OnGo Coexistence Technical Specifications

ONGO-TS-2001

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1 Introduction and Scope

An objective of the CBRS Alliance is to allow flexible use of the CBRS band while supporting coexistence of multiple deployments. This document is a Technical Specification (TS) for coexistence between and among multiple LTE and NR networks. The current version of the document focuses on Band 48 [11] LTE-TDD using Frame Structure 2 (FS2) [4][16] and support for NR-TDD deployment [18][19]. In this release both GAA and PAL aspects are addressed.

Coexistence between CBSDs belonging to the CBRS Alliance Coexistence Group is coordinated by one or multiple Coexistence Managers (CxMs). A Coexistence Manager (CxM) combined with a SAS forms a CBRS Alliance SAS Entity (CSAS). The specification addresses requirements on the CxM pertaining to coexistence. Additionally, the specification includes coexistence requirements for CBSDs such as cell phase synchronization, TDD Configuration for LTE-TDD and NR-TDD CBSDs, GAA channelization and SAS-CBSD protocol extensions.

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 [12].

Note: LTE and E-UTRA are equivalent terms for the purposes of this TS. Furthermore, unless otherwise noted, references to CBSDs refer to CBSDs that are OnGo certified [29] and belong to the CBRS Alliance Coexistence Group.

2 References

[1] J. Sanz Subirana et al, “Time References in GNSS”, at European Space Agency, 2011.

[2] 3GPP TS 36.133, “3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management (Release 14).”

[3] 3GPP TS 36.401, “3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Architecture description (Release 14).”

[4] 3GPP TS 36.211, “3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation (Release 14).”

[5] 3GPP TS 36.104, “3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception (Release 14).”

[6] WINNF-TS-3002, “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).”

[7] Electronic Code of Federal Regulations, Title 47, Chapter I, Subchapter D, Part 96, http://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=0076fe7586178336d9db4c5146da8797&mc=true&n=pt47.5.96&r=PART&ty=HTML.

[8] West, D. B. (2000), Introduction to Graph Theory, Pearson.

[9] 3GPP TS 36.214, “3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Layer: Measurements (Release 14).”

[10] 3GPP TS 32.425, “3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Telecommunications management, Performance Management (PM); Performance measurements Evolved Universal Terrestrial Radio Access (E-UTRAN) (Release 14).”

[11] 3GPP TS 36.101, “3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception (Release 14).”

[12] RFC-2119, “Key Words in RFCs to indicate Requirement Levels.”

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

[14] WINNF-TS-3003, “Signaling Protocols and Procedures for Citizens Broadband Radio Service (CBRS): Extensions to Spectrum Access System (SAS) - SAS Interface Technical Specification (Release 2).”

[15] WINNF-SSC-0010, “Signaling Protocols and Procedures for Citizens Broadband Radio Service (CBRS): WInnForum Recognized CBRS Grouping Parameters.”

[16] 3GPP TS 38.211, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; NR; Physical channels and modulation (Release 15)."

[17] 3GPP TS 38.213, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; NR; Physical layer procedures for control (Release 15)."

[18] 3GPP TS 38.101-1, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone (Release 16)."

[19] 3GPP TS 38.101-3, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; NR; User Equipment (UE) radio transmission and reception; Part 3: Range 1 and Range 2 Interworking operation with other radios (Release 16)."

[20] 3GPP TS 38.331, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; NR; Radio Resource Control (RRC) protocol specification (Release 15)"

[21] WINNF-SSC-0008, "Coordinated Periodic Activities Policy."

[22] WINNF-TR-5001 "CBRS Deployment Guidelines for Installers."

[23] Deprecated

[24] Electronic Code of Federal Regulations, Title 47, Chapter I, Subchapter A, Part 2, Subpart A https://www.ecfr.gov/cgi-bin/text-idx?SID=2a6a4daef214111e0c151e660d2b6bec&mc=true&node=se47.1.2_11&rgn=div8

[25] 3GPP TS 38.133, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; NR; Requirements for support of radio resource management (Release 15)."

[26] 3GPP TS 38.401, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; NG-RAN; Architecture description (Release 15)."

[27] 3GPP TS 38.215, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; NR; Physical layer measurements (Release 15)."

[28] CBRSA-TS-2002, "CBRS Coexistence CSAS Profile."

[29] https://ongoalliance.org/certification/

3 Definition and Abbreviations

3.1 Definitions

Term	Definition
CBRS Alliance SAS Entity (CSAS)	A logical entity that comprises a WInnForum specified SAS [6] and a CBRS Alliance specified Coexistence Manager (CxM).
CCG (Common Channel Group)	A group of CBSDs that are part of the same ICG, where all members of the CCG require the same channel assignment.
Common Desired TDD Configuration	A TDD Configuration which is recognized by the CxM when the desired TDD Configurations of all OnGo CBSDs in a TDD Configuration Connected Set are the same or equivalent among them.
Connected Set	A set of CBSDs represented by the largest set of vertices of a graph, in which any two vertices of the set are connected to each other through at least one path in the graph.
Channel Assignment Connected Set	A Connected Set which is considered for coordination of the spectrum use on GAA basis by the CBSDs.
CxG (Coexistence Group)	A group of CBSDs that abide by a common interference management policy which is used to coordinate their interference within the group.[1]
CxM (Coexistence Manager)	A logical entity responsible for managing coexistence among CBSDs within a specific CxG.
Equivalent TDD Configuration	A TDD Configuration in which, regardless of the SCS (i.e., independently of symbol durations), all UL, DL and gap periods are strictly aligned from a timing point of view with those defined by a reference E-UTRA or NR TDD Configuration.
E-UTRA TDD Configuration	A combination of a UL/DL frame configuration and an associated SSF configuration. **Note:** LTE-TDD Configuration is an equivalent term.
Fallback TDD Configuration	A TDD Configuration from the set of mandatory TDD Configurations a CBSD would prefer to use when its desired TDD Configuration is not allowed by the CxM.
GAA Channel Assignment	An operation performed by the CxM, where the CxM identifies the GAA frequency range that a particular CBSD may request from SAS and informs the CBSD and SAS of the assignment. The CBSD is expected to request grant(s) consistent with the GAA channel assignment and the SAS has the final discretion to accept or reject a CBSD's grant request to use a GAA channel.

[1] In the context of TS-2001 Release 2, support for only a single CBRSA CxG has been defined.

Term	Definition
ICG (Interference Coordination Group)	A group of CBSDs belonging to the CBRSA CxG indicating that they can manage their own interference within the group, and do not require channel orthogonalization.
LTE-TDD	LTE-Time Division Duplex: In the CBRS Band, LTE-TDD corresponds to Band 48 as defined by 3GPP.
NR-TDD	NR-Time Division Duplex: In the CBRS Band, NR-TDD corresponds to Band n48 as defined by 3GPP.
NR-TDD Configuration	A combination of an SCS and a TDD-UL-DL pattern for the NR frame.
Shared TDD Configuration Connected Set	A TDD Configuration Connected Set which represents a result of reconciliation for TDD Configuration Connected Sets generated by two or more CxMs.
TDD Configuration	A term collectively referring to E-UTRA TDD Configuration and NR-TDD Configuration. **Note:** This term is used in this specification when E-UTRA TDD Configuration and NR-TDD Configuration are not necessary to be described with differentiation.
TDD Configuration Connected Set	A Connected Set which is considered for coordination of CBSD TDD Configurations.

3.2 Abbreviations

Abbreviation	Explanation
3GPP	3rd Generation Partnership Project
BS	Base Station
CA	Carrier Aggregation
CBRS	Citizens Broadband Radio Service
CBRSA	CBRS Alliance
CBSD	Citizens Broadband Radio Service Device
CP	Cyclic Prefix
CPAS	Cooperative Periodic Activities among SASs
DL	Downlink
DP	Domain Proxy
E-UTRA	Evolved UTRA
FFS	For Further Study

Abbreviation	Explanation
FS2	Frame Structure 2 corresponding to LTE-TDD operation in 3GPP Band 48.
FSS	Fixed Satellite Service
GAA	General Authorized Access
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
ID	Identification
LTE	Long Term Evolution
NL	Network Listening
NR	New Radio
OOBE	Out Of Band Emission
OTA	Over the Air
PAL	Priority Access License
PTP	Precision Time Protocol
RAN	Radio Access Network
RF	Radio Frequency
SAS	Spectrum Access System
SCS	Sub-Carrier Spacing
SFN	System Frame Number
SSF	Special Subframe
TAI	Temps Atomique International
TDD	Time Division Duplex
TR	Technical Report
TS	Technical Specifications
UE	User Equipment
UL	Uplink
UTC	Coordinated Universal Time

4 CBRS Alliance CxM Information Exchange

Coordination of spectrum use between CBSDs is facilitated by exchanging information between CBSDs and the CxM.

See Section 7 for protocol extensions to support this information exchange.

