Functional Requirements for the U.S. 6 GHz Band under the Control of an AFC System

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Functional Requirements for the U.S. 6 GHz Band under the Control of an AFC System

1 Scope

The scope of this technical specification is to define the functional requirements for the AFC System, AFC System Operator, Standard Power Access Points, Fixed Client Devices and Proxies and to specify the necessary standards to enable test and certification procedures for a properly functioning environment in the 6 GHz band. The functional requirements specified in this specification are based on Federal Communications Commission (FCC) rules governing the use of 6 GHz band subject to the control of an AFC System, which are codified in Part 15 Subpart E of Title 47 the U.S. Code of Federal Regulations [n.1] adopted in the 2021.

The requirements captured in this specification, outside of the normative annexes, are described in a technology neutral manner and applicable for any unlicensed wireless communication technology operating in the 6 GHz band under the Part 15 Subpart E rules in the 6 GHz band. This specification will be further extended to include the following topics in different normative annexes.

- Technology-neutral optional features and the requirements for those features that are not required to be tested for FCC certification;
- Technology-specific optional features and the requirements for those features that are required to be tested for FCC certification if implemented by an AFC System, a Standard Power Access Point or a Fixed Client Device; and,
- Technology-specific optional features and the requirements for those features that are not required to be tested for the FCC certification.

The FCC's Part 15 Subpart E rules will hereafter be referred to as "the FCC Rules", "the Rules" or "Part 15" and reference to specific items in the rules will be given in the form of, for example, 15.407(k)(16) if from Part 15.

NOTE 1: Not all the 6 GHz-specific rules are captured in this specification as this document is not a comprehensive list of requirements for the implementation or operation of an AFC System, Standard Power Access Point or Fixed Client Device. AFC System operation, components and/or devices, as applicable, are expected to comply with the rules that are not considered in this specification.

NOTE 2: Unless otherwise specified, "Standard Power Access Point" and "Fixed Client Device" are collectively referred to as "Standard Power Device" in this document.

2 References

2.1 Normative References

The following referenced documents are necessary for the application of the present document.

[n.1] Title 47, Code of Federal Regulations, Part 15 Subpart E - Unlicensed National Information Infrastructure Devices, available at: https://ecfr.federalregister.gov/current/title-47/chapter-I/subchapter-A/part-15/subpart-E

[n.2] RFC-2119, "Key words for use in RFCs to Indicate Requirement Levels", March 1997. Available at: https://tools.ietf.org/html/rfc2119

[n.3] Federal Communications Commission, Unlicensed Use of the 6 GHz Band Report and Order and Further Notice of Proposed Rulemaking ET Docket No. 18-295; GN Docket No. 17-183, available at: https://docs.fcc.gov/public/attachments/FCC-20-51A1_Rcd.pdf

[n.4] P. Kyösti et al., "WINNER II channel models", IST-4-027756 WINNER II Deliverable D1.1.2, 2008, available at: https://www.cept.org/files/8339/winner2%20-%20final%20report.pdf

[n.5] NTIA – ITS Irregular Terrain Model (ITM) (Longley-Rice) (20MHz-20 GHz), available at: http://www.its.bldrdoc.gov/resources/radio-propagation-software/itm/itm.aspx

[n.6] ITU-R P.2108: Prediction of clutter loss (P.2108-0 (06/2017)), available at https://www.itu.int/rec/R-REC-P.2108/en

[n.7] ITU-R P.452: Prediction procedure for the evaluation of interference between stations on the surface of the Earth at frequencies above about 0.1 GHz (P.452-16 (07/2015)), available at https://www.itu.int/rec/R-REC-P.452-16-201507-I/en

[n.8] Federal Communications Commission, "Unlicensed Use of the 6 GHz Band; Review of the Commission's Rules Governing the 896-901/935-940 MHz Band", Federal Register / Vol. 86, No. 32, available at: https://www.federalregister.gov/documents/2021/02/19/2021-00782/unlicensed-use-of-the-6-ghz-band-review-of-the-commissions-rules-governing-the-896-901935-940-mhz

[n.9] RFC-2616, "Hypertext Transfer Protocol -- HTTP/1.1", Fielding, Gettys, Mogul, Frystyk, Masinter, Leach and Berners-Lee, June 1999.

[n.10] RFC-5246, "The Transport Layer Security (TLS) Protocol Version 1.2", Dierks and Rescorla, August 2008.

[n.11] RFC-8446, "The Transport Layer Security (TLS) Protocol Version 1.3", E. Rescorla and Mozilla, August 2018

[n.12] 3GPP TS 38.101-1, "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone", available at: https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3283

[n.13] 3GPP TS 38.104, "NR; Base Station (BS) radio transmission and reception", available at: https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3202

[n.14] Wi-Fi Alliance AFC System to AFC Device Interface Specification, available at: https://www.wi-fi.org/file/afc-system-to-afc-device-interface-specification

[n.15] ITU Recommendation ITU-R F.699-8, "Reference radiation patterns for fixed wireless system antennas for use in coordination studies and interference assessment in the

frequency range from 100 MHz to 86 GHz", available at https://www.itu.int/rec/R-REC-F.699/en

[n.16] 47 C.F.R. §101.115(b)(2), available at https://www.ecfr.gov/current/title-47/chapter-I/subchapter-D/part-101#101.115

[n.17] WINNF-TS-5008, "6 GHz Supplementary Data Repository Technical Specification", Wireless Innovation Forum

[n.18] National Land Cover Database (NLCD) data for CONUS, Alaska, Hawaii and Puerto Rico, available at https://www.mrlc.gov/data

[n.19] ULS Data File Format, available at, https://www.fcc.gov/sites/default/files/public_access_database_definitions_v6.pdf

2.2 Informative References

The following referenced documents are not necessary for the application of the present document, but they assist the reader with regard to a particular subject area.

[i.1] RFC-8996, "Deprecating TLS 1.0 and TLS 1.1", K. Moriarty, CIS, S. Farrell, Trinity College Dublin, March 2021

[i.2] NIST Special Publication 800-52 Revision 2, "Guidelines for the Selection, Configuration, and Use of Transport Layer Security (TLS) Implementations", August 2019, available at: https://doi.org/10.6028/NIST.SP.800-52r2

[i.3] RFC-7525, "Recommendations for Secure Use of Transport Layer Security (TLS) and Datagram Transport Layer Security (DTLS)", Y. Sheffer, Intuit, R. Holz, NICTA, P. Saint-Andre, &yet, May 2015

[i.4] IEEE Std 802.11ax™-2021, "IEEE Standard for Information Technology--Telecommunications and Information Exchange between Systems Local and Metropolitan Area Networks--Specific Requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 1: Enhancements for High-Efficiency WLAN", May 2021.

[i.5] TIA-10 (2019 Edition), "Interference Criteria for Microwave Systems", The Telecommunications Industry Association

[i.6] ITU Recommendation ITU-R F.758-7, "System parameters and considerations in the development of criteria for sharing or compatibility between digital fixed wireless systems in the fixed service and systems in other services and other sources of interference".

[i.7] Federal Communications Commission, "The Commission Begins The Process For Authorizing 6 GHz Band Automated Frequency Coordination Systems", FCC 21-100, available at: https://ecfsapi.fcc.gov/file/09281454120568/FCC-21-100A1.pdf

[i.8] R. C. Hansen, "A One-Parameter Circular Aperture Distribution with Narrow Beamwidth and Low Sidelobes", Trans. IEEE, vol. AP-24 no.4, pp. 477-480, July 1976.

3 Definitions, Abbreviations and Symbols

3.1 Definitions

3.1.1 FCC Definitions

The Wireless Innovation Forum 6 GHz Committee leverages the definitions provided by the FCC from 47 CFR 15.403. These definitions and others are also available at reference [n.1].

Access Point (AP): A U-NII transceiver that operates either as a bridge in a peer-to-peer connection or as a connector between the wired and wireless segments of the network or as a relay between wireless network segments.

Automated Frequency Coordination (AFC) System: A system that automatically determines and provides lists of which frequencies are available for use by Standard Power Access Points operating in the 5.925-6.425 GHz and 6.525-6.875 GHz bands.

NOTE: Although not explicitly stated in the definition, the AFC System provides lists of which frequencies are available for use by Fixed Client Devices in the same way as to Standard Power Access Points operating in the 5.925-6.425 GHz and 6.525-6.875 GHz bands. (See the definition of Fixed Client Device)

Client Device: A U-NII device whose transmissions are generally under the control of an Access Point and is not capable of initiating a network.

Fixed Client Device: A Client Device intended as customer premise equipment that is permanently attached to a structure, operates only on channels provided by an AFC System, has a geolocation capability, and complies with antenna pointing angle requirements.

NOTE: WInnForum believes that the FCC allows a Fixed Client Device to operate as a Client Device in accordance with 15.407(a)(7), 15.407(d)(5) and 15.407(d)(7), and, while doing so, to communicate with an AFC System.

Maximum Power Spectral Density: The Maximum Power Spectral Density is the maximum Power Spectral Density, within the specified measurement bandwidth, within the U-NII device operating band.

Power Spectral Density: The Power Spectral Density is the total energy output per unit bandwidth from a Pulse or sequence of Pulses for which the transmit power is at its maximum level, divided by the total duration of the Pulses. This total time does not include the time between Pulses during which the transmit power is off or below its maximum level.

Pulse: A Pulse is a continuous transmission of a sequence of modulation symbols, during which the average symbol envelope power is constant.

Standard Power Access Point: An Access Point that operates in the 5.925-6.425 GHz and 6.525-6.875 GHz bands pursuant to direction from an Automated Frequency Coordination System.

U-NII devices: Intentional radiators operating in the frequency bands 5.15-5.35 GHz, 5.470-5.85 GHz, 5.925-7.125 GHz that use wideband digital modulation techniques and provide a wide array of high data rate mobile and fixed communications for individuals, businesses, and institutions.

3.1.2 WInnForum Definitions

AFC System Operator: An entity designated by the Commission to operate an AFC System in accordance with the rules and procedures set forth in the Part 15 Subpart E.

Available Channel: A Channel, determined by an AFC System, on which a Standard Power Device is allowed to operate at its geographic coordinates.

