6 GHz Below Decks

WInnForum Webinar Series #31

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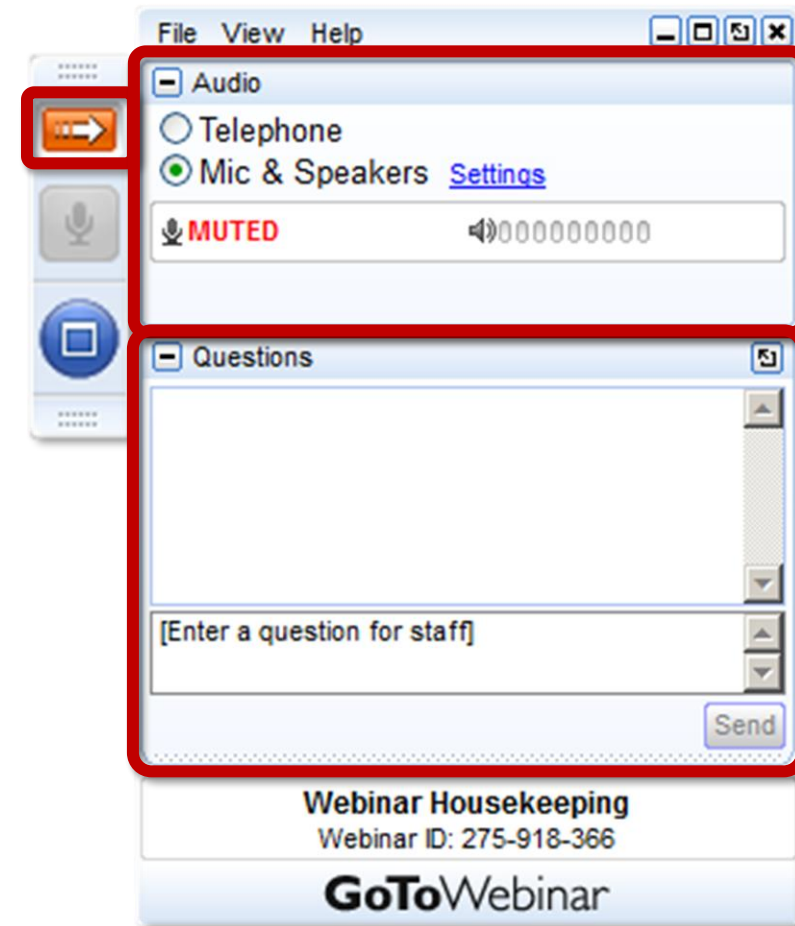- http://www.wirelessinnovation.org/webinars

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Email Lee.Pucker@wirelessinnovation.org if you need more information

Mark Gibson

Director, BD & Regulatory Policy, CommScope

**WInnForum Presents
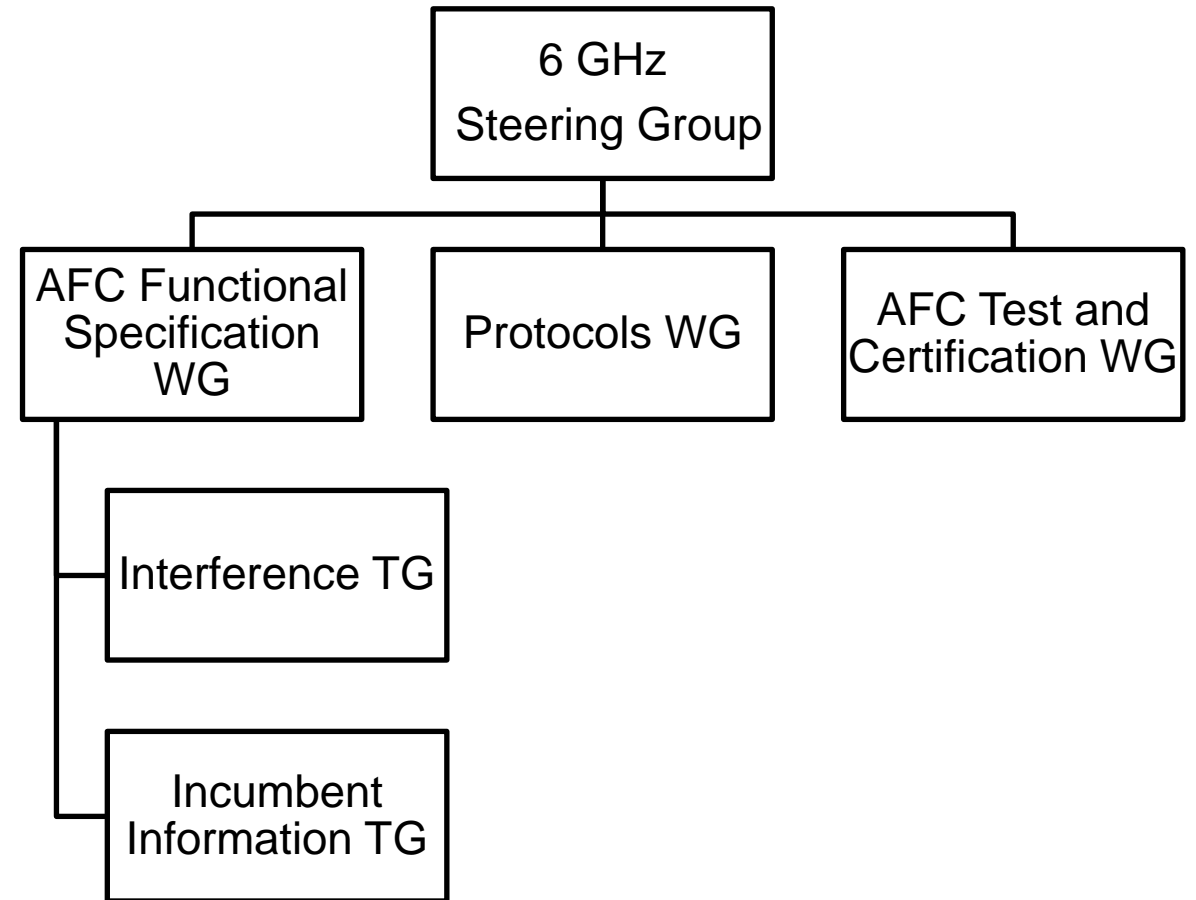6 GHz Below Decks:
WInnForum Work on Specs for the AFC Ecosystem**

July 21, 2022

Agenda

6 GHz Committee Organization

- **AFCs Functional Requirements**
- **Propagation and Interference**
- **Data on Incumbent Systems**
- **Protocols**
- **AFC Testing**
- **Wrap Up and Future Work**

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                6 GHz
            Steering Group
      ┌───────────┼───────────┐
  AFC Functional   Protocols WG   AFC Test and
  Specification                   Certification WG
       WG
       │
   Interference TG
       │
    Incumbent
  Information TG
```

Today's Presenters

Lee Pucker
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TS-1014 FUNCTIONAL REQUIREMENTS FOR THE U.S. 6 GHZ BAND UNDER THE CONTROL OF AN AFC SYSTEM –V1.1.0 OVERVIEW

Navin Hathiramani (NOKIA)

Chair of the AFC Functional Specification Work Group

21st July 2022

WINNF-TS-1014

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 specification is Air Interface Technology agnostic: works for Wi-Fi, 3GPP, Proprietary, Etc.