5 Coexistence Requirements for CBSDs

5.1 Cell Phase Synchronization and TDD Configuration

A lack of frame synchronization (i.e., cell phase synchronization) or the use of incompatible TDD Configurations between CBSDs can create interference from high power downlink signals from the network towards UE transmissions, potentially degrading throughput due to harmful interference [24]. Therefore, cell phase synchronization is necessary and alignment of downlink and uplink resources will be promoted within TDD Configuration Connected Sets (see details in Section 6.3.1) of CBSDs, even when those CBSDs are operated by different operators. The actual interference level associated with the harmful interference as defined by FCC is not addressed in this version of the specification.

5.1.1 Cell Phase Synchronization

Several methods are available to achieve cell-phase synchronization of TDD networks, e.g. GPS or GNSS assistance [1], PTP, and NL. It is possible to achieve multi-operator frame synchronization based on existing parameters in 3GPP specifications in a manner that is independent of the actual source of timing information.

The definition of cell phase synchronization accuracy appears in 3GPP TS 36.133, Section 7.4 [2], for LTE cells and TS 38.133, Section 7.4.1 [25] for NR cells:

> *Cell phase synchronization accuracy is defined as the maximum absolute deviation in frame start timing between any pair of cells on the same frequency that have overlapping coverage areas.*

CBSDs shall conform with all the requirements of cell phase synchronization specified in the 3GPP TS 36.133 [2] for LTE cells and TS 38.133 [25] for NR cells, irrespective of the frequency assigned to them. In particular, the specification [2] establishes a requirement for accuracy at ≤ 3 µs for a wide area BS that has a cell radius ≤ 3 km and at ≤ 10 µs for a wide area BS that has a larger cell radius when measured against a common reference. In addition, the accuracy requirement for Home BS small cells at a propagation distance smaller than or equal to 500 m is ≤ 3 µs, while a large cell Home BS covering more than 500 m distance and operating in Network Listening (NL) mode will have to maintain Cell Phase Synchronization accuracy at a level ≤ 1.33 µs more than the time of propagation from the network synchronization source. The requirement for Home Base Stations without NL is equal to the small cell requirement. The 3GPP TS 36.133 and 3GPP TS 38.133 are the definitive references for all requirements pertaining to cell phase synchronization [2][25].

The parameters that establish synchronization are further detailed in 3GPP TS 36.401 and TS 38.401, Section 9.1 [3][26].

All LTE-TDD CBSDs and NR-TDD CBSDs shall derive frame timing in accordance with the following requirements:

1. **Time reference**: A time reference traceable to a common time reference. This time reference shall not be leap second adjusted according to [3][26]. Temps Atomique International (TAI) shall be used.
2. **SFN init time**: Initialization time for the SFN timing formula shall be according to Section 9.1 of [3][26], expressed in the time reference above and shall follow the detailed SFN initialization time as specified by the GPS epoch 1980-01-06 at midnight UTC, which equals 00:00:19 expressed in TAI [4] or according to the definition of SFN and frame timing difference in Section 5.1.14 of [27]. The use of a common SFN

initialization time serves to align the frame boundaries, and indeed the subframe boundaries, within the required timing accuracy.

CBSDs that use CA shall maintain a common frame reference for all the component carriers in any band combinations including the CBRS band, i.e., Band 48. When a CBSD determines or predicts it is operating outside the allowable limits required for cell phase synchronization, the CBSD shall stop radio transmission. Once the CBSD determines or predicts it is able to operate within the allowable limits required for cell phase synchronization, the CBSD may start radio transmission using spectrum grants authorized by SAS.

5.1.2 TDD Configuration

It is well understood in the industry that a desirable condition for multiple overlapping outdoor LTE- TDD and NR-TDD deployments to coexist in the same band is that they align their frame boundaries and use the same TDD Configuration. Asynchronous operation in the same outdoor area can lead to detrimental interference conditions, and coexistence solutions without alignment of cell phases and TDD Configurations may not be practical and/or efficient.

All LTE-TDD CBSDs shall support the uplink-downlink configurations in Table 5-1 with SSF Configuration 7 [4].

Table 5-1: Mandatory E-UTRA TDD Configurations for E-UTRA CBSDs.

Uplink-Downlink Configuration	UL:DL subframe ratio	Subframe Number									
		0	1	2	3	4	5	6	7	8	9
1	4:4	D	S	U	U	D	D	S	U	U	D
2	2:6	D	S	U	D	D	D	S	U	D	D

All NR-TDD CBSDs shall support NR SCS of 15 kHz or 30 kHz, as defined in Table 5.3.5-1 of TS 38.104.

NR CBSDs operating with 30 kHz SCS shall support the NR-TDD Configurations[2] that are shown in Table 5-2, which are equivalent to the mandatory LTE-TDD Configurations[3]. Slots shown with 'D' shall use 14 DL symbols, slots shown with 'U' shall use 14 UL symbols, and slots shown with 'S' shall have 14 symbols configured as 6 DL symbols followed by 4 Guard symbols followed by 4 UL symbols as shown in Figure 5-1 in order to match LTE-TDD SSF7 [17].

NR CBSDs operating with 15 kHz SCS shall support Equivalent TDD Configurations equivalent to the mandatory E-UTRA TDD Configurations shown in Table 5-1, where the symbols in the special slot shall be configured to match LTE-TDD SSF7 [17].

[2] Note: SCS employed for the TDD Frame configuration does not restrict the SCS that can be employed for the PRACH preamble format.

[3] Note: Initial NR CBSD deployments may not support both mandatory configurations, provided the CBSD stops NR operation if the CxM directs the CBSD to use a mandatory configuration that the CBSD does not yet support.

Table 5-2: Mandatory NR-TDD Configurations for CBSDs supporting 30 kHz SCS

UL:DL slot ratio	Slot Number																			
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
8:10	D	D	D	S	U	U	U	U	D	D	D	D	D	S	U	U	U	U	D	D
4:14	D	D	D	S	U	U	D	D	D	D	D	D	D	S	U	U	D	D	D	D

NR Slot	3, 13													
NR Symbol	0	1	2	3	4	5	6	7	8	9	10	11	12	13
UL-DL pattern	D	D	D	D	D	D	G	G	G	G	U	U	U	U

Figure 5-1: NR-TDD 30 kHz SCS "S" Slot Pattern for CBSDs

CBSDs may use any of the mandatory TDD Configurations listed in Table 5-1 and Table 5-2 without restriction[4]. Note that harmful interference causing operational issues between CBSDs using different mandatory TDD Configurations is not addressed in this version of the specification. Resolution of any reported interference shall be addressed by working with the CSAS Administrators. The methodology to report interference is out of the scope of this release of the specification. Such interactions are voluntary and do not mandate a specific action by the involved parties.

In addition to the mandatory TDD Configurations, the CBSDs may also use an alternative TDD Configuration in Table 5-3 and Table 5-4 with SSF7, or its Equivalent TDD Configuration, as long as they do not cause harmful interference [24] to any CBSD in the same TDD Configuration Connected Set using one of the mandatory TDD Configurations.

For NR CBSDs, the symbols in the special slot shall be configured to match LTE-TDD SSF7. The CBSDs may also use a Common Desired TDD Configuration (i.e., any other TDD Configuration defined in [4][17]) so long as all CBSDs in the same TDD Connected Set are using the same or equivalent TDD Configuration.

An NR CBSD, capable of using NR-TDD Configurations that are not compatible with LTE-TDD Configurations, may inform the CxM of the desired NR-TDD Configuration that is not compatible with LTE-TDD Configuration. In a TDD Configuration Connected Set containing only NR-TDD CBSDs, an NR-TDD Configuration not compatible with LTE-TDD may be used, provided that all NR-TDD CBSDs in the TDD Configuration Connected Set use the same or Equivalent TDD Configuration. Annex A provides a guideline to assist in determining if two NR TDD Configurations with the same or different SCS are equivalent.

A CBSD may request a change of the TDD Configuration at any time and use the new TDD Configuration upon approval from the CxM. How a CxM approves a new TDD Configuration is specified in Section 6.

In the case that the CxM denies a request to use a desired TDD Configuration then the CBSD shall comply with the CxM and fallback to one of the mandatory TDD configurations. The CBSD shall inform CxM about the used TDD Configuration.

[4] Note: LTE TDD Configuration 1 and 2 along with the associated Equivalent TDD Configurations are likely to be dominant in the market, but this specification does not preclude the use of other TDD Configurations

Table 5-3: Alternative E-UTRA TDD Configurations for CBSDs

Uplink-Downlink Configuration	UL:DL subframe ratio	Subframe Number									
		0	1	2	3	4	5	6	7	8	9
0	6:2	D	S	U	U	U	D	S	U	U	U

Table 5-4: Alternative NR-TDD Configuration for CBSDs supporting 30 kHz SCS

UL:DL slot ratio	Slot Number																			
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
12:6	D	D	D	S	U	U	U	U	U	U	D	D	D	S	U	U	U	U	U	U

Indoor CBSDs may inform the CxM of its desire to opt out of TDD Configuration Connected Sets used for TDD Configuration determination via the attributes in the grouping parameters. See more details in Section 6.3.1.