NOTE: For the purpose of this document, the WInnForum definition of *Available Channel* takes precedence over the definition in the 47 CFR Part 15 Subpart E [n.1] since the FCC-defined *Available Channel* applies only in the context of its DFS rules.

Channel: A contiguous frequency range between lower and upper frequency limits.

Proxy: An entity engaging in communications with an AFC System on behalf of one or more Standard Power Devices, or networks of such devices.

Standard Power Device: A terminology collectively referring to Standard Power Access Point and Fixed Client Device.

NOTE: In this document, this terminology is used for R1, R2 and R3 requirements.

3.2 Abbreviations

3GPP	3rd Generation Partnership Project
AFC	Automated Frequency Coordination
AGL	Above Ground Level
BER	Bit Error Rate
DFS	Dynamic Frequency Selection
e.i.r.p.	Equivalent Isotropically Radiated Power
FCC	Federal Communications Commission
FS	Fixed Service
HH	The response of a horizontally polarized antenna port to a horizontally polarized signal

HV	The response of a horizontally polarized antenna port to a vertically polarized signal
IEEE	Institute of Electrical and Electronic Engineers
ITM	Irregular Terrain Model
ITU	International Telecommunication Union
ITU-R	ITU Radiocommunication Sector
NAD	North American Datum
NIST	National Institute of Standards and Technology
NLCD	National Land Cover Database
OET	Office of Engineering and Technology
RPE	Radiation Pattern Envelope
TIA	Telecommunications Industry Association
ULS	Universal Licensing System
U-NII	Unlicensed National Information Infrastructure
VH	The response of a vertically polarized antenna port to a horizontally polarized signal
VV	The response of a vertically polarized antenna port to a vertically polarized signal
WINNER II	Wireless World Initiative New Radio phase II

3.3 Symbols

BW_{FS}	Channel bandwidth of the fixed microwave service receiver
c	The speed of light
D_{DRx}	Fixed service diversity receive antenna diameter
$d_{FSRx\text{-}Eval}$	Distance between the FS receiver antenna and the evaluation point
d_{Limit}	Near field distance limit
D_{Rx}	Fixed service primary receive antenna diameter
$D_{Rx,\ NFA}$	Fixed service primary receive antenna diameter for near field adjustment
dkm_los	Size of the exclusion zone to protect the radio astronomy antenna
$F_{c,\ FS}$	Center frequency of the fixed microwave service receiver
$F_{Rx,\ ULS}$	Operating frequency band of fixed service receiver recorded in the ULS
G_0	The boresight gain of the fixed service receiver antenna

G_{CDisc}	The effective antenna discrimination of the fixed service receiver co-polarization RPE
G_{Common}	The most common antenna gain for the antenna model
G_{Disc}	The effective discrimination of the antenna RPE
G_{DRx}	Fixed service diversity receive antenna gain
G_{MB}	The mid-band antenna gain
G_{Rx}	Fixed service primary receive antenna gain
$G_{Rx, C\text{-}RPE}$	The co-polarization RPE of the fixed service receiver antenna
$G_{Rx, Effective}$	The effective antenna gain of the fixed service receiver antenna
$G_{Rx, Eff\text{-}PolMismatch}$	The effective antenna gain considering polarization mismatch
$G_{Rx, HH\text{-}RPE}$	HH RPE of the fixed service receiver antenna
$G_{Rx, HV\text{-}RPE}$	HV RPE of the fixed service receiver antenna
$G_{Rx, ULS}$	Fixed service primary receive antenna gain recorded in the ULS
$G_{Rx, VH\text{-}RPE}$	VH RPE of the fixed service receiver antenna
$G_{Rx, VV\text{-}RPE}$	VV RPE of the fixed service receiver antenna
$G_{Typical}$	The typical antenna gain for a given antenna of diameter of a fixed service microwave receiver
$G_{Tx, ULS}$	Fixed service transmit antenna gain recorded in the ULS
G_{XDisc}	The effective antenna discrimination of the fixed service receiver cross-polarization RPE
$H_{FS, DRx}$	Fixed service diversity receive antenna height
$H_{FS, Rx}$	Fixed service receive antenna height
H_{SPD}	Height above ground level reported by the Standard Power Device (in meters)
Hrx	Height of the radio astronomy antenna above ground level
Htx	Height of the unlicensed Standard Power Device above ground level
I	Interference from the Standard Power Device at the fixed microwave service receiver

I/N_{Est}	Estimated interference-to-noise ratio
I/N_{Thres}	Interference-to-noise ratio as the interference protection criteria
k_B	Boltzmann's constant
L	Combined path loss
L_{BEL}	Building Entry Loss
$L_{FS,\ Feeder}$	Fixed service receiver feeder loss
L_{LOS}	Line-of-sight path loss
N	Background noise level at the fixed microwave service receiver
NF	Noise figure
P_{LOS}	Probability of line-of-sight
P_{NLOS}	Probability of non-line-of-sight
$P_{SPD,\ Tx}$	The Standard Power Device transmission power across the frequency range I/N_{Est} calculations are performed.
T	Threshold level
T/I	Threshold-to-interference
T_0	Standard temperature
u	FS antenna discrimination parameter
x_{dB}	Normalized separation distance
ΔH_{SPD}	Vertical uncertainty reported by the Standard Power Device (in meters)
η_{Rx}	Antenna aperture efficiency
$\eta_{Rx,\ NFA}$	Antenna aperture efficiency for near field adjustment
θ_{DDisc}	The angle-off-boresight between vectors from Standard Power Device to fixed service diversity receive antenna and from fixed service transmitter to fixed service diversity receive antenna, and reflects both the horizontal azimuth and vertical elevation
θ_{Disc}	The angle-off-boresight between vectors from Standard Power Device to fixed service primary receive antenna and from fixed service transmitter to fixed

service primary receive antenna, and reflects both the horizontal azimuth and vertical elevation

$\varphi_{FSRx\text{-}Eval}$ Off-axis angle in a direction from the FS receiver antenna towards the evaluation point

4 Requirement Organization

Requirements shall be uniquely identified by: R#-<FEATURE>-<CATEGORY>-<XX>-<Y>, where R<#> is defined by:

- R0-: Requirements directly from FCC rules
  R1-: Requirements derived from FCC rules or from the text of an applicable FCC order
  R2-: Requirements imposed by WInnForum to meet FCC rules
  R3-: Requirements imposed by WInnForum to meet industry needs.

  NOTE: Support of R3 requirements for some optional features specified in normative annexes will need to be considered in the protection of fixed service receivers and radio astronomy service facilities in accordance with the technology neutral requirements specified in the main body of this technical specification. See details in each normative annex.

- <FEATURE>: Unique feature identifier for which the requirements are applicable.

  NOTE: If this tag is not present, the requirement is not feature specific.

- <CATEGORY>: Categorization of the requirement by using a code from the table below:

Table 1: Requirements Categorization

Code	Category
DGR	Standard Power Device General Requirements
DSQ	Standard Power Device Security Requirements
AGR	AFC System General Requirements
ASQ	AFC System Security Requirements
AIP	AFC System Incumbent Protection

- <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-DTR-06-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”, “should” or “will” for the rules, which we have included below as “R0” requirements; however, [shall] is inserted to indicate this is considered as a mandatory requirement. In addition, the FCC uses the term “network element” or “network element device” in some of the rules which have been adopted for “R0” requirements in this specification; for these cases the term [Proxy] is inserted for clarification purposes. Furthermore, citations used

in the FCC rule are converted into the corresponding requirement numbers in this specification.

The following terms are used within this document and should be interpreted as described in RFC-2119 [n.2]:

- 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)

5 Standard Power Device General Requirements (DGR)

5.1 Device Registration and Spectrum Inquiry

R0-DGR-01 Device registration requirements:

a. Standard Power Access Points and Fixed Client Devices must [shall] register with and be authorized by an AFC System prior to the Standard Power Access Point and Fixed Client Device's initial service transmission, or after a Standard Power Access Point or Fixed Client Device changes location. (15.407(k)(8)(i))

b. Standard Power Access Points and Fixed Client Devices must [shall] register with the AFC System by providing the following parameters: geographic coordinates (latitude and longitude referenced to North American Datum 1983 (NAD 83)), antenna height above ground level, FCC identification number, and unique manufacturer's serial number. (15.407(k)(8)(ii))

   i. If any of these parameters change, the Standard Power Access Point or Fixed Client Device must [shall] provide updated parameters to the AFC System.

c. Standard Power Access Points and Fixed Client Devices must [shall] provide the registration information to the AFC System either directly and individually or by a network element [Proxy] representing multiple Standard Power Access Points or Fixed Client Devices from the same operating network. (15.407(k)(8)(iii))

R0-DGR-02 Standard Power Access Points and Fixed Client Devices may transmit only on frequencies and at power levels that an AFC System indicates as available. (15.407(k)(1))

R0-DGR-06 Standard Power Access Points and Fixed Client Devices operating under CFR 15.407(a)(4) must [shall] access an AFC System to determine the available frequencies and the maximum permissible power in each frequency range at their geographic coordinates prior to transmitting. (15.407(k)(1))

R0-DGR-03 Standard Power Access Points and Fixed Client Devices must [shall] contact an AFC System at least once per day to obtain the latest list of available frequencies and the maximum permissible power the Standard Power Access Point or Fixed Client Device may operate with on each frequency at the Standard Power Access Point and Fixed Client Device's location. (15.407(k)(8)(iv))

R0-DGR-04 If the Standard Power Access Point or Fixed Client Device fails to successfully contact the AFC System during any given day, the Standard Power Access Point or Fixed Client Device may continue to operate until 11:59 p.m. of the following day at which time it must [shall] cease operations until it re-establishes contact with the AFC System and re-verifies its list of available frequencies and associated power levels. (15.407(k)(8)(iv))

R2-DGR-02 When contacting the AFC System in accordance with R0-DGR-03, the Standard Power Device shall query the AFC System for the frequency availability using one of the following methods:

a. Query the AFC System for a frequency range(s) without specifying a Channel size across which it will operate.

b. Query the AFC System for Channel(s) identified in a manner specific to an air interface that defines its upper and lower frequency boundaries and bandwidth.

