Signaling Protocols and Procedures for Citizens Broadband Radio Service (CBRS): Extensions to Spectrum Access System (SAS) - Citizens Broadband Radio Service Device (CBSD) Interface Technical Specification (Release 2)

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Contributors

The following individuals made significant contributions to this document:

Group Chair: Sho Furuichi (Sony), Amit Mukhopadhyay (Nokia)

Editor: Amit Mukhopadhyay (Nokia)

Feature Leads:
- **Feature Capability Exchange**: Virgil Cimpu (Ericsson), Sho Furuichi (Sony), Navin Hathiramani (Nokia) , Yi Hsuan (Google), Masoud Olfat (Federated Wireless), Idan Raz (Airspan)
- **Enhanced CBSD Group Handling**: Virgil Cimpu (Ericsson), Sho Furuichi (Sony), Navin Hathiramani (Nokia), Yi Hsuan (Google)
- **Enhanced Antenna Pattern**: Virgil Cimpu (Ericsson)
- **CPE-CBSD Indicator**: Yi Hsuan (Google), Masoud Olfat (Federated Wireless)
- **Grant Update**: Sho Furuichi (Sony), Ariful Hannan (CommScope), Yi Hsuan (Google), Masoud Olfat (Federated Wireless)

Other Member Representatives:
- AT&T: Neeti Tandon
- CableLabs: Roy Sun, Zaheer Syed
- Charter: Akram Hassanien
- Ericsson: Kumar Balachandran, Gary Boudreau, Chris Williams
- Google: Ariful Hannan, Kate Harrison
- iPosi: Derek Glass
- MITRE: Dawn Szelc
- Motorola Solutions: David Gurney
- NIST: Anirudha Sahoo
- Nokia: Navin Hathiramani, Orlett Pearson
- Qualcomm: Doug Knisely
- Samsung: Shivani Sahi
- Sony: Naotaka Sato
- Tarana: Christopher Saleem
- Verizon: Max Solondz
- WISPA: Richard Bernhardt, Fred Goldstein

Extensions to Spectrum Access System (SAS) - Citizens Broadband Radio Service Device (CBSD) Interface Technical Specification (Release 2)

1 Introduction

This document is the technical specification of the extended signaling protocol and procedures for the SAS-CBSD Interface. As a prerequisite or foundation, any readers should use this specification together with WINNF-TS-0016 [n.1].

2 Scope

The scope of this document is to specify the extensions to the SAS-CBSD Interface in accordance with WINNF-TS-0016 [n.1] and requirements specified in WINNF-TS-0112 [n.2] and WINNF-TS-1001 [n.3].

The key words "required", "shall", "shall not", "should", "should not", "recommended", "may", and "optional" in this document are to be interpreted as described in RFC-2119 [n.4]. In addition, the key word "conditional" shall be interpreted to mean that the definition is an absolute requirement of this specification only if the stated condition is met.

3 References

3.1 Normative references

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

[n.1] WINNF-TS-0016-V1.2.6, "Signaling Protocols and Procedures for Citizens Broadband Radio Service (CBRS): Spectrum Access System (SAS) - Citizens Broadband Radio Service Device (CBSD) Interface Technical Specification", Wireless Innovation Forum

[n.2] WINNF-TS-0112, "Requirements for Commercial Operation in the U.S. 3550-3700 MHz Citizens Broadband Radio Service Band", Wireless Innovation Forum

[n.3] WINNF-TS-1001, "CBRS Operational and Functional Requirements (Release 2)", Wireless Innovation Forum

[n.4] RFC-2119, "Key words for use in RFCs to Indicate Requirement Levels", March 1997.

[n.5] WINNF-SSC-0011, "Spectrum Sharing Committee Policy and Procedure SSC Abbreviations and Definitions", Wireless Innovation Forum

[n.6] WINNF-SSC-0013, "WInnForum Registry of CBRS Vendor/Admin IDs for Third-Party Proprietary Feature Prefixes", Wireless Innovation Forum

[n.7] Electronic Code of Federal Regulations, Title 47, Chapter I, Subchapter D, Part 96 Citizens Broadband Radio Service, https://www.ecfr.gov/cgi-bin/text-idx?node=pt47.5.96

[n.8] RFC-7542, "The Network Access Identifier", DeKok, May 2015

[n.9] Electronic Code of Federal Regulations, Title 47, Chapter I, Subchapter A, Part 2, Subpart J, §2.926 FCC identifier, https://www.ecfr.gov/cgi-bin/text-idx?node=se47.1.2_1926

[n.10] Electronic Code of Federal Regulations, Title 47, Chapter I, Subchapter A, Part 2, Subpart D, §2.302 Call signs, https://www.ecfr.gov/cgi-bin/text-idx?node=se47.1.2_1302

[n.11] WINNF-SSC-0002, "Signaling Protocols and Procedures for Citizens Broadband Radio Service (CBRS): WInnForum Recognized CBRS Air Interfaces and Measurements", Wireless Innovation Forum

[n.12] WINNF-SSC-0010, "Signaling Protocols and Procedures for Citizens Broadband Radio Service (CBRS): WInnForum Recognized CBRS Grouping Information", Wireless Innovation Forum

[n.13] NGA.STND.0036_1.0.0_WGS84 (Version 1.0.0 - July 8, 2014): Department of Defense (DoD) World Geodetic System (WGS) 1984

[n.14] RFC-7515, "JSON Web Signature (JWS)", Jones, Bradley and Sakimura, May 2015

[n.15] RFC-4648, "The Base16, Base32, and Base64 Data Encodings", Josefsson, October 2006

[n.16] RFC-3339, "Date and Time on the Internet: Timestamps", Klyne, Newman, July 2002

[n.17] RFC-7159, "The JavaScript Object Notation (JSON) Data Interchange Format", December 2017

[n.18] RFC-3986, "Uniform Resource Identifier (URI): Generic Syntax", Berners-Lee, Fielding, Masinter, January 2005

[n.19] RFC-1035, "Domain Names - Implementation and Specification", Mockapetris, November 1987

[n.20] RFC-2818, "HTTP Over TLS", Rescorla, May 2000

[n.21] RFC-2616, "Hypertext Transfer Protocol -- HTTP/1.1", Fielding, Gettys, Mogul, Frystyk, Masinter, Leach and Berners-Lee, June 1999

[n.22] RFC-7231, "Hypertext Transfer Protocol (HTTP/1.1): Semantics and Content", Fielding, Reschke, June 2014

[n.23] WINNF-TS-0245, "Operations for Citizens Broadband Radio Service (CBRS): Priority Access License (PAL) Database Technical Specification", Wireless Innovation Forum

[n.24] WINNF-TS-5006, "Operations for Citizens Broadband Radio Service (CBRS): CBSD Antenna Pattern Database Technical Specifications", Wireless Innovation Forum

[n.25] WINNF-TS-4005, "CBRS Release 2 Self-Testing Policy", Wireless Innovation Forum

4   Definitions and abbreviations

4.1   Abbreviations

For the purposes of the present document, the abbreviations and definitions given in [n.5] and the following apply.

FID   Feature ID

4.2   Definitions

For the purposes of the present document, the abbreviations and definitions given in [n.5] and the following apply.

Antenna Pattern Identifier: A string identifying the explicit antenna pattern.

Authorized State: The state of a Grant where it is currently approved by the SAS and that the radio transmission using the Grant is allowed to occur.

EAP Parameter Set: A set of CBSD antenna parameters required for applying a particular method for CBSD antenna gain calculation defined by Enhanced Antenna Pattern feature.

Feature Capability List: A list of Feature IDs representing all operationally supported features of a SAS or a CBSD.

Feature ID: A string identifying the name of a Release 2 feature.

NOTE: Feature IDs applicable to this specification are WInnForum-defined FIDs included in this document or Third-Party Proprietary FIDs (see section 6.2.1).

Granted State: The state of a Grant where it is currently approved by the SAS but radio transmission using the Grant is not permitted.

Operationally Supported Feature ID: A Feature ID whose corresponding feature is enabled for operational use.

NOTE: Any feature which is enabled for a SAS by the SAS Administrator or which is enabled for a CBSD/DP by the CBSD User is considered as "operationally supported".

Registered State: The state of a CBSD when it is currently registered with a SAS.

Unregistered State: The state of a CBSD when it is not currently registered with a SAS.

5 Architecture of SAS-CBSD Interfaces

5.1 Baseline Architecture

There is no change concerning the architecture from WINNF-TS-0016 [n.1].

6 Release 2 Mandatory and Optional Features

6.1 General

Section 6 defines the procedure enhancements for the SAS-CBSD Interface. Minimum requirements to claim compliance with WInnForum Release 2 SAS-CBSD Protocol specified in this document are the following:

(i) To support Feature Capability Exchange as specified in section 6.2;

(ii) To support additions made to "RELEASE 2 ENHANCEMENT" parameters and response codes marked as "**FEATURE ID**: *n/a*"; and

(iii) To support "RELEASE 2" parameters and response codes marked as "**FEATURE ID**: *n/a*".

NOTE 1:   Labels "RELEASE 2 ENHANCEMENT" and "RELEASE 2" are defined in section 8.1.1 of this document.

NOTE 2:   Items (ii) and (iii) are collectively referred to as "feature-independent extensions" in this document and considered for Release 2 functionalities.

6.2 Feature Capability Exchange

6.2.1 General

This section defines Feature Capability Exchange which ensures backward and forward compatibility between different releases of SAS and CBSD. Operational support of this feature is mandatory for Release 2 operation.

Section 6.2.2 gives backward and forward compatibility principles of inter-release operation. Section 6.2.3 defines details of Feature Capability Exchange and the required procedure.

Feature Capability Exchange is specified to facilitate the exchange of both WInnForum defined Feature IDs and Third-Party Proprietary Feature IDs (hereinafter "Proprietary Feature IDs"). WInnForum-defined Feature IDs (prefixed with "WF_") are specified in this document starting with section 6.3. Proprietary Feature IDs shall be prefixed with CBRS Vendor/Admin IDs registered in WINNF-SSC-0013 [n.6].

6.2.2   Backward and Forward Compatibility Principles of Inter-Release Operation

6.2.2.1   Exchange of Feature Capability List

To allow predictable operation between SASs and CBSDs supporting different releases of SAS-CBSD protocols, the SAS-CBSD protocol in this specification is designed to be backward and forward compatible. To ensure backward and forward compatibility, any SAS and CBSD beyond Release 1 shall perform Feature Capability Exchange as specified in section 6.2.3.

The Feature Capability Exchange enables SAS and CBSD to exchange Feature Capability List over the SAS-CBSD interface upon registration. The recipient shall ignore unrecognized Feature IDs received in the Feature Capability List and proceed as per section 6.2.3. If a CBSD does not share its Feature Capability List with a SAS, the SAS shall treat the CBSD as a Release 1 CBSD and shall not send its Feature Capability List to the CBSD. Likewise, if a SAS does not share its Feature Capability List with a CBSD, the CBSD shall treat the SAS as a Release 1 SAS.

Table 1: SAS/CBSD Operation Mode

		CBSD Capability	
		Rel. 1	**Rel. 2**
SAS Capability	**Rel. 1**	Rel. 1	Rel. 1
	Rel. 2	Rel. 1	Rel. 2

6.2.2.2   Handling of Release 2 Parameters

6.2.2.2.1   Inclusion of Feature-Specific Parameters

Feature-specific parameters are always Conditional, Optional, or REG-Conditional and identified with the corresponding Feature ID in the section 8 of this document. If both SAS and CBSD operationally support a feature (see section 6.2.3.1), the corresponding feature-specific parameter(s) shall be included in the messages as defined in section 8 of this document.

6.2.2.2.2   Parameter Warning in Successful Procedures

The Release 2 SAS may inform a Release 2 CBSD about a parameter warning in successfully completed procedures (i.e. response code 0 (SUCCESS)) by using *responseData* and *responseMessage*. The CBSD shall accept *responseData* and *responseMessage* with response code 0 (SUCCESS).
See sections 6.2.2.2.3 and 6.2.2.2.4 for more details of parameter warnings.

6.2.2.2.3   Handling of Unrecognized Parameters

A Release 2 SAS and a Release 2 CBSD shall ignore a parameter in a received message if the parameter name is unrecognized or the feature associated with the parameter is not operationally supported by both the SAS and the CBSD.