Note: For indoor deployments [22], where the CBSD power levels are comparable to UE power levels, the restriction to utilize a mandatory, alternative or Common Desired TDD Configuration can be relaxed.

5.2 Coexistence Measurement Report

Coexistence measurement reports are conveyed by CBSD/DPs to the CxM using the SAS-CBSD protocol. The measurements reports are carried in the *CoexMeasInfo* object described in Section 7, and can be sent by the CBSD in any SAS-CBSD message that allows a *GroupInfo* object, including the *RegistrationRequest*, *SpectrumInquiryRequest*, *GrantRequest*, and *HeartbeatRequest* [6].

The coexistence measurement reports are intended to provide the CxM with measurement information regarding the radio environment in the vicinity of the CBSD(s) that are performing or collecting the measurement, and thereby assist the CxM in its CBSD channel assignment function.

Coexistence reports may provide identification information, measurements, usability and tolerability indications. The information can pertain to the channels currently in use by the CBSD, or to other channels.

Along with a coexistence measurement report, CBSDs shall also provide the CxM with identification information about their transmitted CBRS E-UTRA/NR signals. This information is carried in *cellInfo* parameter of the *CbrsAllianceInfo* object described in Section 7. *cellInfo* parameter, which is an array of *SignalInfo* objects, shall be included in a heartbeat request when a CBSD starts to transmit a new CBRS E-UTRA/NR signal or whenever the identification information related to a CBRS E-UTRA/NR signal is modified.

The channels for which measurement information is being reported could pertain to a cell with an E- UTRA/NR TDD signal detected at the CBSD, signals corresponding to non-E-UTRA/NR TDD interferers detected at the CBSD, or E-UTRA/NR TDD signals detected by UEs connected to the CBSD.

For all reported channels, the report shall provide the frequency range for the measurements. Additionally, if the measured channel contains an E-UTRA/NR TDD signal, the report may include additional E-UTRA/NR TDD specific identification information regarding the signal, such as PCI, ECGI, etc.

For all reported channels, the CBSD may provide a ternary usability indication for the channel and may report its RSSI. Additionally, if the measured channel contains an E-UTRA/NR TDD signal, the report can contain E-UTRA/NR TDD specific measurements such as RSRP and RSRQ.

If the CBSD is reporting UE-based measurement results, such reports shall contain statistical information based on UE measurement reports received by one or more CBSDs sharing the same E- UTRA/NR Cell Global Identifier. The messages will have to be duplicated for each CBSD that is part of the E-UTRA/NR Cell Global Identifier.

5.3 Coexistence Reporting Assistance from CxM

Coexistence Reporting Assistance Information is guidance that can be provided by the CxM to the CBSDs/DPs as input to coexistence measurement reporting. The guidance information may include a list of channels for which the CxM is interested in receiving measurement information, along with additional identifiers regarding specific E-UTRA/NR TDD cells that may exist in those channels.

5.4 GAA Channelization

For CBSDs that are members of the CBRSA CxG, only combinations of 5 MHz channel units can be used for spectrum inquiry and grant request for GAA. Thirty channel units of 5 MHz width are defined with the following frequency ranges (in MHz)

$$[3550 + (k-1) * 5, 3550 + k * 5], k = 1, 2, \dots, 30.$$

CBSDs shall request a spectrum grant in multiples of these 5 MHz channel units. The CxM shall follow the above GAA channelization for all frequency guidance and guard band assignments in multiples of 5 MHz. NR requires a minimum of 10 MHz contiguous bandwidth. For Channel Assignment Connected Sets which include NR and LTE CBSDs, the CxM shall attempt to employ the same minimum contiguous bandwidth (10MHz) for the GAA Channel Assignment process.

5.5 CBSD Grouping

When a CBSD indicates membership in the CBRSA CxG, it may indicate membership in at most one Interference Coordination Group (ICG) to the CxM in a *cbrsaGroupingParam* parameter. ICG members are capable of managing interference among themselves, so even members with overlapping downlink coverage areas do not require non-overlapping spectrum assignments from the CxM.

A CBSD may further indicate membership in at most one Common Channel Group (CCG). A CCG shall consist of a subset of the CBSDs in a given ICG and shall indicate its CCG membership in the same *cbrsaGroupingParam* parameter that indicates membership in the corresponding ICG. All members of a given CCG require the same channel assignment from the CxM.

Figure 5-2 illustrates the relationship between CBSDs in the CBRSA CxG, ICGs, and CCGs. Note that the ICG and CCG formation are declared by the CBSD Users. The CBSD Users can form the CBSD Groups independently of the TDD Configuration which is determined by the CxM.

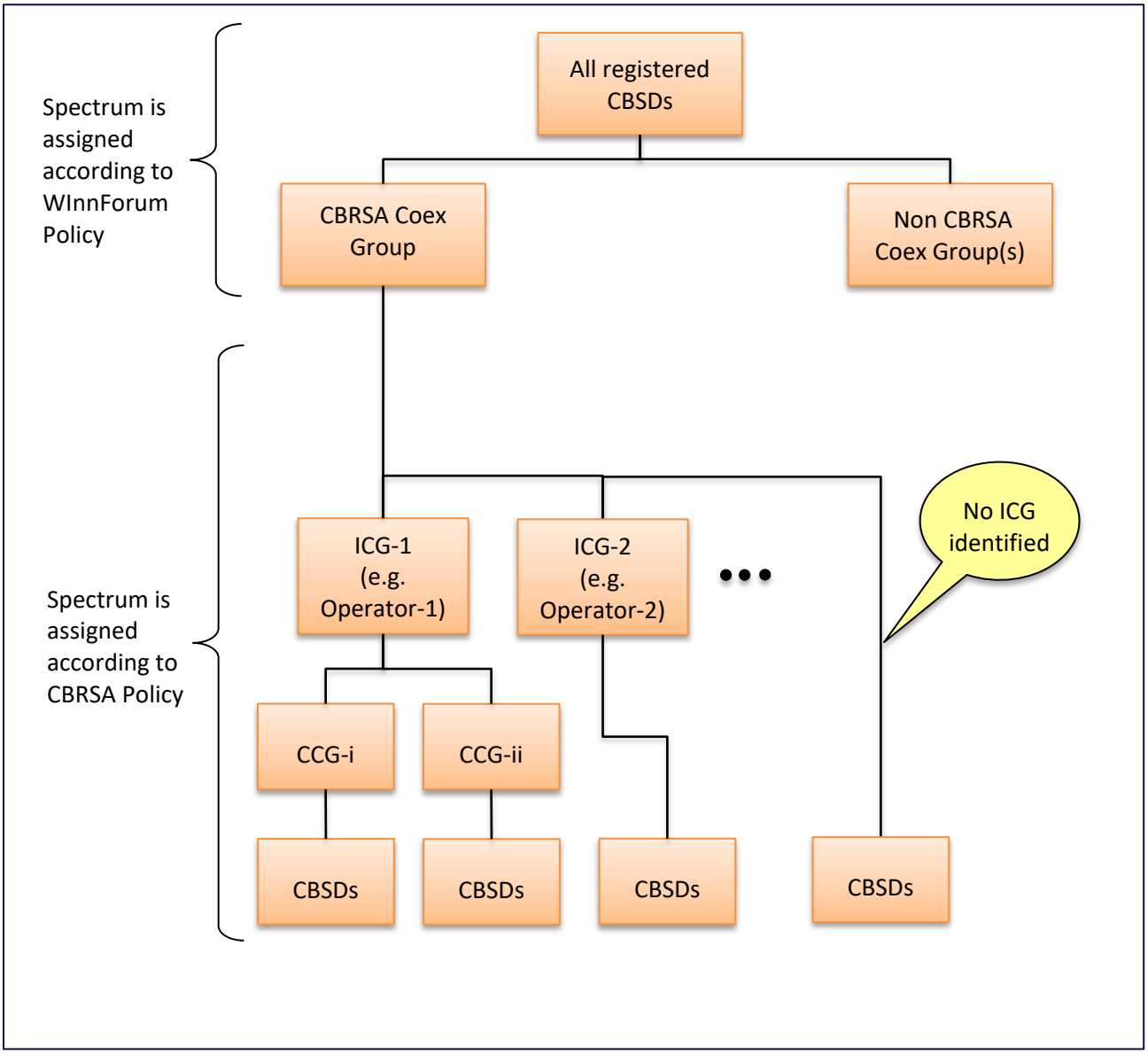

Figure 5-2: Relationship between CBSDs in the CBRSA CxG, ICGs, and CCGs.

6 Coexistence Requirements for CxM

6.1 CBRS Alliance CxG GAA Coexistence Principles

This section describes intra-CxG GAA Channel Assignment (defined in Section 3.2) to be used by CBSDs in the Grant Requests assuming LTE-TDD (FS2) or NR-TDD as the underlying technologies. Incumbent and PAL protection is handled by the SAS per Part-96 requirements [7] and the CxM procedures are subordinate to any decisions imposed by the SAS for this purpose.