R2-DGR-05 The frequency range(s) queried by the Standard Power Device following R2-DGR-02-a shall include up to one and one-half times the device's intended operating Channel bandwidth away from the Channel's center frequency to the extent that such frequencies are within the U-NII-5 and U-NII-7 bands.

R3-DGR-01 Deprecated.

5.2 Geolocation Capability

R0-DGR-05 Geolocation capability:

a. A Standard Power Access Point and a Fixed Client Device must [shall] report such coordinates [its geographic coordinates] and location uncertainty to an AFC System at the time of activation from a power-off condition. (15.407(k)(9)(i))

b. An external geolocation source may be connected to a Standard Power Access Point or Fixed Client Device through either a wired or a wireless connection. A single geolocation source may provide location information to multiple Standard Power Access Points or Fixed Client Devices. (15.407(k)(9)(ii))

c. The applicant for certification of a Standard Power Access Point or Fixed Client Device must [shall] demonstrate the accuracy of the geolocation method used and the location uncertainty. (15.407(k)(9)(iv))

d. For Standard Power Access Points and Fixed Client Devices that may not use an internal geo-location capability, this uncertainty must [shall] account for the accuracy of the geolocation source and the separation distance between such source and the Standard Power Access Point or Fixed Client Device. (15.407(k)(9)(iv))

R1-DGR-01 A Standard Power Device must [shall] include either an internal geolocation capability or an integrated capability to securely connect to an external geolocation devices or service, to automatically determine the Standard Power Device's geographic coordinates and location uncertainty (in meters), with a confidence level of 95%. (15.407(k)(9)(i))

5.3 Use of Proxy

R2-DGR-01 The obligations of one or more Standard Power Devices to communicate with the AFC System may be met in combination with a Proxy.

5.4 Device Emission Limits

R2-DGR-03 A Standard Power Device that follows the available frequencies and the maximum permissible power provided by the AFC System in accordance with R2-AGR-03-a shall ensure that its emissions outside of its intended Channel of operation do not exceed the allowable level on any frequency, on either the upper or lower adjacent Channels, by applying the relative out of Channel emission maxima specified in 15.407(b)(7), or an alternative set of relative emission levels as authorized for the specific device.

R2-DGR-04 Channel emission limits in multiple channel operation:

The Standard Power Device that follows the available frequencies and the maximum permissible power provided by the AFC System in accordance with R2-AGR-03-b, and which operates on more than one Channel simultaneously, shall reduce out of Channel emissions by 3 dB for overlapping frequencies of the out of Channel emission masks corresponding to any of the transmission Channels.

6 Standard Power Device Security Requirements (DSQ)

6.1 Communication Security

R2-DSQ-01 A Standard Power Device or Proxy if applicable shall use, for the purpose of communications with an AFC System, the following protocols: HTTP 1.1 [n.9] or higher and TLS 1.2 [n.10] or higher, or an alternative method of communication which provides a similar or higher level of security.

NOTE: Useful information related to this requirement is available in RFC-8996 [i.1], NIST Special Publication 800-52 Revision 2 [i.2], and RFC-7525 [i.3].

R2-DSQ-02 A Standard Power Device or Proxy shall support at least the following cipher suites when utilizing TLS 1.2 [n.10]:

- TLS_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256
- TLS_ECDHE_RSA_WITH_AES_128_GCM_SHA256

R2-DSQ-03 Cipher suites that offer equivalent or higher levels of protection as those cited in R2-DSQ-02 may also be supported and used.

R2-DSQ-04 All cipher suites supported in TLS 1.3 [n.11] or higher may also be supported and used.

7 AFC System General Requirements (AGR)

7.1 Device Registration

R1-AGR-01 An AFC System must [shall] verify the validity of the FCC identifier (FCC ID) of any Standard Power Device seeking access to its services prior to authorizing the Standard Power Device to begin operation. (15.407(k)(6))

a. A list of Standard Power Devices with valid FCC IDs and the FCC IDs of those devices must [shall] be obtained from the Commission's Equipment Authorization System.

R1-AGR-02 The AFC System shall register, authenticate and authorize Standard Power Device operations, individually or through a network element device [Proxy] representing multiple Standard Power Devices from the same operating network. (15.407(k)(7)(ii))

7.2 Determination of Available Frequencies and the Maximum Permissible Power

R0-AGR-01 An AFC System must [shall] be capable of determining the available frequencies in steps of no greater than 3 dB below the maximum permissible e.i.r.p of 36 dBm, and down to at least a minimum level of 21 dBm. (15.407(k)(2))

R1-AGR-03 An AFC System must [shall] use the information supplied by Standard Power Devices during registration to determine available frequencies and the maximum permissible power in each frequency range for a Standard Power Device at any given location using propagation models and interference protection criteria defined in 47 CFR 15.407(l). (15.407(k)(4), 15.407(k)(7)(iii), 15.407(l))

a. All such determinations and assignments must [shall] be made in a non-discriminatory manner.

R2-AGR-01 An AFC System shall use location uncertainty reported by a Standard Power Device to determine maximum acceptable power levels to protect fixed service receivers. ([n.3], Paragraph 41)

R2-AGR-02 The AFC System shall support one or more query methods specified in R2-DGR-02 for providing frequency availability to the Standard Power Devices.

R2-AGR-03 Available Frequencies and the Maximum Permissible Power:

a. The AFC System responding to the Standard Power Device using the method a in R2-DGR-02 shall identify the maximum allowed Power Spectral Density for each 1 MHz interval across the queried frequency range.

b. The AFC System responding to the Standard Power Device using the method b in R2-DGR-02 shall identify the maximum allowed e.i.r.p for each specified Channel bandwidth.

R3-AGR-01 Deprecated.

R3-AGR-02 Deprecated.

7.3 Storage of Information

R0-AGR-02 An AFC System shall obtain updated protected sites information from Commission databases. (15.407(k)(7)(iv))

R0-AGR-03 Each AFC System Operator designated by the Commission must [shall] maintain a regularly updated AFC System database, including incumbent's information and Standard Power Access Points and Fixed Client Devices registration parameters. (15.407(k)(15)(i))

R1-AGR-04 Storage of registered information (15.407(k)(5)):

a. An AFC System shall store Standard Power Device registration information in a secure database.

b. The stored registration information shall be available for more than three months after the Standard Power Devices last contacted with the AFC System.

7.4 Enforcement Instructions from the Commission

R1-AGR-05 AFC Systems shall have the capability to deny spectrum access to a particular Standard Power Device upon requests by the Commission, in the event of harmful interference caused by a particular device or type of device. ([n.3], Paragraph 83)

R1-AGR-06 Each AFC System Operator designated by the Commission must [shall] comply with enforcement instructions from the Commission, including discontinuance of Standard Power Device operations in designated geographic areas. (15.407(k)(15)(vi))

8 AFC System Security Requirements (ASQ)

8.1 Communication Security

R2-ASQ-01 An AFC System shall use the following protocols for the purpose of communications between itself and a Standard Power Device or Proxy: HTTP 1.1 [n.9] or higher and TLS 1.2 [n.10] or higher, or an alternative method of communication which provides a similar or higher level of security.

NOTE: Useful information related to this requirement is available in RFC-8996 [i.1], NIST Special Publication 800-52 Revision 2 [i.2], and RFC-7525 [i.3].

R2-ASQ-02 An AFC System shall support at least the following cypher suites when utilizing TLS 1.2 [n.10]:

- TLS_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256
- TLS_ECDHE_RSA_WITH_AES_128_GCM_SHA256

R2-ASQ-03 Cypher suites that offer equivalent or higher levels of protection as those cited in R2-ASQ-02 may also be supported and used.

R2-ASQ-04 All cipher suites supported in TLS 1.3 [n.11] or higher may also be supported and used.

9 AFC System Incumbent Protection (AIP)

9.1 Fixed Service Receiver Protection

R0-AIP-01 An AFC System must [shall] obtain information on protected services within the 5.925-6.425 GHz and 6.525-6.875 GHz bands from Commission databases and use that information to determine frequency availability for Standard Power Access Points and Fixed Client Devices based on protection criteria specified in R0-AIP-03 and R0-AIP-04. (15.407(k)(3))

NOTE: The ULS data element corresponding to fixed service parameters referred in this section can be found in Annex C.

R0-AIP-07 Based on the criteria set forth in R0-AIP-03 and R0-AIP-04, an AFC System must [shall] establish location and frequency-based exclusion zones (both co-channel and adjacent channel) around fixed microwave receivers operating in the 5.925-6.425 GHz and 6.525-6.875 GHz bands. (15.407(l))

R0-AIP-02 Propagation models to determine the appropriate separation distance between a Standard Power Access Point or a Fixed Client Device and an incumbent fixed microwave service receiver. For a separation distance:

a. Up to 30 meters, the AFC System must [shall] use the free space path-loss model. (15.407(l)(1)(i))

b. More than 30 meters and up to and including one kilometer, the AFC System must [shall] use the Wireless World Initiative New Radio phase II (WINNER II) model [n.4]. (15.407(l)(1)(ii))

   i. The AFC System must [shall] use site specific information, including buildings and terrain data, for determining the line-of-sight/non-line-of-sight path component in the WINNER II model [n.4], where such data is available.

   ii. For evaluating paths where such data is not available, the AFC System must [shall] use a probabilistic model combining the line-of-sight path and non-line-of-sight path into a single path-loss as follows:

   Path-loss (L) = $\sum_i P(i) * L_i = P_{LOS} * L_{LOS} + P_{NLOS} * L_{NLOS}$,

   where P_{LOS} is the probability of line-of-sight, L_{LOS} is the line-of-sight path loss, P_{NLOS} is the probability of non-line-of sight, L_{NLOS} is the non-line-of-sight path loss, and L is the combined path loss. The WINNER II path loss models include a formula to determine P_{LOS} as a function of antenna heights and distance. P_{NLOS} is equal to (1-P_{LOS}).

iii. In all cases, the AFC System will [shall] use the correct WINNER II parameters to match the morphology of the path between a Standard Power Access Point and a fixed microwave receiver (i.e., Urban, Suburban, or Rural).

c. More than one kilometer, the AFC System must [shall] use Irregular Terrain Model (ITM) [n.5] combined with the appropriate clutter model. (15.407(l)(1)(iii))

i. To account for the effects of clutter, such as buildings and foliage, that the AFC System must [shall] combine the ITM [n.5] with the ITU-R P.2108-0 (06/2017) [n.6] clutter model for urban and suburban environments and the ITU-R P.452-16 (07/2015) [n.7] clutter model for rural environments.

ii. The AFC System should use the most appropriate clutter category for the local morphology when using ITU-R P.452-16 [n.7].

iii. If detailed local information is not available, the "Village Centre" clutter category should be used.

iv. The AFC System must [shall] use 1 arc-second digital elevation terrain data and, for locations where such data is not available, the most granular available digital elevation terrain data.