The Release 2 SAS should inform a Release 2 CBSD, as per section 6.2.2.2.2, about an unrecognized parameter received in a request message, if the SAS is able to properly process and operate with the rest of the parameters in the request message.

6.2.2.2.4   Handling of Parameters with Invalid Values

The Release 2 SAS should inform a Release 2 CBSD, as per section 6.2.2.2.2, about a parameter with an invalid value received in a request message, if the SAS is able to properly process and operate with the rest of the required parameters associated with the feature in the request message.

6.2.2.2.5   Handling of Parameters with Unrecognized Optional Values

For the parameters where an acceptable enumeration is defined and the enumeration includes optional value(s), a Release 2 SAS and a Release 2 CBSD shall ignore an optional value in a received message if the optional value is unrecognized or the feature associated with the optional value is not operationally supported by both the SAS and the CBSD.

The Release 2 SAS should inform a Release 2 CBSD, as per section 6.2.2.2.2, about unrecognized optional value(s) received in a request message, if the SAS is able to properly process and operate with the rest of the parameters in the request message.

> NOTE: The requirements specified in this subsection are not applicable to unrecognized FIDs in the *cbsdFeatureCapabilityList* parameter in *RegistrationRequest* object and the values of the *groupType* and *groupId* parameters in *GroupParam* object. See handling of unrecognized (i.e., not operationally supported) FIDs in section 6.2.3, and see handling of unrecognized (i.e., not operationally supported) values of the *groupType* and *groupId* parameters in Parameter Information of the *supportedBySas* parameter in Table 18.

6.2.3   Details of Feature Capability Exchange

6.2.3.1   Feature Capability Exchange in the CBSD Registration Procedure

For Release 2 operation, CBSD Registration procedure is extended so that SAS and CBSD can perform Feature Capability Exchange.

During CBSD Registration procedure, the CBSD shall include in the Registration Request its Feature Capability List via *cbsdFeatureCapabilityList* in accordance with the specified condition in section 8.2. *cbsdFeatureCapabilityList* may be an empty list if CBSD operationally supports only feature-independent extensions without operationally supporting any Release 2 feature.

SAS shall ignore Feature IDs listed in the *cbsdFeatureCapabilityList* which are not Operationally Supported Feature IDs of the SAS.

The SAS shall include in the Registration Response its Feature Capability List via *sasFeatureCapabilityList* in accordance with the specified condition in section 8.2. The *sasFeatureCapabilityList* may be an empty list if SAS operationally supports only feature-independent extensions without operationally supporting any Release 2 feature.

CBSDs shall ignore Feature IDs listed in the *sasFeatureCapabilityList* which are not operationally supported by the CBSD.

Upon successful completion of CBSD Registration procedure, CBSD and SAS shall understand the common Feature IDs that are operationally supported by both parties and shall operate with the common operationally supported Feature IDs.

6.2.3.2   DEPRECATED

6.3   Enhanced CBSD Group Handling (FID: WF_ENH_GROUP_HANDLING)

6.3.1   General

This feature enhances the exchange of grouping information (*GroupParam* object) between CBSD/DP and SAS by allowing the exchange outside the CBSD Registration procedure. In addition, this feature allows grouping configuration information (*GroupConfig* object) to be provided from SAS to CBSD/DP. The list of applicable Group types, Group ID definition and their information is registered in WINNF-SSC-0010 [n.12]. Operational support of this feature is optional for Release 2 operation.

> NOTE: Any WInnForum-defined Group types for Release 2 operation (see WINNF-TS-1001 [n.3]) are described in section 6 of this document for traceability purposes. Their details are documented in WINNF-SSC-0010 [n.12].

The Enhanced CBSD Group Handling feature can be used only when both the SAS and the CBSD/DP indicate operational support for this feature in the Feature Capability Exchange. When either SAS or CBSD/DP does not operationally support this feature, Release 1 grouping information exchange can still be performed (see Release 1 grouping information exchange in WINNF-TS-0016 [n.1]).

This feature does not specify any particular types/values of grouping information listed in WINNF-SSC-0010 [n.12]. This feature enables a SAS and a CBSD to indicate their operational support of Group types and/or Group IDs. Grouping information and grouping configuration information for the Group types and/or Group IDs that are operationally supported by both a SAS and a CBSD shall be exchanged by using this feature.

> NOTE: Feature Capability Exchange is not used for the purpose of exchanging operational support of Group types and/or Group IDs between a SAS and a CBSD.

6.3.2   Release 2 Feature Dependencies and Interworking

There is no dependency on other features in this document.

The following Group types are handled by this feature, but this does not exclude usage of other Group types that may be added in WINNF-SSC-0010 [n.12] after publication of this version of this document:

- Coexistence Group (Releases 1 and 2) [n.2] [n.12]

- Principal-Subordinate Single Frequency Group (Release 2) [n.3] [n.12]

- Interdependent Single Frequency Group (Release 2) [n.3] [n.12]

- Separable Single Frequency Group (Release 2) [n.3] [n.12]

- Passive DAS Group (Release 2) [n.3] [n.12]

See definitions and requirements applicable for these Group types in WINNF-TS-0112 [n.2] and WINNF-TS-1001 [n.3]. See also WINNF-SSC-0010 [n.12] for more details of the Group types.

6.3.3   Description

There are two types of Grouping Information objects.

GroupParam object is used to communicate grouping information from the CBSD/DP to SAS. The object includes the Group type, the Group ID and optionally more detailed information of the Group that the CBSD is currently associated with. When the *groupingParam* parameter is included in a Request message from CBSD to the SAS, it shall contain:

- All the Groups that CBSD is a member of and optionally updated information (groupInfo) for any of these Groups
- All new Groups that CBSD desires to be a member of and optionally additional information (*groupInfo*) related to these Groups.

The SAS shall consider the CBSD disassociated with any Groups that were previously reported to the SAS but are not included in the *groupingParam* of the Request message.

GroupConfig object is used to communicate grouping configuration from SAS to CBSD/DP. Upon reception of grouping information in a request message, SAS shall communicate grouping configuration information corresponding to the received grouping information. Grouping configuration information indicates whether the SAS operationally supports the Group type and/or Group ID provided by the CBSD. For operationally supported Group type and Group ID, SAS may indicate more detailed grouping configuration to the CBSD/DP. Even if SAS does not receive grouping information in a request message, SAS may communicate grouping configuration to CBSD/DP for the Groups operationally supported by both the CBSD/DP and the SAS.

6.3.3.1   Handling of Errors identified by the SAS in Grouping Information from the CBSD

This section specifies handling of errors identified by the SAS in Grouping Information sent from the CBSD to the SAS included in a request message object (i.e., *RegistrationRequest* object, *SpectrumInquiryRequest* object, *GrantRequest* object, *HeartbeatRequest* object and *RelinquishmentRequest* object).

6.3.3.1.1   Not Operationally Supported Group Types and Group IDs

If a SAS does not operationally support the values of *groupType* and/or *groupId* parameters specified by the CBSD in one or more *GroupParam* objects, the SAS shall set the value of those parameters in a *GroupConfig* object to the same values as in the corresponding *GroupParam* object and set the value of *supportedBySas* parameter to false. For *RegistrationResponse* object, the SAS may use either *responseCode* 0 (SUCCESS) with the *responseData* indicating PARAM_WARNING or *responseCode* 201 (GROUP_ERROR). For *SpectrumInquiryResponse*, *GrantResponse*, *HeartbeatResponse* and *RelinquishmentResponse* objects, the SAS may use either *responseCode* 0 (SUCCESS) with the *responseData* indicating PARAM_WARNING or *responseCode* 105 (DEREGISTER).

NOTE 1:   If *responseCode* 0 (SUCCESS) with the *responseData* indicating PARAM_WARNING is returned in *RegistrationResponse* object, the CBSD is transitioned to *Registered* State and can continue to Spectrum Inquiry procedure and Grant procedure. However, the SAS does not consider the CBSD associated with Group(s) whose *supportedBySas* parameter was set to false.

NOTE 2:   If *responseCode* 105 (DEREGISTER) or 201 (GROUP_ERROR) is returned, the CBSD is in *Unregistered* State. The CBSD management system or CBSD

User needs to remove all the Groups which were indicated *supportedBySas* = false from the CBSD's configuration in order for the CBSD to become registered with SAS.

6.3.3.1.2 Indication of Conflicted/Unsupported Combination of Groups

If the SAS determines that any combination of Groups declared by the CBSD leads to conflict or is unsupported by the SAS, the SAS shall indicate it to the CBSD. For *RegistrationResponse* object, the SAS may use either *responseCode* 0 (SUCCESS) with the *responseData* indicating MULTI_GROUP_HANDLING_WARNING or *responseCode* 201 (GROUP_ERROR). For *SpectrumInquiryResponse*, *GrantResponse*, *HeartbeatResponse* and *RelinquishmentResponse* objects, the SAS may use either *responseCode* 0 (SUCCESS) with the *responseData* indicating MULTI_GROUP_HANDLING_WARNING or *responseCode* 105 (DEREGISTER), where the *responseData* for MULTI_GROUP_HANDLING_WARNING shall contain the name of Group type and/or ID. The SAS shall not apply the management policy of the ignored Group(s) to the CBSD.

6.3.3.1.3 Indication of Errors in *GroupInfo* object

In order to indicate errors in the *groupInfo* parameter associated with the *groupType* and/or *groupId* parameters, the SAS may use either non-zero *responseCode* (e.g. 102, 103, 201) or the *groupInfoResponse* parameter in the *GroupConfig* object.

The *groupInfoResponse* parameter includes *groupInfoResponseCode* indicating errors in the *groupInfo* parameter. Basic common values of *groupInfoResponseCode* parameter available for any Group type and ID are defined in Table 2.

Table 2: Common Definitions of *groupInfoResponseCode* for any Group type and ID

groupInfoResponseCode	Description
VALUE: 0 **NAME:** SUCCESS	All the parameters in the *groupInfo* parameter were successfully processed by the SAS.
VALUE: 100 **NAME:** VERSION	The version of *GroupInfo* object used by the CBSD is not supported by the SAS.
VALUE: 101 **NAME:** *Reserved*	*Reserved for future version of this document.*
VALUE: 102 **NAME:** MISSING_PARAM	One or more Required parameters or Conditional parameters that meet specified inclusion rule are missing from the *groupInfo* parameter. The *groupInfoResponseData* parameter may carry names of the missing parameters.
VALUE: 103 **NAME:** INVALID_VALUE	One or more parameters included in the *groupInfo* parameter have invalid value. The *groupInfoResponseData* parameter may carry parameter names which have invalid value.
VALUE: 104 **NAME:** *Reserved*	*Reserved for future version of this document.*

VALUE: 105 **NAME:** *Reserved*	*Reserved for future version of this document.*
VALUE: 106 **NAME:** NOT_PROCESSED	The SAS cannot provide a proper response to the *groupInfo* parameter temporarily. The CBSD may resend the same *groupInfo* parameter after receiving this *groupInfoResponseCode* value. The *groupInfoResponseData* parameter may carry suggested wait time for the CBSD to resend the *groupInfo*.
NOTE: The *groupInfoResponseCode* values in this table are used when a SAS returns a *GroupConfig* object in a Response Message in response to a Request Message including a *GroupParam* object.	

Even if a non-zero *groupInfoResponseCode* value is returned by the SAS, the CBSD may continue to operate according to the *responseCode* value in the *Response* object.

In addition to the values defined in Table 2, the organization, entity or individual that specifies a Group type and/or ID may define the acceptable values of *groupInfoResponseCode* parameter dedicated to *GroupInfo* object associated with their Group type and ID. See details in WINNF-SSC-0010 [n.12].

6.4 Enhanced Antenna Pattern (EAP) (FID: WF_ENH_ANTENNA_PATTERN)

6.4.1 General

This feature enables the use of enhanced antenna patterns for higher efficiency use of the CBRS band in accordance with requirements and applicable use cases provided in WINNF-TS-1001 [n.3]. Operational support of this feature is optional for Release 2 operation.

The Enhanced Antenna Pattern (EAP) feature can be used only when both the SAS and the CBSD/DP indicate operational support for this feature in the Feature Capability Exchange.