- Does not include all FCC Part 15 Rules an SPD* or an AFC System must comply with.

*SPD: Standard Power Device. This encompasses Standard Power Access Points and Fixed Client Devices

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

Document WINNF-TS-1014

Version V1.1.0

25 May 2022

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Available at: Work Group Products (wirelessinnovation.org)

Types of Requirements and Categorization

Different types of requirements:

- 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.
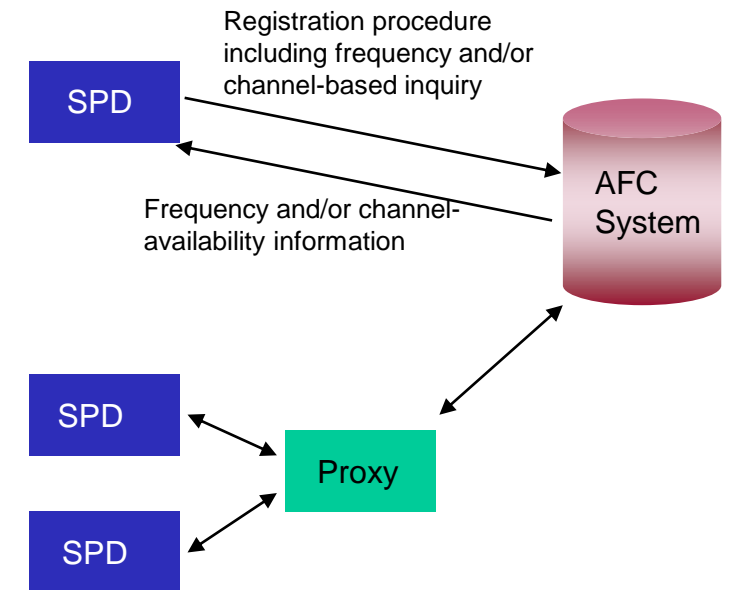
Table 1: Requirements Categorization

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

- Currently no R3 requirements are captured in TS-1014

- The majority of the requirements are R2 AIP , i.e., focused on the AFC System Incumbent Protection

- AFC Systems and SPDs following TS-1014 must be tested against R0, R1 and R2 requirements in order to fully meet FCC rules

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Overview of DGR Requirements

The Standard Power Device General Requirements (DGR) provide requirements for:
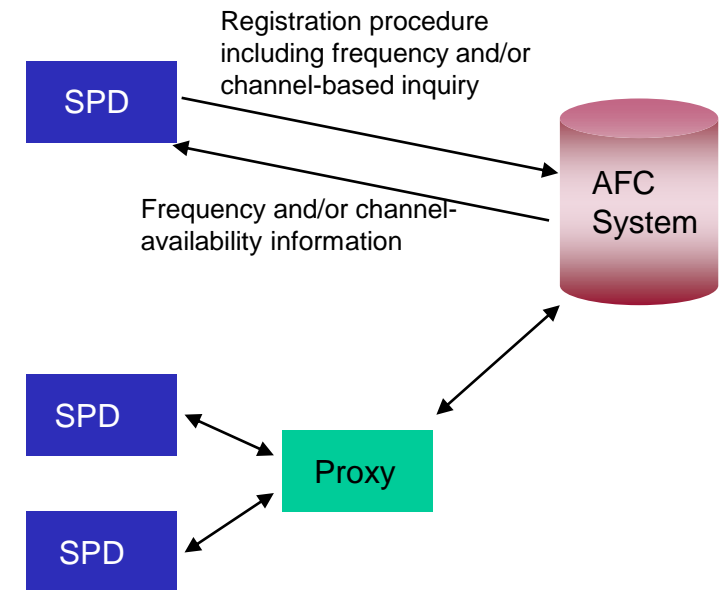
- SPD registration procedure including the information that needs to be included in the registration such as geographic coordinates, antenna height, FCC ID and serial Number

- When the SPD need to re-register, e.g., when the SPD changes location or a registration parameter changes

- Frequencies and power level an SPD may operate on and how long information on available frequencies is valid

- Methods via which the SPD may inquire about frequency availability: Channel based and/or frequency range based inquiry

- SPD emission limits for when frequency range query is performed and for operation using multiple channels

- Frequency with which an SPD needs to obtain frequency availability information

Registration procedure including frequency and/or channel-based inquiry

SPD

AFC System

Frequency and/or channel-availability information

SPD

Proxy
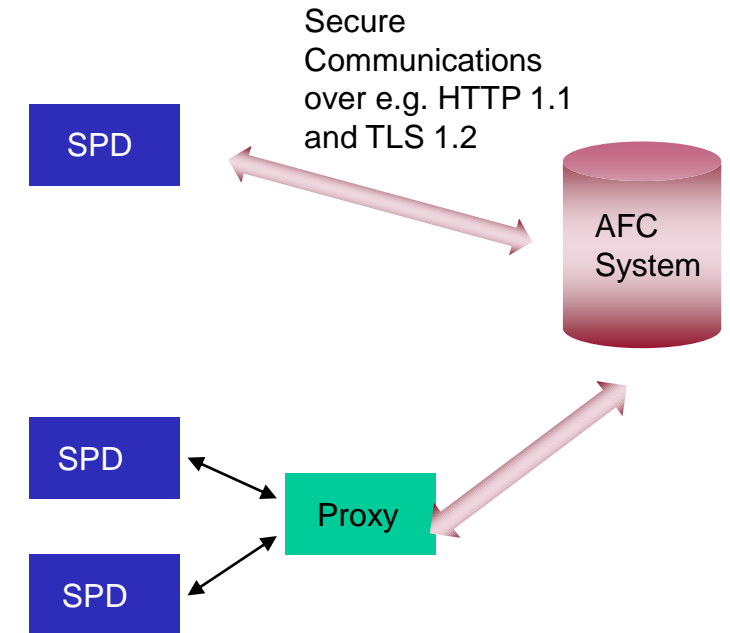
SPD

The AFC System General Requirements (AGR):

- AFC System uses information provided by the SPD to authenticate the device and stores the registration information in a secure manner
- AFC System shall use SPDs geographical coordinates and reported uncertainty when determining available frequencies/channels and max permissible power
- AFC System shall have the capability to deny spectrum access to a particular SPD or enforce discontinuance of SPD operations in a designated geographical area

The Standard Power Device Security (DSQ) and AFC System Security (ASQ) Requirements provide requirements to ensure secure communication between SPD and AFC System

- The requirements allow to employ HTTP 1.1 and TLS 1.2 or other alternative methods which provide similar or higher level of security.