The CxM is responsible for assigning a pool of available spectrum, received from the CSAS for the CBRSA CxG among all CBSDs claiming membership in the CBRSA CxG.

As per Section 5, all the LTE/NR CBSDs in each TDD Configuration Connected Set shall utilize a mandatory, alternative or Common Desired TDD Configuration and shall be cell phase synchronized to reduce CBSD to CBSD or UE to UE interference between different LTE/NR-TDD systems.

Indoor CBSDs which seek to opt out of TDD Configuration Connected Sets, shall also be cell phase synchronized (per Section 5).

In this section, “coverage” refers to the CBSD downlink coverage. Considerations for coverage adjustment based on uplink performance are FFS.

6.1.1 Primary Channel Assignment

The CSAS is responsible for providing the CxG with a spectrum assignment that is meant to be distributed among CBSDs within that CxG. In particular, the CSAS shall identify one or more sets of CBSDs within the CBRSA CxG and shall provide the CxM with a spectrum assignment for each set. The CxM shall perform primary channel assignment consistent with the operation as described in this section below. The CxM is responsible for informing the serving CSAS regarding the GAA Channel Assignment.

For each set of CBRSA CBSDs identified, the CSAS provides the CxM with a list of the CBSDs in the set, information about those CBSDs, and a pool of spectrum assigned for that set. The information provided includes CBSD registration information such as the location of each CBSD, maximum EIRP or requested EIRP (if available), height above average terrain (HAAT) of the antenna placement, antenna characteristics and grouping information [15] (e.g., the contents of *InstallationParam*, grouping parameters, etc.).

For each set of CBSDs identified by the CSAS, using information provided by the CSAS, the CxM may create an “coverage overlap graph”, which represents interference relationships between CBSDs, as follows:

- The CxM creates vertices of the graph.
  - The CxM creates one vertex for all CBSDs belonging to a CCG.
  - The CxM treats a CBSD as one vertex if the CBSD does not indicate any CCG membership.
- The CxM creates edges of the graph. The edge can be created between two vertices as follows:
  - An edge can be created based on the coverage overlap between the corresponding CBSDs.

Note: The definition of coverage overlap is FFS.

- There is an edge between co-situated CBSDs belonging to different ICGs. Refer to Section 6.3.3 for the definition of co-situated CBSDs.
- No edge should be created between the two vertices if all CBSDs corresponding to two vertices belong to the same ICG.
- The edge can also be created based on internal modeling of the propagation environment, RF measurements, network performance, interference condition, and so on.

After the CxM creates the coverage overlap graph, it finds different connected components of the graph, and each connected component becomes a "Channel Assignment Connected Set". At this point, the CxM considers each Channel Assignment Connected Set separately and performs the primary channel assignment independently for each Channel Assignment Connected Set:

- The CxM colors each vertex of a Channel Assignment Connected Set with minimum number of colors in the entire graph such that any two vertices with an edge between them have different colors. This minimum number is called the chromatic number [8].
- The spectrum available to the Channel Assignment Connected Set is divided into orthogonal and equal primary channels, and each vertex is assigned one of these channels corresponding to the color of the vertex in the graph.

The CxM should ensure stability over time (e.g., days) of channel assignment within the CxG as long as there is no instruction from the SAS on the change of channel availability due to the higher- tiers' activity.

Given that a significant CBSD EIRP power reduction (e.g., more than 10 dB in a typical use case) could completely invalidate the CBSD deployment goals, the CxM should recommend channel assignments to CBSDs that will not require more than an indicated EIRP power reduction from the requested EIRP level when higher tier protection is applied. Channel assignment should also consider other aspects such as contiguous and stable channel assignments. In case the CxM is not able to assign any channel that will meet the specified CBSD maximum power reduction, this is conveyed to the CBSD.

The CxM shall convey to the CBSD the set of channels assigned. The CBSD can request one or more Grants with the appropriate requested operational parameters using these channels. Following a successful Grant Request / Response, the SAS entity within the CSAS should notify the CxM of the spectrum grant. For CBSDs relinquishing a spectrum grant during the day, the SAS entity within the CSAS may notify the CxM.

6.1.2 Bandwidth Expansion

Within the spectrum assigned to the CxG by the SAS, the CxM may increase the bandwidth available to a CBSD beyond its primary channel assignment (which is an equal division of available GAA spectrum between the identified colors of a Channel Assignment Connected Set) by assigning any spectrum or part thereof that does not overlap with another CBSD's primary channel assignment, for all pairs of CBSDs where the vertices representing the two CBSDs are connected with an edge.

6.2 GAA Spectrum Inquiry Response to Newly Registered CBSDs

For CBSDs registering and requesting spectrum during the day (prior to the daily scheduled CPAS), in a Spectrum Inquiry Request, the CSAS may provide the following possible channels for consideration, listed in no priority order.

Note: The SAS has the final authority on what spectrum to grant CBSDs that it manages.

For initial deployment, the CxM may not be operational for spectrum inquiry objects during the day.

1. Channels unassigned to CBSDs that would have edges to the new CBSD.
2. Channels which require protection.

Note: To use these channels, power reduction might be required by SAS.

3. Channels already assigned to the same Interference Coordination Group (ICG), provided:
    a. the channel assignment does not violate protection of a higher tier user, and
    b. the channel assignment does not interfere with that of CBSDs in a different Channel Assignment Connected Set, where the channel is already in use by a different CxG (Note 1).
4. Expansion channels currently assigned to other CBRS-Alliance CBSDs in the Channel Assignment Connected Set (provided compliance with higher tier users and no edge to a different CxG).
5. Channels which have additional interference headroom after protecting higher tier users (Note 1).

Note 1: These are included in the list for completeness; however, most likely the CxM is not aware of other CxGs (non CBRS-Alliance CxGs) or incumbents (which would be higher tier users), thus the CxM would not know if these channels are available. The CSAS would need to decide if these channels are available.

6.3 TDD Configuration and Guard Band

6.3.1 Selection of TDD Configuration

This section specifies how CxM coordinates TDD Configurations among CBSDs.

The CxM shall build the TDD Configuration Connected Set by forming edges among all CBSDs, belonging to or not belonging to the CBRSA CxG, that have overlap of their respective -96dBm/10 MHz contours (similar to the Channel Assignment Connected Set). Note that the TDD Configuration Connected Set that the CxM constructs can be different from the Channel Assignment Connected Sets discussed in Section 6.1, which the CxM constructs for a different purpose. For example, these Connected Sets can be different in the case where indoor CBSDs opt out of the TDD Configuration Connected Set. Additional requirements on TDD Configuration Connected Sets for multi-CxM reconciliation can be found in Section 6.3.2.

The CxM shall use the desired TDD Configuration and the Fallback TDD Configuration received from a CBSD to determine the allowed TDD Configurations for a CBSD. The default values of the desired TDD Configuration and the fallback TDD Configuration can be found in Section 7. The Fallback TDD Configuration is chosen from the set of mandatory TDD Configurations listed in Table 5-1. If Fallback TDD Configuration is not provided by a CBSD, the CxM shall assume E-UTRA TDD Configuration 2 in Table 5-1 or the NR TDD Configuration equivalent to it as the Fallback TDD Configuration for that CBSD.

The CxM shall allow the CBSD to use its desired TDD Configuration if any of the following conditions is met:

1. If the CBSD specifies one of the mandatory TDD Configurations as the desired TDD Configuration,

2. If the CBSD specifies an alternative TDD Configuration as the desired TDD Configuration and there is no harmful interference reported in the TDD Configuration Connected Set, or
3. If all CBSDs in the TDD Configuration Connected Set specify the same desired or Equivalent TDD Configuration, i.e., a Common Desired TDD Configuration that is not limited to the mandatory or alternative TDD Configurations in Table 5-1, Table 5-2, Table 5-3 and Table 5-4.

For E-UTRA CBSDs, SSF7 shall be configured for the mandatory E-UTRA TDD Configurations (Table 5-1) and the alternative E-UTRA TDD Configurations (Table 5-3). For NR CBSDs, the symbols in the special slot for the mandatory NR-TDD Configurations (Table 5-2) and the alternative NR-TDD Configurations (Table 5-4) shall be configured to match LTE-TDD SSF7. Other SSF or special slot configurations may be configured for any other TDD Configurations.

If none of the above conditions are met, the CxM shall instruct the CBSD to use its requested Fallback TDD Configuration.

In the case that harmful interference [24] is reported originating from CBSD A not using a mandatory TDD Configuration which is affecting CBSD B in the same TDD Configuration Connected Set using a mandatory TDD Configuration then the CxM shall instruct the CBSD A to use its Fallback TDD Configuration if the CxM cannot resolve the interference through other means.

Resolution of identified cases of harmful interference [24] may be handled by the CxM in collaboration with the affected operators. Resolutions may include: channel re-assignment, increased frequency separation (Section 6.3.4), revoking opt out privileges, revoking use of an alternative TDD Configuration, requiring the use of a Fallback TDD Configuration, or facilitating exchange of data.