R0-AIP-03 The AFC System must [shall] use -6 dB *I*/*N* as the interference protection criteria in determining the size of the co-channel exclusion zone where *I* (interference) is the co-channel signal from the Standard Power Access Point or Fixed Client Device at the fixed microwave service receiver, and *N* (noise) is background noise level at the fixed microwave service receiver (15.407(l)(2)(i))

R0-AIP-04 The AFC System must [shall] use -6 dB *I*/*N* as the interference protection criteria in determining the size of the adjacent channel exclusion zone, where *I* (interference) is the signal from the Standard Power Access Point or Fixed Client Device's out of channel emissions at the fixed microwave service receiver and *N* (noise) is background noise level at the fixed microwave service receiver. (15.407(l)(2)(ii))

a. The adjacent channel exclusion zone must [shall] be calculated based on the emissions requirements specified in 47 CFR 15.407(b)(7).

R2-AIP-01 AFC Systems shall protect temporary fixed links from harmful interference during the term defined by "start date" and "end date" in the ULS database. ([n.3], Paragraph 32, and [n.8])

R2-AIP-16 In determining frequency availability and maximum permissible power as per R2-AGR-03, the AFC System shall determine the maximum permissible power so that the following condition is met for protection of fixed service receivers and diversity receivers:

$$I/N_{Thres} \geq I/N_{Est}$$

$$= P_{SPD,\,Tx} - L_{Propagation} - L_{BEL} + G_{Rx,\,Effective} - N - L_{FS,\,Feeder}$$

where:

- I/N_{Thres} (dB): interference-to-noise ratio as the interference protection criteria as per R0-AIP-03 and R0-AIP-04
- I/N_{Est} (dB): estimated interference-to-noise ratio
- $P_{SPD,\ Tx}$ (dBm): the Standard Power Device transmission power across the frequency range I/N_{Est} calculations are performed.
- $L_{Propagation}$ (dB): propagation losses as per R0-AIP-02
- L_{BEL} (dB): the Building Entry Loss applicable to Standard Power Devices located indoors

  NOTE: The value to be applied is for further study (FFS).
- $G_{Rx,\ Effective}$ (dBi): the FS receiver effective antenna gain determined in the direction of the Standard Power Device (R2-AIP-05, R2-AIP-07, R2-AIP-08 and R2-AIP-09)
- N (dBm): the FS receiver noise level as per R2-AIP-02 scaled to the frequency range I/N_{Est} calculations are performed.
- $L_{FS,\ Feeder}$ (dB): the FS feeder loss as per R2-AIP-10

R2-AIP-02 Fixed Service Receiver Noise Level:

In determining the noise level N of a fixed service receiver, if the AFC System has the needed radio manufacturer data, technique b, technique c or technique d shall be used. Otherwise, technique a shall be used.

a. Use of the typical noise level N determined as follows:

$$N = \begin{cases} \text{-110.0 dBm/MHz (if } F_{c,\ FS} \leq 6425 \text{ MHz)} \\ \text{-109.5 dBm/MHz (if } F_{c,\ FS} > 6425 \text{ MHz)'} \end{cases}$$

where:

- $F_{c,\ FS}$: Center frequency of the FS receiver

NOTE: These noise levels are computed by the formula in c below with a noise figure value of 4 dB below or equal to 6425 MHz and 4.5 dB above 6425 MHz. These values are provided as default FS parameters in ITU-R F.758-7 [i.6]. See Table 7 of ITU-R F.758-7 [i.6] for more information.

b. Use of the noise level N (with proper consideration for the occupied bandwidth) specified by the manufacturer's specification for the given receiver model identified by the corresponding data element in the ULS.

NOTE: For example, if the receiver model is listed as "ACME XYZ" in ULS, an AFC System can use N available in the specification for XYZ receiver model published by the Acme receiver company.

c. Use of the noise level N determined by the following equation:

$$N = -114 \text{ dBm/MHz} + NF,$$

where:

- *NF*: Noise figure specified by the manufacturer's specification for the receiver model identified by the corresponding data element in the ULS

NOTE: –114 dBm/MHz equals 10 $\log_{10}$ ($k_B \cdot T_0$) + 10 $\log_{10}$ (10^6 Hz/MHz) + 10 $\log_{10}$ (10^3 mW/W), where k_B is Boltzmann's constant of $1.38064852 \times 10^{-23}$ $m^2 \cdot kg \cdot s^{-2} \cdot K^{-1}$ and T_0 is the standard reference temperature of 290 K.

d. Use of the noise level *N* determined by the following equation:

$$N \text{ (dBm/MHz)} = T \text{ (dBm)} - T/I \text{ (dB)} - 10 \log_{10}[BW_{FS} \text{ (MHz)}] + 6 \text{ dB},$$

where:

- BW_{FS}: Channel bandwidth of the FS receiver
- *T*: Threshold for 10^{-6} bit error rate (BER) for the channel bandwidth BW_{FS}
- *T*/*I*: Threshold-to-Interference (*T*/*I*) specified by the manufacturer's specification for the given receiver model identified by the corresponding data element in the ULS.

NOTE: The *T*/*I* specification is defined to apply for 10^{-6} BER in TIA-10, 2019 Edition [i.5].

R2-AIP-03 When calculating an adjacent channel exclusion zone in accordance with R0-AIP-04-a, the AFC system following R2-AGR-03-b shall take into account out of channel emission limits (specified in 47 CFR 15.407(b)(7)) up to one and a half times the device's channel bandwidth away from its channel center, where the device's Channel bandwidth refers to Channel bandwidth provided by the device using the methods b in R2-DGR-02.

R2-AIP-04 WINNER II Parameters:

When the AFC System employs the WINNER II model:

a. For urban, suburban, and rural morphologies, scenarios C2 (Typical urban macro-cell), C1 (Suburban), and D1 (Rural macro-cell) of WINNER II model as defined in Table 4-4 of IST-4-027756 [n.4] shall respectively be used.

b. For propagation loss calculations between 30 meters and 50 meters distances, only LOS component of the model shall be used, i.e., Path-loss (L) = L_{LOS}.

R2-AIP-05 Fixed Service Receiver Antenna Gain, Diameter and Aperture Efficiency:

In determining a fixed service receiver antenna gain G_{Rx} (dBi), diameter D_{Rx} (m) and aperture efficiency η_{Rx} for *I*/*N* estimation in R2-AIP-16, the AFC System shall use one of the following methods in order of precedence:

a. If the receiver antenna gain $G_{Rx, ULS}$ (dBi), receive antenna model, receive antenna make and operating frequency band $F_{Rx, ULS}$ (MHz) are available in the ULS, the AFC System

shall determine G_{Rx} (dBi), D_{Rx} (m) and η_{Rx} by using $G_{Rx,\ ULS}$ (dBi), receive antenna model, receive antenna make and $F_{Rx,\ ULS}$ (MHz) in the method specified by R2-AIP-06.

b. If $G_{Rx,\ ULS}$ (dBi), and $F_{Rx,\ ULS}$ (MHz) are available in the ULS and receive or passive end antenna model is not available, but the antenna model of the transmitter of the same segment is available in the ULS and $G_{Rx,\ ULS}$ (dBi) is equal to the transmit antenna gain $G_{Tx,\ ULS}$ (dBi), the AFC System shall determine G_{Rx} (dBi), D_{Rx} (m) and η_{Rx} by using $G_{Rx,\ ULS}$ (dBi), transmit antenna model, transmit antenna make, and $F_{Rx,\ ULS}$ (MHz) in the method specified by R2-AIP-06.

c. If $G_{Rx,\ ULS}$ (dBi) and $F_{Rx,\ ULS}$ (MHz) are available in the ULS, receive or passive antenna model and make are not available, but the return path's segment is known and the transmitter antenna gain for that return path segment, $G_{Tx,\ ULS}$ (dBi), transmit antenna model, transmit antenna make of the return path are available in the ULS and $G_{Rx,\ ULS}$ (dBi) is equal to $G_{Tx,\ ULS}$ (dBi), the AFC System shall determine G_{Rx} (dBi), D_{Rx} (m) and η_{Rx} by using $G_{Tx,\ ULS}$ (dBi), return path segment transmit antenna model, return path segment transmit antenna make and $F_{Rx,\ ULS}$ (MHz) in the method specified by R2-AIP-06.