- If TLS 1.2 is chosen as the implementation option, the support of at least 2 cipher suites is mandated and others are optional
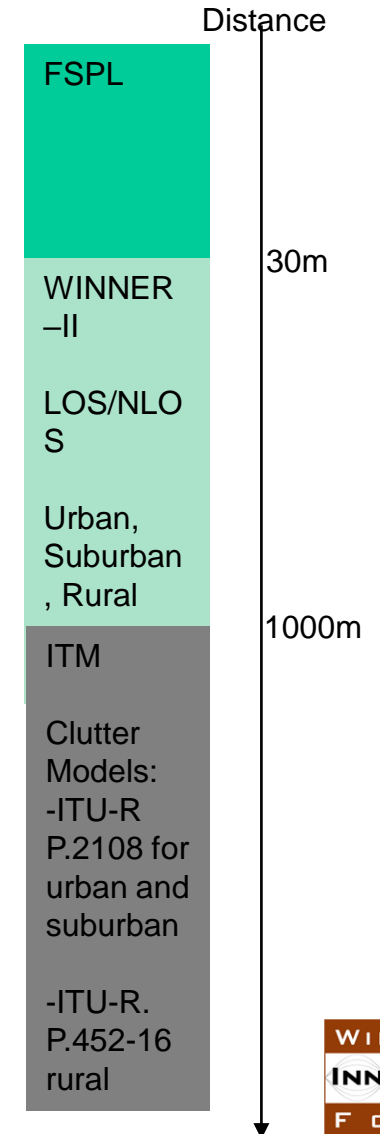
Secure Communications over e.g. HTTP 1.1 and TLS 1.2

SPD

AFC System

SPD

Proxy

SPD

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Applicable Propagation models based on distance

Distance

AFC System Incumbent Protection (AIP):

- AFC System shall obtain information on protected services within the 5925-6425 and 6525-6875 MHz band from the ULS on a daily basis
- AFC System shall protect incumbents operating (both co-channel and adjacent channel) to the SPD
- AFC requirements to ensure protection of Radio Astronomy Services
- Link budget formula employed for protection of fixed service receivers:
  - $I/N_{Thres} \geq I/N_{Est} = P_{SPD, Tx} - L_{Propagation} - L_{BEL} + G_{Rx, Effective} - N - L_{FS, Feeder}$

  - Requirements on how to derive information for the determination of I/N_{Est} based on available ULS data, e.g. Noise Level (N) or near field adjustment factors.
  - To facilitate the determination of certain parameters which are required to determine the level of interference, Supplementary Data Repositories have been specified in WINNF-TS-5008
  - Requirements on how to determine frequency availability considering SPD reported location and uncertainty region

FSPL

WINNER –II

LOS/NLOS

Urban, Suburban, Rural

30m

ITM

Clutter Models:
-ITU-R P.2108 for urban and suburban

-ITU-R. P.452-16 rural

1000m

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Overview of Specific RAT supported

- **Requirements to ensure support of 3GPP defined 6 GHz channelization (NR-U)**
  - Requirements to ensure device can query based on a 3GPP 6 GHz channelization and an AFC System can respond to the query

- **Support of IEEE 802.11 ax**
  - Specification of these requirements can be found in the Wi-Fi Alliance AFC System to AFC Device Interface

- **Note that other non specified RAT can always be supported via frequency range inquiries**

INTERFERENCE ANALYSIS

Tom Willis (AT&T)

Chair of the AFC Functional Specification Interference Analysis Task Group

SPD Emission Restrictions
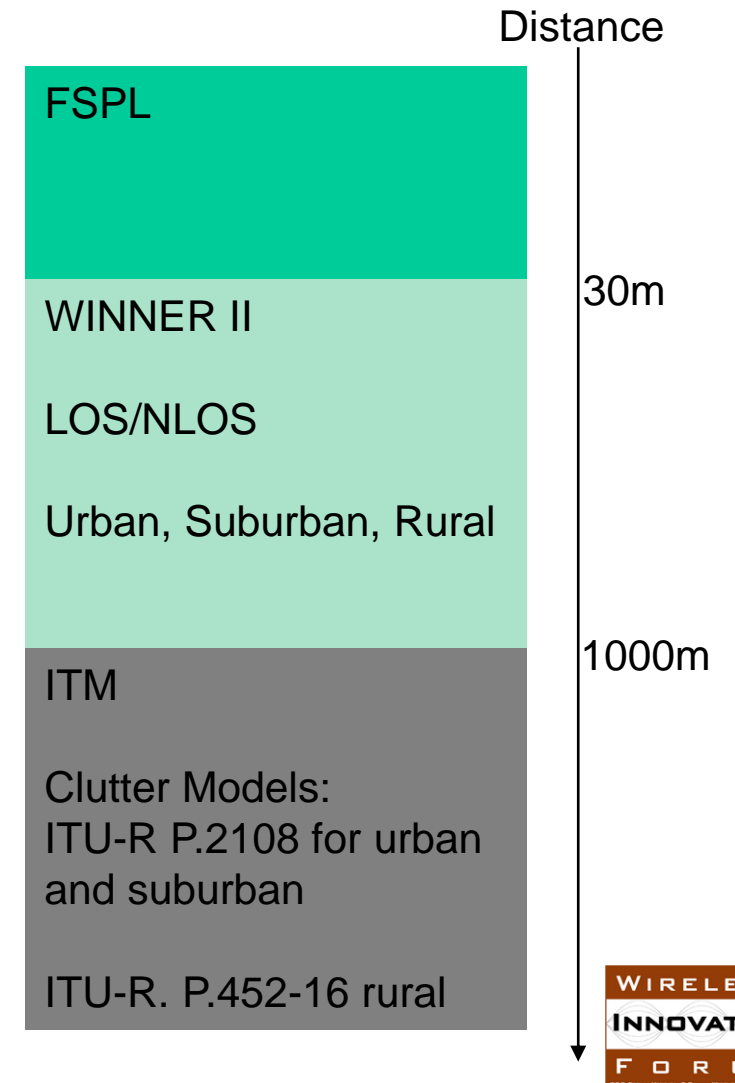
Based on interference link budget:

$$I/N_{Est} = P_{SPD,\,Tx} - L_{Propagation} - L_{BEL} + G_{Rx,\,Effective} - N - L_{FS,\,Feeder} < \text{-6 dB}$$

Propagation Models as Specified in FCC Report and Order Include:

- Free Space Loss (d < 30m)
- WINNER II (d >= 30 m and d < 1Km)
- ITM (d > 1Km)
- ITU-R P.2108-0 Clutter Loss (suburban, urban)
- ITU-R P.452-16 Clutter Loss (rural)
- ITU-R P.2109 Building Entry Loss (BEL)

However several parameters used in these models not specified.