6.4.2 Release 2 Feature Dependencies and Interworking

There is no dependency on other features.

6.4.3 Description

In WINNF-TS-1001 [n.3], the six methods (A, B, C, D, E and F) for calculation of CBSD antenna gain using this feature are defined.

- Method A: Use of one two-dimensional antenna pattern recorded in the CBSD Antenna Pattern Database [n.24]

- Method B: Use of horizontal and vertical antenna patterns recorded in the CBSD Antenna Pattern Database [n.24]

- Method C: Use of horizontal and vertical antenna patterns derived from the CBSD Registration parameters

- Method D: Use of horizontal antenna pattern recorded in the CBSD Antenna Pattern Database [n.24] and vertical antenna pattern derived from the CBSD Registration parameters

- Method E: Use of horizontal antenna pattern recorded in the CBSD Antenna Pattern Database [n.24] (NOTE: Vertical antenna pattern is not used in this method.)

- Method F: Use of horizontal antenna pattern derived from the CBSD Registration parameters (NOTE: This is equivalent to Release 1-based CBSD antenna gain calculation and vertical antenna pattern is not used in this method)

In order to allow the CBSD/DP to provide necessary information to the Managing SAS and to enable the Managing SAS to employ these methods, the following enhancements to SAS-CBSD Protocol are defined in this document:

a. Addition of vertical 3dB-beamwidth (*antennaVerticalBeamwidth*):
    o This information is used together with the antenna downtilt (*antennaDowntilt*)

b. Extension of antenna model parameter (*antennaModel*) definition:
    o It is treated as Antenna Pattern Identifier (ID) for the purpose of this feature.
    o SAS identifies an explicit antenna pattern by using the Antenna Pattern ID from the CBSD Antenna Pattern Database available to the SAS (see WINNF-TS-5006 [n.24]).
        ▪ Explicit antenna pattern may be a form of either a 1D antenna pattern, one horizontal plus one vertical antenna patterns or a 2D antenna pattern.
    o The explicit antenna pattern is used together with antenna azimuth (*antennaAzimuth*) and antenna downtilt (*antennaDowntilt*).

c. Addition of front-to-back ratio (*frontToBackRatio*):
    o Front-to-back ratio is defined in WINNF-TS-1001 as a value (in dB) provided by the antenna or equipment manufacturer that generally describes the ratio of power radiated in the boresight direction to the power radiated in the opposite direction.
    o This information is used by the Managing SAS to derive antenna patterns according to the formula specified in WINNF-TS-1001 [n.3].
    o This is defined as Optional parameter in *InstallationParam* object. If this parameter is not provided, the Managing SAS will use 20 dB as front-to-back ratio of the CBSD antenna pattern.

The CBSD shall declare the support of this feature in the Feature Capability Exchange if it operationally supports at least one of the above enhanced parameters (i.e., a. and/or b.). The SAS shall declare the support of this feature in the Feature Capability Exchange if it supports the above enhanced parameters and meets the requirements defined in WINNF-TS-1001 [n.3].

In order for the Managing SAS to apply an appropriate EAP method, the CBSD (in case of single-step registration) or the CBSD registrant (in case of multi-step registration) should include a particular set of antenna parameters (i.e., EAP Parameter Set) in the *InstallationParam* object according to Table X in addition to mandatory antenna parameters for the CBSD Registration. If *antennaModel* is included in the *InstallationParam* object as part of an EAP Parameter Set, the format of *antennaModel* shall follow the rule specified in Table 8. The Managing SAS shall not reject the CBSD Registration so long as the Release 1 based CBSD Registration requirement is met (See columns for mandatory/optional registration parameters in Table X).

NOTE: The Managing SAS will select an EAP method in order of precedence based on the antenna parameters provided in the *InstallationParam* object. If any EAP method (A to E) is not applicable, the Managing SAS will use Method F, as per requirements in WINNF-TS-1001, which is identical to Release 1 based CBSD antenna gain calculation.

Table 3: EAP Parameter Sets Necessary for Each Method

Antenna parameters for EAP feature	Defined Release	Mandatory/Optional for CBSD Registration[(*1)]		EAP Parameter Sets				
		Cat. A CBSD	Cat. B CBSD	A	B	C	D	E
antennaModel	Rel-1	O	O	Y	Y		Y	Y
antennaGain[(*1)]	Rel-1	M	M	Y	Y	Y	Y	Y
antennaAzimuth	Rel-1	O	M	Y	Y	Y	Y	Y
antennaDowntilt	Rel-1	O	M	Y	Y	Y	Y	
antennaBeamwidth	Rel-1	O	M			Y		
antennaVerticalBeamwidth	Rel-2	O	O			Y	Y	
frontToBackRatio	Rel-2	O	O			Y	Y	

NOTE 1: This column is shown for informational purpose. Inclusion rule (R/O/C) of each parameter is defined in Table 8 (*InstallationParam* object Definition).

NOTE 2: CBSD Antenna Pattern Records File in WINNF-TS-5006 is defined to include *peakAntennaGain* column, but the Managing SAS is required to use the *antennaGain* parameter provided by the CBSD or CPI during the CBSD Registration for calculation of CBSD antenna gain. More details can be found in WINNF-TS-5006 [n.24].

6.5 CPE-CBSD Indicator (FID: WF_CPE_CBSD_INDICATOR)

6.5.1 General

This feature allows the CBSD to indicate to the SAS that it is a CPE-CBSD. Operational support of this feature is optional for Release 2 operation.

NOTE: See definition of CPE-CBSD in WINNF-SSC-0011 [n.5].

The CPE-CBSD Indicator feature takes effect only when both the SAS and the CBSD/DP indicate operational support for this feature in the Feature Capability Exchange.

6.5.2 Release 2 Feature Dependencies and Interworking

There is no dependency on other features.

6.5.3 Description

The CBSD shall declare operational support of this feature in the Feature Capability Exchange if it operationally supports this feature. If the CBSD indicates operational support of this feature during the CBSD Registration procedure, then the CBSD shall also include the *cpeCbsdIndication* parameter in the Registration Request message. If the CBSD indicates operational support of this feature in the Feature

Capability Exchange Request message, then the CBSD shall also include the *cpeCbsdIndication* parameter in the *cbsdFeatureInfo* parameter. The SAS shall declare the support of this feature in the Feature Capability Exchange if it can recognize the information carried in the *cpeCbsdIndication* parameter.

6.6   Grant Update (FID: WF_GRANT_UPDATE)

6.6.1   General

This feature enables CBSD and SAS to transition a CBSD's existing Grant on a frequency range to a new Grant on the same frequency range but with modified *maxEirp* and/or *channelType*.

Operational support of this feature is optional for Release 2 operation. The Grant Update feature takes effect only when both the SAS and the CBSD/DP indicate operational support for this feature in the Feature Capability Exchange.

6.6.2   Release 2 Feature Dependencies and Interworking

There is no dependency on other features.

6.6.3   Description

This feature allows two mechanisms for update of a Grant:

(a)   Replacement of an existing Grant by a new Grant without Grant Relinquishment procedure, where only *maxEirp* is modified in the new Grant request.

(b)   Update of *channelType* through Heartbeat procedure.

For the mechanism (a), the following enhancements apply for each Grant:

- A SAS may approve a Grant request from a CBSD where the requested frequency range is exactly the same as an existing Grant of the CBSD but with modified *maxEirp.* Upon approval of such Grant request, the SAS shall terminate the existing Grant. A SAS shall respond with response code 103, if a CBSD sends any heartbeat on the terminated Grants as done in normal operation.

- A CBSD is not required to relinquish its existing Grant for replacement before requesting a new Grant with exactly the same frequency range as the existing Grant. Upon receiving approval of the new Grant, the CBSD shall consider the existing Grant as terminated.

For the mechanism (b), the following enhancements apply:

- A SAS may include *channelType* parameter in a *HeartbeatResponse* object for a Grant whose *channelType* is updated.

- Upon receiving the *channelType* parameter in a *HeartbeatResponse* object, the CBSD should consider it the latest channel type (i.e., PAL or GAA) of the Grant associated with the *HeartbeatResponse* object.

6.7 Feature-Agnostic Enhancements

In this version of the specification, the following feature-agnostic enhancements to SAS-CBSD Interface are specified.

- Extensions to the format of some number-type parameters (see Table 9)

- Recommendation of multiple sets of operational parameters in responses for new Grant requests (see Table 30 and Table 34)

- New response codes (see section 8.16)

> NOTE: For use of these feature-agnostic enhancements, the SAS and the CBSD are not required to perform Feature Capability Exchange.

7 Extensions to Message Encoding and Transport

7.1 SAS URLs of Different Releases

A SAS administrator may choose to use the same or different URLs for transporting messages defined in different releases of SAS-CBSD protocols. A SAS administrator shall ensure that all operational URLs are able to properly receive and respond to request messages from CBSDs/DPs supporting different releases of SAS-CBSD protocols pursuant to the backward and forward compatibility principles described in section 6.2.2.

7.2 SAS Method Names

Mapping of the SAS-CBSD messages, the corresponding JSON array names and the corresponding SAS method names shall be defined as per the following table.

Table 4: Mapping of SAS-CBSD Messages to JSON Array Names

SAS method names and baseline release number	SAS-CBSD Message Name	JSON Array Name
sas_method_name: `registration` **RELEASE:** Release 1	Registration Request Message	*registrationRequest*
	Registration Response Message	*registrationResponse*
sas_method_name: `featureCapabilityExchange` **RELEASE:** Release 2	Feature Capability Exchange Request Message	*featureCapabilityExchangeRequest*
	Feature Capability Exchange Response Message	*featureCapabilityExchangeResponse*
sas_method_name: `spectrumInquiry` **RELEASE:** Release 1	Spectrum Inquiry Request Message	*spectrumInquiryRequest*
	Spectrum Inquiry Response Message	*spectrumInquiryResponse*
sas_method_name: `grant` **RELEASE:** Release 1	Grant Request Message	*grantRequest*
	Grant Response Message	*grantResponse*
sas_method_name: `heartbeat` **RELEASE:** Release 1	Heartbeat Request Message	*heartbeatRequest*
	Heartbeat Response Message	*heartbeatResponse*
sas_method_name: `relinquishment` **RELEASE:** Release 1	Relinquishment Request Message	*relinquishmentRequest*
	Relinquishment Response Message	*relinquishmentResponse*
sas_method_name: `deregistration` **RELEASE:** Release 1	Deregistration Request Message	*deregistrationRequest*
	Deregistration Response Message	*deregistrationResponse*

SAS method name shall be used in the SAS URL for the SAS-CBSD Interface as defined in WINNF-TS-0016 [n.1].

8 Baseline Parameters of SAS-CBSD Messages and Extensions

8.1 General

Section 8 defines baseline parameters of SAS-CBSD messages and the extensions specified in section 6.

8.1.1 Label for Extension Parameters and Response Codes

Parameters concerning the extensions specified in section 6 are described with the following column format:

Table 5: Column Format for Extension Parameters

Parameter
NAME: [Name of extension parameter]
DATA TYPE: [One of JSON Data Types specified in section 8.1.2]
EXTENSION TYPE: ["RELEASE 2 ENHANCEMENT" or "RELEASE 2"]
FEATURE ID: [Feature ID(s) or *n/a*]

OP_OR_CD_EXTENSION:
     SAS: ["*Conditional*" or "*Optional*"]
     CBSD: ["*Conditional*" or "*Optional*"]

The label "**EXTENSION TYPE**" describes which types of extensions are made. The followings are the definitions of values used for this label:

- "RELEASE 2 ENHANCEMENT": Parameters and response codes which were defined originally in Release 1 [n.1] and which have the definitions extended or modified only for the purpose of Release 2 operation. Extended or modified definitions are captured in the Parameter Information column of the table.

- "RELEASE 2": Parameters and response codes which do not exist in Release 1 [n.1] and which are defined for the purpose of Release 2 operation.

The label "**FEATURE ID**" describes in which specific feature(s) this parameter is used. The values used for this label are WInnForum-defined FID(s) or "*n/a*", where "*n/a*" means that the parameter does not depend on any specific feature (i.e., feature-independent extension) and shall be supported (mandatory) for Release 2 operation.