NOTE: A return path is available in the ULS if the same licensee has a path within the same frequency band with transmit and receive location coordinates that match the receive and transmit location coordinates respectively.

d. If $G_{Rx,\ ULS}$ (dBi) and $F_{Rx,\ ULS}$ (MHz) are available in the ULS but the methods in a-to-c above are not applicable, the AFC System shall determine G_{Rx} (dBi), D_{Rx} (m) and η_{Rx} by using the following formula:

$$G_{Rx} = \begin{cases} 32 \text{ dBi} & \text{for } G_{Rx,\ ULS} < 32 \text{ dBi} \\ G_{Rx,\ ULS} \text{ dBi} & \text{for } 32 \le G_{Rx,\ ULS} \le 48 \text{ dBi} \\ 48 \text{ dBi} & \text{Otherwise} \end{cases}$$

$$D_{Rx} = \frac{c}{\pi \cdot F_{c,\ FS}} \cdot \sqrt{\frac{10^{G_{Rx}/10}}{\eta_{Rx}}} \text{ (m)}$$

- c: The speed of light (= 299,792,458 m/s)
- $F_{c,\ FS} := \begin{cases} 6{,}175{,}000{,}000 \text{ Hz (if } F_{Rx,\ ULS} \text{ is within the U-NII-5 band)} \\ 6{,}700{,}000{,}000 \text{ Hz (if } F_{Rx,\ ULS} \text{ is within the U-NII-7 band)} \end{cases}$
- η_{Rx}: 55% typical antenna aperture efficiency (0.55)

e. If $G_{Rx,\ ULS}$ (dBi) is not available in the ULS, the AFC System shall determine G_{Rx} (dBi), D_{Rx} (m) and η_{Rx} as follows:

$$G_{Rx}\,(\text{dBi}) = \begin{cases} 38.8\ \text{dBi (if } F_{Rx,\,ULS} \text{ is within the U-NII-5 band)} \\ 39.5\ \text{dBi (if } F_{Rx,\,ULS} \text{ is within the U-NII-7 band)} \end{cases}$$

$$D_{Rx}\,(\text{m}) = 1.83 \text{ meters (= 6 feet)}$$

$$\eta_{Rx} = 0.55$$

R2-AIP-06 Determination of Fixed Service Receiver Antenna Gain, Diameter and Aperture Efficiency using ULS information:

In the methods a-to-c in R2-AIP-05, the AFC System shall determine the fixed service receiver antenna gain G_{Rx} (dBi), D_{Rx} (m) and η_{Rx} as follows:

- D_{Rx} (m):= Antenna diameter specified for the antenna model (depending on which method is selected in R2-AIP-05)
- $G_{Rx}\,(\text{dBi}) := \begin{cases} G_{ULS} & \text{if } G_{Typical} - 0.7 \le G_{ULS} \le G_{Typical} + 0.7 \\ G_{Common} & \text{else if } G_{Typical} - 0.7 \le G_{Common} \le G_{Typical} + 0.7 \\ G_{MB} & \text{else if } G_{MB} \text{ is available} \\ G_{Typical} & \text{otherwise} \end{cases}$

$$\eta_{Rx} = \begin{cases} 10^{0.1(G_{Rx} - 25.90 - 20\log_{10}(D_{Rx}))} & (\text{if } F_{Rx,\,ULS} \text{ is within U-NII-5 and } G_{Rx} \neq G_{Typical}) \\ 10^{0.1(G_{Rx} - 26.61 - 20\log_{10}(D_{Rx}))} & (\text{if } F_{Rx,\,ULS} \text{ is within U-NII-7 and } G_{Rx} \neq G_{Typical}) \\ 0.55 & (\text{if } G_{Rx} = G_{Typical}) \end{cases}$$

where:

G_{ULS} (dBi): $G_{Rx,\,ULS}$ or $G_{Tx,\,ULS}$, depending on which method is selected in R2-AIP-05

G_{Common} (dBi): The most common antenna gain for the antenna model (depending on which method is selected in R2-AIP-05)

G_{MB} (dBi): The mid-band antenna gain from the specifications of receive antenna model produced by receive antenna make, depending on which method is selected in R2-AIP-05.

$G_{Typical}$ (dBi): The typical antenna gain for an antenna of diameter D_{Rx} (m), determined by using the following formula:

$$G_{Typical} = 10\log_{10}\left[\eta_{Rx}\cdot\left(\frac{\pi\cdot F_{c,\,FS}\cdot D_{Rx}}{c}\right)^2\right]\ (\text{dBi})$$

- c: The speed of light (= 299,792,458 m/s)
- $F_{c,\,FS}$: $= \begin{cases} 6{,}175{,}000{,}000\ \text{Hz (if } F_{Rx,\,ULS} \text{ is within the U-NII-5 band)} \\ 6{,}700{,}000{,}000\ \text{Hz (if } F_{Rx,\,ULS} \text{ is within the U-NII-7 band)} \end{cases}$

- D_{Rx}: Antenna diameter specified for the antenna model (depending on which method is selected in R2-AIP-05)

R2-AIP-13 Use of Supplementary Data Repository:

The AFC System shall obtain the following data from the Supplementary Data Repository [n.17].

- Category B1 Antenna data (if supporting the procedure specified in R2-AIP-07-b)
- High Performance Antenna data (if supporting the procedure specified in R2-AIP-07-b)
- Indoor Radio Unit data (see R2-AIP-10)

R2-AIP-07 Fixed Service Receiver and Diversity Receiver Antenna Radiation Pattern Envelope:

a. For the purpose of fixed service receiver protection, the AFC System shall use the FS antenna radiation pattern envelope (RPE).

b. The AFC System shall support at least one of the following methods to determine the FS antenna RPE:

- To use RPE provided by the manufacturer.
- To follow the following procedures:
    - For primary receive antennas with $G_{Rx} < 38$ dBi:
        - Use the formulas in ITU-R F.699-8 [n.15] by using D_{Rx} and G_{Rx} determined in accordance with R2-AIP-05 if $|\theta_{Disc}| < 5$ degrees.
        - Use the minimum radiation suppression in Table 2 for the $F_{Rx,\ ULS}$ (MHz) and Category B2 if $|\theta_{Disc}| \geq 5$ degrees.
    - For primary receive antennas with $G_{Rx} \geq 38$ dBi:
        - Use the formulas in ITU-R F.699-8 [n.15] by using D_{Rx} and G_{Rx} determined in accordance with R2-AIP-05 if $|\theta_{Disc}| < 5$ degrees.
        - If $|\theta_{Disc}| \geq 5$ degrees:
            - Use the minimum radiation suppression in Table 2 for the $F_{Rx,\ ULS}$ (MHz) and Category B1 if antenna model is blank in the ULS or is known to be a Category B1 antenna.
            - Use the greater discrimination value of:
                - the minimum radiation suppression in Table 2 for the $F_{Rx,ULS}$ (MHz) and Category A and

- G_{Rx} - $G_{Rx}(\theta_{Disc})$, where $G_{Rx}(\theta_{Disc})$ is determined using the formulas in ITU-R F.699-8 [n.15] by using D_{Rx} and G_{Rx} determined in accordance with R2-AIP-05 and $F_{Rx,\ ULS}$

  if antenna model is known to be a high-performance antenna.

- Use the minimum radiation suppression in Table 2 for the $F_{Rx,\ ULS}$ (MHz) and Category A otherwise.

- For diversity receive antennas with $G_{DRx} < 38$ dBi:
  - Use the formulas in ITU-R F.699-8 [n.15] by using D_{DRx} and G_{DRx} determined in accordance with R2-AIP-08 if $|\theta_{DDisc}| < 5$ degrees.
  - Use the minimum radiation suppression in Table 2 for the $F_{Rx,\ ULS}$ (MHz) and Category B1 if $|\theta_{DDisc}| \geq 5$ degrees.
- For diversity receive antennas with $G_{DRx} \geq 38$ dBi:
  - Use the formulas in ITU-R F.699-8 [n.15] by using D_{DRx} and G_{DRx} determined in accordance with R2-AIP-08 if $|\theta_{DDisc}| < 5$ degrees.
  - If $|\theta_{DDisc}| \geq 5$ degrees:
    - Use the minimum radiation suppression in Table 2 for the $F_{Rx,\ ULS}$ (MHz) and Category B1 if antenna model is blank in the ULS or is known to be a Category B1 antenna.
    - Use the greater discrimination value of
      - the minimum radiation suppression in Table 2 for the $F_{Rx,ULS}$ (MHz) and Category A and
      - G_{DRx} - $G_{DRx}(\theta_{DDisc})$, where $G_{DRx}(\theta_{DDisc})$ is determined using the formulas in ITU-R F.699-8 [n.15] by using D_{DRx} and G_{DRx} as specified in R2-AIP-08 and $F_{Rx,\ ULS}$

      if antenna model is known to be a high-performance antenna.
    - Use the minimum radiation suppression in Table 2 for the $F_{Rx,\ ULS}$ (MHz) and Category A otherwise.

Table 2: Minimum radiation suppression defined in FCC Rules Part 101.115 [n.16]

Frequency (MHz)	Category	Maximum beamwidth to 3 dB point (included angle in degrees)	Minimum antenna gain (dBi)	Minimum radiation suppression to angle in degrees from centerline of main beam in decibels						
				5° to 10°	10° to 15°	15° to 20°	20° to 30°	30° to 100°	100° to 140°	140° to 180°
5,925 to 6,425	A	2.2	38	25	29	33	36	42	55	55
	B1	2.2	38	21	25	29	32	35	39	45
	B2	4.1	32	15	20	23	28	29	60	60
6,525 to 6,875	A	2.2	38	25	29	33	36	42	55	55
	B1	2.2	38	21	25	29	32	35	39	45
	B2	4.1	32	15	20	23	28	29	60	60

R2-AIP-08 Fixed Service Diversity Receive Antenna Gain and Diameter:

In determining a fixed service diversity receive antenna gain G_{DRx} (dBi) and diameter D_{DRx} (m), the AFC System shall use one of the following methods in order of precedence:

a. If the receive antenna gain $G_{Rx, ULS}$ (dBi), receive antenna model, receive antenna make are available as determined in R2-AIP-05, and diversity receiver antenna gain $G_{DRx, ULS}$ (dBi), operating frequency band $F_{Rx, ULS}$ (MHz) are available in the ULS, and $G_{Rx, ULS}$ (dBi) = $G_{DRx, ULS}$ (dBi), the AFC System shall determine G_{DRx} (dBi) and D_{DRx} (m) by using $G_{Rx, ULS}$ (dBi), receive antenna model, receive antenna make and $F_{Rx, ULS}$ (MHz) in the method specified by R2-AIP-05.

b. If $G_{DRx, ULS}$ (dBi) and $F_{Rx, ULS}$ (MHz) are available in the ULS but the method a above is not applicable, the AFC System shall determine G_{DRx} (dBi) and D_{DRx} (m) by using the following formula:

$$G_{DRx} = \begin{cases} G_{DRx, ULS} \text{ dBi} & \text{for } 28 \le G_{Rx, ULS} \le 48 \text{ dBi} \\ G_{Rx, ULS} \text{ dBi} & \text{Otherwise} \end{cases}$$

$$D_{DRx} = \frac{c}{\pi \cdot F_{c, FS}} \cdot \sqrt{\frac{10^{G_{DRx}/10}}{\eta_{Rx}}} \ (m)$$

- c: The speed of light (= 299,792,458 m/s)
- $F_{c, FS} := \begin{cases} 6{,}175{,}000{,}000 \text{ Hz (if } F_{Rx, ULS} \text{ is within the U-NII-5 band)} \\ 6{,}700{,}000{,}000 \text{ Hz (if } F_{Rx, ULS} \text{ is within the U-NII-7 band)} \end{cases}$