The CxM shall be able to receive CBSD request to opt out of the TDD Configuration Connected Set. Indoor CBSDs which select to opt out are not exempt from applying the Fallback TDD Configuration if instructed by the CxM. If an indoor CBSD's opt-out request is denied, the CxM shall include the indoor CBSD in a TDD Configuration Connected Set when determining the TDD Configuration.

The CxM shall instruct indoor CBSDs to use the Fallback TDD Configuration only when harmful interference [24] scenarios originated by the indoor CBSDs are reported.

The CxM shall use the protocol defined in Section 7 to inform each CBSD of the TDD Configuration to be used.

6.3.2 Selection of TDD Configuration with Multiple CxMs

In case where multiple CxMs manage different CBSDs in the same area, TDD Configuration Connected Sets created by each CxM could be different. Under these circumstances, each CxM shall follow the following steps to reconcile differences in independently created TDD Configuration Connected Sets in order to form Shared TDD Configuration Connected Sets:

1. Each CxM shall create TDD Configuration Connected Sets following the procedure described in Section 6.3.1. Each TDD Configuration Connected Set created by a CxM shall have at least one CBSD under the management of the CxM. Each CBSD under the management of a CxM shall belong to exactly one TDD Configuration Connected Set created by the CxM.
2. Each CxM shall exchange the list of CBSD IDs of CBSDs in each TDD Configuration Connected Set with its peer CxMs as part of the CBRS Alliance CxM Record (*CbrsAllianceCxm*) as defined in Section 7.3.

Note: This step could happen potentially in the CPAS process performed by the associated CSAS.

3. Using the lists of CBSDs in TDD Configuration Connected Sets created by peer CxMs, each CxM shall create Shared TDD Configuration Connected Sets independently by evaluating pairs of CBSDs and including each pair of CBSDs in the same Shared TDD Configuration Connected Sets if and only if
    a. at least one CxM puts the pair of CBSDs in the same TDD Configuration Connected Set, and
    b. no CxM puts the pair of CBSDs in different TDD Configuration Connected Sets.

Once Shared TDD Configuration Connected Sets are created, each CxM shall follow the procedure in Section 6.3.1 to select TDD Configurations for CBSDs under its control in each Shared TDD Configuration Connected Set. The following parameters received from CBSDs, as defined in Table 7-2, shall be exchanged between CxMs to facilitate consistent selection of TDD Configurations.

1. *desiredTddConfig*
2. *desiredNrTddConfig*
3. *usedTddConfig*
4. *usedNrTddConfig*
5. *fallbackTddConfig*
6. *indoorCbsdOptOut*

6.3.3 Changes in TDD Configuration Connected Sets

After the allowed TDD Configurations for all of the CBSDs for a given TDD Configuration Connected Set have been selected according to Section 6.3.1 and 6.3.2, the CxM shall determine the need to change the used TDD Configurations of the CBSDs in a TDD Configuration Connected Set in at least the following scenarios:

1. Addition of a new CBSD to a TDD Configuration Connected Set that is using a Common Desired TDD Configuration and the CBSD desires a different TDD Configuration than the Common Desired TDD Configuration.
2. Change of desired TDD Configuration of an existing CBSD in a TDD Configuration Connected Set using a Common Desired TDD Configuration.

The CxM shall determine if any of the CBSDs that are part of the TDD Configuration Connected Set require a change of TDD Configuration and order the affected CBSDs to use their Fallback TDD Configuration.

When adding a new CBSD to a TDD Configuration Connected Set, the CBSD shall be assigned initially to a single TDD Configuration Connected Set that has the greatest affinity to the CBSD; this is indicated by the edge corresponding to the highest estimated interference connection to the CBSD. After the initial assignment, the CxM shall over time determine whether two or more TDD Configuration Connected Sets bear merging due to the introduction of the CBSD, for example during occurrences of the Cooperative Periodic Activities among SASs (CPAS) [21] process for the CxG. The decision of whether and when to reconcile will consider additional factors such as a possible change of TDD Configuration for one or more TDD Configuration Connected Sets. The exact schedule of such reconfigurations is an operational matter that is left to the discretion of the CxM.

When the CxM has identified the need for CBSDs to change their TDD Configuration in a TDD Configuration Connected Set, it shall inform the SAS entity in the CSAS, and the CSAS shall enforce the new TDD configuration on grants belonging to the impacted CBSDs as per the following procedure:

- The CBSD shall modify the used TDD Configuration as instructed by the CxM and generate grant request(s) or heartbeat request(s) which reflect the use of the instructed TDD Configuration.
- The CSAS may terminate the grant(s) of the CBSDs in the impacted Connected Sets or it may suspend the grants.
- The CSAS may re-authorize the suspended Grants upon receiving the grant request(s) or the heartbeat request(s) that include grouping parameters indicating the use of the instructed TDD Configuration.

After a grace period (maximum 30 minutes), the CSAS shall terminate any grants that do not conform with the new TDD Configuration.

A Grant request in violation of the allowed TDD Configurations determined by the CxM for the TDD Configuration Connected Set shall be rejected by the CSAS.

6.3.4 Guard Band considerations for TDD Configurations

Cell-phase synchronized and co-situated CBSDs that use different channels and the same or Equivalent TDD Configuration do not need guard bands among them. Co-situated CBSDs are CBSDs sharing the same physical site and potentially the same antenna, i.e., sharing infrastructure or in close physical proximity.

Co-situated CBSDs that do not belong to the same ICG shall not be assigned the same frequency.

The CxM should maximize the frequency separation between different ICGs as necessary.

6.3.5 Statistical Distribution of TDD Configuration Use

CxM/CSAS should provide information about statistical distribution of TDD Configuration use per 10 MHz channel in a TDD Configuration Connected Set to an operator having CBSDs in the Connected Set upon request from the operator. The methodology of how the CxM/CSAS may provide this information is out of scope of this release of the specification.

The CxM may also inform operators of non-OnGo CBSDs of information about statistical distribution of TDD Configuration use per 10 MHz channel in the same TDD Configuration Connected Set and collect TDD Configuration information of those CBSDs. How the CxM exchanges the TDD Configuration statistics with operators of non-OnGo CBSDs is out of scope of this specification.

7 Protocol Extensions

To facilitate management of the CBRSA CxG by the CxM, all CBSDs that declare themselves to be part of the CBRSA CxG shall exchange information with the CxM. This is accomplished by including this information in JSON objects known as CBRS Alliance Coexistence Objects transported by using various existing messages of the SAS-CBSD protocol [6] and SAS-SAS protocol [14] as needed.

In order to be part of the CBRSA CxG, a CBSD and CSAS shall support the following features as also described by the CSAS profiles in TS-2002 [28]:

- WInnForum Release 2 (or higher) Specifications [6], [14]
- The "WF_ENHANCED_GROUP_HANDLING" optional feature ([6], [14])
- The *groupType* "COEXISTENCE_GROUP" ([15]).
- The CBRS Alliance Coexistence Objects described below.

The CBRS Alliance Coexistence Objects are:

- *CbrsAllianceInfo* object from CBSD/DP to CxM
- *CbrsAllianceConfig* object from CxM to CBSD/DP.
- *CbrsAllianceCxm* object from CxM to CxM

In the CBSD/DP to CxM direction, the *CbrsAllianceInfo* object is contained in the *groupInfo* parameter of the *GroupParam* data object [6].

In the CxM to CBSD/DP direction, the *CbrsAllianceConfig* object is contained in the *groupConfigInfo* parameter of the *GroupConfig* data object [6]. The details are in the following subsections.

In the CxM to CxM direction, the *CbrsAllianceCxm* object is contained in the *groupInfo* parameter of the *GroupParam* data object [14].

7.1 Information Transfer from CBSD/DP to CxM

A CBSD may send grouping information to a CxM by including the *groupingParam* parameter in the *RegistrationRequest*, the *SpectrumInquiryRequest*, the *GrantRequest* or the *HeartbeatRequest* object [6]. The *groupingParam* parameter and its content are defined in [6]. The latest *groupingParam* received by the CSAS shall supersede any previously received *groupingParam*.

An LTE-TDD or NR-TDD CBSD shall indicate membership in the CBRSA CxG by use of a *GroupParam* object. In particular, it shall set *groupType* to "COEXISTENCE_GROUP" and *groupId* to "CBRS_ALLIANCE" in the *GroupParam* object [15].

GroupInfo is a data object that enables CBSD/DP to share its group information. The *GroupInfo* object and its content are specified in Table 7-1 to Table 7-12.

If any request message towards the CSAS includes *groupingParam*, the CBSD shall include the CBRS Alliance coexistence group (CxG) with the most up-to-date information contained in *GroupInfo*. Otherwise, if the *groupingParam* does not contain the CBRSA Coexistence Group, the CSAS/CxM shall consider that the CBSD relinquishes its membership in the CBRSA CxG and the CxM shall:

- remove the CBSD from the corresponding Channel Assignment Connected Set. As a consequence, the GAA primary channel assignment will be updated as per Section 6.1.1.
- remove the CBSD from the TDD Configuration Connected Set. As a consequence, the TDD Configuration will be updated as per Section 6.3.3.