Applicable Propagation models based on distance

Distance

| |
| FSPL |
| 30m |
| WINNER II |
| LOS/NLOS |
| Urban, Suburban, Rural |
| 1000m |
| ITM |
| Clutter Models:
ITU-R P.2108 for urban and suburban |
| ITU-R. P.452-16 rural |

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Propagation Model Parameters

WINNER II path loss and ITU-R P.452 clutter models

- Morphology (environment category) - USGS NLCD 30 m x 30 m in SPD uncertainty area

ITM path loss model (in ballot)
- Path profile - USGS 30 arc second terrain data
- Atmospheric refractive index - ITU-R P.453 data
- Climate category - ITU-R P.617-3 30 min x 30 min data

Probabilistic Parameters

ITM and WINNER II path loss, P.2108 clutter, P.2109 BEL models (in ballot)
- Confidence parameter
    ITM: 95%, WINNER II: 84%, P.2108: 75%, BEL: 50%

ITM path loss model (in ballot)
- Reliability parameter: 80%

Other Concerns

Incumbent Receive Antenna Effective Gain

- Near field adjustment factor

- Polarization mismatch factor

- 2D antenna patterns – azimuthal and elevation discrimination (in ballot)
    - Calculation of discrimination angles
    - Discrimination estimation from available pattern data

Passive Reflectors and Repeaters (in ballot)
- Interference relayed back to incumbent receive antenna
    - Billboard reflectors
    - Back-to-back antenna passive repeaters

DATA

Pete Young (Commscope)
Chair of the AFC Functional Specification Incumbent Information Task Group

Key Observations on ULS Data

- **Most of the 6 GHz data are in good shape.**

- **However, there are inherent issues with the ULS and some of the data contained in it.**
  - See WINNF-RC-1010 for details on the data issues.

- **These issues can be classified as:**
  - *Blank Data* – data fields required to protect incumbents properly that are empty. This is mostly due to older license records that predate ULS.
  - *Conflicting Data* – data that are not consistent across multiple fields (e.g., antenna gain does not match model)
  - *Uncollected Data* – data that are not collected that would be useful to the AFC.

- **TS-1014 includes requirements on how ULS data should be handled by the AFC system in determining FS receiver data for the link budget formula.**

Examples of ULS Data that are Blank

- **Antenna manufacturer**
- **Antenna model**
- **Antenna gain**
- **Antenna height**
- **Emission designator**
- **Passive billboard receive dimensions**
- **Passive billboard transmit dimensions**
- **Passive back-to-back receive antenna gain**
- **Passive back-to-back transmit antenna gain**
- **No passive receive antenna data**
- **No passive transmit antenna data**

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Examples of Conflicting ULS Data

- **Antenna manufacturer, model and gain**
- **Antenna heights that are 0, negative or very large**
- **Emission designators that reflect a 0 MHz bandwidth or too large for the band.**
- **Diversity antenna height and gain**
- **Receive parabolic antenna model is provided with billboard dimensions**
- **Transmit parabolic antenna model is provided with billboard dimensions**

Examples of Data Uncollected in the ULS

- **Antenna radiation pattern envelopes**
- **Receive-only loss**
- **Receiver noise figure**
- **Diversity receive antenna manufacturer and model**

Scope

- The scope of this specification is to define the access to, schema and use of different Supplementary Data Repositories which assist AFC Systems in more accurately defining the level of protection required for fixed service receivers.

- Version 1.0 Repositories include:
  - FCC Category B1 Antenna Model Listing
  - High Performance Antenna Model Listing
  - Indoor Radio Unit Listing
  - FCC Fixed Service Channelization Repository

- Coming Soon: Version 1.1 Repositories will include:
  - Billboard Reflector Data
  - Back-to-Back Antenna Data
  - Antenna Model, Diameter and Gain

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6 GHz Supplementary Data Repository Technical Specification

Document WINNF-TS-5008

Version V.1.0.0

31 May 2022

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Available at: Work Group Products (wirelessinnovation.org)

Overview of AIP Data Requirements

Emission Bandwidth

- The emission designator in ULS provides the expected receiver bandwidth.
- If it is blank, 0 or greater than 60 MHz, use the assigned frequency along with the FCC channel plans summarized in the TS-5008 Fixed Service Channelization repository to determine the bandwidth.

Receiver Noise Level – N (dBm/MHz)

- Use radio model along with manufacturer data to determine the noise level.
- If manufacturer data is not known, use a noise figure of 4 dB for the U-NII-5 band or 4.5 dB for the U-NII-7 band along with the emission bandwidth to calculate the noise level.

Feeder Loss – $L_{FS, Feeder}$(dB)

- While the FCC ULS has a Feeder Loss field in it's "AN" record, this is not visible through the ULS interface on its publicly facing web site, or when licensees apply for authorizations. It is suspected that this field is filled in for some licenses through its electronic batch filing system.
- If the radio model is a known indoor unit per TS-5008 Indoor Radio Unit repository, apply a 3 dB feeder loss.
- Otherwise, 0 dB feeder loss is assumed.

Overview of AIP Data Requirements

Antenna Data

- Use antenna model to look up / validate gain and diameter of the receive antenna using the TS-5008 Antenna Model, Diameter and Gain repository.
    - If not available, try finding it using the transmit antenna of the receive location's license.
    - Apply defaults as a fallback.
- Use manufacturer provided RPE, if available.
    - As a fallback, apply a combination of FCC suppression requirements and ITU-R-F.699-8, with the TS-5008 FCC Category B1 Antenna Model and High-Performance Antenna Model repository to classify the performance of the antenna.

Antenna Height

- Use the ULS receive antenna height with a minimum value of 1.5 meters.
- If blank, try finding it using the transmit antenna of the receive location's license.
- Otherwise use 42.5 meters, which is an average value for this band.
- Diversity antenna heights, if not provided in ULS are space 11 meters from the primary.

Overview of AIP Data Requirements

Currently in Ballot for TS-1014 Version 1.2:

Passive Repeater Data

- Identify billboard reflector or back-to-back antenna using the antenna model in conjunction with the TS-5008 Billboard Reflector and Back-To-Back Antenna repositories.

- For billboard reflectors, validate the ULS model's dimensions match the ULS height and width.
  - In the case of mismatches, use a list of common sizes to determine the likely dimensions.
