] T. Vincenty, “Direct And Inverse Solutions Of Geodesics On The Ellipsoid With Application Of Nested Equations”, Survey Review, Volume 23, Issue 176 (01 April 1975), pp. 88-93.
- [11] “Feasibility study for enhanced uplink for UTRA FDD”, 3GPP TR 25.896
- [12] <https://www.its.bldrdoc.gov/media/50674/itm.pdf> section §47
- [13] Federal Communications Commission, “Wireless Telecommunications Bureau and Office of Engineering and Technology Announce Methodology for Determining the Protected Contours for Grandfathered 3650-3700 MHz Band Licensees,” GN Docket No. 12-354, Public Notice DA 16-946 (Aug. 19, 2016) available at https://apps.fcc.gov/edocs_public/attachmatch/DA-16-946A1.pdf
- [14] National Telecommunications & Information Administration, DPA information to be available at: <https://www.ntia.doc.gov/category/3550-3650-mhz>. (Note: information not published as of 14.Aug.2017)

Appendix A: Informative Annex

Deprecated

Note: Contents available in WINNF-15-S-0112-v2.0.0 Appendix A or in soon to be published WINNF-17-P-0205, which will supersede WINNF-15-S-0112-v2.0.0 Appendix A.

Appendix B: Revision History

Document History		
V1.0.0	May 2016	Forum approval
V2.0.0	February 2017	<p>V2 requirements includes the following major enhancements:</p> <ul style="list-style-type: none"> • FCC Order on Reconsideration and Second Report & Order (FCC 16-55) • Measurement Reporting • Domain Proxy Functionality • SAS Initial Propagation Model • PAL support • SAS information sharing • Certified Professional Installer
V 1.1.0	13 July 2017	Document Number update to reflect change in configuration management policy
V1.2.0	13 July 2017	Forum Approval of recent technical revisions
V1.3.0	27 Sep 2017	Forum Approval of recent technical revisions
V1.4.0	15 January 2018	Forum Approval of recent technical revisions