The label "**OP_OR_CD_EXTENSION**" is included in the column if the parameter is feature-independent extension and support of the parameter is not mandatory. This label describes whether support of feature-independent extension is conditional ("*Conditional*") or optional ("*Optional*") for SAS and CBSD. If "**OP_OR_CD_EXTENSION**" is marked "*Conditional*", the condition is specified in the Parameter Information column of the table. For the parameters having this label, "**FEATURE ID**" does not exist in the column.

These labels and their values are also used for the definitions of extension or modified response codes and response data in Table 43 and Table 44.
Any parameter and response code which does not have labels "FEATURE ID", "EXTENSION TYPE" and "OP_OR_CD_EXTENSION" is specified in WINNF-TS-0016 [n.1] and its description is reproduced in sections starting from section 8.2 <u>for information only</u>.

8.1.2 JSON Data Type

A parameter value can be one of the primitive JSON data types, i.e., string, number, boolean, array, or object. If data type of a parameter is an object, a name for the object is given and a separate table

describes parameters in the object. If an object is defined in another document, definition of the object is left to such document and the citation is put in the column of Parameter Information.

8.1.3   Parameter Inclusion Criteria

Each parameter is indicated as "Required", "Optional" or "Conditional". The definitions of these indicators are as follows:

"Required":	The parameter shall always be included in the message.
"Optional":	The parameter may be included in the message.
"Conditional":	The parameter shall be included in the message if and only if the specified conditions are satisfied.

The tables of parameters in this section have a column marked R/O/C that indicates whether the particular parameter is required, optional, or conditional.

8.1.4   REG-Conditional Registration Parameters

REG-Conditional Registration Parameter is a parameter that is required by the SAS to complete the CBSD registration process but may be omitted in the *RegistrationRequest* object. If not included in the *RegistrationRequest* object, the parameter, to the extent that it is needed by the SAS to satisfy the 47 CFR Part 96 [n.7], shall be provided to the SAS by other means outside the protocol specified in this document, e.g., it may be provided by a CPI as required by 47 CFR Part 96 [n.7] for Category B CBSDs or CBSDs without automatic location determination, or for operational reasons. Other means based on CBSD device characteristics that are beyond the scope of this specification, are not precluded from use.

Such parameters are labeled as "REG-Conditional" in a column marked R/O/C.

8.2   Registration Request Message

Table 6: Registration Request Message

Parameter	R/O/C	Parameter Information
NAME: *registrationRequest* **DATA TYPE**: array of object: *RegistrationRequest*	Required	Array of *RegistrationRequest* data objects. Each *RegistrationRequest* data object represents a registration request of a CBSD.

8.2.1   RegistrationRequest object

Table 7: *RegistrationRequest* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *userId* **DATA TYPE**: string	Required	The User Registration Identifier (UR-ID) per [n.2] R2-SRR-02 conformant per section 2.2 of [n.8].
NAME: *fccId* **DATA TYPE**: string	Required	The FCC certification identifier of the CBSD. The value is a string of up to 19 characters as described in [n.9].

Parameter	R/O/C	Parameter Information
NAME: *cbsdSerialNumber* **DATA TYPE**: string	Required	A serial number assigned to the CBSD by the CBSD device manufacturer having a maximum length of 64 octets. This serial number shall be unique for every CBSD instance sharing the same value of the *fccId*. Each CBSD has a single CBSD Antenna and has a single *cbsdSerialNumber*. NOTE: See definition of CBSD Antenna in [n.5].
NAME: *callSign* **DATA TYPE**: string	Optional	A device identifier provided by the FCC per [n.10]. NOTE: This parameter is FFS.
NAME: *cbsdCategory* **DATA TYPE**: string	REG-Conditional	Device Category of the CBSD. Allowed values are "A" or "B" as defined in Part 96 [n.7].
NAME: *cbsdInfo* **DATA TYPE**: object: *CbsdInfo*	Optional	Information about this CBSD model.
NAME: *airInterface* **DATA TYPE**: object: *AirInterface*	REG-Conditional	A data object that includes information on the air interface technology of the CBSD.
NAME: *installationParam* **DATA TYPE**: object: *InstallationParam*	REG-Conditional	A data object that includes information on CBSD installation.
NAME: *measCapability* **DATA TYPE**: array of string	REG-Conditional	The array of string lists measurement reporting capabilities of the CBSD. The permitted enumerations are specified in [n.11].
NAME: *groupingParam* **DATA TYPE**: array of object: *GroupParam* **EXTENSION TYPE**: RELEASE 2 ENHANCEMENT **FEATURE ID**: WF_ENH_GROUP_HANDLING	Optional	An array of data objects that includes information about all of the Group(s) being declared by the CBSD (see section 6.3).
NAME: *cpiSignatureData* **DATA TYPE**: object: *CpiSignatureData*	Optional	The CPI is vouching for the parameters included in this object. In addition, the digital signature for these parameters is included.

Parameter	R/O/C	Parameter Information
NAME: *cbsdFeatureCapabilityList* **DATA TYPE**: array of string **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: *n/a*	Required	This parameter represents CBSD's Feature Capability List containing zero or more FIDs. CBSD shall include all its Operationally Supported FIDs. WInnForum-defined FIDs shall be conformant with those described in the headings of sections specifying features in section 6 of this document. Proprietary FIDs shall be prefixed with CBRS Vendor/Admin IDs registered in WINNF-SSC-0013 [n.6]. This parameter shall be included if the CBSD supports any Release 2 functionality. If it is not included, the CBSD is treated as a Release 1 CBSD according to section 6.2.2 of this document.
NAME: *cpeCbsdIndication* **DATA TYPE**: boolean **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: WF_CPE_CBSD_INDICATOR	Conditional	This parameter shall be set by the CBSD if and only if the CBSD indicates operational support of the CPE-CBSD Indicator feature in the *cbsdFeatureCapabilityList* parameter. This parameter, when set to TRUE, indicates the CBSD is a CPE-CBSD. The value FALSE indicates the CBSD is not a CPE-CBSD.

NOTE: JSON format of *cbsdFeatureCapabilityList* parameter is according to the following:

```
"cbsdFeatureCapabilityList": []
```
(for zero FID) OR

```
"cbsdFeatureCapabilityList": ["FID_1"]
```
OR

```
"cbsdFeatureCapabilityList": ["FID_1", "FID_2", "FID_3"]
```

8.2.2   AirInterface object

Table 8: *AirInterface* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *radioTechnology* **DATA TYPE**: string	REG-Conditional	This parameter specifies the radio access technology that the CBSD uses for operation in the CBRS band. The permitted values are specified in [n.11].

8.2.3 *InstallationParam object*

Table 9: *InstallationParam* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *latitude* **DATA TYPE**: number	REG-Conditional	Latitude of the CBSD Antenna location in degrees relative to the WGS 84 datum [n.13]. The allowed range is from -90.000000 to +90.000000 and the values are specified using 6 digits to the right of the decimal point. Positive values represent latitudes north of the equator; negative values south of the equator. NOTE: Use of WGS84 will also satisfy the NAD83 positioning requirements for CBSDs with the accuracy specified by 47 CFR Part 96 [n.7]. For reporting the CBSD location to the FCC, the SAS is responsible for converting coordinates from the WGS84 datum to the NAD83 datum.
NAME: *longitude* **DATA TYPE**: number	REG-Conditional	Longitude of the CBSD Antenna location in degrees relative to the WGS84 datum [n.13]. The allowed range is from -180.000000 to +180.000000 and the values are specified using 6 digits to the right of the decimal point. Positive values represent longitudes east of the prime meridian; negative values west of the prime meridian. NOTE: Use of WGS84 will also satisfy the NAD83 positioning requirements for CBSDs with the accuracy specified by 47 CFR Part 96 [n.7]. For reporting the CBSD location to the FCC, the SAS is responsible for converting coordinates from the WGS84 datum to the NAD83 datum.

Parameter	R/O/C	Parameter Information
NAME: *height* **DATA TYPE**: number	REG-Conditional	The CBSD Antenna height in meters. When the value of *heightType* parameter value is "AGL", the antenna height should be given relative to ground level. When the *heightType* parameter value is "AMSL", it is given with respect to WGS84 datum. For reporting the CBSD location to the FCC, the SAS is responsible for converting coordinates from the WGS84 datum to the NAD83 datum.
NAME: *heightType* **DATA TYPE**: string	REG-Conditional	The value should be "AGL" or "AMSL". AGL height is measured relative to the ground level. AMSL height is measured relative to the mean sea level.
NAME: *horizontalAccuracy* **DATA TYPE**: number	Optional	A positive number in meters to indicate accuracy of the CBSD antenna horizontal location. This optional parameter should only be present if its value is less than the FCC requirement of 50 meters.
NAME: *verticalAccuracy* **DATA TYPE**: number	Optional	A positive number in meters to indicate accuracy of the CBSD antenna vertical location. This optional parameter should only be present if its value is less than the FCC requirement of 3 meters.
NAME: *indoorDeployment* **DATA TYPE**: boolean	REG-Conditional	Whether the CBSD antenna is deployed indoor or not. ▪ true: indoor. ▪ false: outdoor.

Parameter	R/O/C	Parameter Information
NAME: *antennaAzimuth* **DATA TYPE**: number **EXTENSION TYPE**: RELEASE 2 ENHANCEMENT **FEATURE ID**: WF_ENH_ANTENNA_PATTERN	REG-Condition al	Boresight direction of the horizontal plane of the antenna in degrees with respect to true north. The value of this parameter is an integer with a value between 0 and 359 inclusive. A value of 0 degrees means true north; a value of 90 degrees means east. This parameter is Optional for Category A CBSDs and REG-Conditional for Category B CBSDs. For Release 2 EAP feature, if the *InstallationParam* object of Category A CBSD does not include this parameter with valid value, the SAS operationally supporting EAP feature shall assume the CBSD employs omni-directional antenna.
NAME: *antennaDowntilt* **DATA TYPE**: number **EXTENSION TYPE**: RELEASE 2 ENHANCEMENT **FEATURE ID**: WF_ENH_ANTENNA_PATTERN	REG-Condition al	Antenna down tilt in degrees and is an integer with a value between -90 and +90 inclusive; a negative value means the antenna is tilted up (above horizontal). This parameter is Optional for Category A CBSDs and REG-Conditional for Category B CBSDs. For Release 2 EAP feature, the value of this parameter shall be within the range between -15 degrees and 15 degrees inclusive. NOTE: If the value is outside the range, the SAS will not use vertical antenna pattern in calculation of the CBSD antenna gain.
NAME: *antennaGain* **DATA TYPE**: number **EXTENSION TYPE**: RELEASE 2 ENHANCEMENT **FEATURE ID**: *n/a*	REG-Condition al	Peak antenna gain in dBi. This parameter is an integer with a value between -127 and +128 (dBi) inclusive. In Release 2, this parameter may also be a floating-point value. NOTE: This parameter is used also for EAP feature but no additional extension is defined for the purpose of EAP feature.

Parameter	R/O/C	Parameter Information
NAME: *eirpCapability* **DATA TYPE**: number **EXTENSION TYPE**: RELEASE 2 ENHANCEMENT **FEATURE ID**: *n/a*	Optional	This parameter is the maximum EIRP in units of dBm/10MHz to be used by the CBSD and shall be no more than the rounded-up FCC certified maximum EIRP. The value of this parameter is an integer with a value between -127 and +47 (dBm/10MHz) inclusive. If not included, SAS shall set *eirpCapability* as the rounded-up FCC certified maximum EIRP of the CBSD. In Release 2, this parameter may also be a floating-point value.
NAME: *antennaBeamwidth* **DATA TYPE**: number **EXTENSION TYPE**: RELEASE 2 ENHANCEMENT **FEATURE ID**: WF_ENH_ANTENNA_PATTERN	REG-Conditional	3-dB antenna beamwidth of the antenna in the horizontal-plane in degrees. This parameter is an unsigned integer between 0 and 360 (degrees) inclusive. It is Optional for Category A CBSDs and REG-Conditional for Category B CBSDs. For Release 2 EAP feature, if the *InstallationParam* object of Category A CBSD does not include this parameter with valid value, the SAS operationally supporting EAP feature shall assume the CBSD employs omni-directional antenna (i.e., 360 degrees). NOTE: A value of 360 (degrees) means the antenna has an omnidirectional radiation pattern in the horizontal plane.
NAME: *antennaVerticalBeamwidth* **DATA TYPE**: number **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: WF_ENH_ANTENNA_PATTERN	Optional	3-dB antenna beamwidth of the antenna in the vertical-plane in degrees. This parameter is an unsigned integer having a value between 0 and 360 (degrees) inclusive. This parameter may be included only if the CBSD operationally supports EAP feature.