Table 7-1: *GroupInfo* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *cbrsAllianceInfo* DATA TYPE: object: *CbrsAllianceInfo*	Required	This parameter includes CBSD-specific information required for the management of the CBRSA CxG by the CxM. The data from the latest *cbrsAllianceInfo* object received by the CxM supersedes any previously received *cbrsAllianceInfo* data.

Table 7-2: *CbrsAllianceInfo* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *cbrsaVersion* DATA TYPE: string	Required	This parameter indicates the version of the CBRSA Coexistence Objects(s) implemented by the CBSD/DP. The version of CBRSA Coexistence Objects sent to the CBSD/DP shall be the same as the version of the *CbrsAllianceInfo* object from the CBSD/DP. In this version of this specification, this parameter shall be set to the value “v4.1”.
NAME: *desiredTddConfig* DATA TYPE: object: *EutraTddConfig*	Optional	This parameter indicates the desired E- UTRA TDD Configuration of the CBSD. If the desired TDD Configuration is an NR TDD Configuration equivalent to an E-UTRA TDD Configuration, this parameter shall be used to indicate the desired TDD Configuration. If neither *desiredTddConfig* nor *desiredNrTddConfig* is specified by a CBSD, the CxM shall use the *fallbackTddConfig* as the desired TDD Configuration.
NAME: *desiredNrTddConfig* DATA TYPE: object: *NrTddConfig*	Optional	This parameter indicates the desired NR- TDD Configuration which is not equivalent to any E-UTRA TDD Configuration. This parameter shall not be used to specify the NR-TDD Configuration which is equivalent to any E-UTRA TDD Configuration (see desiredTddConfig above).

Parameter	R/O/C	Parameter Information
		If neither *desiredTddConfig* nor *desiredNrTddConfig* is specified by a CBSD, the CxM shall use the *fallbackTddConfig* as the desired TDD Configuration.
NAME: *usedTddConfig* DATA TYPE: object: *EutraTddConfig*	Conditional	This parameter shall be included in the *GrantRequest* object, indicating the E- UTRA TDD Configuration to be used by the CBSD for the requested Grant or the E-UTRA TDD Configuration equivalent to the NR TDD Configuration to be used by the CBSD for the requested Grant. This parameter shall not be included when *usedNrTddConfig* is included in this object.
NAME: *usedNrTddConfig* DATA TYPE: object: *NrTddConfig*	Conditional	This parameter shall be included in the *GrantRequest* object, indicating the NR- TDD Configuration to be used for the grant. This parameter is used if the CBSD is employing an NR TDD configuration not compatible with an E-UTRA TDD Configuration. This parameter shall not be included when *usedTddConfig* is included in this object.
NAME: *fallbackTddConfig* DATA TYPE: object: *EutraTddConfig*	Optional	This parameter indicates the Fallback E- UTRA TDD Configuration or an NR TDD Configuration equivalent to it from the allowed mandatory choices in Table 5-1. If *fallbackTddConfig* is not provided by a CBSD, the CxM shall assume E-UTRA TDD Configuration 2 in Table 5-1 or an NR TDD Configuration equivalent to it as the *fallbackTddConfig* for that CBSD.
NAME: *cbrsaGroupingParam* DATA TYPE: array of object: *CbrsaGroupParam*	Optional	This parameter indicates the CBSD membership of one or more Group types specified in Section 5.5 of this document. A CBSD may belong to at most one ICG and at most one CCG. **Note:** Guidance for CBSD configuration of OnGo Alliance specific Group types can be found in Appendix B of this document.

Parameter	R/O/C	Parameter Information
NAME: *cellInfo* DATA TYPE: array of object: *SignalInfo*	Conditional	This parameter includes information about the signals transmitted by the CBSD. This parameter is included in a heartbeat request as described in Section 5.2.
NAME: *coexMeasInfo* DATA TYPE: object: *CoexMeasInfo*	Optional	This parameter includes coexistence related measurement information.
NAME: *indoorCbsdOptOut* DATA TYPE: Boolean	Optional	The indoor CBSD may use this parameter to indicate if they request to opt out of TDD Configuration Connected Sets. True: The indoor CBSD selects to opt out False: The indoor CBSD selects not to opt out The default value of this parameter is False.

Note: *CbrsAllianceInfo* Object is used also for CxM-to-CxM information exchange, but parameters included in *CbrsAllianceInfo* Object for CxM-to-CxM information exchange are different from that defined in Table 7-2. See details in Section 7.3 of this document.

Table 7-3: *EutraTddConfig* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *ulDLConfig* DATA TYPE: number	Required	This parameter represents E-UTRA TDD UL/DL configuration [4]. If this object represents the *fallbackTddConfig* parameter, permitted values are restricted as per Table 5-1 (see Section 5.1.2 for more details)[5]. Otherwise, permitted values are 0, 1, 2, 3, 4, 5, and 6.
NAME: *ssfConfig* DATA TYPE: number	Required	This parameter represents a special subframe configuration [4]. If this object represents the *fallbackTddConfig* parameter, permitted value is 7 (see Section 5.1.2 for more details)[5]. Otherwise, permitted values are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10.

[5] Note: Table 5-2 describes the NR TDD Configurations for NR SCS=30 kHz that are equivalent to the mandatory E-UTRA TDD Configurations specified in Table 5-1. Likewise, Figure 5-1 only specifies the special slot configuration for NR SCS=30 kHz which is equivalent to the LTE SSF7.

Table 7-4: *NrTddConfig* Definition

Parameter	R/O/C	Parameter Information
NAME: *subcarrierSpacing* DATA TYPE: string	Required	NR subcarrier spacing in kHz. The permitted values are “kHz15” and “kHz30”, representing 15 kHz and 30 kHz subcarrier spacing, respectively.
NAME: *nrTddUlDlPattern1* DATA TYPE: *NrTddUlDlPattern*	Required	NR TDD UL-DL Pattern, similar to the one defined in [20] (section describing TDD-UL-DL-Config information element)
NAME: *nrTddUlDlPattern2* DATA TYPE: *NrTddUlDlPattern*	Optional	NR TDD UL-DL Pattern, similar to the one defined in [20] (section describing TDD-UL-DL-Config information element)

Table 7-5: *NrTddUlDlPattern* Definition

Parameter	R/O/C	Parameter Information
NAME: *dlUlTransmissionPeriodicity* DATA TYPE: string	Required	Periodicity of the DL-UL pattern in milliseconds. Permitted values are “ms0p5”, “ms1”, “ms2”, “ms2p5”, “ms3”, “ms4”, “ms5”, “ms10”.
NAME: *nrofDownlinkSlots* DATA TYPE: number	Required	Number of consecutive full DL slots at the beginning of each DL-UL pattern. Maximum value is 20. This parameter is an integer number.
NAME: *nrofDownlinkSymbols* DATA TYPE: number	Required	Number of consecutive DL symbols in the beginning of the slot following the last full DL slot (as derived from *nrofDownlinkSlots*). The value 0 indicates that there is no partial-downlink slot. The symbols after the last DL symbol and before the first UL symbol, are considered to be guard symbols with no UL or DL signal being transmitted. The maximum number of symbols in a slot is 14. This parameter is an integer number.
NAME: *nrofUplinkSlots* DATA TYPE: number	Required	Number of consecutive full UL slots at the end of each DL-UL pattern. Maximum value is 20. This parameter is an integer number.
NAME: nrofUplinkSymbols DATA TYPE: number	Required	Number of consecutive UL symbols in the end of the slot preceding the first full UL slot (as derived from *nrofUplinkSlots*).

Parameter	R/O/C	Parameter Information
		The value 0 indicates that there is no partial-uplink slot. The maximum number of symbols in a slot is 14. The symbols after the last DL symbol and before the first UL symbol, are considered to be guard symbols with no UL or DL signal being transmitted. This parameter is an integer number.

Table 7-6: *CbrsaGroupParam* Definition

Parameter	R/O/C	Parameter Information
NAME: *cbrsaGroupType* DATA TYPE: string	Required	Allowed values are "CBRSA_ICG" or "CBRSA_CCG". If *cbrsaGroupType* is set to "CBRSA_ICG", the CBSD belongs to an Interference Coordination Group (ICG) defined by the CBRSA. If *cbrsaGroupType* is set to "CBRSA_CCG", the CBSD belongs to a common Channel Group (CCG).
NAME: *cbrsaGroupId* DATA TYPE: string	Required	This field specifies the identifier for this group of CBSDs. *cbrsaGroupId* shall be the concatenation of CBSD *userId* (as defined in [6]) and a string chosen by the user to uniquely identify the group among CBSDs with the same *userId*.