  - As a default, use a 16 x 20 ft billboard reflector, one of the most common dimensions.

- For back-to-back antennas, use the model and the receive and transmit gains, along with the TS-5008 Antenna Model, Diameter and Gain repository to determine which antenna model is represented.
  - Apply the appropriate antenna data methodology to determine proper antenna gain and RPE for the receive end and transmit end of the back-to-back antenna passive.

TS-3005 SIGNALING PROTOCOLS AND PROCEDURES FOR 6 GHZ BAND; AFC SYSTEM – STANDARD POWER DEVICE INTERFACE V1.0.0 OVERVIEW

Protocols WG Chair: Naotaka Sato (Sony Group)

Protocols WG Editor: Sho Furuichi (Sony Group)

July 21, 2022

**Signaling Protocols and Procedures for 6 GHz Band;
AFC System - Standard Power Device Interface Technical Specification**

Scope

- **To specify the WInnForum specific extensions to the AFC System – Proxy/Standard Power Access Point (SPAP)/Fixed Client Device (FCD) Interface in accordance with "AFC System to AFC Device Interface Technical Specification" produced by Wi-Fi Alliance (WFA) SDI document and based on requirements specified in WINNF-TS-1014.**

Signaling Protocols and Procedures for 6 GHz Band; AFC System - Standard Power Device Interface Technical Specification

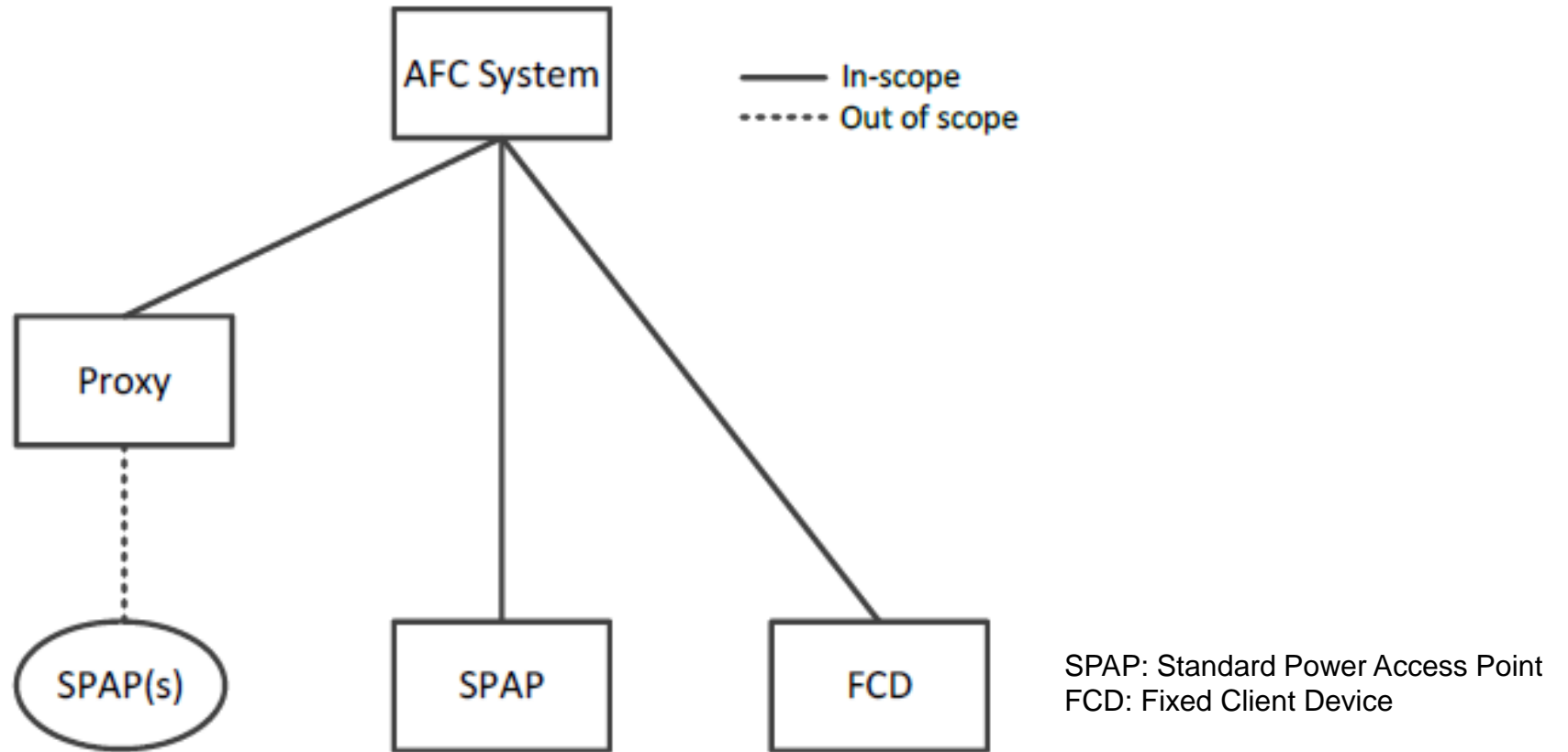Document WINNF-TS-3005

Version V1.0.0

17 February 2022

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SPAP: Standard Power Access Point
FCD: Fixed Client Device

Endorsement of Wi-Fi Alliance AFC System to Device Interface specification

Endorsement Statement

- The Wireless Innovation Forum endorses the Wi-Fi Alliance AFC System to AFC Device Interface Specification, including appendices, as a preferred AFC System - Standard Power Device interface protocols. This endorsement is non-exclusive and the Wireless Innovation Forum may endorse additional interface for application areas where the Wi-Fi Alliance AFC System to AFC Device Interface Specification is not an ideal match. This endorsement does not imply deprecation of the endorsement of the WINNF-TS-3005, that remains valid.

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Endorsement of Wi-Fi Alliance AFC System to AFC Device Interface Specification

Document WINNF-RC-3006

Version V1.0.0

20 December 2021

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Relationship between TS-3005 and WFA SDI protocol specification

TS-3005 can be used to comply with TS-1014 when implementing "AFC Device Responder Function".