- η_{Rx}: 55% typical antenna efficiency (0.55)

R2-AIP-09 Use of Fixed Service Receiver Effective Antenna Gain:

a. In R2-AIP-16, the AFC System shall use the effective antenna gain $G_{Rx,\ Effective}$ (in dBi) calculated by using the following equations:

$$G_{Rx,\ Effective} = G_0 + G_{Disc}$$

where:

- G_0: the boresight gain of the fixed service receiver antenna in dBi,

$$G_0 = \begin{cases} G_{Rx} & \text{for primary receive antenna} \\ G_{DRx} & \text{for diversity receive antenna} \end{cases}$$

- G_{Disc} (≤ 0): the effective discrimination of the antenna RPE in dB

$$G_{Disc} = G_{Rx,\ RPE}(\theta_{Disc})$$

b. Instead of the effective antenna gain $G_{Rx,\ Effective}$ (in dBi) above, the AFC System may use the effective antenna gain considering polarization mismatch $G_{Rx,\ Eff\text{-}PolMismatch}$ (in dBi) calculated by using the following equations:

$$G_{Rx,\ Eff\text{-}PolMismatch} = G_0 + G_{Disc} - 3\ \text{dB}$$

where:

- G_{Disc} (≤ 0): the effective discrimination of the antenna RPE in dB,

$$G_{Disc} = \begin{cases} G_{Rx,\ RPE}(\theta_{Disc}) & \text{for default RPE} \\ G_{Rx,\ C\text{-}RPE}(\theta_{Disc}) & \text{for actual RPE without cross-polarization data} \\ 10\log_{10}\left(10^{0.1G_{CDisc}} + 10^{0.1G_{XDisc}}\right) & \text{for actual RPE with cross-polarization data} \end{cases}$$

- $G_{Rx,\ C\text{-}RPE}(\theta)$: the co-polarization RPE of the fixed service receiver antenna
- G_{CDisc} (≤ 0): the effective antenna discrimination of the fixed service receiver co-polarization RPE in dB.
- G_{XDisc} (≤ 0): the effective antenna discrimination of the fixed service receiver cross-polarization RPE in dB.

NOTE 1: -3 dB is the polarization mismatch factor.

NOTE 2: Actual RPE and default RPE refer to RPEs determined by using the Method A and Method B in R2-AIP-07, respectively.

i. For actual RPE with cross-polarization data, the AFC System shall set G_{CDisc} and G_{XDisc} as follows:

- For vertically-polarized receive antenna (i.e., “V”):

$$G_{CDisc} = G_{Rx,\ VV\text{-}RPE}(\theta_{Disc})$$

$$G_{XDisc} = G_{Rx,\ VH\text{-}RPE}(\theta_{Disc})$$

- For horizontally-polarized receive antenna (i.e., "H"):

$$G_{CDisc} = G_{Rx,\ HH\text{-}RPE}(\theta_{Disc})$$

$$G_{XDisc} = G_{Rx,\ VH\text{-}RPE}(\theta_{Disc})$$

- For other cases (i.e., "S", blank or anything else):

$$G_{CDisc} = \begin{cases} \max\left[G_{Rx,\ HH\text{-}RPE}(\theta_{Disc}),\ G_{Rx,\ VV\text{-}RPE}(\theta_{Disc})\right] & \text{if } G_{Rx,\ HH\text{-}RPE}(\theta) \text{ and } G_{Rx,\ HH\text{-}RPE}(\theta) \text{ are available} \\ G_{Rx,\ HH\text{-}RPE}(\theta_{Disc}) & \text{if only } G_{Rx,\ HH\text{-}RPE}(\theta) \text{ is available} \\ G_{Rx,\ VV\text{-}RPE}(\theta_{Disc}) & \text{if only } G_{Rx,\ VV\text{-}RPE}(\theta) \text{ is available} \end{cases}$$

$$G_{XDisc} = \begin{cases} \max\left[G_{Rx,\ HV\text{-}RPE}(\theta_{Disc}),\ G_{Rx,\ VH\text{-}RPE}(\theta_{Disc})\right] & \text{if } G_{Rx,\ HV\text{-}RPE}(\theta) \text{ and } G_{Rx,\ VH\text{-}RPE}(\theta) \text{ are available} \\ G_{Rx,\ VH\text{-}RPE}(\theta_{Disc}) & \text{if only } G_{Rx,\ VH\text{-}RPE}(\theta) \text{ is available} \\ G_{Rx,\ HV\text{-}RPE}(\theta_{Disc}) & \text{if only } G_{Rx,\ HV\text{-}RPE}(\theta) \text{ is available} \end{cases}$$

where:

- $G_{Rx,\ HH\text{-}RPE}(\theta)$: HH RPE of the fixed service receiver antenna
- $G_{Rx,\ VV\text{-}RPE}(\theta)$: VV RPE of the fixed service receiver antenna
- $G_{Rx,\ HV\text{-}RPE}(\theta)$: HV RPE of the fixed service receiver antenna
- $G_{Rx,\ VH\text{-}RPE}(\theta)$: VH RPE of the fixed service receiver antenna

c. In R2-AIP-09-b, if the fixed service antenna receive polarization is not available but the transmit polarization is available in the ULS, the AFC System shall assume that the receive polarization is the same as the transmit polarization specified in the ULS.

R2-AIP-10 Feeder Loss:

a. In R2-AIP-16, the AFC System shall use the fixed service receiver feeder loss, $L_{FS,\ Feeder}$, determined by using one of the following methods in order of precedence:

i. The feeder loss as provided in the ULS, if it is not null.

ii. A feeder loss of 3 dB shall be used if the radio make and model is available in the ULS and it is known to be a common indoor radio unit.

NOTE These fallback feeder loss values are computed by calculating the average feeder/multiplexer loss values provided in ITU-R F.758-7 [i.6]. See Table 7 of ITU-R F.758-7 [i.6] for more information.

iii. A feeder loss of 0 dB.

R2-AIP-24 Use of National Land Cover Database (NLCD):

For R2-AIP-11 and R2-AIP-12, the AFC System shall employ the National Land Cover Database (NLCD) data[1] [n.18].

R2-AIP-11 WINNER II Morphology:

[1] Suggested baseline versions of NLCD data are NLCD 2019 Land Cover (CONUS), NLCD 2016 Land Cover (ALASKA), NLCD 2001 Land Cover (HAWAII) and NLCD 2001 Land Cover (PUERTO RICO).

The AFC System shall determine morphology for the WINNER II model based on the corresponding NLCD code at the location of Standard Power Device as following:

- Code 23 or 24: Urban
- Code 21 or 22: Suburban
- Else: Rural

R2-AIP-12 Clutter Morphology for ITM:

a. The AFC System shall determine the morphology for the clutter model using the corresponding NLCD code at the location of application (Standard Power Device or FS receiver locations). The following classification shall be used:
   - Code 23 or 24: Urban (use ITU-R P.2108)
   - Code 21 or 22: Suburban (use ITU-R P.2108)
   - Else: Rural (use ITU-R P.452)

b. When using P.452 for rural regions, the following model types shall be used:
   - Code 11, 12, 31, 51, 71, 72, 73, 74, 81, 95: No clutter loss is added.
   - Code 52, 82: High Crop fields (use ITU-R P.452-16 Table 4, Row 1)
   - Code 41, 43, or 90: Deciduous trees (use ITU-R P.452-16 Table 4, Row 3)
   - Code 42: Coniferous (use ITU-R P.452-16 Table 4, Row 4)
   - Else: Village Center (use ITU-R P.452-16 Table 4, Row 2)

   NOTE: This requirement is mandatory WInnForum requirement which overrides the optionality provided by R0-AIP-02-c-ii and the recommendation provided by R0-AIP-02-c-iii.

R2-AIP-14 Fixed Service Receive Antenna Height:

In determining a fixed service receive antenna height $H_{FS,Rx}$ (m), the AFC System shall use one of the following methods in order of precedence:

a. The receive antenna height as provided in ULS, if it is not blank.

b. If the return path's segment is known, the return path's transmit antenna height, if it is not blank.

   NOTE: A return path is available in the ULS if the same licensee has a path within the same frequency band with transmit and receive location coordinates that match the receive and transmit location coordinates respectively.

c. A receive antenna height of 42.5 meters.

R2-AIP-15 Fixed Service Diversity Antenna Height:

In determining a fixed service diversity antenna height $H_{FS,DRx}$ (m) in cases where it is determined that a diversity receiver is in use, the AFC System shall use one of the following methods in order of precedence:

a. The diversity antenna height as provided in ULS, if it is not blank.

b. The following formula:

$$H_{\text{FS, DRx}} = \begin{cases} H_{\text{FS, Rx}} + 11 \text{ (m)} & \text{for } H_{\text{FS, Rx}} < 14 \text{ m} \\ H_{\text{FS, Rx}} - 11 \text{ (m)} & \text{for } H_{\text{FS, Rx}} \geq 14 \text{ m} \end{cases}$$

R2-AIP-17 Near Field Adjustment of the Fixed Service Receiver Antenna RPE:

a. When determining the maximum permissible power at the evaluation point as per R2-AIP-16, the AFC System shall perform near field adjustment to the fixed service antenna RPE as per the item b of this requirement if the following inequalities are met.

$$\begin{cases} d_{\text{FSRx-Eval}} < d_{\text{Limit}} \\ -90 \text{ (deg)} < \varphi_{\text{FSRx-Eval}} < 90 \text{ (deg)} \end{cases}$$

where:

- $d_{\text{FSRx-Eval}}$: Distance (in meters) between the FS receiver antenna and the evaluation point (see R2-AIP-22)
- d_{Limit}: Near field distance limit (in meters) computed by the following formula:

$$d_{\text{Limit}} = \frac{0.185806 \cdot F_{\text{c, FS}} \cdot D_{\text{Rx, NFA}}^2}{c}$$

- $\varphi_{\text{FSRx-Eval}}$: Off-axis angle (in degrees) in a direction from the FS receiver antenna towards the evaluation point (see R2-AIP-22)
- $D_{\text{Rx, NFA}}$: Antenna diameter (in feet) used for near field adjustment. See the item i below.

i. $D_{\text{Rx, NFA}}$ shall be determined by using one of the following methods in order of precedence:

- Set $D_{\text{Rx, NFA}}$ to the antenna diameter specified for the receive antenna make and the receive antenna model.
- Determine $D_{\text{Rx, NFA}}$ by using the ULS antenna gain data $G_{\text{Rx, ULS}}$ according to Table 4 (if $F_{\text{Rx, ULS}}$ is 5,925 – 6,425 MHz band) or Table 5 (if $F_{\text{Rx, ULS}}$ is 6,525 – 6,875 MHz band).
- Set $D_{\text{Rx, NFA}}$ to 6 feet.