Table 7-7: *SignalInfo* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *eutraInfo* DATA TYPE: object: *EutraInfo*	Required	Indicates information on an E-UTRA signal or E-UTRA compatible NR signal.

Table 7-8: *EutraInfo* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *signalEarfcn* DATA TYPE: number	Required	Indicates the EARFCN of the LTE signal or NR-ARFCN of the NR signal. For *signalRat* = LTE, permitted values are integers between 55240 and 56739 inclusive. For *signalRat* = NR, permitted values are even integers between 636668 and 646666.
NAME: *signalRat* DATA TYPE: string	Conditional	Indicates the RAT associated with the signal. When used in the *cellInfo* parameter of the *CbrsAllianceInfo* object, the allowed values

Parameter	R/O/C	Parameter Information
		are “LTE” and “NR”. Otherwise, allowed values are “LTE”, “NR”, and “UNKNOWN”. This parameter shall be included if used in the *cellInfo* parameter of the *CbrsAllianceInfo* object.
NAME: *signalPci* DATA TYPE: number	Conditional	Indicates the PCI associated with the signal. For *signalRat* = LTE, permitted values are integers between 0 and 503 inclusive. For *signalRat* = NR, permitted values are integers between 0 and 1007 inclusive. This parameter shall be included if the *EutraInfo* object carries information of the transmitted signal. This parameter shall be included if used in the *cellInfo* parameter of the *CbrsAllianceInfo* object.
NAME: *signalEcgi* DATA TYPE: string	Conditional	For *signalRat* = LTE, indicates the ECGI associated with the signal. It is a string of length 52, containing 0’s and 1’s. For *signalRat* = NR, indicates the NCGI associated with the signal. It is a string length 60, containing 0’s and 1’s. This parameter shall be included if the *EutraInfo* object carries information of the transmitted signal. This parameter shall be included if used in the *cellInfo* parameter of the *CbrsAllianceInfo* object.
NAME: *signalBandwidth* DATA TYPE: number	Required	Indicates the bandwidth of the signal. Bandwidth of the signal is in 100’s of kHz (E.g., number 200 indicates bandwidth of 20MHz).

Table 7-9: *CoexMeasInfo* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *channelReport* DATA TYPE: array of object: *ChannelReport*	Optional	Provides CxM reports about a set of channels
NAME: *signalReport* DATA TYPE: array of object: *SignalReport*	Optional	Provides CxM reports about a set of detected signals

Table 7-10: *ChannelReport* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *channelFrequencyRange* DATA TYPE: object: *FrequencyRange*	Required	Indicates the frequency range of the reported channel.
NAME: channelUsability DATA TYPE: string	Optional	Permitted values are "USABLE", UNUSABLE" and "UNKNOWN". Indicated values should only be interpreted as relative comparison between channel usabilities reported by CBSDs belonging to the same CCG and ICG.
NAME: *channelRssi* DATA TYPE: number	Optional	Indicates the estimated RSSI of the channel in dBm. Permitted values are integers between -110 and -19 (including - 110 and -19). Indicated values should only be interpreted as relative comparison between channel RSSIs reported by CBSDs belonging to the same CCG and ICG.
NAME: *measurementInterval* DATA TYPE: object: *TimeInterval*	Optional	This parameter indicates the time interval when the measurement included in the *ChannelReport* object is performed.

Table 7-11: *TimeInterval* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *startTime* DATA TYPE: string	Required	Indicates the beginning of a time interval. This parameter is UTC time expressed in the format, YYYY-MM- DDThh:mm:ssZ as defined by [13].
NAME: *endTime* DATA TYPE: string	Required	Indicates the end of a time interval. This parameter is UTC time expressed in the format, YYYY-MM- DDThh:mm:ssZ as defined by [13].

Table 7-12: *SignalReport* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *detectedSignalInfo* DATA TYPE: object: *SignalInfo*	Required	Provides information about the detected signal
NAME: *signalTolerability* DATA TYPE: string	Optional	Indicates the tolerance to interference from the reported signal. Permitted values are

Parameter	R/O/C	Parameter Information
		"TOLERABLE", INTOLERABLE" and "UNKNOWN".
NAME: *cbsdSignalRsrp* DATA TYPE: number	Optional	Indicates the estimated RSRP of the detected downlink LTE waveform or estimated SS-RSRP of the detected downlink NR waveform. Permitted values are integers between -17 and 97 (including -17 and 97). The value is based on measurement at the CBSD.
NAME: *cbsdSignalRsrq* DATA TYPE: number	Optional	Indicates the estimated RSRQ of the detected downlink LTE waveform or estimated SS-RSRQ of the detected downlink NR waveform. Permitted values are integers between -30 and +46 (including -30 and +46). The value is based on measurement at the CBSD.
NAME: *ueSignalRsrpHistogram* DATA TYPE: array of number	Optional	A length-48 array, where each element indicates number of occurrences of UE-reported RSRP for this LTE signal or SS- RSRP for this NR signal that fall within each bin *i*, *i =0,…,47*. The RSRP range for each bin is as specified in [10], Section 6.1.
NAME: *ueSignalRsrqHistogram* DATA TYPE: array of number	Optional	A length-18 array, where each element indicates number of occurrences N_i of UE-reported RSRQ for this LTE signal or SS- RSRQ for this NR signal that fall within each bin *i*, *i =0,…,17*. The RSRQ range for each bin is as specified in [10], Section 6.2.
NAME: *measurementInterval* DATA TYPE: object: *TimeInterval*	Optional	This parameter indicates the time interval when the measurement(s) included in the *SignalReport* object is performed.

7.2 Information Transfer from CxM to CBSD/DP

Based on the CBRSA Coexistence policies, described in Section 6.3, a CxM may suggest coexistence parameters for a CBSD by using the *GroupConfigInfo* object in the *groupingConfig* parameter in the *RegistrationResponse,* the *SpectrumInquiryResponse,* the *GrantResponse,* or the *HeartbeatResponse* object [6]. The *GroupConfigInfo* object and its content are defined in Table 7-13 to Table 7-16.

Table 7-13: *GroupConfigInfo* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *cbrsAllianceConfig* DATA TYPE: object: *CbrsAllianceConfig*	Optional	This parameter is included if the CxM intends to configure the CBSD with specified coexistence parameter values.

Table 7-14: *CbrsAllianceConfig* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *cbrsaVersion* DATA TYPE: string	Required	This parameter indicates the version of the CBRSA Coexistence Objects(s) sent to the CBSD/DP. The version of CBRSA Coexistence Objects sent to the CBSD/DP shall be the same as the version of the *CbrsAllianceInfo* object from the CBSD/DP.
NAME: *eutraTddConfig* DATA TYPE: object: *EutraTddConfig*	Optional	If included, this parameter specifies the E-UTRA TDD Configuration or its NR Equivalent TDD Configuration that the CBSD shall use for all its grants.
NAME: *nrTddConfig* DATA TYPE: object: *NrTddConfig*	Optional	If included, this parameter specifies the NR-TDD Configuration that the CBSD shall use for all its grants. This parameter may be included by the CxM if the *eutraTddConfig* parameter is not present.
NAME: *coexMeasAssist* DATA TYPE: object: *CoexMeasAssist*	Optional	The CxM uses this parameter to send assistance information for coexistence measurements to the CBSD
NAME: *cbsdFrequencyGuidance* DATA TYPE: array of object: *FrequencyRange*	Optional	CxM uses this parameter to provide guidance on the frequency range(s) the CBSD is instructed to request and use going forward. Upon receiving this information, the CBSD is expected to only request and hold spectrum grants that are within the received *cbsdFrequencyGuidance*. In the scenario where the guidance last received from the *SpectrumInquiryResponse -> availableChannel* object is in conflict with the last received *cbsdFrequencyGuidance*, the CBSD should follow the latter for determining the frequencies on which to request spectrum grants.

Inclusion of a parameter to indicate primary or expansion channels is FFS.

Table 7-15: *CoexMeasAssist* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *channelAssistance* DATA TYPE: *FrequencyRange*	Optional	Indicates the frequency range of the reported channel.
NAME: *signalAssistance* DATA TYPE: array of object: *SignalInfo*	Optional	The CxM uses this parameter to inform CBSD the list of signals the CxM is interested about.

Table 7-16: *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.

7.3 Information Transfer from CxM to CxM

As described in Section 6.3.1, CxMs need to exchange information on TDD Configuration Connected Sets and some CBSD specific TDD Configuration information to ensure consistent TDD Configuration selection for CBSDs in the same Shared TDD Configuration Connected Set.

> CBSD specific TDD Configuration information within the *groupInfo* parameter of the *GroupParam* object (see Table 7-1) is exchanged during the CPAS process as a part of CBSD Data Records (i.e., *CbsdData* object) [14], where *cbrsaGroupingParam*, *cellInfo* and *coexMeasInfo* parameters shall not be included in the *cbrsAllianceInfo* parameter of the *GroupInfo* object.