Parameter	R/O/C	Parameter Information
NAME: *antennaModel* **DATA TYPE**: string **EXTENSION TYPE**: RELEASE 2 ENHANCEMENT **FEATURE ID**: WF_ENH_ANTENNA_PATTERN	Optional	This parameter contains the antenna model. If an external antenna is used, the antenna model is optionally provided. The string has a maximum length of 128 octets. For Release 2 operation of EAPfeature, this parameter represents, if included, an Antenna Pattern ID. Format of the value shall be "$RECORD_CREATOR_ID" + ":" + "$ANTENNA_PATTERN_ID", where: · $RECORD_CREATOR_ID is the value of *recordCreatorId* field in the Record Creator File [n.24], and · $ANTENNA_PATTERN_ID is the value of *antennaPatternId* field in CBSD Antenna Pattern Records file [n.24].
NAME: *frontToBackRatio* **DATA TYPE**: number **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: WF_ENH_ANTENNA_PATTERN	Optional	Front-to-back ratio (in dB) of the antenna patterns employed by the CBSD operationally supporting EAP feature. This parameter may be included only if the CBSD operationally supports EAP feature. If this parameter does not exist in the *InstallationParam* object or if the value is invalid, the SAS operationally supporting EAP feature shall use 20 dB front-to-back ratio for the CBSD.

8.2.4   CbsdInfo object

Table 10: *CbsdInfo* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *vendor* **DATA TYPE**: string	Optional	The name of the CBSD vendor. The maximum length of this string is 64 octets.
NAME: *model* **DATA TYPE**: string	Optional	The name of the CBSD model. The maximum length of this string is 64 octets.
NAME: *softwareVersion* **DATA TYPE:** string	Optional	Software version of this CBSD. The maximum length of this string is 64 octets.

Parameter	R/O/C	Parameter Information
NAME: *hardwareVersion* **DATA TYPE:** string	Optional	Hardware version of this CBSD. The maximum length of this string is 64 octets.
NAME: *firmwareVersion* **DATA TYPE:** string	Optional	Firmware version of this CBSD. The maximum length of this string is 64 octets.

NOTE: The *CbsdInfo* object can be extended with other vendor information in additional key-value pairs.

8.2.5 *CpiSignatureData object*

Table 11: *CpiSignatureData* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *protectedHeader* **DATA TYPE:** string	Required	The value of this parameter is the BASE64-encoded JOSE protected header. This is a JSON object equivalent to the JWT RS256 method or the ES256 method described in RFC 7515 [n.14]. BASE64 encoding is per RFC 4648 [n.15]. Valid values are equivalent to the JSON: `{"typ": "JWT", "alg": "RS256"}` or `{"typ": "JWT", "alg": "ES256"}`
NAME: *encodedCpiSignedData* **DATA TYPE**: string	Required	The value of this parameter is the encoded JOSE payload data to be signed by the CPI's private key. This parameter is calculated by taking the BASE64 encoding of a *CpiSignedData* object according to the procedures as specified in RFC 7515 [n.14].
NAME: *digitalSignature* **DATA TYPE:** string	Required	The value of this parameter is the CPI digital signature applied to the *encodedCpiSignedData* field. This signature is calculated by taking the BASE64URL encoding of the digital signature, prepared according to the procedures in Section 3 of RFC 7515 [n.14], using the algorithm as declared in the *protectedHeader* field.

NOTE 1: The JOSE JSON Web Signature per RFC 7515 [n.14] is used to ensure data integrity and CPI non-repudiation of the signed parameters.

NOTE 2: The JOSE compact serialization is formed by concatenating the
protectedHeader, *encodedCpiSignedData* and *digitalSignature* parameters with
dot "." characters as described in section 3 of RFC 7515 [n.14].

8.2.6   CpiSignedData object

Table 12: *CpiSignedData* Object Definition

Parameter Name	R/O/C	Parameter Information
NAME: *fccId* **DATA TYPE:** string	Required	The value of this parameter is the FCC ID of the CBSD. Shall be equal to the *fccId* parameter value in the enclosing registration request.
NAME: *cbsdSerialNumber* **DATA TYPE:** string	Required	The value of this parameter is the CBSD serial number. Shall be equal to the *cbsdSerialNumber* of the enclosing registration request.
NAME: *installationParam* **DATA TYPE:** object: *InstallationParam*	Required	The value of this parameter is the *InstallationParam* object containing the parameters being certified by the CPI, and only those.
NAME: *professionalInstallerData* **DATA TYPE:** object: *ProfessionalInstallerData*	Required	The value of this parameter is the data identifying the CPI vouching for the installation parameters included in the *installationParam* value contained in this object.

8.2.7   ProfessionalInstallerData object

Table 13: *ProfessionalInstallerData* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *cpiId* **DATA TYPE:** string	Required	The value of this parameter is the ID of the CPI providing information to the SAS. This string has a maximum length of 256 octets.
NAME: *cpiName* **DATA TYPE:** string	Required	This parameter contains the human-readable name of the CPI providing information to the SAS. This string has a maximum length of 256 octets.
NAME: *installCertificationTime* **DATA TYPE**: string	Required	The value of this parameter is the UTC date and time at which the CPI identified in this object certified the CBSD's installed parameters. It is expressed using the format, YYYY-MM-DDThh:mm:ssZ, as defined by [n.16].

8.2.8   GroupParam object

Table 14: *GroupParam* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *groupType* **DATA TYPE:** string **EXTENSION TYPE**: RELEASE 2 ENHANCEMENT **FEATURE ID**: WF_ENH_GROUP_HANDLING	Required	Identifies the type of Group that the CBSD belongs to. For Release 2 operation of Enhanced CBSD Group Handling feature, acceptable values of this parameter are defined in WINNF-SSC-0010 [n.12]. Otherwise, see permitted enumerations in WINNF-TS-0016 [n.1].
NAME: *groupId* **DATA TYPE:** string **EXTENSION TYPE**: RELEASE 2 ENHANCEMENT **FEATURE ID**: WF_ENH_GROUP_HANDLING	Required	Identifies a particular Group of the specified type of Group (*groupType*). For Release 2 operation of Enhanced CBSD Group Handling feature, acceptable values of this parameter are defined in WINNF-SSC-0010 [n.12]. Otherwise, see permitted enumerations in WINNF-TS-0016 [n.1].
NAME: *groupInfo* **DATA TYPE**: object: *GroupInfo* **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: WF_ENH_GROUP_HANDLING	Optional	This JSON object is specified by the organization, entity or individual that specifies the *groupId*. See details of *GroupInfo* object definition in WINNF-SSC-0010 [n.12].

8.3   Registration Response Message

Table 15: Registration Response Message

Parameter	R/O/C	Parameter Information
NAME: *registrationResponse* **DATA TYPE:** array of object: *RegistrationResponse*	Required	This parameter is an array of *RegistrationResponse* data objects. Each *RegistrationResponse* data object represents a registration response to a registration request from a CBSD.

8.3.1   RegistrationResponse object

<p style="text-align:center">**Table 16:** *RegistrationResponse* **Object Definition**</p>

Parameter	R/O/C	Parameter Information
NAME: *cbsdId* **DATA TYPE:** string	Conditional	This is a CBRS-wide unique identifier for this CBSD. This parameter shall be included if and only if the *responseCode* indicates SUCCESS. The CBSD shall set its CBSD identity to the value received in this parameter. The string has a maximum length of 256 octets.
NAME: *measReportConfig* **DATA TYPE**: array of string	Optional	The SAS uses this parameter to configure CBSD measurement reporting. The measurement report requested by SAS shall be consistent with the CBSD measurement capabilities reported during the registration request. The CBSD shall report the measurement listed in this array. The permitted enumerations are specified in [n.11].
NAME: *groupingConfig* **DATA TYPE**: array of object: *GroupConfig* **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: WF_ENH_GROUP_HANDLING	Conditional	An array of data objects that includes information concerning group configuration being declared by the CBSD in the associated request message of the procedure. The SAS shall include this parameter if the *groupingParam* parameter was included in the corresponding *RegistrationRequest* object. *GroupConfig* objects for all the Groups declared by the CBSD shall be included in this parameter.

Parameter	R/O/C	Parameter Information
NAME: *sasFeatureCapabilityList* **DATA TYPE**: array of string **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: *n/a*	Conditional	This parameter represents SAS's Feature Capability List containing zero or more FIDs. SAS shall include all its WInnForum-defined FIDs operationally supported by the SAS. WInnForum-defined FIDs shall be conformant with those described in the headings of sections specifying features in section 6 of this document. SAS may include its Proprietary FIDs operationally supported by the SAS. Proprietary FIDs shall be prefixed with CBRS Vendor/Admin IDs registered in WINNF-SSC-0013 [n.6]. This parameter shall be included if: ▪ Response Code is SUCCESS; and ▪ the corresponding *RegistrationRequest* object included the *cbsdFeatureCapabilityList* parameter; and ▪ the SAS supports any Release 2 functionality. If this parameter is not included when the response code indicates SUCCESS, the SAS is treated as a Release 1 SAS according to section 6.2.2 of this document. If response code is not SUCCESS, then SAS may optionally include this parameter.
NAME: *response* **DATA TYPE**: object: *Response*	Required	This parameter includes information on whether the corresponding CBSD request is approved or disapproved for a reason.

NOTE: JSON format of *sasFeatureCapabilityList* is similar to the above example JSON format of *cbsdFeatureCapabilityList*.

8.3.2 Response Object

Table 17: *Response* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *responseCode* **DATA TYPE**: number	Required	An integer to indicate the type of result. The value 0 means the corresponding CBSD request is successful. This shall be one of the values defined in Table 43.

Parameter	R/O/C	Parameter Information
NAME: *responseMessage* **DATA TYPE**: string	Optional	A short description of the result.
NAME: *responseData* **DATA TYPE**: Dependent on *responseCode* **EXTENSION TYPE**: RELEASE 2 ENHANCEMENT **FEATURE ID**: *n/a*	Optional	Additional data can be included to help the CBSD resolve failures. For Release 2 operation, this parameter may contain supplemental information even in case of response code 0 (SUCCESS). See Table 44 for more details.

8.3.3   GroupConfig object

Table 18: *GroupConfig* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *groupType* **DATA TYPE:** string **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: WF_ENH_GROUP_HANDLING	Required	Identifies the type of Group that the CBSD belongs to. If the *GroupConfig* object is provided in response to a request message which includes a *GroupParam* object, the value of this parameter shall be identical to that was provided by the CBSD in the corresponding *GroupParam* object in the request message. If the *GroupConfig* object is provided in response to a request message which did not include a *GroupParam* object, the value of this parameter shall be conformant with WINNF-SSC-0010 [n.12].
NAME: *groupId* **DATA TYPE:** string **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: WF_ENH_GROUP_HANDLING	Required	Identifies a particular Group of the specified type of Group (*groupType*). If the *GroupConfig* object is provided in response to a request message which includes a *GroupParam* object, the value of this parameter shall be identical to that was provided by the CBSD in the corresponding *GroupParam* object in the request message. If the *GroupConfig* object is provided in response to a request message which did not include a *GroupParam* object, the value of this parameter shall be conformant with WINNF-SSC-0010 [n.12].