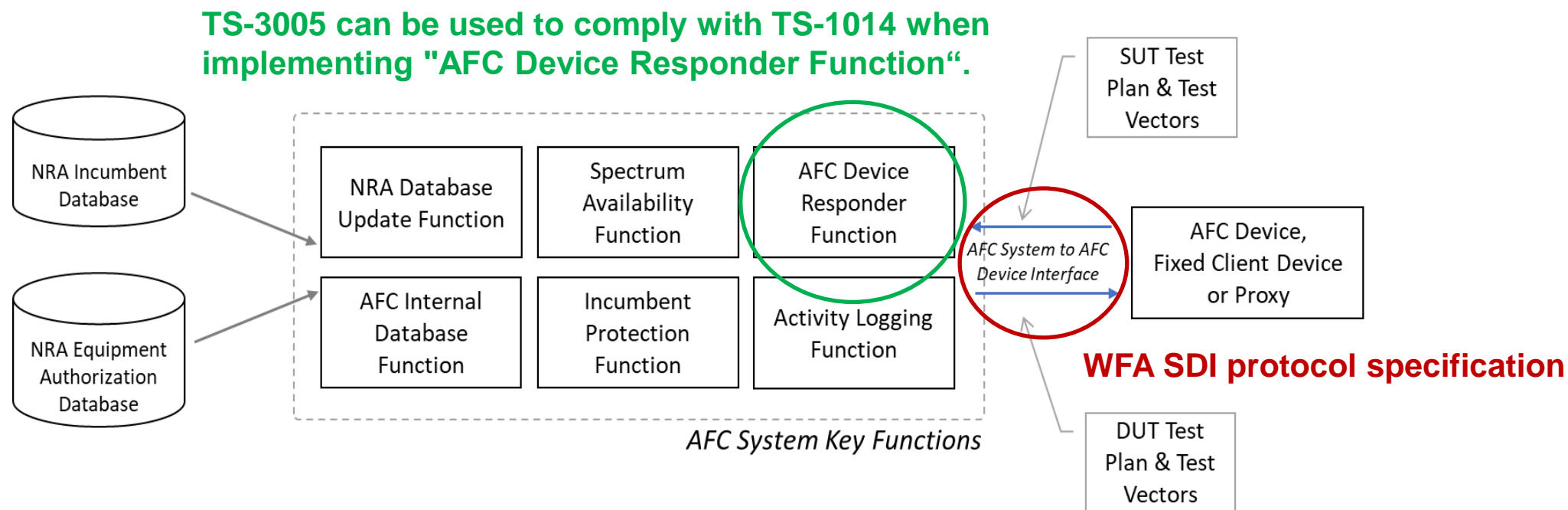

Figure 3. Overall system reference model

WInnForum-Specific Extensions defined by TS-3005-V1.0.0

NRU1 feature

- This feature enables an AFC System and a Standard Power Devices employing the channel-based frequency availability query method to support 3GPP-defined 6 GHz Channels (e.g., Channels within the 3GPP-defined n96 band)
  - Requirements are specified in Annex A of WINNF-TS-1014
- TS-3005 specifies how NRU1 feature is enabled when employing WFA SDI specification

WInnForum-Specific *VendorExtension* Object and Feature Capability Exchange

- Feature Capability Exchange is designed to allow selective implementations of "features" by an AFC System and SPD based on industry interests and/or use cases and facilitates interworking between the AFC System and the SPD for their use of the features.
- To facilitate interworking and interoperability between the AFC System and the SPD, TS-3005 provides the standardized format of *VendorExtension* object (defined by WFA SDI as a container JSON object) and the Feature Capability Exchange messaging procedure.
- So far, there is no defined "feature" requiring Feature Capability Exchange. Therefore, WInnForum-Specific *VendorExtension* Object and Feature Capability Exchange are not expected to have impacts to the FCC certification.

NRU1 feature

"Global Operating Class" for Band n96

- When performing channel-based query, the Standard Power Device must include *inquiredChannels* field in the *AvailableSpectrumInquiryRequest* object. The AFC System must respond to the channel-based query by including *availableChannelInfo* field in the *AvailableSpectrumInquiryResponse* object.
- Data type of *inquiredChannels* field is array of object: *Channels*, where *Channels* is designed to include:
  - Global operating class
  - Channel CFIs
- Data type of *availableChannelInfo* field is array of object: *AvailableChannelInfo*, where *AvailableChannelInfo* is designed to include:
  - Global operating class
  - Channel CFIs
  - Maximum EIRP

- To leverage the schema defined in the WFA SDI specification, TS-3005 defines the global operating classes for Band n96.

Mapping among the global operating classes, channel bandwidth and CFIs for 3GPP 6 GHz channelization

Global Operating Class	Channel Bandwidth (MHz)	Channel CFIs
300	20	797000, 798332, 799668, 801000, 802332, 803668, 805000, 806332, 807668, 809000, 810332, 811668, 813000, 814332, 815668, 817000, 818332, 819668, 821000, 822332, 823668, 825000, 826332, 827668[*], 829000[*], 830332[*], 831668[*], 833000[*], 834332[*], 835668, 837000, 838332, 839668, 841000, 842332, 843668, 845000, 846332, 847668, 849000, 850332, 851668, 853000, 854332, 855668, 857000, 858332[*], 859668[*], 861000[*], 862332[*], 863668[*], 865000[*], 866332[*], 867668[*], 869000[*], 870332[*], 871668[*], 873000[*], 874332[*]
301	40	797668, 800332, 803000, 805668, 808332, 811000, 813668, 816332, 819000, 821668, 824332, 827000, 829668[*], 832332[*], 835000[*], 837668, 840332, 843000, 845668, 848332, 851000, 853668, 856332, 859000[*], 861668[*], 864332[*], 867000[*], 869668[*], 872332[*]
302	60	798332, 799668, 803668, 805000, 809000, 810332, 814332, 815668, 819668, 821000, 825000, 826332, 830332[*], 831668[*], 835668[*], 837000, 841000, 842332, 846332, 847668, 851668, 853000, 857000[*], 858332[*], 862332[*], 863668[*], 867668[*], 869000[*], 873000[*]
303	80	799000, 804332, 809668, 815000, 820332, 825668, 831000[*], 836332[*], 841668, 847000, 852332, 857668[*], 863000[*], 868332[*]
304-305	Reserved	

NOTE: The Channel CFIs are equivalent to the NR Absolute Radio Frequency Channel Numbers (NR-ARFCNs) defined by 3GPP for band n96. The CFIs values which results in the Channel at least partially outside of U-NII-5 and U-NII-7 bands are marked with asterisk (*).

Center frequency of a 3GPP 6GHz channel can be determined by using the following formula.

$$F_{c,\text{SPD}}\,(\text{MHz}) = 3000 + 15 \cdot \frac{CFI - 600000}{1000}$$

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AFC TEST AND CERTIFICATION

Masoud Olfat, Federated Wireless

**Chair of the AFC Test and Certification Program Development Task Group**

Background

- According to FCC 6GHz R&O, prospective AFC Applicants have submitted their proposals describing how their systems would comply with all Commission AFC rules to OET
  - FCC subsequently received the public comments on these AFC system proposals.
  - AFC applicants are awaiting the conditional approval demonstrating their compliance with AFC requirements.

- Beyond conditional approval, the AFC systems will undergo a testing phase in a controlled environment (lab) followed by some type of demonstration projects (e.g., field testing), to be determined in future phases.