Table 3: U-NII-5 Antenna Size versus Gain

Range of ULS Antenna Gain Data $G_{\text{Rx, ULS}}$ [dBi]		**Antenna Diameter for Near Field Adjustment $D_{\text{Rx, NFA}}$ [ft]**
Min	**Max**	
32.0	34.3	3
34.4	37.5	4
37.6	40.3	6
40.4	42.5	8
42.6	44.5	10

44.6	46.1	12
46.2	48.0	15

Table 4: U-NII-7 Antenna Size versus Gain

Range of ULS Antenna Gain Data $G_{Rx,\ ULS}$ [dBi]		**Antenna Diameter for Near Field Adjustment $D_{Rx,\ NFA}$ [ft]**
Min	**Max**	
32.0	34.5	3
34.6	37.6	4
37.7	40.5	6
40.6	42.7	8
42.8	44.5	10
44.6	46.2	12
46.3	48.0	15

b. The near field adjustment shall be performed by adding the near field adjustment factor to the FS antenna RPE, where the near field adjustment factor is computed by linear interpolation of the data in the Appendix[2] using the normalized separation distance x_{dB} in dB, fixed service antenna discrimination parameter, u, and the antenna aperture efficiency $\eta_{Rx,\ NFA}$.

i. The normalized separation distance x_{dB} in dB shall be computed as follows:

$$x_{dB} = 10\log_{10}\left(\frac{c \cdot d_{FSRx\text{-}Eval}}{2F_{c,\ FS} \cdot D_{Rx,\ NFA}^2}\right) + 10.32$$

ii. The FS antenna discrimination parameter u shall be computed as follows:

$$u = \frac{0.3048 \cdot F_{c,\ FS} \cdot D_{Rx,\ NFA}}{c} \sin\varphi_{FSRx\text{-}Eval}$$

iii. The antenna aperture efficiency $\eta_{Rx,\ NFA}$ for near field adjustment shall be determined as follows:

$$\begin{cases} 0.4 & \text{if } \eta_{Rx,\ NFA} < 0.4 \\ 0.7 & \text{if } \eta_{Rx,\ NFA} > 0.7 \\ \eta_{Rx,\ NFA} & \text{otherwise} \end{cases}$$

where:

- $\eta_{Rx,\ NFA} := 10^{\frac{\eta_{Rx,NFA\ (dB)}}{10}}$
- $\eta_{Rx,\ NFA(dB)}$: If the ULS antenna gain data $G_{Rx,\ ULS}$ is more than 0.3 dB outside the range from Table 3 or Table 4 for the antenna diameter $D_{Rx,\ NFA}$ determined as per the first method of the R2-AIP-17-a-i, or if the ULS antenna gain data $G_{Rx,\ ULS}$ is not available or if the diameter $D_{Rx,\ NFA}$ is determined as 6 feet as per

[2] The Appendix is available at https://6ghz.wirelessinnovation.org/work-group-products. See also Annex E (Informative): for the information about the Appendix.

the third method of the R2-AIP-17-a-i, the value is set to -2.6 dB. Otherwise, the value is set according to the following formula:

$$\eta_{\text{Rx, NFA (dB)}} = \begin{cases} G_{\text{dBi}} - 25.90 - 20\log_{10}(D_{\text{Rx, NFA}}) & (\text{if } F_{\text{Rx, ULS}} \text{ is within 5,925 – 6,425 MHz}) \\ G_{\text{dBi}} - 26.61 - 20\log_{10}(D_{\text{Rx, NFA}}) & (\text{if } F_{\text{Rx, ULS}} \text{ is within 6,525 – 6,875 MHz}) \end{cases}$$

where:

- G_{dBi}: the antenna gain

NOTE: The theoretical dBi gain of a 100 % efficient dish antenna is 25.90 + 20 $\log_{10}$ (D) at 6.175 GHz and is 26.61 + 20 $\log_{10}$ (D) at 6.700 GHz, and these values can be used in the computation of actual antenna efficiency.

R2-AIP-19 Reserved

R2-AIP-22 Use of Location Uncertainty in Fixed Service Receiver Protection:

a. The AFC System shall determine the available frequencies and maximum radiated PSD per frequency or maximum allowed e.i.r.p. for each specified channel bandwidth consistent with the most restrictive radiated PSD or e.i.r.p. for each point and frequency or channel evaluated within the uncertainty volume.

b. The evaluation points within this uncertainty volume shall be determined based on a grid superimposed on the Standard Power Device's horizontal area of location uncertainty as reported in the request, along with the height and associated vertical uncertainty, sampled at intervals no greater than 1 arc second of latitude and longitude and no greater than 5 meters of elevation.

c. The minimum and maximum Standard Power Device heights (i.e., reported height +/- vertical uncertainty) shall always be included in the range covered by the set of evaluation points, where the minimum height is equal to or greater than 1 meters.

d. The morphology shall be determined as per R2-AIP-11 and R2-AIP-12 at each evaluation point within the horizontal area of location uncertainty

R3-AIP-01 Deprecated.

9.2 Radio Astronomy Service Protection

R0-AIP-05 Protection of radio observatories:

a. The AFC System must [shall] enforce an exclusion zones to the following radio observatories that observe between 6650-6675.2 MHz:

- Arecibo Observatory,
- the Green Bank Observatory,
- the Very Large Array (VLA),
- the 10 Stations of the Very Long Baseline Array (VLBA),

- the Owens Valley Radio Observatory, and
- the Allen Telescope Array.

b. The exclusion zone sizes are [shall be] based on the radio line-of-sight and determined using 4/3 earth curvature and the following formula:

dkm_los = 4.12 * (sqrt(Htx) + sqrt(Hrx)),

where Htx is the height of the unlicensed Standard Power Access Point or Fixed Client Device and Hrx is the height of the radio astronomy antenna in meters above ground level. (15.407(m))

R1-AIP-01 Radio Astronomy Service protection:

For protection of radio astronomy facilities listed in R0-AIP-05-a, the following reference coordinates and receiver antenna heights above ground level (AGL) shall be used.

Table 5: Reference coordinates and receiver heights above ground level (AGL)

Observatory	North latitude	West longitude	AGL (in meters)
Arecibo Observatory, PR	18° 20′ 37″	66° 45′ 11″	142.2
Green Bank Telescope (GBT), WV	38° 25′ 59″	79° 50′ 23″	139.6
Very Large Array (VLA), Socorro, NM	34° 04′ 44″	107° 37′ 06″	25
Very Long Baseline Array (VLBA) Stations:			
Brewster, WA	48° 07′ 52″	119° 41′ 00″	25
Fort Davis, TX	30° 38′ 06″	103° 56′ 41″	25
Hancock, NH	42° 56′ 01″	71° 59′ 12″	25
Kitt Peak, AZ	31° 57′ 23″	111° 36′ 45″	25
Los Alamos, NM	35° 46′ 30″	106° 14′ 44″	25
Mauna Kea, HI	19° 48′ 05″	155° 27′ 20″	25
North Liberty, IA	41° 46′ 17″	91° 34′ 27″	25
Owens Valley, CA	37° 13′ 54″	118° 16′ 37″	25
Pie Town, NM	34° 18′ 04″	108° 07′ 09″	25
St. Croix, VI	17° 45′ 24″	64° 35′ 01″	25
Allen Telescope Array	40° 49' 03"	121° 28' 24"	6.1
Owens Valley Radio Observatory	37° 14' 02"	118° 16' 56"	40

R2-AIP-20 Use of Vertical Location Uncertainty in Radio Astronomy Service Protection:

In determining the size of the exclusion zone using the formula in R0-AIP-05-b, the AFC System shall use the following value of Htx.

$$Htx = H_{SPD} + \Delta H_{SPD}$$

where:

- H_{SPD}: the height above ground level reported by the Standard Power Device (in meters)
- ΔH_{SPD}: the vertical uncertainty reported by the Standard Power Device (in meters)

R2-AIP-21 Frequency Availability Determination using Horizontal Location Uncertainty in Radio Astronomy Service Protection:

The AFC System shall determine that 6650 – 6675.2 MHz frequency range is unavailable for the Standard Power Device if the horizontal area of location uncertainty reported by the Standard Power Device overlaps with at least one of the exclusion zones determined as per R0-AIP-05, R1-AIP-01 and R2-AIP-20.

9.3 International Border Protection

R0-AIP-06 An AFC System must [shall] implement the terms of international agreements with Mexico and Canada. (15.407(k)(14))

Annex A (Normative): 3GPP Specific Features (Optional)

A.1 Description

This annex provides requirements for 3GPP specific features. In this section, unless otherwise specified, Standard Power Devices refer to those employing 3GPP based radio access technology for operations in the 6 GHz band.

A.1.1 NRU1: 3GPP-defined 6 GHz Channel

An NRU1 feature enables an AFC System and a Standard Power Devices employing the frequency availability query method specified in R2-DGR-02-b and R2-AGR-03-b to support 3GPP-defined 6 GHz Channels (e.g., Channels within the 3GPP-defined n96 band [n.12][n.13]).

The support of this feature is optional for AFC System and Standard Power Devices.

A.2 Use for Operations that could impact Part 15 Subpart E Regulatory Compliance

Requirements for the NRU1 feature in this section need to be considered in the protection of fixed service receivers and radio astronomy service facilities in accordance with the technology neutral requirements specified in the main body of this technical specification.