Parameter	R/O/C	Parameter Information
NAME: *supportedBySas* **DATA TYPE:** boolean **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: WF_ENH_GROUP_HANDLING	Conditional	This parameter indicates whether *groupType* and/or *groupId* is operationally supported by the SAS. true: supported, false: not supported This parameter shall be included if the *GroupConfig* object is provided in a response message in response to a request which includes the *groupingParam* parameter.
NAME: *groupConfigInfo* **DATA TYPE:** object: *GroupConfigInfo* **EXTENSION TYPE:** RELEASE 2 **FEATURE ID:** WF_ENH_GROUP_HANDLING	Optional	This JSON object is specified by the organization, entity or individual that specifies the *groupId*. See details of *GroupConfigInfo* object definition in WINNF-SSC-0010 [n.12].
NAME: *groupInfoResponse* **DATA TYPE:** object: *GroupInfoResponse* **EXTENSION TYPE:** RELEASE 2 **FEATURE ID:** WF_ENH_GROUP_HANDLING	Optional	This parameter is a JSON object that includes information about errors in the *groupInfo* parameter associated with the *groupType* and/or *groupId* parameters. This parameter may be included only if the value of *supportedBySas* parameter is true or *supportedBySas* parameter is not included in the *GroupConfig* object.

8.3.4 *GroupInfoResponse Object*

Table 19: *GroupInfoResponse* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *groupInfoResponseCode* **DATA TYPE:** number **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: WF_ENH_GROUP_HANDLING	Required	This is an integer value indicating errors in the *groupInfo* parameter for the Group type and/or Group ID that the CBSD belongs to. Basic common values for any Groups are defined in Table 2 of section 6.3.3.1.3 in this document. The organization, entity or individual that specifies the *groupId* and/or *groupType* may additionally define the acceptable values of this parameter. See details in WINNF-SSC-0010 [n.12].
NAME: *groupInfoResponseData* **DATA TYPE:** array of string **EXTENSION TYPE:** RELEASE 2 **FEATURE ID:** WF_ENH_GROUP_HANDLING	Optional	Additional data can be included to help the CBSD take an action associated with the value of the *groupInfoResponseCode* parameter.
NAME: *groupInfoResponseMessage* **DATA TYPE:** string **EXTENSION TYPE:** RELEASE 2 **FEATURE ID:** WF_ENH_GROUP_HANDLING	Optional	Human readable string describing errors identified by the *groupInfoResponseCode* parameter.

8.4 DEPRECATED

This section was deprecated in V1.5.0 of this technical specification.

8.5 DEPRECATED

This section was deprecated in V1.5.0 of this technical specification.

8.6 Spectrum Inquiry Request Message

Table 20: Spectrum Inquiry Request Message

Parameter	R/O/C	Parameter Information
NAME: *spectrumInquiryRequest* **DATA TYPE**: array of object: *SpectrumInquiryRequest*	Required	Array of *SpectrumInquiryRequest* objects. Each *SpectrumInquiryRequest* object represents a spectrum inquiry request of a CBSD.

8.6.1   SpectrumInquiryRequest object

Table 21: *SpectrumInquiryRequest* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *cbsdId* **DATA TYPE**: string	Required	The CBSD shall set this parameter to the value of the *cbsdId* parameter obtained in the *RegistrationResponse* object.
NAME: *inquiredSpectrum* **DATA TYPE**: array of object: *FrequencyRange*	Required	This field describes the spectrum for which the CBSD seeks information on spectrum availability.
NAME: *measReport* **DATA TYPE**: object: *MeasReport*	Conditional	The CBSD uses this parameter to report measurements to the SAS. The format of the *MeasReport* object is provided in WINNF-SSC-0002 [n.11]. Refer to section 8 of WINNF-TS-0016 [n.1] and WINNF-SSC-0002 [n.11] for inclusion rules.
NAME: *groupingParam* **DATA TYPE**: array of object: *GroupParam* **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: WF_ENH_GROUP_HANDLING	Optional	An array of zero or more *GroupParam* objects that includes information about all of the Group(s) being declared by the CBSD in this request message. This parameter shall contain the most recent information about the Groups and supersedes any previously declared Group information. NOTE: The *groupingParam* parameter with empty array means that the CBSD is disassociated from all the Groups which were previously declared by the CBSD to the SAS.

8.6.2   FrequencyRange object

Table 22: *FrequencyRange* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *lowFrequency* **DATA TYPE**: number	Required	The lowest frequency of the frequency range in Hz.
NAME: *highFrequency* **DATA TYPE**: number	Required	The highest frequency of the frequency range in Hz.

8.7 Spectrum Inquiry Response Message

Table 23: Spectrum Inquiry Response Message

Parameter	R/O/C	Parameter Information
NAME: *spectrumInquiryResponse* **DATA TYPE**: array of object: *SpectrumInquiryResponse*	Required	Array of *SpectrumInquiryResponse* objects. Each *SpectrumInquiryResponse* object represents a spectrum inquiry response to a spectrum inquiry request of a CBSD.

8.7.1 SpectrumInquiryResponse object

Table 24: *SpectrumInquiryResponse* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *cbsdId* **DATA TYPE**: string	Conditional	This parameter is included if and only if the *cbsdId* parameter in the *SpectrumInquiryRequest* object contains a valid CBSD identity. If included, the SAS shall set this parameter to the value of the *cbsdId* parameter in the corresponding *SpectrumInquiryRequest* object.
NAME: *availableChannel* **DATA TYPE**: array of object: *AvailableChannel*	Conditional	This parameter is an array of zero or more *AvailableChannel* objects, which describes a channel that is available for the CBSD. Included: If and only if the Spectrum Inquiry is successful.
NAME: *groupingConfig* **DATA TYPE**: array of object: *GroupConfig* **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: WF_ENH_GROUP_HANDLING	Conditional	An array of data objects that includes information concerning group configuration being declared by the CBSD in the associated request message of the procedure. The SAS shall include this parameter if the *groupingParam* parameter was included in the corresponding *SpectrumInquiryRequest* object. *GroupConfig* objects for all the Groups declared by the CBSD in the *SpectrumInquiryRequest* object shall be included in this parameter. The SAS may optionally include this parameter even if the corresponding *SpectrumInquiryRequest* object did not include the *groupingParam* parameter.

Parameter	R/O/C	Parameter Information
NAME: *featureCapabilityExchangeTrigger* **DATA TYPE**: boolean **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: *n/a*		DEPRECATED in V1.5.0 of this technical specification.
NAME: *response* **DATA TYPE**: object: *Response*	Required	This parameter includes information on whether the corresponding CBSD request is approved or disapproved for a reason.

8.7.2   *AvailableChannel object*

Table 25: *AvailableChannel* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *frequencyRange* **DATA TYPE**: object: *FrequencyRange*	Required	This parameter is the frequency range of the available channel.
NAME: *channelType* **DATA TYPE**: string	Required	▪ "PAL": the frequency range is a PAL channel. ▪ "GAA": the frequency range is for GAA use.
NAME: *ruleApplied* **DATA TYPE**: string	Required	The regulatory rule used to generate this response, e.g., "FCC_PART_96".
NAME: *maxEirp* **DATA TYPE**: number	Optional	Maximum EIRP likely to be permitted for a Grant on this *frequencyRange,* given the CBSD registration parameters, including location, antenna orientation and antenna pattern. The maximum EIRP is in the units of dBm/MHz and is an integer or a floating-point value between -137 and +37 (dBm/MHz) inclusive.

8.8   Grant Request Message

A *GrantRequest* object contains operating parameters that the CBSD plans to operate with. Operation parameters include a continuous segment of spectrum and the maximum EIRP.

Table 26: Grant Request Message

Parameter	R/O/C	Parameter Information
NAME: *grantRequest* **DATA TYPE**: array of object: *GrantRequest*	Required	Array of *GrantRequest* objects. Each *GrantRequest* object represents a Grant request of a CBSD.

8.8.1   GrantRequest object

<p align="center">Table 27: GrantRequest Object Definition</p>

Parameter	R/O/C	Parameter Information
NAME: *cbsdId* **DATA TYPE**: string	Required	The CBSD shall set this parameter to the value of the *cbsdId* parameter obtained in the *RegistrationResponse* object.
NAME: *operationParam* **DATA TYPE**: object: *OperationParam*	Required	This data object includes operation parameters of the requested Grant.
NAME: *measReport* **DATA TYPE**: object: *MeasReport*	Conditional	The CBSD uses this parameter to report measurements to the SAS. The format of the *MeasReport* object is provided in WINNF-SSC-0002 [n.11]. Refer to section 8 of WINNF-TS-0016 [n.1] and WINNF-SSC-0002 [n.11] for inclusion rules.
NAME: *groupingParam* **DATA TYPE**: array of object: *GroupParam* **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: WF_ENH_GROUP_HANDLING	Optional	An array of zero or more *GroupParam* objects that includes information about all of the Group(s) being declared by the CBSD in this request message. This parameter shall contain the most recent information about the Groups and supersedes any previously declared Group information. NOTE: The *groupingParam* parameter with empty array means that the CBSD is disassociated from all the Groups which were previously declared by the CBSD to the SAS.

8.8.2   OperationParam object

<p align="center">Table 28: OperationParam Object Definition</p>

Parameter	R/O/C	Parameter Information
NAME: *maxEirp* **DATA TYPE**: number	Required	Maximum EIRP permitted by the Grant. The maximum EIRP is in the units of dBm/MHz and is an integer or a floating-point value between -137 and +37 (dBm/MHz) inclusive. The value of *maxEirp* represents the average (RMS) EIRP that would be measured per the procedure defined in §96.41(e)(3) [n.7] and shall not exceed *eirpCapability* - 10.

Parameter	R/O/C	Parameter Information
NAME: *operationFrequencyRange* **DATA TYPE**: object: *FrequencyRange*	Required	This parameter is frequency range of a contiguous segment.

8.9   Grant Response Message

Table 29: Grant Response Message

Parameter	R/O/C	Parameter Information
NAME: *grantResponse* **DATA TYPE**: array of object: *GrantResponse*	Required	Array of *GrantResponse* objects. Each *GrantResponse* object represents a Grant response to a Grant request of a CBSD.

8.9.1   *GrantResponse object*

Table 30: *GrantResponse* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *cbsdId* **DATA TYPE**: string	Conditional	This parameter is included if and only if the *cbsdId* parameter in the *GrantRequest* object contains a valid CBSD identity. If included, the SAS shall set this parameter to the value of the *cbsdId* parameter in the corresponding *GrantRequest* object.
NAME: *grantId* **DATA TYPE**: string	Conditional	An ID provided by the SAS for this Grant. Included: If and only if the Grant request is approved by the SAS. The CBSD shall set the Grant identity for this Grant to the value received in this parameter.

Parameter	R/O/C	Parameter Information
NAME: *grantExpireTime* **DATA TYPE**: string	Conditional	The *grantExpireTime* indicates the time when the Grant associated with the *grantId* expires. This parameter is UTC time expressed in the format, YYYY-MM-DDThh:mm:ssZ as defined by [n.16]. This parameter shall be included if and only if the *responseCode* parameter indicates SUCCESS. If the *channelType* parameter is included in this object and the value is set to "PAL", the *grantExpireTime* parameter shall be set to the value that does not extend beyond the *licenseExpiration* of the corresponding PAL recorded in the PAL Database [n.23].
NAME: *heartbeatInterval* **DATA TYPE**: number	Conditional	This parameter is a positive integer and indicates the maximum time interval in units of seconds between two consecutive heartbeat requests that the CBSD should attempt to meet. This parameter shall be included if the *responseCode* parameter indicates SUCCESS.
NAME: *measReportConfig* **DATA TYPE**: array of string	Optional	The SAS uses this parameter to configure CBSD measurement reporting. The measurement report requested by the SAS shall be consistent with the CBSD measurement capabilities reported during the registration request. The CBSD shall report the measurements listed in this array. The permitted enumerations are specified in [n.11].
NAME: *operationParam* **DATA TYPE**: object: *OperationParam*	Optional	If the Grant request is disapproved, using this object the SAS can optionally provide a new set of operation parameters to the CBSD for use in a new Grant request.