- WinnForum Test and Certification WG is tasked to collaborate with other SDO (e.g. WiFi Alliance) to develop an AFC certification framework to demonstrate that AFC Systems (SUT) can manage devices without causing harmful interference to fixed wireless services.
  - Develop the test and certification program
  - Develop the test software (Test Harness)
  - Define and propose procedures for lab selection
  - Develop proposals for demonstration project phase

- SPD Device (DUT) is out of the scope of WinnF TCWG and is handles solely by WiFi Alliance AFC TG

AFC Test and Certification Framework

- WinnF Traceability Matrix is composed of all Part 15 and TS-1014 requirements
- For every row, the WinnF Test & Cert. WG determine one of the following treatments
  - Testing not applicable (e.g., definitions, or Device Requirements)
  - AFC Attestation (e.g., data retainment
  - Tested during Field Test
  - Identify test vector (s) to determine the conformance

§ 15.407(k)(8)(ii)	Standard power access points and fixed client devices: Must 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. If any of these parameters change, the standard power access point or fixed client device must provide updated parameters to the AFC system. All information provided by the standard power access point and the fixed client device to the AFC system must be true, complete, correct, and made in good faith.	n/a	n/a	Standard Power Device	Manufacturer Report		AFCS.SRS.1, AFCS.URS.1, AFCS.URS.2, AFCS.URS.3, AFCS.URS.4, AFCS.URS.5, AFCS.URS.6,
§ 15.407(n)	*Incumbent Protection by AFC system: Fixed-Satellite Services.* Standard power access points and fixed client devices located outdoors must limit their maximum e.i.r.p. at any elevation angle above 30 degrees as measured from the horizon to 21 dBm (125 mW) to protect fixed satellite services.	n/a	n/a	Standard Power Device	n/a (operational requirement)	n/a	n/a (Device Requirement)
§ 15.407(k)(7)(iv)	The general purposes of AFC system include: Obtaining updated protected sites information from Commission databases.	R0-AGR-02	An AFC System shall obtain updated protected sites information from Commission databases. (15.407(k)(7)(iv))	AFC System			Attestation

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AFC Test and Certification Framework
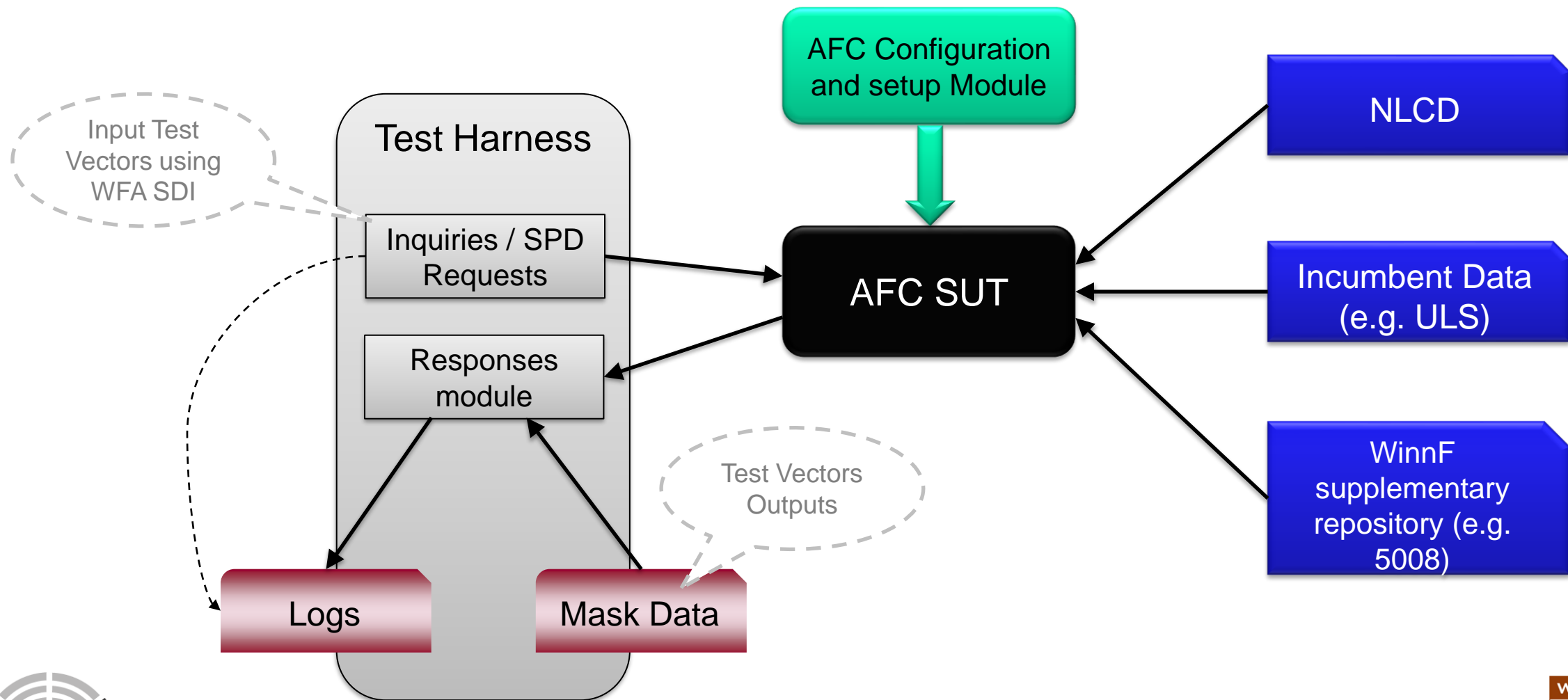
Test Plan

- WinnForum is working closely with WiFi Alliance AFC TG through Liaison relationship to develop the test and certification plan including
  - AFC SUT Test cases
  - AFC SUT Test Vectors

- AFC SUT Test Cases
  - AFC.SRS: Successful Registration and Spectrum Availability
  - AFC.URS: Unsuccessful Registration and Spectrum Availability
  - AFC.FSP: Fixed Services Protection
  - AFC.IBP: International Border Protection
  - AFS.SIP: Special Incumbent Protection
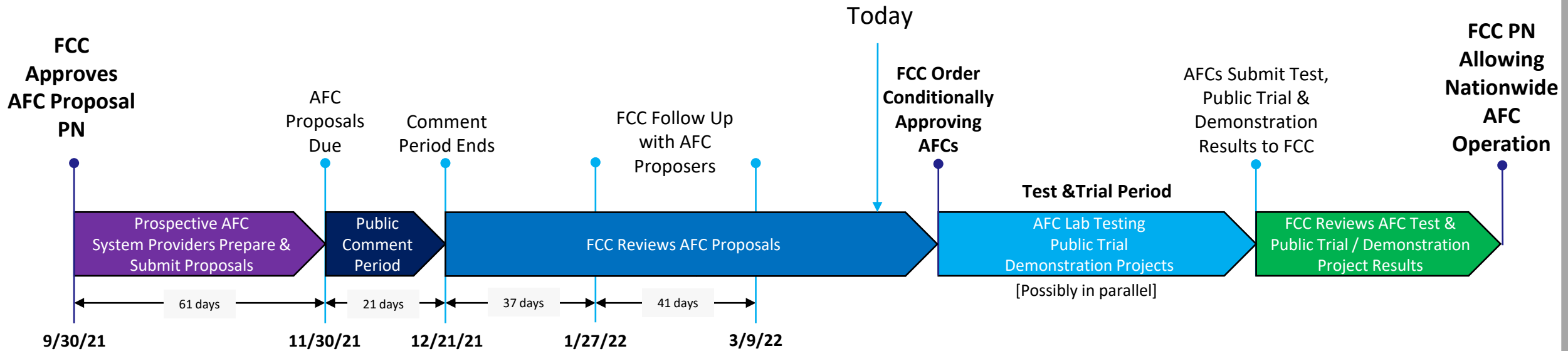
Test Vectors

Inputs / Requests

- For each test case, one or several input configuration are defined encapsulating the following information
  - Device Information (e.g. S/N, FCC-ID, etc.)