A.2.1 AFC System General Requirements (AGR)

R2-NRU1-AGR-01 The AFC System shall support the query method specified in R2-DGR-02-b

R2-NRU1-AGR-02 Support of 3GPP-defined 6 GHz channelization [n.12][n.13]:
When an AFC System determines and provides a list of Available Channels and the associated maximum power levels in accordance with R2-AGR-03-b, for a Standard Power Device request based on R2-NRU1-DGR-02, each Channel in the list shall be aligned with 3GPP-defined 6 GHz channelization.

R3-NRU1-AGR-01 Deprecated (Converted into R2-NRU1-AGR-02).

A.2.2 Device General Requirements (DGR)

R2-NRU1-DGR-01 The Standard Power Device shall support the query method specified in R2-DGR-02-b

R2-NRU1-DGR-02 Support of 3GPP-defined 6 GHz channelization [n.12][n.13]:
A Standard Power Device using the method in R2-DGR-02-b shall be able to request from an AFC System that each Channel in the list of Available Channels be aligned with 3GPP-defined 6 GHz channelization.

R3-NRU1-DGR-01 Deprecated (Converted into R2-NRU1-DGR-02).

A.3 Use for Operations not impacting Part 15 Subpart E Regulatory Compliance

Not applicable for this version of this document.

Annex B (Normative): IEEE 802.11ax Specific Features (Optional)

B.1 Feature Description

This annex provides requirements for the support of IEEE 802.11ax specific features [i.4].

In this release of the specification, all mandatory and optional requirements for IEEE 802.11ax-specific features are found in the Wi-Fi Alliance AFC System to AFC Device Interface Specification [n.14].

Annex C (Normative): Reference Table for Fixed Service Receiver Parameters

This annex provides a reference of how to obtain fixed service receiver parameters referenced in this specification from the ULS. For each parameter, the ULS Record Type and ULS Data Element [n.19] are provided.

"Antenna Type Code" element in "AN" type of record specifies whether the antenna identified by the record is receive antenna ("R") or transmit antenna ("T").

Table 6: Relationship between ULS data elements and fixed service receive antenna parameters employed in this specification

ULS		**WINNF-TS-1014**		
ULS Data Element	**Record Type**	**Parameter**	**Symbol**	**Requirement ID(s)**
Gain	AN	receive antenna gain	$G_{Rx,\ ULS}$	R2-AIP-05, R2-AIP-06, R2-AIP-08,
Antenna Model	AN	receive antenna model	*n/a*	R2-AIP-05, R2-AIP-06, R2-AIP-07, R2-AIP-08,
Antenna Make	AN	receive antenna make	*n/a*	R2-AIP-05, R2-AIP-06, R2-AIP-08,
Height to Center RAAT	AN	receive antenna height	*n/a*	R2-AIP-14
Polarization Code	AN	receive polarization	*n/a*	R2-AIP-09
Latitude Degrees Latitude Minutes Latitude Seconds Latitude Direction Longitude Degrees Longitude Minutes Longitude Seconds Longitude Direction	LO	receive location coordinates	*n/a*	R2-AIP-05, R2-AIP-14

Frequency Assigned	FR	operating frequency band	$F_{Rx,\ ULS}$	R2-AIP-05, R2-AIP-06, R2-AIP-08, R2-AIP-14
Diversity Gain	AN	diversity receive antenna gain	$G_{DRx,\ ULS}$	R2-AIP-08,
Diversity Height	AN	diversity antenna height	*n/a*	R2-AIP-15
Line Loss	AN	feeder loss	*n/a*	R2-AIP-10
Transmitter Make	FR	radio make	*n/a*	R2-AIP-10
Transmitter Model	FR	radio model	*n/a*	R2-AIP-10

Table 7: Relationship between ULS data elements and fixed service transmit antenna parameters employed in this specification

ULS		**WINNF-TS-1014**		
ULS Data Element	**Record Type**	**Parameter**	**Symbol**	**Requirement ID(s)**
Gain	AN	transmit antenna gain	$G_{Tx,\ ULS}$	R2-AIP-05, R2-AIP-06,
Antenna Make	AN	transmit antenna model	*n/a*	R2-AIP-05,
Antenna Model	AN	transmit antenna make	*n/a*	R2-AIP-05,
Height to Center RAAT	AN	transmit antenna height	*n/a*	R2-AIP-14

Latitude Degrees Latitude Minutes Latitude Seconds Latitude Direction Longitude Degrees Longitude Minutes Longitude Seconds Longitude Direction	LO	transmit location coordinates	*n/a*	R2-AIP-05
Polarization Code	AN	transmit polarization	*n/a*	R2-AIP-09,

Annex D (Informative): AFC System Operator Certification Procedure Information

The FCC has provided the information about the certification procedure for AFC System Operators in its Public Notice [i.7]. The descriptions below can be found in the Public Notice and are shown for informational purpose only.

- As specified in the 6 GHz Report and Order [n.3], OET will follow a multistep process to approve AFC Systems in which each prospective AFC System Operator must demonstrate its ability to perform the required functions pursuant to the Commission's 6 GHz unlicensed rules [n.1]. ([i.7], Paragraph 7)
- We request that parties interested in becoming an AFC System operator as part of the initial evaluation process submit their proposals no later than November 30, 2021. ([i.7], Paragraph 7)
    - The AFC System proposals must describe how the prospective AFC System Operator will comply with the requirements and core functions described in Section 15.407(k) of the Commission's rules [n.1] and the 6 GHz Report and Order [n.3]. ([i.7], Paragraph 9)
    - The public will then have an opportunity to review and comment on these proposals, including on each prospective operator's fitness to operate an AFC System as well as the technical and operational description of each proposed AFC System. Comments on these proposals must be submitted by December 21, 2021. ([i.7], Paragraph 7)
    - OET will review all proposals submitted by November 30, 2021 concurrently and with equal priority. Proposals submitted after this date will be considered by OET, but they may not be considered concurrently with proposals submitted by November 30, 2021. For any proposal received after November 30, 2021, OET will issue a public notice announcing receipt of the proposal and establishing a period for the public to review and comment on the proposal. ([i.7], Paragraph 7)
- Proposals will not be considered mutually exclusive and OET will conditionally approve as many proposals as are found to satisfy all AFC System requirements. ([i.7], Paragraph 7)
- Applicants who receive a conditional approval will then be required to allow access to their AFC System for a public trial period to provide interested parties an opportunity to check that it provides accurate results. ([i.7], Paragraph 8)
    - This trial period shall include thorough testing, both in a controlled environment (e.g., lab testing) and through demonstration projects (e.g., field testing). OET may also require prospective AFC System Operators to attend workshops and meetings as part of the assessment process. ([i.7], Paragraph 8)
- Prospective AFC system operators must comply with all instructions from OET and must provide any requested information in a timely manner. ([i.7], Paragraph 8)

Annex E (Informative): Near Field Antenna Pattern Data Interpolation

This informative annex provides the information about the Appendix (in .xlsx format) of WINNF-TS-1014 which is used for FS receiver near field adjustment specified in R2-AIP-17.

The Appendix lists the difference, in dB, between the near field and far field RPE of a parabolic dish antenna assuming a Hansen single parameter dish illumination. This difference in the near and far field is a function of three parameters: 1) antenna illumination efficiency, 2) normalized distance from the antenna and 3) the discrimination parameter.

The antenna illumination efficiency is defined as the ratio of the far field boresight gain for a given illumination to the gain of the antenna with a uniform illumination [i.8]. This efficiency can be expressed in dB or as a simple ratio. For a Hansen illumination, the efficiency η is a function of its H parameter. The table below lists the H parameter for a number of efficiencies.

Table 8: H parameter vs efficiency η

H parameter	efficiency η	efficiency η [dB]
2.817	0.40	-3.98
2.454	0.45	-3.47
2.161	0.50	-3.01
1.918	0.55	-2.60
1.711	0.60	-2.22
1.532	0.65	-1.87
1.371	0.70	-1.55

The normalized distance x and the discrimination parameter u can be calculated as follows:

$$x = \lambda d/(2D^2),$$

$$u = (D/\lambda)\sin\theta,$$

where:

- D: the diameter of the dish antenna;
- λ: the wavelength of the microwave signal;
- d: the distance from the fixed service microwave antenna;
- θ: the discrimination angle from boresight;
- x can be expressed in dB as $10\log_{10}(x)$; and
- all distances are expressed in the same units.

A different tab is present in the Appendix for 18 different normalized distances expressed in dB ranging from 0 dB (x = 1) to -17 dB (x = 0.02). On each tab the near field - far field difference is listed for the seven efficiencies in the table above as a function of the discrimination parameter. A properly interpolated value from these curves can be used to estimate the near field RPE from the far field RPE given an efficiency, normalized distance and discrimination parameter.

Steps to interpolate the data are as follows:

1. First determine the fixed service antenna efficiency along with the discrimination parameter and the normalized distance in dB to the interference source. Then, find the two worksheets in the workbook that bracket the normalized distance. If the normalized distance is greater than or equal to 0 dB, no near field adjustment is needed, and no further calculations are necessary. If the normalized distance is less than -17 dB, use the -17 dB worksheet.
2. Next find the two column pairs on each worksheet that bracket the antenna efficiency (η). If the efficiency is less than 0.4, use the 0.4 column pair. If the efficiency is greater than 0.7, use the 0.7 column pair.
    - In the left column of each column pair, find the two discrimination parameter (u) values that bracket the discrimination parameter. If the discrimination parameter is greater than the largest value listed in the column, use an adjustment factor value of zero. Otherwise use linear interpolation between the two bracketing values and the desired discrimination parameter for each column pair.
    - If working with two column pairs in a worksheet, use linear interpolation between the two determined column values for the desired antenna efficiency. This is the adjustment factor associated with the worksheet.
    - If working with two worksheets, use linear interpolation between the two adjustment factors for each worksheet and the desired normalized distance in dB. This will result in the final adjustment factor to be added to the far field RPE value at the discrimination angle.

Annex F (Informative): Revision History

Document History		
V1.0.0	15 December, 2021	Initial version.
V1.1.0	25 May, 2022	New revision incorporating the following features: ▪ Formula for I/N determination ▪ Propagation model parameters ▪ Fixed Service receiver primary and diversity antenna RPE, and polarization mismatch ▪ Feeder loss ▪ Use of location uncertainty ▪ Query methods for a list of available frequencies