Parameter	R/O/C	Parameter Information
NAME: *operationParamArray* **DATA TYPE**: array of object: *OperationParam* **EXTENSION TYPE:** RELEASE 2 **OP_OR_CD_EXTENSION** 　**SAS:** *Optional* 　**CBSD:** *Optional*	Optional	This parameter contains one or more sets of recommended operation parameters for new Grant(s). If Grant request is disapproved or the SAS intends to change the CBSD operation parameters, the SAS can provide a new set(s) of operation parameters to the CBSD using this array of object as a recommendation to request a new Grant(s). If Grant response includes both *operationParam* and *operationParamArray* parameter, then there is no restriction on the overlap (if any) in the recommended operation parameters of *operationParam* and *operationParamArray*.
NAME: *channelType* **DATA TYPE**: string	Conditional	This parameter is included if and only if the *responseCode* parameter indicates SUCCESS, i.e., the Grant request was successful. ▪ "PAL": the frequency range has been granted as a PAL channel. ▪ "GAA": the frequency range has been granted for GAA use.
NAME: *groupingConfig* **DATA TYPE**: array of object: *GroupConfig* **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: WF_ENH_GROUP_HANDLING	Conditional	An array of data objects that includes information concerning group configuration being declared by the CBSD in the associated request message of the procedure. The SAS shall include this parameter if the *groupingParam* parameter was included in the corresponding *GrantRequest* object. *GroupConfig* objects for all the Groups declared by the CBSD in the *GrantRequest* object shall be included in this parameter. The SAS may optionally include this parameter even if the corresponding *GrantRequest* object did not include the *groupingParam* parameter.
NAME: *featureCapabilityExchangeTrigger* **DATA TYPE**: boolean **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: *n/a*		DEPRECATED in V1.5.0 of this technical specification.

Parameter	R/O/C	Parameter Information
NAME: *response* **DATA TYPE**: object: *Response*	Required	This parameter includes information on whether the corresponding CBSD request is approved or disapproved for a reason.

8.10 Heartbeat Request Message

Table 31: Heartbeat Request Message

Parameter	R/O/C	Parameter Information
NAME: *heartbeatRequest* **DATA TYPE**: array of object: *HeartbeatRequest*	Required	Array of *HeartbeatRequest* objects. Each *HeartbeatRequest* object represents a heartbeat request of a CBSD.

8.10.1   HeartbeatRequest object

Table 32: *HeartbeatRequest* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *cbsdId* **DATA TYPE**: string	Required	The CBSD shall set this parameter to the value of the *cbsdId* parameter obtained in the *RegistrationResponse* object.
NAME: *grantId* **DATA TYPE**: string	Required	The CBSD shall set this parameter to the value of the Grant identity of this Grant.
NAME: *grantRenew* **DATA TYPE**: boolean	Optional	If set to True, the CBSD asks for renewal of the current Grant. SAS shall include a *grantExpireTime* parameter in the following *HeartbeatResponse* object.
NAME: *operationState* **DATA TYPE**: string	Required	This parameter indicates the current state of this Grant in the CBSD. The CBSD shall set this parameter to the CBSD's current state of the Grant. "AUTHORIZED": The Grant is in Authorized State. "GRANTED": The Grant is in Granted State.
NAME: *measReport* **DATA TYPE**: object: *MeasReport*	Conditional	The CBSD uses this parameter to report measurements to the SAS. The format of the *MeasReport* object is provided in WINNF-SSC-0002 [n.11]. Refer to section 8 of WINNF-TS-0016 [n.1] and WINNF-SSC-0002 [n.11] for inclusion rules.

Parameter	R/O/C	Parameter Information
NAME: *groupingParam* **DATA TYPE**: array of object: *GroupParam* **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: WF_ENH_GROUP_HANDLING	Optional	An array of zero or more *GroupParam* objects that includes information about all of the Group(s) being declared by the CBSD in this request message. This parameter shall contain the most recent information about the Groups and supersedes any previously declared Group information. NOTE: The *groupingParam* parameter with empty array means that the CBSD is disassociated from all the Groups which were previously declared by the CBSD to the SAS.

8.11 Heartbeat Response Message

Table 33: Heartbeat Response Message

Parameter	R/O/C	Parameter Information
NAME: *heartbeatResponse* **DATA TYPE**: array of object: *HeartbeatResponse*	Required	Array of *HeartbeatResponse* objects. Each *HeartbeatResponse* object represents a heartbeat response of a CBSD.

8.11.1 HeartbeatResponse object

Table 34: *HeartbeatResponse* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *cbsdId* **DATA TYPE**: string	Conditional	This parameter is included if and only if the *cbsdId* parameter in the *HeartbeatRequest* object contains a valid CBSD identity. If included, the SAS shall set this parameter to the value of the *cbsdId* parameter in the corresponding *HeartbeatRequest* object.
NAME: *grantId* **DATA TYPE**: string	Conditional	This parameter is included if and only if the *grantId* parameter in the *HeartbeatRequest* object contains a valid Grant identity. If included, the SAS shall set this parameter to the value of the *grantId* parameter in the corresponding *HeartbeatRequest* object.

Parameter	R/O/C	Parameter Information
NAME: *transmitExpireTime* **DATA TYPE**: string	Required	The CBSD shall cease radio transmission using the SAS authorized radio resource within 60 seconds after the value of the *transmitExpireTime* parameter expires, in accordance with §96.39(c)(2) [n.7]. The *transmitExpireTime* is UTC time expressed in the format, YYYY-MM-DDThh:mm:ssZ as defined by [n.16]. The *transmitExpireTime* value shall be no later than the value of the *grantExpireTime* parameter.
NAME: *grantExpireTime* **DATA TYPE**: string	Conditional	Required if the *responseCode* parameter indicates SUCCESS or SUSPENDED_GRANT and the *grantRenew* parameter was included and set to True in the corresponding *HeartbeatRequest* object. This parameter may be included at other times by SAS choice. When included, if the *channelType* of this Grant is "PAL", this parameter shall be set to the value that does not extend beyond the *licenseExpiration* of the corresponding PAL recorded in the PAL Database [n.23].
NAME: *heartbeatInterval* **DATA TYPE**: number	Optional	This parameter is a positive integer and indicates the maximum time interval in units of seconds between two consecutive heartbeat requests that the CBSD should attempt to meet. This parameter is included when the SAS wants to change the heartbeat interval.
NAME: *operationParam* **DATA TYPE**: object: *OperationParam*	Optional	If heartbeat request is disapproved or the SAS intends to change the CBSD operation parameters, the SAS can provide a new set of operation parameters to the CBSD using this object as a recommendation to request a new Grant.

Parameter	R/O/C	Parameter Information

NAME: *operationParamArray*
DATA TYPE: array of object:
OperationParam
EXTENSION TYPE: RELEASE 2
OP_OR_CD_EXTENSION
   SAS: *Optional*
   CBSD: *Optional*
	Optional	This parameter contains one or more sets of recommended operation parameters for new Grant(s).
		
		If heartbeat request is disapproved or the SAS intends to change the CBSD operation parameters, the SAS can provide a new set(s) of operation parameters to the CBSD using this array of object as a recommendation to request a new Grant(s).
		
		If heartbeat response includes both *operationParam* and *operationParamArray* parameter, then there is no restriction on the overlap (if any) in the recommended operation parameters of *operationParam* and *operationParamArray*.

NAME: *channelType* **DATA TYPE**: string **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: WF_GRANT_UPDATE	Optional	The SAS may use this parameter to indicate the latest channel type of the Grant associated with the *grantId* parameter in this object. ▪ "PAL": the frequency range is a PAL channel. ▪ "GAA": the frequency range is for GAA use.
NAME: *measReportConfig* **DATA TYPE**: array of string	Optional	The SAS uses this parameter to configure CBSD measurement reporting. The measurement report requested by the SAS shall be consistent with the CBSD measurement capabilities reported during the registration request. The CBSD shall report the measurement listed in this array. The permitted enumerations are specified in WINNF-SSC-0002 [n.11].

Parameter	R/O/C	Parameter Information
NAME: *groupingConfig* **DATA TYPE**: array of object: *GroupConfig* **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: WF_ENH_GROUP_HANDLING	Conditional	An array of data objects that includes information concerning group configuration being declared by the CBSD. The SAS shall include this parameter if the *groupingParam* parameter was included in the corresponding *HeartbeatRequest* object. *GroupConfig* objects for all the Groups declared by the CBSD in the *HeartbeatRequest* object shall be included in this parameter. The SAS may optionally include this parameter even if the corresponding *HeartbeatRequest* object did not include the *groupingParam* parameter.
NAME: *featureCapabilityExchangeTrigger* **DATA TYPE**: boolean **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: *n/a*		DEPRECATED in V1.5.0 of this technical specification.
NAME: *response* **DATA TYPE**: object: *Response*	Required	This parameter includes information on whether the corresponding CBSD request is approved or disapproved for a reason.

8.12 Relinquishment Request Message

Table 35: Relinquishment Request Message

Parameter	R/O/C	Parameter Information
NAME: *relinquishmentRequest* **DATA TYPE**: array of object: *RelinquishmentRequest*	Required	Array of *RelinquishmentRequest* objects. Each *RelinquishmentRequest* object Represents a request of a CBSD.

8.12.1   RelinquishmentRequest object

Table 36: *RelinquishmentRequest* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *cbsdId* **DATA TYPE**: string	Required	The CBSD shall set this parameter to the value of its CBSD identity.
NAME: *grantId* **DATA TYPE**: string	Required	The CBSD shall set this parameter to the value of the Grant identity of the Grant.

8.13 Relinquishment Response Message

Table 37: Relinquishment Response Message

Parameter	R/O/C	Parameter Information
NAME: *relinquishmentResponse* **DATA TYPE**: array of object: *RelinquishmentResponse*	Required	Array of *RelinquishmentResponse* objects. Each *RelinquishmentResponse* object represents a response to a request of a CBSD to relinquish a Grant.

8.13.1   RelinquishmentResponse object

Table 38: *RelinquishmentResponse* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *cbsdId* **DATA TYPE**: string	Conditional	This parameter is included if and only if the *cbsdId* parameter in the *RelinquishmentRequest* object contains a valid CBSD identity. If included, the SAS shall set this parameter to the value of the *cbsdId* parameter in the corresponding *RelinquishmentRequest* object.
NAME: *grantId* **DATA TYPE**: string	Conditional	This parameter is included if and only if the *grantId* parameter in the *RelinquishmentRequest* object contains a valid Grant Identity. If included, the SAS shall set this parameter to the value of the *grantId* parameter in the corresponding *RelinquishmentRequest* object.
NAME: *featureCapabilityExchangeTrigger* **DATA TYPE**: boolean **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: *n/a*		DEPRECATED in V1.5.0 of this technical specification.
NAME: *response* **DATA TYPE**: object: *Response*	Required	This parameter includes information on whether the corresponding CBSD request is approved or disapproved for a reason.

8.14 Deregistration Request Message

<p align="center">Table 39: Deregistration Request Message</p>

Parameter	R/O/C	Parameter Information
NAME: *deregistrationRequest* **DATA TYPE**: array of object: *DeregistrationRequest*	Required	Array of *DeregistrationRequest* data objects. Each *DeregistrationRequest* data object represents a deregistration request of a CBSD.

8.14.1   DeregistrationRequest object

<p align="center">Table 40: DeregistrationRequest Object Definition</p>

Parameter	R/O/C	Parameter Information
NAME: *cbsdId* **DATA TYPE**: string	Required	The CBSD shall set this parameter to the value of its CBSD identity.

8.15 Deregistration Response Message

<p align="center">Table 41: Deregistration Response Message</p>

Parameter	R/O/C	Parameter Information
NAME: *deregistrationResponse* **DATA TYPE**: array of object: *DeregistrationResponse*	Required	Array of *DeregistrationResponse* data objects. Each *DeregistrationResponse* object represents a response to a deregistration request of a CBSD.

8.15.1   DeregistrationResponse object

<p align="center">Table 42: DeregistrationResponse Object Definition</p>

Parameter	R/O/C	Parameter Information
NAME: *cbsdId* **DATA TYPE**: string	Conditional	This parameter is included if and only if the *cbsdId* parameter in the *DeregistrationRequest* object contains a valid CBSD identity. If included, the SAS shall set this parameter to the value of the *cbsdId* parameter in the corresponding *DeregistrationRequest* object.
NAME: *response* **DATA TYPE**: object: *Response*	Required	This parameter includes information on whether the corresponding CBSD request is approved or disapproved for a reason.