  - SPD Location
  - SPD uncertainty (type and area)
  - Indoor vs. outdoor
  - Frequency or Channel Request
    - Frequency-based Request : Expecting per MHz EIRP mask for the requested frequency range
    - Channel-based Request: Expecting total EIRP for all channels included in the requested channel configuration
  - Morphology
  - A minimum set of incumbents impacted by the SPD (could be more)

Output / Responses

- For every test vector, some or all of the AFC applicants provide channel availability

- Through a reconciliation process, the expected responses are determined using AFC Reponses, such that incumbent protections are not violated

- The expected responses constitute the mask file used by the Test Harness
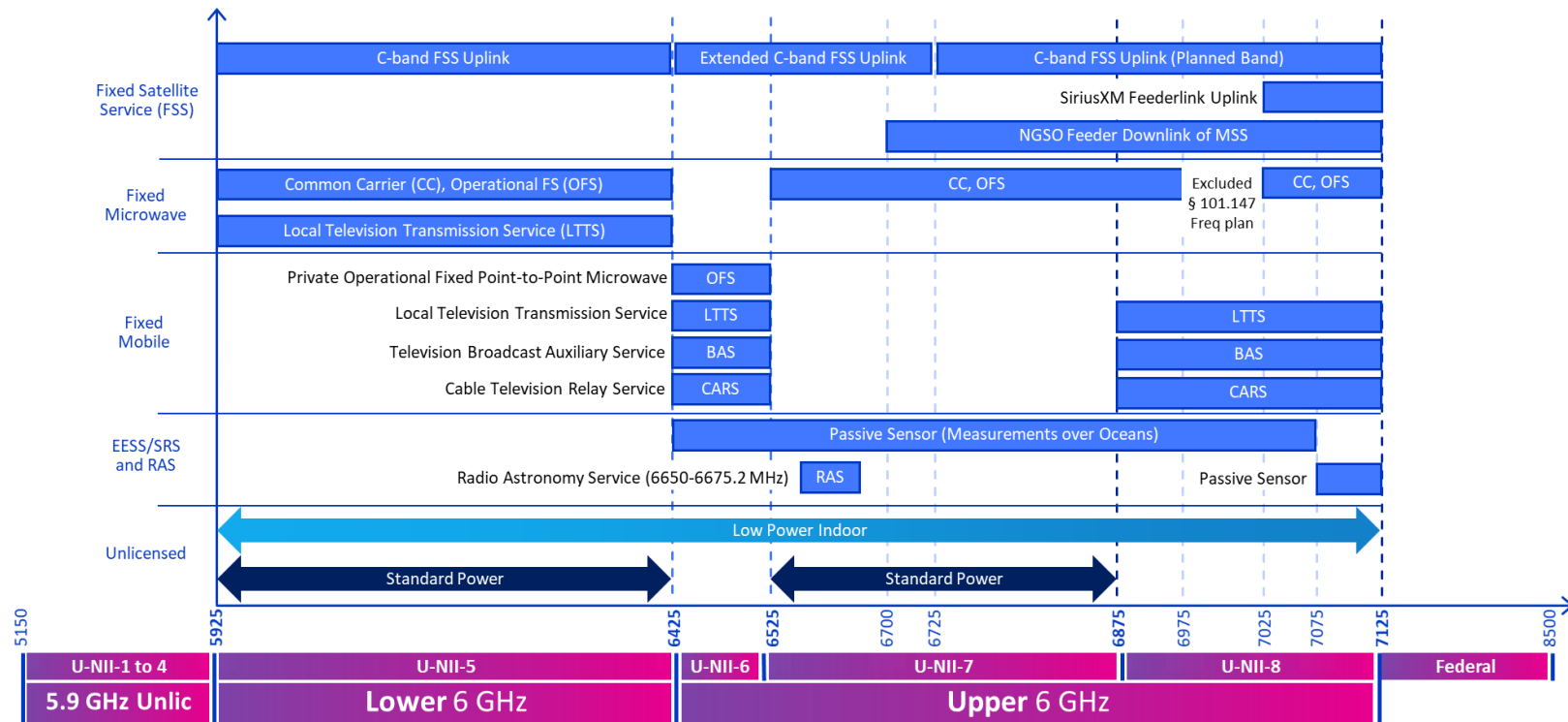
WRAP UP

AFC Test & Certification Steps and Timeline

FCC Approves AFC Proposal PN

AFC Proposals Due

Comment Period Ends

FCC Follow Up with AFC Proposers

Today

FCC Order Conditionally Approving AFCs

AFCs Submit Test, Public Trial & Demonstration Results to FCC

FCC PN Allowing Nationwide AFC Operation

Prospective AFC System Providers Prepare & Submit Proposals

Public Comment Period

FCC Reviews AFC Proposals

Test &Trial Period

AFC Lab Testing Public Trial Demonstration Projects

[Possibly in parallel]

FCC Reviews AFC Test & Public Trial / Demonstration Project Results

61 days | 21 days | 37 days | 41 days

9/30/21 | 11/30/21 | 12/21/21 | 1/27/22 | 3/9/22

WInnForum Standards™

WIRELESS INNOVATION FORUM

Ongoing Work

- **TS-1014 V1.2.0 available in late Aug.**

- **Looking at other NRA data sources for international applications**

- **Meetings with FCC to discuss specifications, testing, certification and AFC public availability**

- **Modifications to specifications as necessary**

6 GHz Band Allocations

Thank You!