The information on TDD Configuration Connected Sets is exchanged using the CBRS Alliance CxM Record by CxMs. The CBRS Alliance CxM Record, composed of the *CbrsAllianceCxm* object, may be exchanged during the CPAS process as a part of Full Activity Dump [14], where the value of *recordType* field in *ActivityDumpFile* object shall be “cbrs_alliance_cxm”. The *CbrsAllianceCxm* object is defined in Table 7-17.

Table 7-17: *CbrsAllianceCxm* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *cbrsaVersion* DATA TYPE: string	Required	This parameter indicates the version of the CBRSA Coexistence Objects(s) implemented by the CxM. In this version of this specification, this parameter shall be set to the value “v4.0”.

Parameter	R/O/C	Parameter Information
NAME: *tddConfigConnectedSets* DATA TYPE: array of object: *ConnectedSet*	Required	This parameter includes one or more TDD Configuration Connected Sets created by the CxM.

Table 7-18: *ConnectedSet* Object Definition

Parameter	R/O/C	Parameter Information
NAME: *cbsdsInConnectedSet* DATA TYPE: array of string	Required	This parameter includes CBSD Reference IDs (the *id* parameter in Table 6 of WINNF-TS-3003 [14]) of all CBSDs in a Connected Set.

Appendices (Informative)

Appendix A Equivalent TDD Configuration Determination

This appendix provides a pseudo-code to verify if two NR TDD Configurations are equivalent. Note that the proposed pseudo-code is targeted to providing clarity in the required process to verify equivalency between NR TDD Configurations and should in no way be considered an optimized solution. The interpretation of the different parameters and the creation of the frame structure based on these, is as per 3GPP 38.213 [17].

Assume two NR TDD Configurations in the following table:

Object	Parameter Name	Parameter Value for TDD Config. #1	Parameter Value for TDD Config. #2
NrTddConfig	subcarrierSpacing	scs1	scs2
NrTddConfig	nrTddUlDlPattern1	config1-Pattern1	config2-Pattern1
NrTddConfig	nrTddUlDlPattern2	config1-Pattern2	config2-Pattern2
NrTddUlDlPattern (for Pattern1)	dlUlTransmissionPeriodicity	config1-Pattern1-period	config2-Pattern1-period
NrTddUlDlPattern (for Pattern1)	nrofDownlinkSlots	config1-Pattern1-dlslots	config2-Pattern1-dlslots
NrTddUlDlPattern (for Pattern1)	nrofDownlinkSymbols	config1-Pattern1-dlsymb	config2-Pattern1-dlsymb
NrTddUlDlPattern (for Pattern1)	nrofUplinkSlots	config1-Pattern1-ulslots	config2-Pattern1-ulslots
NrTddUlDlPattern (for Pattern1)	nrofUplinkSymbols	config1-Pattern1-ulsymb	config2-Pattern1-ulsymb
NrTddUlDlPattern (for Pattern2)	dlUlTransmissionPeriodicity	config1-Pattern2-period	config2-Pattern2-period
NrTddUlDlPattern (for Pattern2)	nrofDownlinkSlots	config1-Pattern2-dlslots	config2-Pattern2-dlslots
NrTddUlDlPattern (for Pattern2)	nrofDownlinkSymbols	config1-Pattern2-dlsymb	config2-Pattern2-dlsymb
NrTddUlDlPattern (for Pattern2)	nrofUplinkSlots	config1-Pattern2-ulslots	config2-Pattern2-ulslots
NrTddUlDlPattern (for Pattern2)	nrofUplinkSymbols	config1-Pattern2-ulsymb	config2-Pattern2-ulsymb

The method to determine if two NR TDD Configurations are equivalent could be based on:

1. Establish common periodicity:

```
config1Periodicity =(config1-Pattern1-period + config1-Pattern2-period)*2

config2Periodicity =(config2-Pattern1-period + config2-Pattern2-period)*2

common-Periodicity = Lowest common multiple (config1Periodicity, config2Periodicity)/2
```

2. Set reference grid parameters:

```
reference-SCS=max(scs1,scs2)

reference-Slot-Duration=1/(reference-SCS / 15)

reference-Grid-Symbols= common-Periodicity / reference- Slot-Duration *14
```

3. Create combined pattern for TDD Config. #1 based on reference SCS:

```
t=0

tddFrameConfig1Array=[]

duration-multiplier=(reference-SCS / scs1)

i=0

while t<common-Periodicity:
   dl_symb=i+( config1-Pattern1-dlslots*14+ config1-Pattern1-dlsymb) * duration-multiplier
   while i<dl_symb:
      tddFrameConfig1Array[i]='DL'
      i++
   gap_symb=i+ ((config1-Pattern1-period/(15/scs1) - config1-Pattern1-dlslots - config1-Pattern1-ulslots)*14 - config1-Pattern1-dlsymb - config1-Pattern1-ulsymb)* duration-multiplier
   while i<gap_symb:
      tddFrameConfig1Array[i]='Gap'
      i++
   ul_symb=i+(config1-Pattern1-ulsymb + config1-Pattern1-ulslots*14)* duration-multiplier
   while i<ul_symb:
      tddFrameConfig1Array[i]='UL'
      i++
   t=t+ config1-Pattern1-period
   dl_symb=i+(config1-Pattern2-dlslots*14+ config1-Pattern2-dlsymb) * duration-multiplier
```

```
while i<dl_symb:
   tddFrameConfig2Array[i]='DL'
   i++
gap_symb=i+((config1-Pattern2-period/(15/scs1) - config1-
Pattern2-dlslots - config1-Pattern2-ulslots)14 - config1-
Pattern2-dlsymb - config1-Pattern2-ulsymb)* duration-multiplier
while i<gap_symb:
   tddFrameConfig2Array[i]='Gap'
   i++
ul_symb=i+(config1-Pattern2-ulsymb + config1-Pattern2-
ulslots*14)* duration-multiplier
while i<ul_symb:
   tddFrameConfig2Array[i]='UL'
   i++
t=t+ config1-Pattern2-period
```

4. Create combined pattern for TDD Config. #2 following the same procedure as in step 3 to compute tddFrameConfig2Array
5. NR TDD Patterns comparison:

```
t=0
while t< reference-Grid-Symbols
   if tddFrameConfig1Array[t]==tddFrameConfig2Array[t]:
      t++
   else:
      print("NR TDD Patterns are NOT equivalent")
      break;
if t== reference-Grid-Symbols:
   print("NR TDD Patterns are equivalent")
```

Appendix B WInnForum and OnGo Alliance CBSD Group Type Handling

This appendix provides a guidance on using OnGo Alliance specific group types mentioned in Section 5.5 of this specification and group types defined by WInnForum [15].

When a user configures a CBSD to indicate membership in a SRG group [15], then it is recommended to also configure the CBSD to inform the CxM that the CBSD belongs to a CBRSA_ICG (in *cbrsaGroupingParam* parameter) with the same *cbrsaGroupId* as the *groupId* of SRG [15]. In the scenario, where CBSD has informed the desire to be part of both an SRG group and CBRSA_ICG group, SAS and CxM will both have a common view of the grouping for channel allocation purposes. However, if user configures a CBSD to only belong to a CBRSA_ICG then the grouping information will be only visible to CxM for channel allocation purposes.

When a user configures a CBSD to indicate membership in the Single Frequency Group (SFG) [15], then it is recommended to also configure the CBSD to inform the CxM that the CBSD belongs to a CBRSA_CCG (in *cbrsaGroupingParam* parameter) with the same *cbrsaGroupId* as the *groupId* of SFG [15]. In this scenario, where CBSD has informed the desire to be part of an SFG group and CBRSA_CCG group, SAS and CxM will both have view of the grouping for channel allocation purposes. However, if user configures a CBSD to only belong to a CBRSA_CCG then the grouping information is only visible to CxM for channel allocation purposes. It is recommended to be further noted that fixed wireless deployments (e.g. during re-assignment of grant), could require identification of the BTS-CBSD and CPE-CBSD which is only possible via the WInnForum defined Principal – Subordinate SFG [15].

For the purposes of passive DAS deployments, a CBSD indicating membership in CBRSA CxG is recommended to use CBRSA_CCG to inform the CxM in a *cbrsaGroupingParam* parameter and also indicate its managing SAS its desire to be part of a Passive DAS group [15]. In this case, SAS and CxM will both have view of the grouping for channel allocation purposes.

An OnGo CBSD can also indicate its membership of groups other than those defined in this specification for the CBRSA CxG or the above mentioned SRG, SFG and Passive DAS group, via the WInnForum Enhanced CBSD Group Handling feature.

Appendix C (Informative): Change History

Table C-1: Change History

Version	Date	Description
V4.0.0	2021-04-15	V4.0.0 April 15, 2021 Introduction of enhanced support for NR TDD configurations and inter-CxM operation for TDD configuration coordination.
V4.1.0	2021-08-12	Include text for the following completed work items: • TDD configuration coordination with CBSDs using GAA and/or PAL spectrum • TDD configuration coordination with non-OnGo CBSDs • Handling of WInnForum and OnGo CBSD group types