8.16 Response Codes and Data

In the *Response* object of a SAS-CBSD response message, the SAS shall include a *responseCode* parameter to inform the CBSD of the status of the corresponding request. The response codes are grouped into the following categories and defined in the Table 43. The name associated with each *responseCode* parameter is not included in the *Response* object, but can be attached to a *responseCode* parameter by the CBSD or other network entity for logging or human-involved troubleshooting.

CBSD shall support any "RELEASE 2 ENHANCEMENT" and "RELEASE 2" response code whose value of **FEATURE ID** is "*n/a*". For "RELEASE 2 ENHANCEMENT" and "RELEASE 2" response codes which are associated with a specific feature, CBSD shall support it if the CBSD Operationally-Supports that feature.

0: success

100 – 199: general errors related to the SAS-CBSD Protocol

200 – 299: error events related to the CBSD Registration Procedure

300 – 399: error events related to the CBSD Spectrum Inquiry Procedure

400 – 499: error events related to the CBSD Grant Procedure

500 – 599: error events related to the CBSD Heartbeat Procedure

600 – 699: error events related to the Feature Capability Exchange Procedure

> NOTE: No response codes for the Feature Capability Exchange Procedure are defined in this version of the document.

Table 43: Response Code Definitions

Response Codes	Description
VALUE: 0 **NAME**: SUCCESS **EXTENSION TYPE**: RELEASE 2 ENHANCEMENT **FEATURE ID**: *n/a*	This response code was defined in WINNF-TS-0016 [n.1]. CBSD request is approved by SAS. In Release 2 operation, the *responseData* and/or *responseMessage* parameters may contain a string providing supplemental information. See more details in Table 44.
VALUE: 100 **NAME**: VERSION	This response code was defined in WINNF-TS-0016 [n.1]. SAS protocol version used by CBSD is not supported by SAS

Response Codes	Description
VALUE: 101 **NAME**: BLACKLISTED	This response code was defined in WINNF-TS-0016 [n.1]. CBSD is blacklisted. This *responseCode* is returned if the CBSD is under a SAS or FCC enforcement action and is barred from CBRS operation. In general, the CBSD should not try to re-register until actions external to this specification are taken. NOTE: Blacklisting behavior by the SAS and CBSD is FFS.
VALUE: 102 **NAME**: MISSING_PARAM **EXTENSION TYPE**: RELEASE 2 ENHANCEMENT **FEATURE ID**: *n/a*	This response code was defined in WINNF-TS-0016 [n.1]. Required parameters missing. In Release 2, this response code is not applicable if the *cbsdFeatureCapabilityList* parameter is missing in *RegistrationRequest* object.
VALUE: 103 **NAME**: INVALID_VALUE	This response code was defined in WINNF-TS-0016 [n.1]. One or more parameters have invalid value
VALUE: 104 **NAME**: CERT_ERROR	This response code was defined in WINNF-TS-0016 [n.1]. There is an error in the certificate used to make the request (e.g. the credential is of the wrong role). NOTE: Most certificate errors, such as expired or syntactically invalid certificates, will cause errors at the TLS connection.
VALUE: 105 **NAME**: DEREGISTER	This response code was defined in WINNF-TS-0016 [n.1]. A CBSD receiving this *responseCode* is automatically deregistered by the SAS. The CBSD shall cease all transmissions, terminate all Grants, and consider itself *Unregistered*. The SAS may include this *responseCode* parameter in any message. The *responseMessage* parameter may contain a string describing the reason for deregistration. See NOTE 1 below.

Response Codes	Description
VALUE: 106 **NAME**: NOT_PROCESSED **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: *n/a*	This response code is defined for Release 2 operation. The SAS cannot provide a proper response to the CBSD request temporarily. The CBSD can resend the same request message or send a different request message after receiving this *responseCode*. The *responseData* parameter may carry suggested wait time for the CBSD to resend the request message.
VALUE: 200 **NAME**: REG_PENDING	This response code was defined in WINNF-TS-0016 [n.1]. Incomplete registration information. The registration process is pending. One or more REG-Conditional parameters have not yet been supplied to the SAS. The CBSD is likely to accomplish a successful registration when the missing registration information is made available to the SAS.
VALUE: 201 **NAME**: GROUP_ERROR **EXTENSION TYPE**: RELEASE 2 ENHANCEMENT **FEATURE ID**: WF_ENH_GROUP_HANDLING	This response code was defined in WINNF-TS-0016 [n.1]. An error has been identified in the grouping parameters of the CBSD. In Release 2, it is also used by feature "Enhanced CBSD Group Handling". This response code can be used for indicating errors in *GroupParam* object.
VALUE: 300 **NAME**: UNSUPPORTED_SPECTRUM	This response code was defined in WINNF-TS-0016 [n.1]. The frequency range indicated in the spectrum inquiry request or grant request is at least partially outside of the CBRS band.
VALUE: 400 **NAME**: INTERFERENCE	This response code was defined in WINNF-TS-0016 [n.1]. Requested operation parameters cause too much interference. This *responseCode* value indicates that the Grant request is unlikely to be successful if retried by the CBSD.

Response Codes	Description
VALUE: 401 **NAME**: GRANT_CONFLICT **EXTENSION TYPE**: RELEASE 2 ENHANCEMENT **FEATURE ID**: WF_GRANT_UPDATE	This response code was defined in WINNF-TS-0016 [n.1]. Conflict with an existing Grant of the same CBSD. The CBSD should be able to remediate this using the data returned in the *responseData* structure, by synchronizing its Grant state with the SAS and relinquishing any out-of-sync Grants. In Release 2 operation, when both a SAS and a CBSD operationally support Grant Update feature, the SAS shall not send this *responseCode* value when the CBSD requests a new Grant whose requested frequency range is exactly same as the existing Grant of the same CBSD.
VALUE: 500 **NAME**: TERMINATED_GRANT	This response code was defined in WINNF-TS-0016 [n.1]. The Grant is terminated. This condition occurs if, for example, incumbent status has changed permanently causing the current Grant to terminate. The CBSD shall terminate radio operation by turning off its radio transmission associated with this Grant within 60 seconds after the value of the *transmitExpireTime* parameter expires, in accordance with §96.39©(2) [n.7]. The Grant is considered terminated by the SAS, but the CBSD may relinquish the Grant. If the *operationParam* parameter is included in the *HeartbeatResponse* object, the CBSD should consider it as a recommendation by the SAS to obtain a new Grant using the included operational parameter values, and may request a new Grant using those operational parameters.

Response Codes	Description
VALUE: 501 **NAME**: SUSPENDED_GRANT	This response code was defined in WINNF-TS-0016 [n.1]. The Grant is suspended. This condition occurs if incumbent status has changed temporarily. The CBSD shall terminate radio operation by turning off its radio transmission associated with this Grant within 60 seconds after the value of the *transmitExpireTime* parameter expires, in accordance with §96.39(c)(2) [n.7]. In such a case the CBSD may continue to send *HeartbeatRequest* objects and waiting until the Grant is re-enabled, or may relinquish the Grant and request another. If the *operationParam* parameter is included in the *HeartbeatResponse* object, the CBSD should consider it as a recommendation by the SAS to obtain a new Grant using the included operational parameter values, and may request a new Grant using those parameters.
VALUE: 502 **NAME**: UNSYNC_OP_PARAM	This response code was defined in WINNF-TS-0016 [n.1]. The Grant state is out of sync between the CBSD and the SAS. The CBSD shall turn off the radio transmission associated with this Grant within 60 seconds from receiving this *responseCode* value, in accordance with §96.39(c)(2) [n.7], and shall relinquish this Grant.

NOTE 1 (Informative): This is an assistive *responseCode* parameter value to reset the CBSD out of a situation where it is out of sync with the SAS and there is no easier solution than to reset the registration. Examples are: The CBSD has been deregistered by the owner or deregistration is required by authorities, and presumably the CBSD needs to refresh its local configuration management.

In the *Response* object, the SAS can optionally include supplemental data (e.g., using the *responseData* parameter) to help the CBSD with further investigation of the error. The following table describes the *responseData* definitions to be included with some *responseCode* values.

Table 44: *responseData* Definitions

Response Codes	Data Type of *responseData*	Description of *responseData*
VALUE (NAME): 0 (SUCCESS) **EXTENSION TYPE**: RELEASE 2 ENHANCEMENT **FEATURE ID**: *n/a*	array of string	Not applicable to Release 1 operation. For Release 2 operation, the value of the first element of the array shall be either of the followings: ▪ "GENERAL" ▪ "PARAM_WARNING" ▪ "FID_WARNING" ▪ "MULTI_GROUP_HANDLING_WARNING" "GENERAL" notifies supplemental general information (not related specifically to a Feature ID or parameter) is available in the *responseMessage*. No subsequent element of the array is included. "PARAM_WARNING" notifies the warning about the parameters indicated by the subsequent elements of the array. The value(s) of the subsequent element(s) shall be name(s) of non-critical parameter(s) (see section 6.2.3). "FID_WARNING" notifies CBSDs that one or more common operationally supported feature(s), listed in subsequent element(s) of the array, miss critical information and therefore not considered operational by the SAS. The value(s) of the subsequent element(s) shall be FID(s). "MULTI_GROUP_HANDLING_WARNING" notifies CBSDs that a combination of two or more declared Groups leads to conflict or is unsupported by the SAS. The value(s) of the subsequent element(s) shall be name(s) of such Groups which are ignored by the SAS due to a conflict or are unsupported by the SAS. "EAP_METHOD" notifies the CBSD of the EAP method determined by the SAS. This value may be used only in the *responseData* in the *RegistrationResponse* object. The value of the subsequent element shall be one of the followings: "A", "B", "C", "D", "E" or "F".
VALUE (NAME): 100 (VERSION)	array of string	Protocol versions supported by the SAS administrator
VALUE (NAME): 101 (BLACKLISTED)	*n/a*	*n/a*
VALUE (NAME): 102 (MISSING_PARAM)	array of string	A list of missing parameter name(s)

Response Codes	Data Type of *responseData*	Description of *responseData*
VALUE (NAME): 103 (INVALID_VALUE)	array of string	A list of parameter name(s) with invalid value(s)
VALUE (NAME): 104 (CERT_ERROR)	*n/a*	*n/a*
VALUE (NAME): 105 (DEREGISTER)	*n/a*	*n/a*
VALUE (NAME): 106 (NOT_PROCESSED) **EXTENSION TYPE**: RELEASE 2 **FEATURE ID**: *n/a*	array of string	The first element of the array contains a number in the string format. The number is the suggested wait time in seconds before the CBSD may resend the request message after receiving this *responseCode*.
VALUE (NAME): 200 (REG_PENDING)	array of string	A list of missing registration parameter name(s)
VALUE (NAME): 201 (GROUP_ERROR)	*n/a*	*n/a*
VALUE (NAME): 300 (UNSUPPORTED_SPECTRUM)	*n/a*	*n/a*
VALUE (NAME): 400 (INTERFERENCE)	*n/a*	*n/a*
VALUE (NAME): 401 (GRANT_CONFLICT)	array of string	The Grant ID of an existing Grant that causes the conflict.
VALUE (NAME): 500 (TERMINATED_GRANT)	*n/a*	*n/a*
VALUE (NAME): 501 (SUSPENDED_GRANT)	*n/a*	*n/a*
VALUE (NAME): 502 (UNSYNC_OP_PARAM)	*n/a*	*n/a*

Appendix A (Informative) Document History

		Document history
V1.0.0	5 March 2020	Initial Release
V1.1.0	30 September 2020	Technical Revision addressing numerous change requests
V1.1.1	19 February 2021	Editorial correction of reference [n.6]
V1.2.0	30 June 2021	Technical Revision addressing numerous change requests in Enhanced CBSD Group Handling feature.
V1.2.1	30 June 2021	Technical Clarification clarifying support of this TS for Release 2 compliance in section 6.1.
V1.3.0	20 December 2021	Technical revision adding new Release 2 feature "Grant Update".
V1.4.0	22 November 2022	Technical revision implementing the following changes: ▪ Array-type of operation parameters (*operationParamArray*) in *GrantResponse* and *HeartbeatResponse* objects. ▪ Parameter table format changes.
V1.5.0	6 June 2023	Implemented: ▪ WINNF-22-I-00142-r2 CR TS-3002 EAP feature.docx ▪ WINNF-22-I-00146_CR for Feature Capability Exchange _approved.docx